Priority Setting and Disinvestment in Healthcare:

Economic Evidence, Policy Processes and Potential Consequences

Sergio Torres-Rueda

Thesis submitted in accordance with the requirements for the degree of Doctor of Philosophy (Ph.D.)

University of London

March 2023

Department of Global Health and Development

Faculty of Public Health and Policy

London School of Hygiene & Tropical Medicine

No funding received

Research group affiliation: Global Health Economics Centre

ABSTRACT

Background: In the context of increasing healthcare demand and rising costs, and in the absence of substantial increases in financing for health, disinvestment from comparatively less cost-effective interventions has been proposed as a way to optimise health outcomes within available resources. However, explicit disinvestment rarely happens in practice despite the fact that evidence-based priority setting has garnered increasing attention in low- and middle-income countries. The aim of this dissertation is to explore economic evidence requirements and uses, policy processes and potential consequences of disinvestment in healthcare in the context of priority setting.

Methods: This study is composed of three broad analytical sections: (1) a cost-effectiveness analysis of an incremental disinvestment decision (discontinuation of cotrimoxazole preventive therapy in Uganda), (2) an analysis tracking investment and disinvestment in the context of health sector-wide priority setting (health benefit package, or HBP, design in Pakistan), including a cost analysis of interventions across the health system and a study on the prioritisation of decision criteria and intervention characteristics by decisionmakers at different stages of the processes, and (3) the formulation of an explicit disinvestment model to design reduced HBPs during times of health system shocks, accompanied with a dataset of costs of care and treatment for COVID-19 in low- and middle-income countries.

Results: Standard economic evaluation approaches were successfully applied to an incremental disinvestment decision in Uganda. However, inappropriate communication once the disinvestment decision was implemented created disquiet. HBP design processes can offer transparent and explicit ways of making decisions on investment and disinvestment. Rapid costing methods can be effectively used in system-wide priority setting exercises. However, uptake of cost-effectiveness evidence is not necessarily uniform across stakeholders involved in HBP design. An aversion to disinvest, even from interventions that produce low value for money, was observed but the reasons remain unclear. Shocks to the health system, such as those observed worldwide during the COVID-19 pandemic may result in intervention displacement. Without explicit evidence-based approaches to disinvestment, intervention displacement can lead to sub-optimal and inequitable outcomes. Quantitative data on intervention feasibility and urgency may improve decision-making and shine light on decisionmaker preferences.

Conclusion: High quality economic evidence can be instrumental for successful decision-making in disinvestment. Data from HBP design processes can be leveraged pragmatically to aid decisionmakers in making explicit disinvestment decisions in situations of health-system shocks such as pandemics.

ACKNOWLEDGEMENTS

First and foremost, thank you to Anna Vassall, my primary PhD supervisor, as well as line manager and mentor, for years of unwavering support and encouragement. I've learnt enormously from working with you. Thank you for including me in so many research adventures over the years. To my secondary supervisor, Frank Sandmann, thank you for your guidance and for sharing your insights and experience with me; my work is all the better for it.

Sandra Mounier-Jack and Mishal Khan gave valuable qualitative input as members of the advisory panel; Mark Jit and Lorna Guinness provided thoughtful suggestions during the upgrading process; Giulia Ferrari supported an earlier iteration of this PhD; Emma McIntosh and Edina Sinanovic, my viva examiners, helped me piece it all together. Many thanks to all.

The work presented in this thesis would not have happened without a number of collaborators and colleagues for whom I am extremely grateful. From the work carried out for COSTOP in Uganda I would like to thank Joseph Lutaakome, Kenneth Katumba and, especially, Paula Munderi. From our large DCP3 Country Translation family, many thanks to: Nikki Kitson and Nuru Saadi in London, Rob Baltussen and Maarten Jansen in the Netherlands, and, particularly, the team in Pakistan, both in Karachi and Islamabad, for their generosity and hospitality: Wajeeha Raza, Mashal Murad Shah, Maryam Huda and Sameen Siddiqi at the Aga Khan University; and Raza Zaidi, Muhammad Khalid, Wahaj Zulfiqar; Urooj Gul and Shehrbano Akhtar at the HPSIU. Thank you as well to the COVID-19 economics and modelling team: Carl Pearson, Simon Procter, Roz Eggo and Nichola Naylor.

I would like to acknowledge the many people who have been part of my broader journey at the LSHTM since 2011. My sincere gratitude to a number of Professors: Kara Hanson and Catherine Goodman for hiring me; Fern Terris-Prestholt for taking a chance on me and teaching me the ropes in economic evaluation; Anne Mills and Mitzy Gafos for mentoring me along the way. A big debt of gratitude as well to my fellow researchers in the trenches, who prove that you learn as much from those above you as from those beside you—and who have made the last eleven years enjoyable. In vague chronological order: Ben Palafox, Silke Fernandes, Fiona Cianci, Ngozi Erondu from the early days; Adam Bourne and Jackie Cook for their friendship outside of the office, especially at the Rising Sun; Melisa Martinez-Alvarez, Neha Singh, Meghna Ranganathan and Helen Walls from the later days; Fiammetta Bozzani, Sedona Sweeney and Catherine Pitt, thank you, as well, for your help on the upgrading process; Manon Haemmerli, Roxanne Kovacs, Sadie Bell, Matt Quaife, and Mark Marchant, because you can't possibly wish for better officemates; and to David Bath for always having my back, inside and outside of the office. A very special thank you as well to Nicola Lord and

Linda Amarfio for looking after me; and to Sharon Ghuman, from my LSE days, for sparking my interest in global health research and setting me on this path.

I would not have been able to complete this PhD (or much else!) without the support of my family. I had the immense fortune of growing up with three parents. To my dad, thank you for always teaching by example and instilling in us the value of hard work; to my mom for putting our education above all else and for teaching us the value of empathy; and to my aunt, Tona, for broadening our horizons and for reminding us daily that life is there to be enjoyed. To Jorge, for knowing how to be an older brother and providing reassurance when it was most needed, to my uncle, Tis, for being part of this journey and to my nephew, Santi, for being a ray of sunshine. To my friends in London and scattered around the world, thank you, gracias, merci. And last, but most certainly not least, my immense gratitude to Flo, without whom none of this would have been possible. Thank you, always, mon chou, for your patience, love and support.

I lovingly dedicate this PhD to my three parents:

Papa, Mama y Tona

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure 4 (a): Pathway to full EPHS package: Distribution of included interventions by stage in the appraisal process broken down by (1) cost-effectiveness, (2) budget impact, (3) burden of disease, (4) ICER quality, (5) current coverage), (6) platform, (7) cluster, (8) vulnerable populations, (9) rule of rescue, and (10) intervention purpose

Figure 4 (b): Pathway to immediate implementation package: Distribution of included interventions by stage in the appraisal process broken down by (1) cost-effectiveness, (2) budget impact, (3) burden of disease, (4) ICER quality, (5) current coverage), (6) platform, (7) cluster, (8) vulnerable populations, (9) rule of rescue, and (10) intervention purpose

Figure 5 (a): Distribution of interventions throughout the process by current coverage and cost-effectiveness for the full EPHS

Figure 5 (b): Distribution of interventions throughout the process by current coverage and cost-effectiveness for the IIP

7.3 Research Paper 4

Figure 1(a): Health system costs of COVID-19 response per capita as % of GDP per Capita (nominal)

Figure 1(b): Health system costs of COVID-19 response per capita as % of total health spending (excl. OOP) per capita

Figure 1(c): Health system costs of COVID-19 Response per capita as % of total health spending (incl. OOP) per Capita

Figure 1(d): Health System Costs of COVID-19 Response per Capita as % of government health spending per capita

8.3 Research Paper 5

Figure 1: Schematic representation of optimal displacement

Figure 2: Number of interventions included/excluded in each scenario

Figure 3: Difference in DALYs averted between scenario and base case (immediate implementation package)

Figure 4: Inclusion/exclusion by cluster: (a) number of interventions, (b) the percentage of total cost per capita, and (c) the percentage of total disability-adjusted life years (DALYs) averted broken down by cluster by scenario

LIST OF ABBREVIATIONS AND ACRONYMS

A4R	Accountability for Reasonableness
AIDS	acquired immunodeficiency syndrome
ART	antiretroviral therapy
CE	cost-effectiveness
CET	cost-effectiveness threshold
CMMID	Centre for Mathematical Modelling of Infectious Disease
COVID-19	coronavirus disease 2019
CPT	cotrimoxazole-preventive therapy
CT	[COVID-19] care and treatment [interventions]
DALY	disability-adjusted life year
DCP3	Disease Control Priorities 3
EPHS	essential package of health services
EUHC	essential Universal Health Coverage
GDP	gross domestic product
GHCEA	Global Health Cost-Effectiveness Analysis
HBP	health benefit package
HIC	high income country
HIP	Health Intervention Prioritisation
HIV	human immunodeficiency virus
HPSIU	Health Planning, System Strengthening & Information Analysis Unit
HTA	health technology assessment
IAG	International Advisory Group
ICER	incremental cost-effectiveness ratio
ICU	intensive care unit
IHME	Institute of Health Metrics and Evaluation
IIP	immediate implementation package
KP	Khyber Pakhtunkhwa province
LIC	low-income country
LMIC	low- and middle-income country
LSHTM	London School of Hygiene & Tropical Medicine

MCDA	multi-criteria decision analysis
MIC	middle-income country
MNHSR&C	Federal Ministry of National Health Services, Regulation & Coordination [Pakistan]
MRC	Medical Research Council
NAC	National Advisory Council
OOP	out-of-pocket
PBMC	programme budgeting and marginal analysis
PCR	polymerase chain reaction
PHC	primary healthcare
PLC	placebo
PLHIV	people living with HIV
QALY	quality-adjusted life year
RCT	randomised controlled trial
RH	Referral hospital
RMNCH	reproductive, maternal, neonatal and child health
RR	'rule of rescue' [interventions]
SARS-CoV2	severe acute respiratory syndrome coronavirus 2
SC	Steering Committee
TB	tuberculosis
TWG	technical working group
UGX	Ugandan Shilling
UHC	Universal Health Coverage
UHC-BP	UHC benefit package
UK	United Kingdom
US	United States
USD	United States dollar
UVRI	Uganda Virus Research Institute
WHO	World Health Organization
WTA	willingness-to-accept
WTP	willingness-to-pay

Chapter 1: Introduction

The costs of healthcare are rising across countries of all income levels [1-3]. Aging populations, higher numbers of people with chronic diseases and a greater range of available health interventions have increased pressure on health budgets [4-6]. Furthermore, the COVID-19 pandemic has created an unexpected strain on health services across the globe [7-9]. In the absence of sustainable increases in funding for health, disinvestment, defined as the withdrawal of health resources from an existing healthcare practice [10], has been seen a potential solution. Disinvesting from comparatively less cost-effective and less desirable health interventions could free up resources that could be reallocated more efficiently elsewhere within the health sector, maximising health outcomes within existing budget constraints [11].

However, in practice, explicit disinvestment happens seldomly. A survey from the World Health Organization (WHO) from 2020-21 found that 60 out of 87 countries surveyed did not consider intervention withdrawal when revising health benefit packages (HBPs). The figure was particularly low in lower-middle income countries (4 out of 24 countries surveyed). This lack of policy engagement with intervention disinvestment is particularly concerning in severely resource-constrained settings: low- and middle -income countries (LMICs) are faced with more difficult trade-offs in deciding what health interventions can be provided as the opportunity costs are greater than in high-income countries (HICs). While there is some published evidence describing barriers and facilitators to successful disinvestment in HICs [10, 12-17], next to nothing has been written on LMICs.

Explaining why disinvestment in healthcare, while optimal from an economic perspective, does not happen in practice, is complex. The answer to this question likely lies at the intersection of disciplines, including economics, ethics, political science, philosophy, psychology and public policy studies. It is evidently beyond the scope of one doctoral thesis to address such a broad question from a plurality of disciplines and approaches. The aim of this dissertation is to explore economic evidence requirements and uses, policy processes and potential consequences of disinvestment in healthcare in the context of priority setting. I use empirical evidence from two case studies in LMICs. The first case study explores the discontinuation of cotrimoxazole-preventive therapy in HIV-positive adults in Uganda. The second case study analyses the process of HBP design in Pakistan.

Thesis structure

This thesis is broadly structured around the 'research paper style' described in the Research Degrees Handbook for Doctoral (PhD and DrPH) and MPhil Students (2021-22) [18]. At the heart of this thesis, there are five Results chapters (Chapters 4-8), each containing a research paper written and formatted for the purposes of submission to a peer-review journal. Research chapters also contain prologues and epilogues to ensure all necessary context is provided and that the chapters connect logically between one another, as well as to allow for additional reflection. The five research chapters can be divided broadly into three broad analytical sections: (i) Chapter 4 is a cost-effectiveness analysis of an incremental disinvestment decision (ii) Chapter 5 and 6 present an analysis tracking investment and disinvestment in the context of health sector-wide priority setting (health benefit package, or HBP, design), including a cost analysis of interventions across the health system and a study on evidence and intervention characteristic prioritisation by decisionmakers at different stages of the processes, and (iii) Chapters 7 and 8 present the formulation of an explicit disinvestment model to design reduced HBPs during times of health system shocks, such as global pandemics, accompanied with a dataset of costs of care and treatment for COVID-19 in low- and middle-income countries.

In addition to the Results chapters, the thesis contains this brief Introduction (Chapter 1), a Background section (Chapter 2) and a section on the Aim, Scope and Objectives (Chapter 3). After the Results chapters, there is a Discussion section (Chapter 9) and a Conclusion (Chapter 10). References are included at the end of each chapter. Relevant appendixes are included at the end of the document. An Abstract, List of Tables, List of Figures and List of Abbreviations and Acronyms can be found at the start of the thesis.

References

1. Watson, W.T., *2020 Global Medical Trends Survey Report*. 2020.
2. Cameron, A., et al., *Medicine prices, availability, and affordability in 36 developing and middle-income countries: a secondary analysis.* Lancet, 2009. **373**(9659): p. 240-9.
3. AON, *2020 Global Medical Trend Rates Report: Global Benefits*. 2020.
4. Godman, B., et al., *Barriers for Access to New Medicines: Searching for the Balance Between Rising Costs and Limited Budgets.* Frontiers in Public Health, 2018. **6**(328).
5. Hajat, C. and E. Stein, *The global burden of multiple chronic conditions: A narrative review.* Prev Med Rep, 2018. **12**: p. 284-293.
6. Divo, M.J., C.H. Martinez, and D.M. Mannino, *Ageing and the epidemiology of multimorbidity.* Eur Respir J, 2014. **44**(4): p. 1055-68.
7. Torres Rueda, S., et al., *The health sector cost of different policy responses to COVID-19 in low- and middle- income countries.* medRxiv, 2020: p. 2020.08.23.20180299.
8. Dudine, P., H. K-P;, and S. Jahan, *A Framework for Estimating Health Spending in Response to COVID-19*, in *IMF Working Papers*, I.M. Fund, Editor. 2020.
9. Tan-Torres Edejer, T., et al., *Projected health-care resource needs for an effective response to COVID-19 in 73 low-income and middle-income countries: a modelling study.* Lancet Glob Health, 2020. **8**(11): p. e1372-e1379.
10. Elshaug, A.G., J.E. Hiller, and J.R. Moss, *Exploring policy-makers' perspectives on disinvestment from ineffective healthcare practices.* Int J Technol Assess Health Care, 2008. **24**(1): p. 1-9.
11. Fineberg, H.V., *Shattuck Lecture. A successful and sustainable health system--how to get there from here.* N Engl J Med, 2012. **366**(11): p. 1020-7.
12. Elshaug, A.G., et al., *Challenges in Australian policy processes for disinvestment from existing, ineffective health care practices.* Aust New Zealand Health Policy, 2007. **4**: p. 23.
13. Lim, B.P., et al., *Health Technology Disinvestment in Singapore.* Ann Acad Med Singap, 2018. **47**(8): p. 338-344.
14. Mayer, J. and A. Nachtnebel, *Disinvesting from Ineffective Technologies: Lessons Learned from Current Programs.* Int J Technol Assess Health Care, 2015. **31**(6): p. 355-62.
15. Polisena, J., et al., *Disinvestment Activities and Candidates in the Health Technology Assessment Community: An Online Survey.* Int J Technol Assess Health Care, 2019. **35**(3): p. 189-194.
16. Robinson, S., et al., *Priority-setting and rationing in healthcare: evidence from the English experience.* Soc Sci Med, 2012. **75**(12): p. 2386-93.
17. Rooshenas, L., et al., *"I won't call it rationing...": an ethnographic study of healthcare disinvestment in theory and practice.* Soc Sci Med, 2015. **128**: p. 273-81.
18. London School of Hygiene & Tropical Medicine, *Research Degrees Handbook for Doctoral (PhD and DrPH) and MPhil Students: 2021-22*. 2021.

Chapter 2: Background

This background section is structured as follows. Priority-setting in health is described and discussed, focussing on three process types. Decision criteria used in the assessment and appraisal phases of priority setting are explained, followed by a definition of disinvestment across a number of key dimensions. The differences between investment and disinvestment are explored, in particular the relationship between willingness to pay (WTP), willingness to accept (WTA) and endowment effects. Later, economic evaluation evidence is discussed, and in particular 'decremental' cost-effectiveness, followed by a review of barriers and facilitators of successful disinvestment from the perspective of policymakers, frontline clinical staff and patients. Lastly, relevant contextual information about the two case study countries is mentioned.

Priority setting in health

Priority setting in health is, at its core, about allocating scarce resources. There are a number of different ways to explicitly set priorities in health. Below I describe three of them: health technology assessment (HTA), which is commonly interpreted as an incremental approach, health benefit package (HBP) design, which encompasses the broader health system, and programme budgeting and marginal analysis (PBMA), which focuses on specific programmes.

Health Technology Assessment (HTA) can be defined as a "systematic approach to evaluate the properties, effects and impacts of health technologies or interventions" [1]. This approach has traditionally been employed in an incremental fashion, assessing one intervention against similar alternatives. Originally HTA was largely concerned with assessing clinical efficacy, but, as expenditure for healthcare rose, cost-effectiveness analyses became an important part of HTA, motivating methodological developments [2]. Other criteria have become a part of the HTA process but product safety, clinical effectiveness and cost-effectiveness continue to be the most commonly-covered aspects [1].

In the global context of achieving Universal Health Coverage (UHC), broader exercises in priority setting have been attempted in recent decades. HBP design exercises attempt to define services provided through public expenditure. While there is debate around specific formulations of the HBP design process, it is generally acknowledged that successful HBP design should be rooted within a

known budget constraint and be defined explicitly and secure the maximum value for available resources and reflecting societal values [3, 4].

HTA has certain strengths, as it is systematic, multi-disciplinary, and involves a multiplicity of actors. Another one of its strengths, its scope, is also a disadvantage. The HTA process is incremental, and therefore it most often pertains to only one intervention. As a result, the decision-making process is relatively contained, making it an implementable approach that can be repeated with new interventions whenever necessary. However, this approach lacks contextualisation and may not adequately quantify positive and negative externalities of introduction. This systems-wide perspective is perhaps the greatest strength of the HBP approach. However, this approach requires a great amount of resources, expertise and time and thus can only be carried out in exceptional circumstances.

PBMA seeks to maximise the health-related impact of available resources at a broader programme-wide level. Programme budgeting appraises past resource allocation as an objective to track future resource use. Marginal analysis assesses costs and benefits (or financial gains and lost benefits) of investment and disinvestment [5]. PBMA operates under a fixed budget premise and often includes a 'wish list' (new interventions to be added/expanded) and a 'hit list' (existing interventions to be downsized/removed) [6]. Case studies using PBMA for disinvestment found the framework to be structured and transparent; the explicit inclusion of a programme budget and clarity on criteria included help ensure process aims were achieved [7].

While these three processes could be used for making both investment and disinvestment decisions, explicit disinvestment decisions happen infrequently. A 2020-21 survey from the World Health Organization showed that a minority of countries report including intervention withdrawal in their health benefit package revisions [8]. This is paradoxical given the increasing attention to the use of actionable health benefit packages, set within a budget constraint, to achieve Universal Health Coverage [9].

Decision criteria, assessment and appraisal

A range of decision criteria used for priority setting have been identified in literature reviews [10, 11]. Cost, cost-effectiveness and budget impact have traditionally been some of the more frequently cited criteria [12], but more recently, other criteria have become more prominent, such as equity and financial risk protection in the context of Universal Health Coverage. Considerations on political

and social acceptability and feasibility have also gained traction [10]. Criteria can sometimes be interpreted as reflecting specific value judgments or societal priorities, such as utilitarianism or egalitarianism.

Priority setting processes often engage with evidence in two stages: assessment and appraisal. In the assessment stage a particular aspect of an intervention is evaluated to form the basis for a decision [13]. There are established techniques to quantitatively assess some of these decision criteria. Perhaps the most commonly used and well-known is the incremental cost-effectiveness ratio (ICER), which expresses the incremental cost per additional unit of health utility gained (or lost). Often used to express a cost per disability-adjust life year averted (DALY), ICERs can be used to compare the cost-effectiveness of interventions across different disease areas and are therefore useful in priority-setting. However, unlike cost-effectiveness, some criteria are difficult to assess quantitatively, such as feasibility, and therefore assessment tend to happen more qualitatively.

The appraisal stage relates to the recommendation for adoption of an intervention based on the assessment [13]. It may be simple to compare two interventions on their respective cost-effectiveness based on their ICERs; however, it is considerably more complex to compare the performance of an intervention across different criteria. What is preferable: a highly cost-effective intervention that only addresses the need of the most privileged? Or an intervention that provides health to the most vulnerable but produces low value for money overall? There is no correct answer and trade-offs between criteria should reflect societal values. How criteria are weighed against one another is complex and can be done qualitatively or through more formal quantitative techniques, such as multi-criteria decision analysis (MCDA). While the use of MCDA has been criticised for being mechanistic, it adds transparency to the process and does not exclude additional deliberative approaches [14].

Definitions and typologies of disinvestment

Disinvestment, in its broadest sense, refers to the withdrawal of health resources from an existing healthcare practice [15]. The withdrawal can be complete or partial (e.g., restricting eligibility or imposing financial barriers to the patient). Disinvestment can be carried out on a range of health interventions (e.g., drug therapies, diagnostics, vaccines, surgical and non-surgical procedures) [7].

Disinvestment can be the product of deliberate and explicit policy choices, but it can also take place implicitly, or by ‘natural attrition’ [16]; in response to new interventions, clinicians can modify their

practices and reduce or suspend the use of older, less effective or less cost-effective interventions [17]. Disinvestment can occur in the context of public sector provision of services, but also as a result of changes to insurance reimbursement arrangements and other types of healthcare provision. Disinvestment can also happen *de facto* when routine services are displaced due to an inability of the health system to manage surges in demand and can be either temporary or permanent.

There are important distinctions in the rationales behind disinvestment. A substantial portion of the literature is devoted to disinvestment of interventions that are unsafe or ineffective; in this case disinvestment is largely about financial optimisation not necessarily coupled with substantial losses in health utility [15, 18]. A second rationale entails the withdrawal of interventions that provide comparatively less health benefit for their cost (i.e., not cost-effective relative to a similar intervention) [19]. There is, however, also disinvestment of safe, effective and cost-effective interventions due to resource constraints, leading to temporary or permanent service withdrawal. It is this last type of disinvestment that proves more controversial as it involves stark trade-offs and which is the focus of this dissertation [18, 20].

Investment and disinvestment: why are they different in theory?

Eighteenth-century political philosopher David Hume wrote that "*men generally fix their affections more on what they are possess'd of, than what they never enjoy'd: For this reason, it wou'd be greater cruelty to dispossess a man of any thing, than not to give [to] him" [21].* Without referring to them as such, Hume was writing about two of the key concepts necessary to understand disinvestment: willingness to pay (WTP) and willingness to accept (WTA). WTP refers to the maximum amount an individual is willing to pay in order to purchase a good (or to avoid a negative outcome) and WTA to the minimum that an individual is willing to accept to sell a good (or to accept a negative outcome) [22, 23]. The relationship between WTA and WTP has been a matter of longstanding debate.

Endowment effect

A fundamental tenet of neoclassical economic theory is that, in the context of small income effects and a range of available substitutes, the measure of value of an object should be roughly equal between WTP and WTA [24]. However, a large body of empirical evidence suggests that this is not the case, and that WTA is greater than WTP (known as the 'WTP-WTA gap') [25-27]. The 'gap' is

explained by endowment effects, which can be defined as the behavioural tendency for people to value goods more highly when they own them, relative to when they do not [28].

Examples of the endowment effect

A commonly cited experiment on WTP-WTA gap was carried out by Kahneman et al. (1990) and involved trading off coffee mugs and pens [29]. Once adult participants were in possession of a mug, they required twice as much compensation (in this case pens) than that they were willing to pay to acquire the mug in the first place. This type of experiment has been repeated by other behavioural economists and scientists with similar results. Van de ven et al. (2005) found endowment effects when exploring WTA/WTP with lottery tickets, Knetsch (1989) with chocolates and van Dijk et al. (1998) with bottles of wine [30-32].

Endowment effects have also been reported in children. Harbaugh et al. (2001) carried out experiments with children ages five and ten years old and young adults aged 20 years old. Subjects were given one age-relevant good and asked if they wanted to keep it or exchange it for a different one; the process was repeated with different goods. Endowment effects were found across all age groups and there was no evidence that the strength of the effect changed with age [33].

Studies carried out with chimpanzees suggest that other primates may exhibit endowment effects as well. Brosnan et al. (2007) report on a study where chimpanzees were observed favouring received items over other items known to be preferred which could be acquired through trading [34]. This experiment suggests that the deviation from rational choice predictions may have a common evolutionary root.

Endowment effects may not be limited to those goods possessed by the subject him/herself, but also by those close to the subject. Feng et al. (2013) carried out an experiment asking subjects to decide whether to buy or sell their own or their mothers' possessions at various prices and found that the endowment effect was present not just on the subjects' goods but also those belonging to their mothers, suggesting the extensibility of the effect [35].

The overwhelming majority of studies on endowment effects have been carried out with individuals from North America and Western Europe [36]. However, Maddux et al. (2010) carried out a set of studies with subjects of both North American and East Asian subjects and found that self-construal (how individuals define themselves as independent from, or interdependent with, others) and self-enhancement (tendency for individuals to take credit for their success), both of which are valued different between cultures, had an impact on endowment effects [36].

Explanations for the endowment effect

Endowment effects have often been explained by Prospect Theory and the concept of loss aversion [37]. Briefly, the pain of losing an item exceeds the pleasure of acquiring it; increased financial compensation is therefore require to mitigate the pain of loss [38, 39]. Reference points play an important role: buyers frame goods as gains (and sellers frame goods as losses) relative to the status quo [25, 40]. There are some suggestions that there is a physiological component to loss aversion. Losses and gains activate different parts of the brain [35]. Further, a study by DeWall et al. (2015) suggested that ingesting acetaminophen (a well-known pain relief medicine) reduces how much a seller demands to relinquish a good [41].

However, while loss aversion has been traditionally used to explain endowment effects, other theories have also been posited, some of which have been summarised in a review by Morewedge and Giblin (2015) [25]. Gal (2006) suggest endowment effects are linked to a propensity towards maintaining the status quo (i.e., inertia) rather than only by a loss/gain trade-off [42]. This may be particularly the case as, according to Gal, preferences are often "fuzzy and ill-defined" (as opposed to precise and well-defined), which lead individuals to have unclear preferences and therefore to prefer maintaining the status quo.

Evolutionary theorists suggest that a predisposition to overvalue goods was advantageous in bargaining: those who overvalued what they possessed were able to obtain more gains through trade and therefore support more offspring [43]. Other theorists propose that endowment effects can be explained by looking at ownership: sellers own a good a that buyers do not. Ownership creates associations with a good and can mean that the good is incorporated into the self-concept of the owner, which is generally positive, and therefore the association with the good is positive as well [44]. Ownership can lead to emotional attachment and the loss of the good can be perceived as a threat to the self [45]. Lastly, some posit that the WTP-WTA gap can be explained by a misunderstanding of the elicitation procedure; if a person believes she is in a negotiation, she may strategically misrepresent the valuation of the good [46]. Other explanations can be found elsewhere [25].

Endowment effects and non-market goods

Many studies examining endowment effects for different types of goods have been carried out in recent decades. Several meta-analyses have been carried out attempting to survey the evidence and draw conclusions, including Horowitz and McConnell (2002) and Tuncel and Hammitt (2014) [47, 48]. Horowitz and McConnell (2002) reviewed 45 experimental studies and found a smaller WTP-WTA

gap for ordinary private goods than for public goods or those not available in markets. Tuncel and Hammitt (2014) performed an updated review with 76 studies. They found that the geometric mean WTA/WTP ratio for all goods was 3.28, meaning that, on average, people want to receive a compensation that is 3.28 times higher to relinquish a good in relation to the amount that they are willing to pay than to buy it in the first place. There was a large disparity between different types of goods: 1.63 for ordinary private goods, 5.09 for health and safety goods and 6.23 for environmental goods. They found that goods with available substitutes tended to have lower mean ratios (1.95) than those where substitutes were not available (4.36). Ratios tended to be higher when studies were performed in non-student subjects (3.73 v. 1.99) and in studies performed before 2002 (4.17 v. 1.88), likely due to improved study designs.

Rotteveel et al. (2020) carried out a review and meta-analysis on the WTA-WTP gap [49], specifically on healthcare goods and services using 13 papers reporting on WTA and WTP from 19 experiments. The goods and services included in the meta-analysis included: methadone maintenance, life-extending treatment at end of life, hearing aid provision, primary care nursing consultations, visits to family physicians, paediatric cochlear implants, access to telehealth, access to informal care, and cancer drugs. Like Tuncel and Hammitt (2014). Rotteveel et al. (2020) also found also found a positive WTA/WTP ratio albeit one of lower magnitude: 5.09 in the former vs. 1.73 (mean) in the latter. The WTA/WTP ratio found in the studies reviewed by Rotteveel et al. (2020) ranged from 0.60 to 4.01. Individual participant data meta-analysis suggested that income category and age had a significant impact on the WTA/WTP ratio. Possible reasons stated for the lower mean rations reported in the Rotteveel et al. (2020) study include inadequate search terms that failed to capture studies identified by other meta-analyses and that previous meta-analyses grouped together health with safety goods (which may have greater disparity). Further, the studies in the Rotteveel et al. (2020) analysis tended to involve relatively small changes in healthcare goods and services, such as one-hour of informal care, or one consultation with a general practitioner.

Economic Evaluation

Economic evaluations compare the costs and outcomes of alternative policy options [50]. In economic evaluations, the analysis of costs and effects is done incrementally. Incremental costs of an intervention (i.e., the difference in cost between an intervention evaluated and a comparator intervention) are examined in relation to incremental effects (i.e., the difference in effect between an intervention and comparator). An ICER is calculated by dividing the differences in costs by the differences in effect. ICERs represent the amount of additional health gained (or lost) by an additional unit of resources spent. Policymakers generally use ICERs in order to compare the value

for money of different interventions as part of priority-setting [51]. Cost-effectiveness thresholds (CET) suggest the maximum amount that a payer is willing to pay for an additional unit of health utility [52]. Interventions with ICER values below the CET represent good value for money (and can thus be described as 'cost-effective'), whereas those above do not.

To aid in the decision process, ICERs are often plotted in a cost-effectiveness plane (representing cost on the y-axis and effectiveness in the x-axis). The four quadrants in the plane represent different policy decisions. If the only decision-making criterium was cost-effectiveness, interventions with an ICER in the northwest quadrant (more costly and less effective) would be rejected and those in the southeast quadrant (less costly and more effective) would be adopted. CETs are helpful in the policy decision for interventions in the northeast (more costly and more effective) and southwest (less costly and less effective) quadrants; the ICER's location in relation to the CET would determine whether the intervention should be considered for adoption or rejection.

The southwest quadrant and 'decrementally' cost-effective interventions

Given the abovementioned debates on WTP and WTA, the southwest quadrant (corresponding to ICERs of interventions that are both less costly and less effective) is controversial. Assessing these types of interventions could potentially lead to a decision to withdraw existing services, in other words disinvesting in the comparator altogether (see section 'Definitions and typologies of disinvestment' above for a more formal definition) and investing some of the newly available resources on interventions that are less effective (but more cost-effective). However, some decision-making bodies require that new interventions first be established as 'effective' before cost-effectiveness can be assessed [53]. For a long time, this led to a lack of evidence on interventions that reduce effectiveness but that could potentially be cost-effective (known as 'decrementally' cost-effective interventions) [54]. A review published in 2009 by Nelson et al. (covering studies between 2002 to 2007) found that only 0.4% (n=9) of all cost-utility analyses focus on potentially 'decrementally' cost-effective interventions [55]. These interventions were related to a range of disease types, including cardiovascular disease, gastrointestinal illness and mental health-related illnesses. Nelson et al. (2009) found that, on a per-patient basis, these interventions saved between 2009 US$ 122 and US$12,000 but only accounted for losses of 0.001-0.021 QALYs (so a week in full health or less).

This topic, however, seems to have garnered greater attention in recent years, possibly due to greater financial constraints globally following the financial crises of 2008 and 2020. Darlington et al. (2022) carried out a systematic review of technologies in non-inferiority studies [56]. In non-

inferiority trials an alternative treatment has efficacy that is not worse (or at least not much worse), than the standard treatment, while having possible advantages in safety, convenience, compliance and cost. In the last decade, the number of non-inferiority trials more than quadrupled from around 6000 in 1999-2009 to 29,000 in 2009-2019. However, there is still minimal guidance globally on decision-making around 'decrementally' cost-effective interventions.

Darlington et al. (2022) aimed to identify technologies that were both cost and outcome reducing in order to produce a list of technologies that could be considered 'decrementally' cost-effective, finding 107, of which 31 were medicines and 29 were services [56]. A large number of papers identified were about cancer, cardiovascular diseases, musculoskeletal disorders and respiratory diseases. There was an almost even split between papers examining new technology alternatives and those using the same technology but in different ways (such as drug tapering and changes in delivery mode). Decremental cost-utility ratios ranged from 2022 US$159 to US$5,304,373 saved per quality-adjusted life year (QALY) lost. Importantly, fewer than one-third of studies were carried out from a societal perspective and rarely included out-of-pocket costs.

Another review, published as a report by Scarica et al. (2019) in the context of the European Union's Horizon 2020, asked a similar research question as Darlington et al. (2022), but with a narrower scope, focussing on European countries [57]. Scarica et al. (2019) found 94 'decrementally' cost-effective technologies. Similarly to Darlington et al. (2022), about one-third of interventions were medicines, and one-third were services. Only one non-pharmaceutical intervention was found.

Technologies with minimal efficacy losses could produce greater societal gains once savings are redistributed. However, while this area (i.e., research on the opportunity cost of implementing 'decrementally' cost-effective interventions) remains systematically understudied, a few studies suggest that the financial and health consequences could be substantial.

Triple therapy (TT) is a combination therapy for patients with rheumatoid arthritis. A randomised controlled trial found that TT was non-inferior to the standard of care (etanercept-methotrexate therapy) for certain patients, with an average reduction of 0.017 QALYs and a cost saving of 2017 US$ 977,805 per QALY lost [58,59]. A budget impact analysis in France suggested that increasing the use of TT would save approximated 2018 €51 million, a 41% reduction in pharmacy expenditure for rheumatoid arthritis for the eligible population [57].

Another example involves changing treatment for some people living with HIV in the United Kingdom from triple antiretroviral therapy to the clinically non-inferior protease inhibitor monotherapy. Modelled lifetime costs suggested protease inhibitor monotherapy was associated

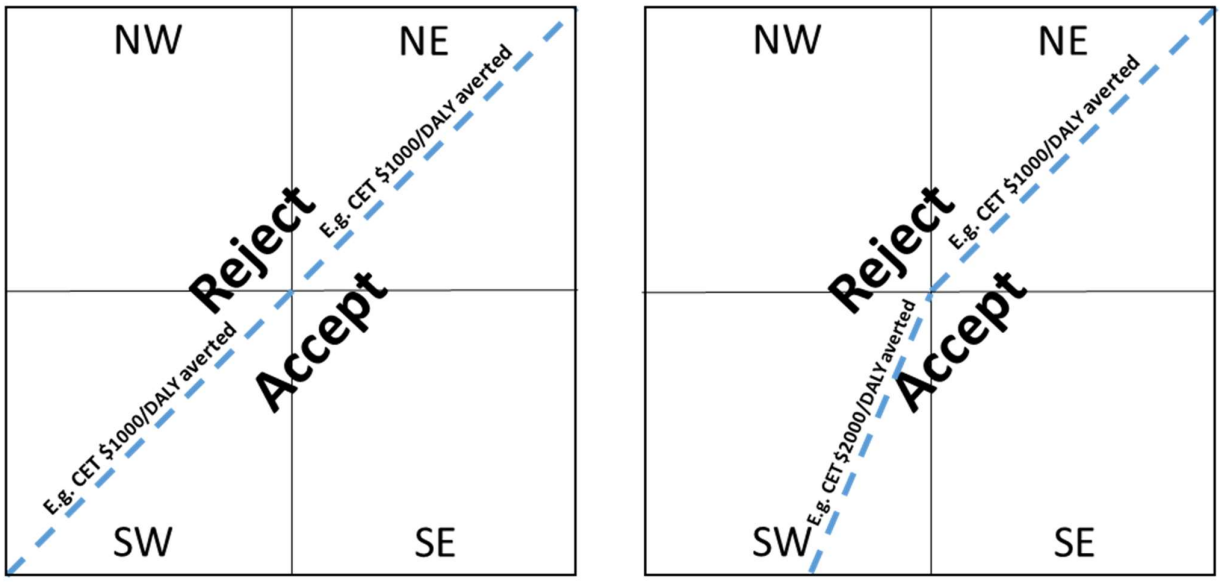
with substantial cost savings and only minor reductions in effectiveness. The cost savings from switching were estimated to be sufficient to generate over 22,000 QALYs elsewhere [56,60,61].

Debates on southwest thresholds

Further, even among those arguing that 'decremental' cost-effectiveness should be estimated, there is debate around the appropriate CET in the southwest quadrant. Given that in the southwest quadrant the policy decision is whether to give up a unit of health utility for a reduction in cost, the relevant question is whether the price of buying and selling of a unit of health utility is the same. O'Brien et al (2002) argue that there is a disparity in the ratio between WTP and WTA and therefore a downward kink in the CET is justified (see Figure 1). Whilst the magnitude of the kink is unclear, a downward direction in the CET enlarges the region in the plane where the corresponding policy decision is to reject, resulting in the need for greater compensation when giving up a unit of health [62]. See an example in Figure 1. Severens et al. (2005) agree that there are differences in WTA and WTP and highlight the effect that kinks to the CET have on how uncertainty is characterised; a kink in the CET changes the proportion of simulations in a probabilistic sensitivity analysis located in an area where the policy decision is to reject/accept. As ascertaining societal preferences to determine the WTA/WTP ratio (particularly if said ratio is dependent on the intervention assessed) is difficult, they suggest that economic evaluations in the southwest quadrant present multiple cost-effectiveness acceptability curves (CEACs) based on a range of WTP/WTA ratios in order to highlight different societal preferences [63].

Dowie (2004, 2005) disagrees that different quadrants should have different CETs. Differences between WTP and WTA are based on individual self-interest but cost-effectiveness analyses exist within an extra-welfarist framework where the goal is the maximisation of overall utility. A 'Rawlsian' patient, operating behind a 'veil of ignorance' (i.e., who does not know from which ailment he/she may suffer) should be in favour of the most efficient distribution of utility, which comes from applying decision rules consistency [64]. Dowie distinguishes between individual preferences in a market situation and those in the context of resource allocation decisions in a public healthcare system. An individual may be entitled to buy or sell a unit health utility at different prices in the former, but this asymmetry is inappropriate in the latter. While other social preferences could be considered (e.g., equity), they need to be incorporated and weighted within the measure of effect to ensure transparency [65].

Figure 1: (a) A cost-effectiveness plane where WTA=WTP shows a straight line through the northeast and southwest quadrants, and (b) a cost-effectiveness plane where WTA>WTP shows a kinked curve in the southwest quadrant



Disinvestment: what are the barriers and facilitators in practice?

The empirical literature on the barriers and facilitators to disinvestment is based on the experience of high-income countries. The literature broadly organises potential barriers and facilitators at three levels: policymakers, implementers, and the general public. The review of the literature on barriers and facilitators below was carried out non-systematically through a snowballing method to broadly map key concepts and debates [66].

Policymakers

This review identified analyses of disinvestment in Australia [15, 19], the United Kingdom (UK) [18, 67], Sweden [68], Singapore [69] and Canada [70]. Two articles engage stakeholders across multiple countries [71, 72]. Research methods were mostly qualitative, largely involving interviews with stakeholders. One carried out a survey [72]. Most articles refer to national-level stakeholders and processes, but four focus on the sub-national level [18, 67-69]. A number of recurrent themes can be found in the literature. These themes are lack of evidence, lack of processes and guidance, lack of adequate financial and human resources, difficulty in decision making specific to certain sectors and actors, difficulties in identifying candidates for disinvestment, competing interests among actors,

disconnection between decision making and implementation, negative connotations and public perceptions, and appropriate communication and transparency.

A lack of appropriate and sufficient evidence was cited as a major barrier in decision-making [19, 69, 71, 72]. Here 'evidence' and 'data' refer broadly to information considered necessary in order to make a decision on disinvestment of an existing intervention or technology. The type of information that is reported as lacking pertains largely to clinical effectiveness, often described generally as 'benefit', as well as cost and cost-effectiveness. This dearth of information is felt to be particularly substantial for interventions or technologies that have been implemented for a long time. This dearth of evidence is confirmed by a review of research grants funded by US research agencies: between 2000-17 only 4% of grants focused on technologies suspected of being ineffective, overused, or of low value [73]. Available data was found to be insufficient, irrelevant, inconsistent and difficult to interpret [69, 72], making unequivocal assessments of inferiority difficult. There was a perception that the consequential effects of disinvestment varied widely between types of interventions (e.g., shifts of financial burden to disadvantage groups) and were more complex than those involved in adoption decisions; the decision process thus necessitates a broader range of methods and criteria [19].

Some stakeholders felt that, compared to the adoption decision-making process, disinvestment decisions lacked formal, systemic and explicit processes and guidelines [15, 67, 72]. The formation of parallel assessment structures was proposed as a solution [15]. Greater emphasis in advancing methodological underpinnings of disinvestment was also seen as a priority [15].

A lack of human and financial resources devoted to the process of decision-making and implementation around disinvestment was commonly cited [15, 19, 67, 71, 72]. Some stakeholders reported insufficient time and incentives, with some already feeling overburdened with adoption decisions [19, 67]. Concerns were also expressed about the short-term funding available for outsourced technical appraisals, particularly from academic institutions, highlighting a conflict between traditionally scientific knowledge and user-oriented knowledge [19, 74].

The difficulty of the decision-making process varied. Certain stakeholders in Australia suggested that decision-making and implementation of disinvestment was particularly difficult in certain health sectors, such as the acute sector, where only modifications to patient pathways were acceptable [18], suggesting different criteria may need to be considered when disinvestment affects 'the rule of rescue' (i.e., the imperative to help individuals facing death) [75]. Researchers in Sweden found that some politician stakeholders tended to avoid contentious disinvestment decisions, in order to

maintain unity in the process, by effectively postponing the final decision into the longer term [68]. There was a difference between disinvestment decisions regarding ineffective interventions, versus those regarding effective interventions in the context of budget cuts (the latter being more politically difficult) [18].

Identifying candidates for disinvestment was seen as a major difficulty [19, 69, 71]. While many existing interventions were adopted before assessment of effectiveness and cost-effectiveness was standardised, there are no standard procedures to determine which merit re-assessment [19]. Unsafe technologies can be identified through records of adverse events. Analogous processes are not in place to identify comparatively ineffective ones, nor are comparators in economic evaluations automatically considered candidates for disinvestment [19]. Solutions proposed included international low-value health technology lists, systematic and coordinated global processes to identify obsolete technologies, as well as coupling discussions on adoption with candidate selection for reassessment [69].

Competing interests among certain actors was also said to complicate the process [19, 68, 72]. A survey with key stakeholders suggested the strength of well-established interest groups was the greatest barrier in the process. Some politicians saw their role as safeguarding the interest of patient groups instead of impartial reviewers of evidence [68]. Others suggested politicians safeguard commercial and other vested interests as well. Some stakeholders expressed concern that disinvestment could create disincentives for pharmaceutical or other technology companies to innovate if their products were seen to be in continual risk of being reassessed and potentially discarded [19], while others suggest it could be a tool to engage in price negotiations. The involvement of clinicians in the decision-making process was seen by some as enabling implementation [71], whereas the involvement of regular citizens tended to be avoided until after a decision was already made [18] to avoid potential delays.

A disconnect between decision-making and implementation was reported by stakeholders [18, 67, 70]. Some felt that discussions were overly focused on evidence over implementation concerns [70]. Decisions to disinvest were also perceived as non-enforceable and only succeeded with voluntary cooperation from providers [18].

The general concept of disinvestment carried negative connotations and was often understood as ‘cost-cutting’ and as financially motivated denial of care [67, 72]. The process was described as ‘countercultural’ and ‘unsettling’ [18]. Some discerned positive connotations from the minimisation of wasteful practices, interpreted as necessary to invest in new technologies [67]. Disinvestment was

seen as more palatable when presented alongside narratives of national financial hardship and the need for financial austerity [15, 18].

A fear of negative public perceptions was important. Concerns with negative reactions from the media were a hindering factor [18]. Some stakeholders were concerned with interpretation of disinvestment as waste, particularly when involving sunk costs related to equipment [19, 72]. In a decentralised system, local stakeholders feared being accused of creating 'postcode lotteries' and sought national-level political support [67].

Appropriate communication was key for successful decision-making [18, 70, 71]. Clarity during the dissemination process, particularly on changes in clinician guidance, was important [71]. The need for locally specific recommendations and engagement of knowledge-brokers (who juggle technical concepts and local understandings of feasibility and values) [70, 71] was also important.

Transparency in the process was also perceived as essential [18, 67, 69, 71]. Legitimacy in the process, was enhanced when the process involved clear and explicit use of empirical evidence [18]. Clear methods for identification and assessment, and clarity on criteria used, were perceived as essential [69, 71].

Frontline clinical staff

Fewer studies exploring views on disinvestment from clinicians were found.

Some clinicians in the literature surveyed had negative attitudes towards disinvestment [18, 19, 67, 69, 76]. Disinvestment rationales related to financial issues, particularly those framed as 'cost-cutting', were seen as unacceptable [76]. There was a reticence from providers to enact disinvestment policy changes, particularly in acute settings [18]. Attitudes were found to be different between cadres of workers. Some nurses were particularly resistant to change, with some voicing intentions to continue delivering services even if it went against hospital directives [76]. Attitudes appeared to soften over time, particularly with appropriate communication strategies [76].

Disinvestment was largely interpreted by certain clinicians as anathema to their professional values. Some felt an ideological reluctance to engage in disinvestment and felt powerless when implementing policies [67]. Many clinicians considered themselves, and not policymakers, to be best placed in deciding on patients' wellbeing [67] and perceived certain technologies to be integral to their professional identity [72]. Some clinicians feared that disinvestment would be met with resistance from patients [67] and they perceived it as a blunt tool limiting choice and autonomy [19].

Clinician attitudes were linked to inertia, both as entrenchment to long-standing practices [69] and to fundamental notions of resistance to change, such as those termed as 'dynamic conservatism', a phenomenon that explains how social systems (or health systems) work hard to resist change [19, 77].

General public

Two studies exploring patient and general public attitudes towards disinvestment were found [78, 79]. Both were from Australia.

When asked to identify criteria necessary for disinvestment decision-making, some members of the general public placed greater emphasis on the 'public good' over any individual's changes in health utility. They identified the need to ascertain direct and consequential costs and benefits and did not identify equity as an important consideration in the Australian context [78].

Broader socio-political implications of disinvestment through analyses of print and social media have also been explored. While traditional print media focused on emotive narratives, discussions in online forums were more complex. The concept of cost-effectiveness was not explicitly discussed online, but participants saw disinvestment as a way to control excessive profits going to medical professionals, and an opportunity to achieve greater equity [79].

Reflection on using a snowballing approach when scoping the literature

To understand the barriers and facilitators of disinvestment I carried out a scoping review using a snowballing approach, which could be defined as non-systematic.

A scoping review is an approach to evidence synthesis which is different to systematic reviews in that the former is used largely used to identify knowledge gaps, scope a body of literature and clarify concepts whereas the latter tends be used to retrieve evidence, review evidence quality and identify trends in research [80]. Given that the aim of my review was to understand the general landscape of the literature on barriers and facilitators, and to have a broad understanding on the distribution of the research (e.g., geography, population), as well as explore interpretations of healthcare disinvestment, I opted for a scoping review using a snowballing approach.

A snowballing approach to a scoping review means using an initial search to identify a set of key papers (also known as 'start set'). The papers are reviewed, along with their references lists. Snowballing can be done both in 'backwards' and 'forwards' manners. In backwards snowballing the relevant papers cited in the reference lists from papers reviewed are then searched and reviewed. Forward snowballing is a process where new papers are identified by using databases (such as

Google Scholar) that show which papers cite the initially reviewed paper. Several rounds of this process are done to capture webs of connected papers. Evidence shows that this kind of review can capture a high proportion of papers that would be picked up by more systematic searches [81].

This approach has strengths and weaknesses. It is a rapid and efficient way of conducting a review because it starts from a set of papers known to be relevant [82]. This is particularly important, and helpful, when conducting research on a broad area, such as disinvestment, where systematic reviews would be impractical [82]. Further, a snowball approach allows for the researcher to link papers to one another thematically and methodologically. These strengths persuaded me to use this method in my review. I did not intend the review to be exhaustive and was satisfied with a broad and comprehensive review. After several rounds of snowballing, new papers found did not seem to bring forth any themes that had not been previously identified.

The snowball approach also has weaknesses. It could potentially introduce bias that can skew the overall landscape. When only using snowball sampling it is difficult to know whether there are other 'webs' of papers, dealing with the same subject, not connected to any of the 'start set' papers (or those linked to them both upstream and downstream); those may only be identified through a broader search. Further, a snowball approach can be more subjective than a systematic review in that it is the individual researcher who decides on the 'start set'. This means that the research is in someone harder to reproduce.

Case studies: country backgrounds

The two case studies in this dissertation are the discontinuation of cotrimoxazole-preventive therapy in HIV-positive adults in Uganda, and the process of health benefit package design and review in Pakistan. Further descriptions of the case studies can be found in the Results chapters. Short country backgrounds for Uganda and Pakistan are found below.

Uganda

Uganda is located in East Africa, with a population of 44.7 million [84]. Classified as a low-income country, Uganda's nominal gross domestic product (GDP) per capita is US$822 and US$2,294 once adjusted for purchasing power parity (PPP) (2020) [85]. Forty-two percent of the population lived below the extreme poverty line (US$1.90 per day) in 2016, a decrease from 67% in 1999 [86]. The country is one of the youngest and most rapidly growing in the world; 48% of the population is

under the age of 14 years and the total fertility rate is 5.5 per woman. Only about one-fourth of the population lives in urban areas. The literacy rate (defined as the percentage of the population over 15 that can read and write) is 77%, although unevenly distributed between men (83%) and women (71%) [84].

Life expectancy at birth in Uganda is 63 years [87]. The country is affected by a double burden of disease; the top five causes of death include HIV, tuberculosis (TB) and malaria, as well as maternal and neonatal disorders and cardiovascular diseases [88]. A large percentage of health spending comes from external aid (42% of total health spending), followed by out-of-pocket spending (38%). Government health spending makes up 15% [89]. Healthcare provision in Uganda is highly decentralised. While the national Ministry of Health retains responsibility for policy formulation and planning, districts have increasing devolved responsibilities in operational matters, service delivery, human resource planning and, to a certain extent, expend resources according to local priorities [90, 91].

The first cases of HIV were reported in Uganda in 1982 [92] and by the mid-1980s Uganda was one of the countries in the world most severely hit by HIV and AIDS. However, by the late 1990s the country became the first in sub-Saharan Africa to reverse a generalised epidemic [93]. By 2022, about 1.4 million people in Uganda were living with HIV. Prevalence among adults aged 15 to 49 continued to be high, at 5.4%, with a large disparity between men (3.9%) and women (6.8%) [94]. Uganda has made substantial progress towards the Joint United Nations Programme on HIV/AIDS (UNAIDS) 95-95-95 targets, which aim at 95% of people living with HIV knowing their status, 95% of people who know their status on antiretroviral treatment (ART), and 95% of people on ART treatment with supressed viral loads by 2030 [95]. By 2022, around 1.3 million people (91%) living with HIV in Uganda knew their status, over 1.27 million received ART (90%) and 1.2 million (82%) had suppressed viral loads. Coverage of antiretrovirals for prevention of mother-to-child transmission was over 98% [94]. Provision of ART is free of charge for all people living with HIV; people are generally initiated on ART as soon as they receive a positive diagnosis [96].

Pakistan

Pakistan is located in South Asia. It is the world's fifth most populous country with a population of 221 million [97]. Pakistan is classified as a lower middle-income country and has a nominal GDP per capita of US$1,189 and a PPP-adjusted GDP per capita of US$4,813 (2020) [85]. The country has successfully reduced extreme poverty in recent decades; about 4% of the population lived below the extreme poverty line in 2015, compared to 29% in 1999 [98]. Thirty-six percent of the population is

below the age of 14 and about one-third of the population lives in urban areas. The literacy rate is low at 58% and substantially lower among women (47%) than men (69%) [99].

Life expectancy at birth is 67 years [97]. The top cause of death in Pakistan is cardiovascular diseases, followed by maternal and neonatal disorders, cancers, respiratory infections and TB and enteric infections [88]. Despite being a lower-middle income country, Pakistan suffers from unique health challenges. It is one two remaining countries in the world, along with Afghanistan, where polio remains endemic [100]. The country has also struggled to improve maternal and child health outcomes. Neonatal mortality rate in Pakistan is among the highest in the world; in 2016 one in every 22 new-borns died within their first month, making Pakistan the riskiest place to be born, according to UNICEF [101].

Health expenditure as a proportion of the government budget is low at 3.4% and well below the world average (9.8%) [85]. In 2019, the main source of current health expenditure was out-of-pocket payments (54%); only 32% of total health expenditure came from government sources [89]. Further, some have pointed out that a large proportion of the health budget is allocated to tertiary care in urban centres which does not match the burden of disease needs in the country at large [102]. As a result, there has been a movement towards improving primary healthcare and reassessing the delivery of services, particularly at the district level. As part of that initiative, the Government of Pakistan initiated a process of health benefit package design and review, which culminated in 2020 with the introduction of an Essential Package of Health Services (EPHS) [103].

References

1. World Health Organization, *2015 Global Survey on Health Technology Assessment by National Authorities: Main Findings*. 2015.
2. Banta, D., *The development of health technology assessment.* Health Policy, 2003. **63**(2): p. 121-32.
3. Ochalek, J., et al., *Supporting the development of a health benefits package in Malawi.* BMJ Glob Health, 2018. **3**(2): p. e000607.
4. Glassman, A., et al., *Defining a Health Benefits Package: What Are the Necessary Processes?* Health Syst Reform, 2016. **2**(1): p. 39-50.
5. Edwards, R.T., et al., *A national Programme Budgeting and Marginal Analysis (PBMA) of health improvement spending across Wales: disinvestment and reinvestment across the life course.* BMC Public Health, 2014. **14**: p. 837.
6. Knowledge, H., *Chapter 4: Marginal Analysis in Action*, in *Programme Budgeting and Marginal Analysis*.
7. Polisena, J., et al., *Case studies that illustrate disinvestment and resource allocation decision-making processes in health care: a systematic review.* Int J Technol Assess Health Care, 2013. **29**(2): p. 174-84.
8. World Health Organization, *Health Technology Assessment and Health Benefit Package Survey 2020/2021*. 2021.
9. World Health Organization, *Principles of health benefit packages*. 2021: Geneva.
10. Tromp, N. and R. Baltussen, *Mapping of multiple criteria for priority setting of health interventions: an aid for decision makers.* BMC Health Services Research, 2012. **12**(1): p. 454.
11. Hayati, R., et al., *Scoping literature review on the basic health benefit package and its determinant criteria.* Globalization and Health, 2018. **14**(1): p. 26.
12. Bertram, M.Y., et al., *Methods for the Economic Evaluation of Health Care Interventions for Priority Setting in the Health System: An Update From WHO CHOICE.* Int J Health Policy Manag, 2021. **10**(11): p. 673-677.
13. Sandman, L. and E. Heintz, *Assessment vs. appraisal of ethical aspects of health technology assessment: can the distinction be upheld?* GMS Health Technol Assess, 2014. **10**: p. Doc05.
14. Baltussen, R., et al., *Multicriteria Decision Analysis to Support Health Technology Assessment Agencies: Benefits, Limitations, and the Way Forward.* Value Health, 2019. **22**(11): p. 1283-1288.
15. Elshaug, A.G., J.E. Hiller, and J.R. Moss, *Exploring policy-makers' perspectives on disinvestment from ineffective healthcare practices.* Int J Technol Assess Health Care, 2008. **24**(1): p. 1-9.
16. Parkinson, B., et al., *Disinvestment and Value-Based Purchasing Strategies for Pharmaceuticals: An International Review.* Pharmacoeconomics, 2015. **33**(9): p. 905-24.
17. Chambers, J.D., et al., *A Review of Empirical Analyses of Disinvestment Initiatives.* Value Health, 2017. **20**(7): p. 909-918.
18. Robinson, S., et al., *Priority-setting and rationing in healthcare: evidence from the English experience.* Soc Sci Med, 2012. **75**(12): p. 2386-93.
19. Elshaug, A.G., et al., *Challenges in Australian policy processes for disinvestment from existing, ineffective health care practices.* Aust New Zealand Health Policy, 2007. **4**: p. 23.
20. Williams, I., S. Robinson, and H. Dickinson, *Rationing in health care: the theory and practice of priority setting*. 2012, Bristol: Policy Press.
21. Hume, D., *A Treatise on Human Nature* Vol. Book 3; Part 1; Section 1.
22. Evans, W., et al., *Willingness to Pay for Condoms among Men in Sub-Saharan Africa.* Int J Environ Res Public Health, 2018. **16**(1).
23. Gleason-Comstock, J., et al., *Willingness to pay and willingness to accept in a patient-centered blood pressure control study.* BMC Health Serv Res, 2017. **17**(1): p. 538.

24. Kling CL, List JA, Zhao J. A dynamic explanation of the willingness to pay wliingness to accept disparity. Economic Inquiry. 2013;51(1):909-21.
25. Morewedge CK, Giblin CE. Explanations of the endowment effect: an integrative review. Trends Cogn Sci. 2015;19(6):339-48.
26. Sayman S, Onculer A. A meta analysis of the willingness-to-accept and willingness-to-pay disparity. 2002.
27. Chapman J, Dean M, Ortoleva P, Snowberg E, Camerer C. Willingness to Pay and Willingness to Accept are Probably Less Correlated Than You Think. 2017.
28. Humphrey SJ, Lindsay L, Starmer C. Consumption experience, choice experience and the endowment effect. Journal of the Economic Science Association. 2017;3(2):109-20.
29. Kahneman D, Knetsch JL, Thaler RH. Experimental Tests of the Endowment Effect and the Coase Theorem. Journal of Political Economy. 1990;98(6):1325-48.
30. van de Ven N, Zeelenberg M, van Dijk E. Buying and selling exchange goods: Outcome information, curiosity and the endowment effect. Journal of Economic Psychology. 2005;26(3):459-68.
31. van Dijk E, van Knippenberg D. Trading wine: On the endowment effect, loss aversion, and the comparability of consumer goods. Journal of Economic Psychology. 1998;19(4):485-95.
32. Knetsch JL. The endowment effect and evidence of non-reversible indifference curves. American Economic Review. 1989;79:1277-84.
33. Harbaugh WT, Krause K, Vesterlund L. Are adults better behaved than children? Age, experience, and the endowment effect. Economic Letters. 2001;70:175-81.
34. Brosnan SF, Jones OD, Lambeth SP, Mareno MC, Richardson AS, Schapiro SJ. Endowment effects in chimpanzees. Curr Biol. 2007;17(19):1704-7.
35. Feng T, Zhao W, Donnay GF. The endowment effect can extend from self to mother: evidence from an fMRI study. Behav Brain Res. 2013;248:74-9.
36. Maddux WW, Yang H, Falk C, Adam H, Adair W, Endo Y, et al. For whom is parting with possessions more painful? Cultural differences in the endowment effect. Psychol Sci. 2010;21(12):1910-7.
37. Kahneman D, Tversky A. Prospect Theory: An Analysis of Decision under Risk. Econometrica. 1979;47(2):263-91.
38. Collard P, Walford A, Vernon L, Itagaki F, Turk D. The relationship between endowment and ownership effects in memory across cultures. Consciousness and Cognition. 2020;78:102865.
39. Zhang Y, Fishbach A. The Role of Anticipated Emotions in the Endowment Effect. Journal of Consumer Psychology. 2005;15(4):316-24.
40. Novemsky N, Kahneman D. The Boundaries of Loss Aversion. Journal of Marketing Research. 2005;42(2):119-28.
41. DeWall CN, Chester DS, White DS. Can acetaminophen reduce the pain of decision-making? Journal of Experimental Social Psychology. 2015;56:117-20.
42. Gal D. A psychological law of inertia and the illusion of loss aversion. Judgment and Decision Making. 2006;1(1):23-32.
43. Huck S, Kirchsteiger G, Oechssler J. Learning to Like What You Have – Explaining the Endowment Effect. The Economic Journal. 2005;115(505):689-702.
44. Weiss L, Johar GV. Egocentric Categorization and Product Judgment: Seeing Your Traits in What You Own (and Their Opposite in What You Don't). Journal of Consumer Research. 2013;40(1):185-201.
45. Shu SB, Peck J. Psychological ownership and affective reaction: Emotional attachment process variables and the endowment effect. Journal of Consumer Psychology. 2011;21(4):439-52.

46. Plott CR, Zeiler K. The Willingness to Pay-Willingness to Accept Gap, the "Endowment Effect," Subject Misconceptions, and Experimental Procedures for Eliciting Valuations. American Economic Review. 2005;95(3):530-45.
47. Horowitz JK, McConnell KE. A Review of WTA/WTP Studies. Journal of Environmental Economics and Management. 2002;44(3):426-47.
48. Tunçel T, Hammitt JK. A new meta-analysis on the WTP/WTA disparity. Journal of Environmental Economics and Management. 2014;68(1):175-87.
49. Rotteveel AH, Lambooij MS, Zuithoff NPA, van Exel J, Moons KGM, de Wit GA. Valuing Healthcare Goods and Services: A Systematic Review and Meta-Analysis on the WTA-WTP Disparity. Pharmacoeconomics. 2020;38(5):443-58.
50. Drummond MF, et al., *Methods for the Economics Evaluation of Health Care Programmes*. 2005, Oxford: Oxford University Press.
51. Bertram, M.Y., et al., *Cost-effectiveness thresholds: pros and cons.* Bull World Health Organ, 2016. **94**(12): p. 925-930.
52. Cleemput, I., et al., *Using threshold values for cost per quality-adjusted life-year gained in healthcare decisions.* Int J Technol Assess Health Care, 2011. **27**(1): p. 71-6.
53. Dowie J. Why cost-effectiveness should trump (clinical) effectiveness: the ethical economics of the South West quadrant. Health Econ. 2004;13(5):453-9.
54. Kent DM, Fendrick AM, Langa KM. New and dis-improved: on the evaluation and use of less effective, less expensive medical interventions. Med Decis Making. 2004;24(3):281-6.
55. Nelson AL, Cohen JT, Greenberg D, Kent DM. Much cheaper, almost as good: decrementally cost-effective medical innovation. Ann Intern Med. 2009;151(9):662-7.
56. Darlington M, Scarica R, Chavez-Pacheco X, Blamplain Segar L, Durand-Zaleski I. Decrementally cost-effective health technologies in non-inferiority studies: A systematic review. Front Pharmacol. 2022;13:1025326.
57. Scarica R, Chavez Pacheco X, Dupont JCK, Rochaix L, Durand Zaleski I, Darlington M. A systematic review of decrementally cost-effective health technologies and case studies. 2019.
58. O'Dell JR, Mikuls TR, Taylor TH, Ahluwalia V, Brophy M, Warren SR, et al. Therapies for Active Rheumatoid Arthritis after Methotrexate Failure. New England Journal of Medicine. 2013;369(4):307-18.
59. Bansback N, Phibbs CS, Sun H, O'Dell JR, Brophy M, Keystone EC, et al. Triple Therapy Versus Biologic Therapy for Active Rheumatoid Arthritis: A Cost-Effectiveness Analysis. Ann Intern Med. 2017;167(1):8-16.
60. Oddershede L, Walker S, Stöhr W, Dunn DT, Arenas-Pinto A, Paton NI, et al. Cost Effectiveness of Protease Inhibitor Monotherapy Versus Standard Triple Therapy in the Long-Term Management of HIV Patients: Analysis Using Evidence from the PIVOT Trial. Pharmacoeconomics. 2016;34(8):795-804.
61. Oddershede L, Walker S, Paton N, Stöhr W, Dunn D, Sculpher M. Cost-effectiveness analysis of protease inhibitor monotherapy vs. ongoing triple-therapy in the long-term management of HIV patients. J Int AIDS Soc [Internet]. 2014 2014; 17(4 Suppl 3):[19498 p.].
62. O'Brien, B.J., et al., *Is there a kink in consumers' threshold value for cost-effectiveness in health care?* Health Econ, 2002. **11**(2): p. 175-80.
63. Severens, J.L., et al., *Cost-effectiveness acceptability curves and a reluctance to lose.* Pharmacoeconomics, 2005. **23**(12): p. 1207-14.
64. Dowie, J., *Why cost-effectiveness should trump (clinical) effectiveness: the ethical economics of the South West quadrant.* Health Econ, 2004. **13**(5): p. 453-9.
65. Dowie, J., *No room for kinkiness in a public healthcare system.* Pharmacoeconomics, 2005. **23**(12): p. 1203-5.
66. Wohlin, C., *Guidelines for snowballing in systematic literature studies and a replication in software engineering*, in *Proceedings of the 18th International Conference on Evaluation and*

Assessment in Software Engineering. 2014, Association for Computing Machinery: London, England, United Kingdom. p. Article 38.
67. Rooshenas, L., et al., *"I won't call it rationing...": an ethnographic study of healthcare disinvestment in theory and practice.* Soc Sci Med, 2015. **128**: p. 273-81.
68. Garpenby, P. and A.C. Nedlund, *Political strategies in difficult times - The "backstage" experience of Swedish politicians on formal priority setting in healthcare.* Soc Sci Med, 2016. **163**: p. 63-70.
69. Lim, B.P., et al., *Health Technology Disinvestment in Singapore.* Ann Acad Med Singapore, 2018. **47**(8): p. 338-344.
70. Paprica, P.A., et al., *From Talk to Action: Policy Stakeholders, Appropriateness, and Selective Disinvestment.* Int J Technol Assess Health Care, 2015. **31**(4): p. 236-40.
71. Mayer, J. and A. Nachtnebel, *Disinvesting from Ineffective Technologies: Lessons Learned from Current Programs.* Int J Technol Assess Health Care, 2015. **31**(6): p. 355-62.
72. Polisena, J., et al., *Disinvestment Activities and Candidates in the Health Technology Assessment Community: An Online Survey.* Int J Technol Assess Health Care, 2019. **35**(3): p. 189-194.
73. Norton, W.E., A.E. Kennedy, and D.A. Chambers, *Studying de-implementation in health: an analysis of funded research grants.* Implement Sci, 2017. **12**(1): p. 144.
74. Lehoux, P., *The Problem of Health Technology: Implications for Modern Health Care Systems*. 2006, New York: Taylor and Francis Group.
75. McKie, J. and J. Richardson, *The rule of rescue.* Soc Sci Med, 2003. **56**(12): p. 2407-19.
76. Mitchell, D., et al., *Understanding Health Professional Responses to Service Disinvestment: A Qualitative Study.* Int J Health Policy Manag, 2019. **8**(7): p. 403-411.
77. DA, S., *Beyond the stable state: public and private learning in a changing society*. . 1971, London: Temple Smith.
78. Street, J.M., et al., *Citizens' Perspectives on Disinvestment from Publicly Funded Pathology Tests: A Deliberative Forum.* Value Health, 2015. **18**(8): p. 1050-6.
79. Street, J.M., et al., *News and social media: windows into community perspectives on disinvestment.* Int J Technol Assess Health Care, 2011. **27**(4): p. 376-83.
80. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Medical Research Methodology. 2018;18(1):143.
81. Greenhalgh T, Peacock R. Effectiveness and efficiency of search methods in systematic reviews of complex evidence: audit of primary sources. Bmj. 2005;331(7524):1064-5.
82. Wohlin C. Guidelines for snowballing in systematic literature studies and a replication in software engineering. Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering; London, England, United Kingdom: Association for Computing Machinery; 2014. p. Article 38.
83. Skoglund M, Runeson P. Reference-based search strategies in systematic reviews. Proceedings of the 13th international conference on Evaluation and Assessment in Software Engineering; UK: BCS Learning & Development Ltd.; 2009. p. 31–40.
84. CIA, *The World Factbook: Uganda*. 2022.
85. World Bank, *Data*. 2022.
86. United Nations Department of Economics and Social Affairs, *SDG Country Profile: Uganda*. 2022.
87. World Bank, *Country Profile: Uganda*. 2022.
88. IHME, *GBD Compare*. 2022.
89. World Health Organization, *Global Health Expenditure Database*. 2022.
90. Chen, J., et al., *Does decentralization of health systems translate into decentralization of authority? A decision space analysis of Ugandan healthcare facilities.* Health Policy and Planning, 2021. **36**(9): p. 1408-1417.

91. Ssengooba, F., et al., *Universal Health Coverage in Uganda: Looking Back and Forward to Speed up the Progress. Makerere University, Kampala Uganda.* 2017.
92. Mugerwa, R.D., L.H. Marum, and D. Serwadda, *Human immunodeficiency virus and AIDS in Uganda.* East Afr Med J, 1996. **73**(1): p. 20-6.
93. Kuhanen, J., *The Historiography of HIV and AIDS in Uganda.* History in Africa, 2008. **35**: p. 301-325.
94. UNAIDS, *Country Factsheet: Uganda*. 2022.
95. UNAIDS, *Understanding fast-track: accelerating action to end the AIDS epidemic by 2030.* 2015.
96. Republic of Uganda Ministry of Health, *Consolidated Guidelines for Prevention and Treatment of HIV in Uganda*. 2018.
97. World Bank, *Country Profile: Pakistan*. 2022.
98. United Nations Department of Economics and Social Affairs, *SDG Country Profile: Pakistan*. 2022.
99. CIA, *The World Factbook: Pakistan*. 2022.
100. Din, M., et al., *Impact of COVID-19 on polio vaccination in Pakistan: a concise overview.* Reviews in Medical Virology, 2021. **31**(4): p. e2190.
101. UNICEF, *Every child alive: the urgent need to end newborn deaths*. 2018.
102. Malik, S.M. and Z.A. Bhutta, *Reform of primary health care in Pakistan.* Lancet, 2018. **392**(10156): p. 1375-1377.
103. Government of Pakistan Ministry of Health Services Regulations & Coordination, *Monitoring progress towards Universal Health Care District EPHS implementation*. 2021.

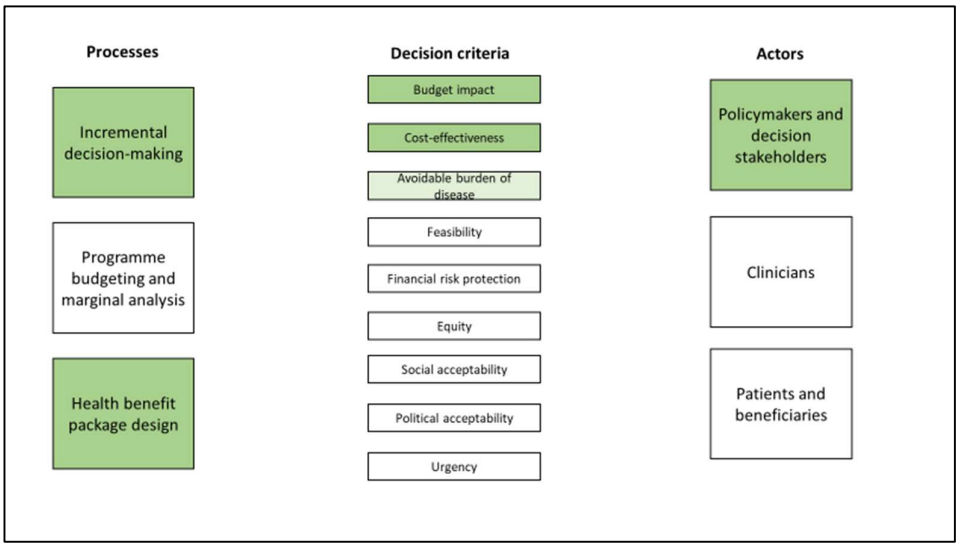
Chapter 3: Aim, scope and objectives

The overall aim of this doctoral dissertation is to explore economic evidence requirements and uses, policy processes and potential consequences of disinvestment in healthcare in the context of priority setting in low- and middle-income settings.

Figure 1 presents and acknowledges a list of processes, decision criteria and actors involved in, or affected by, priority setting in healthcare both for investment and disinvestment decisions. This Figure was developed using some of the literature I reviewed in Chapter 2 [1-22]. It was also influenced through my own experience working in the health benefit package design process in Pakistan (Chapters 5 and 6). It is important to note this list is a non-exhaustive. I include it simply to highlight the areas I plan to explore in this dissertation, as well as point out some other related areas which this dissertation will not address.

I plan to explore the areas highlighted in green namely: incremental decision-making and health benefit package design processes, economic evidence in the form of budget impact and cost-effectiveness, and policy makers and stakeholders involved in decision-making. Avoidable burden of disease is shaded a lighter green because while it is a component of cost-effectiveness analyses, it is not the primary focus of this dissertation.

Figure 1: Processes, decision criteria and actors involved in, or affected by, priority setting in healthcare



The dissertation contains five results chapters. Within each chapter there is a paper written in the style of peer-reviewed publications. Each paper has a distinct research question, as follows:

Paper in Chapter 4: What is the cost-effectiveness of disinvesting from cotrimoxazole preventive therapy in HIV-positive ART-stable adults in Uganda?

Paper in Chapter 5: For the purpose of informing investment and disinvestment decisions, what are the unit costs of interventions considered for Pakistan's health benefit package?

Paper in Chapter 6: What decision criteria and intervention characteristics were prioritised by policymakers when choosing which interventions to invest in and disinvest from during the health benefit package deliberation process in Pakistan?

Paper in Chapter 7: For the purpose of understanding possible resource reallocation (and consequential disinvestment) during health system shocks, what are the costs of COVID-19 care and treatment in Pakistan and other low- and middle-income countries?

Paper in Chapter 8: What are the potential consequences (in terms of costs, health outcomes and health benefit package composition) of different approaches to disinvestment following health system shocks?

In addition to the above-mentioned paper-specific research questions, the dissertation overall has the following objectives:

- To carry out an economic evaluation of a disinvestment intervention in the context of incremental decision making in priority setting in Uganda
- To estimate the costs and health benefits of investment and disinvestment decisions in the context of health sector wide priority setting in Pakistan
- To calculate ingredients-based, normative costs used for disinvestment decision-making, reflecting on strengths and weaknesses
- To develop an analytical approach to capture the consequences of potential health sector wide disinvestment in times of health system shocks using explicit criteria for prioritisation
- To examine the uptake of evidence in priority setting processes of investment and disinvestment and reflect on evidence requirements and uses
- To reflect on factors hindering and facilitating successful disinvestment and make recommendations for both methods and processes

References

1. World Health Organization, *2015 Global Survey on Health Technology Assessment by National Authorities: Main Findings*. 2015.
2. Banta, D., *The development of health technology assessment.* Health Policy, 2003. **63**(2): p. 121-32.
3. Ochalek, J., et al., *Supporting the development of a health benefits package in Malawi.* BMJ Glob Health, 2018. **3**(2): p. e000607.
4. Glassman, A., et al., *Defining a Health Benefits Package: What Are the Necessary Processes?* Health Syst Reform, 2016. **2**(1): p. 39-50.
5. Edwards, R.T., et al., *A national Programme Budgeting and Marginal Analysis (PBMA) of health improvement spending across Wales: disinvestment and reinvestment across the life course.* BMC Public Health, 2014. **14**: p. 837.
6. Knowledge, H., *Chapter 4: Marginal Analysis in Action*, in *Programme Budgeting and Marginal Analysis*.
7. Polisena, J., et al., *Case studies that illustrate disinvestment and resource allocation decision-making processes in health care: a systematic review.* Int J Technol Assess Health Care, 2013. **29**(2): p. 174-84.
8. Tromp, N. and R. Baltussen, *Mapping of multiple criteria for priority setting of health interventions: an aid for decision makers.* BMC Health Services Research, 2012. **12**(1): p. 454.
9. Hayati, R., et al., *Scoping literature review on the basic health benefit package and its determinant criteria.* Globalization and Health, 2018. **14**(1): p. 26.
10. Elshaug, A.G., J.E. Hiller, and J.R. Moss, *Exploring policy-makers' perspectives on disinvestment from ineffective healthcare practices.* Int J Technol Assess Health Care, 2008. **24**(1): p. 1-9.
11. Chambers, J.D., et al., *A Review of Empirical Analyses of Disinvestment Initiatives.* Value Health, 2017. **20**(7): p. 909-918.
12. Robinson, S., et al., *Priority-setting and rationing in healthcare: evidence from the English experience.* Soc Sci Med, 2012. **75**(12): p. 2386-93.
13. Elshaug, A.G., et al., *Challenges in Australian policy processes for disinvestment from existing, ineffective health care practices.* Aust New Zealand Health Policy, 2007. **4**: p. 23.
14. Rooshenas, L., et al., *"I won't call it rationing...": an ethnographic study of healthcare disinvestment in theory and practice.* Soc Sci Med, 2015. **128**: p. 273-81.
15. Garpenby, P. and A.C. Nedlund, *Political strategies in difficult times - The "backstage" experience of Swedish politicians on formal priority setting in healthcare.* Soc Sci Med, 2016. **163**: p. 63-70.
16. Lim, B.P., et al., *Health Technology Disinvestment in Singapore.* Ann Acad Med Singapore, 2018. **47**(8): p. 338-344.
17. Paprica, P.A., et al., *From Talk to Action: Policy Stakeholders, Appropriateness, and Selective Disinvestment.* Int J Technol Assess Health Care, 2015. **31**(4): p. 236-40.
18. Mayer, J. and A. Nachtnebel, *Disinvesting from Ineffective Technologies: Lessons Learned from Current Programs.* Int J Technol Assess Health Care, 2015. **31**(6): p. 355-62.
19. Polisena, J., et al., *Disinvestment Activities and Candidates in the Health Technology Assessment Community: An Online Survey.* Int J Technol Assess Health Care, 2019. **35**(3): p. 189-194.
20. Mitchell, D., et al., *Understanding Health Professional Responses to Service Disinvestment: A Qualitative Study.* Int J Health Policy Manag, 2019. **8**(7): p. 403-411.
21. Street, J.M., et al., *Citizens' Perspectives on Disinvestment from Publicly Funded Pathology Tests: A Deliberative Forum.* Value Health, 2015. **18**(8): p. 1050-6.
22. Street, J.M., et al., *News and social media: windows into community perspectives on disinvestment.* Int J Technol Assess Health Care, 2011. **27**(4): p. 376-83.

Chapter 4: Disinvestment of a healthcare intervention in the context of incremental cost-effectiveness and decision-making

4.1 Prologue

While this doctoral thesis has five results chapters (Chapters 4-8), the overall results can be grouped into three analytical sections: (i) an incremental cost-effectiveness analysis of a disinvestment intervention in Uganda (Chapter 4), (ii) an analysis to determine what decision criteria and intervention characteristics were prioritised during the health benefit package design process in Pakistan, which involved investment and disinvestment of interventions (Chapters 5 and 6), and (iii) an analytical model quantifying the potential consequences of different explicit approaches to health system wide disinvestment following health system shocks (Chapters 7 and 8).

The research paper in Chapter 4 aims to answer the following research question: what is the cost-effectiveness of disinvesting from cotrimoxazole preventive therapy in HIV-positive ART-stable adults in Uganda? It therefore explores the costs, health benefits and 'value for money' of disinvestment in the context of an incremental analysis and decision.

As I go on to explain in the epilogue to this chapter, the results here presented became part of the evidence base used to make a policy decision in Uganda: CPT was eventually partially discontinued in 2018 and not without controversy.

***

Working on the discontinuation of CPT marked a departure in my career in global health research. I joined the London School of Hygiene & Tropical Medicine (LSHTM) in 2011. Before carrying out the research project presented in this chapter, all projects I had worked on, whether economic evaluations or health systems research, involved the introduction of, and investment in, new healthcare interventions: antiretrovirals in Botswana, antimalarials in Madagascar, vaccines in Ethiopia, Rwanda and Cameroon, demand creation strategies for HIV prevention in Tanzania, and point-of-care HIV diagnostics in Tanzania and Zambia.

Priority setting should, in theory, consider both investment and disinvestment decisions. In many ways, they are two sides of the same coin. Yet, explicit investment decisions happen frequently and disinvestment decisions happen seldomly. The work I carried out in Uganda, as well as the aftermath of the disinvestment decision, led me to think critically about the evidence requirements of

disinvestment and reflect on whether standard methods of economic evaluation can support priority setting in disinvestment.

Candidate's role in the research paper

The candidate, Sergio Torres-Rueda, reviewed trial outcome data and designed and wrote the economic evaluation research protocol. This process included: (i) reviewing the literature for other economic evaluations on cotrimoxazole, as well as (ii) designing methodological approaches for resource use quantification through a mix of primary data collection and secondary data analysis, and (iii) choosing and adapting methods for health outcome estimation through trial record review and expert elicitation approaches. He prepared the submissions for ethics approval in the United Kingdom and Uganda. He developed data collection tools, piloted them, and carried out data collection in Uganda (which included expert elicitation exercises, patient record review and data extraction), with support from the Uganda-based team. He also carried out secondary data analysis using the trial dataset. The candidate carried out the analysis, including several rounds of revision of assumptions according to input from the trial's principal investigator. He wrote the manuscript and reviewed and incorporated co-author comments. He has presented the results at two international conferences and an internal seminar at the London School of Hygiene & Tropical Medicine.

4.2 Cover sheet for Research Paper 1

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT

T: +44 (0)20 7299 4646
F: +44 (0)20 7299 4656
www.lshtm.ac.uk

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed for each research paper included within a thesis.

SECTION A – Student Details

Student ID Number	1702569	**Title**	Mr.
First Name(s)	Sergio		
Surname/Family Name	Torres-Rueda		
Thesis Title	Priority Setting and Disinvestment in Healthcare: Economic Evidence, Policy Processes and Potential Consequences		
Primary Supervisor	Prof. Anna Vassall		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Choose an item.	Was the work subject to academic peer review?	Choose an item.

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	Lancet Global Health
Please list the paper's authors in the intended authorship order:	Sergio Torres-Rueda (corresponding author), Paula Munderi, Jonathan Levin, Zacchaeus Anywaine, Joseph Lutaakome, Andrew Abaasa, Ronnie Kasirye, Sedona Sweeney, David Bath, Frank Sandmann, Kenneth R. Katumba, Stella

	Settumba, Anna Vassall
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	STR designed the economic evaluation research protocol after reviewing trial outcome data. STR prepared submissions for ethical approval with institutional review boards in the United Kingdom and Uganda. STR planned data collection tools and carried out data collection in Uganda (with assistance from JL(2) and supervision from PM). STR designed and carried out the analysis. STR wrote the manuscript and disseminated results. JL(1), ZA, JL(2), AA, RK, SS(1), DB, FS, KK, SS(2) and AV reviewed the findings and manuscript and provided feedback. AV and PM offered supervision throughout the project.

SECTION E

Student Signature	Sergio Torres-Rueda
Date	05/04/22

Supervisor Signature	Anna Vassall
Date	05/04/22

4.3 Research Paper 1

Title

Is prevention really better than cure? A cost-effectiveness analysis of cotrimoxazole preventive therapy discontinuation among HIV-positive ART-stable adults in Uganda

Authors

Sergio Torres-Rueda[1]*

Paula Munderi[2]

Jonathan Levin[3]

Zacchaeus Anywaine[2]

Joseph Lutaakome[2]

Andrew Abaasa[2]

Ronnie Kasirye[2]

Sedona Sweeney[1]

David Bath[1]

Frank Sandmann[1]

Kenneth R. Katumba[2]

Stella Settumba[2]

Anna Vassall[1]

*Corresponding author

Institutional Affiliations

[1]London School of Hygiene & Tropical Medicine, London, United Kingdom

[2]Medical Research Council (MRC)/Uganda Virus Research Institute (UVRI) & London School of Hygiene & Tropical Medicine (LSHTM) Research Unit, Entebbe, Uganda

[3]School of Public Health, University of the Witwatersrand, Johannesburg, South Africa

Abstract

Introduction: Cotrimoxazole preventive therapy (CPT), which reduces opportunistic infections and malaria, is part of the package of care for HIV-positive people in Africa. However, the added value of long-term CPT has been questioned given its cost, related haematological adverse events, and the wide availability of effective antiretroviral therapy (ART). A placebo-controlled trial in Uganda investigated the safety and effectiveness of discontinuing CPT in ART-stable patients. I carried out an economic evaluation using trial data to determine the cost-effectiveness of CPT discontinuation.

Methods: Patient-specific data on resources used to diagnose and treat CPT-preventable events, malaria cases, and severe CPT-related haematological adverse events, as well as CPT use, were collected from patient files. Morbidity data (frequency and duration of individual events) and mortality data were collected from the trial dataset. An expert clinician panel determined illness severity, from which disability weights were derived. Disability-adjusted life years (DALYs) were calculated and an incremental cost-effectiveness ratio (ICER) estimated.

Results: The trial found that discontinuing CPT led to statistically significant increases in CPT-preventable events and malaria, and a decrease in severe CPT-related haematological adverse events. More deaths were observed in the placebo arm, but the difference was not statistically significant. Despite additional costs of diagnosing and treating more CPT-preventable events and malaria in the placebo arm, total costs were lower in the placebo arm than in the CPT arm ($23,634 v. $43,300) largely due to the cost of cotrimoxazole in the latter. Mean costs per person per year were $9.84 in the placebo arm and $17.50 in the CPT arm. Better health outcomes were observed in the CPT arm (with a mean of 0.06 DALYs averted per person during the trial) than in the placebo arm (0.03 DALYs averted), largely driven by improvements in mortality. The ICER point estimate of CPT discontinuation was $744 per DALY averted, which is considered cost-effective by most commonly used cost-effectiveness thresholds. Given that CPT discontinuation was both less costly and less effective, the ICER was located in the southwest quadrant of the cost-effectiveness plane. Probabilistic sensitivity analysis confirms that discontinuing CPT is very likely (>89%%) to be cost-effective.

Conclusion: Policymakers should consider CPT discontinuation for HIV-positive ART-stable adults in Uganda. However, disinvestment decisions can be politically difficult and may have spill over effects that should also be evaluated, such as impacts on the broader health system and on out-of-pocket expenditure.

Introduction

Daily prophylactic intake of the broad spectrum antibiotic cotrimoxazole, also known as cotrimoxazole preventive therapy (CPT), has been proven to reduce HIV-related mortality, bacterial infections, malaria and related hospital admissions among antiretroviral-naïve patients [1, 2]. Consequently, in 2001 the World Health Organization (WHO) recommended that CPT be included in the minimum package of care for people living with HIV/AIDS (PLHIV) in sub-Saharan Africa [3].

In 2014, despite the widespread availability of antiretroviral therapy (ART) and subsequent reduction in mortality for PLHIV across low- and middle-income countries (LMICs) [4], WHO continued to recommend that CPT remain in the package of services in settings with high prevalence of bacterial infections and malaria [5]. This recommendation was conditional on context-specific factors, such as risks and benefits, costs and budgetary implications, acceptability and feasibility. LMICs have adopted this recommendation unevenly; a policy review published in 2014 found that while 41 LMICs have discontinued CPT, seven countries recommended that CPT not be discontinued for patients on ART [6].

A recent randomised-controlled trial looking at the safety of CPT discontinuation in Uganda (called COSTOP) found mixed outcomes. Discontinuing CPT among ART-stable adults did not lead to statistically significant increases in mortality and, while it significantly reduced the risk of haematological adverse events, it also significantly increased the risks of severe bacterial infections and malaria [7].

Given the substantial budget impact CPT represents for HIV programmes [8], the benefits and costs of CPT in terms of preventing bacterial infections and malaria need to be weighed against the harm of haematological toxicity and compared to whether larger health benefits could be achieved by funding different healthcare interventions. It is thus critical to understand the value for money of CPT discontinuation in order to determine whether its sustained provision can be justified in the context of limited funding and alternative investment opportunities.

To date, there is limited evidence on the cost-effectiveness of CPT and much of it is outdated. Previous studies examined the cost-effectiveness of CPT initiation at different points of disease progression in the absence of ART [9, 10], or modelled the cost-effectiveness of co-delivery of ART and CPT but using efficacy data obtained from patients receiving only one of the two treatments [11]. Abimbola and Marston (2012) modelled the cost-effectiveness of expanding coverage of CPT in ART-initiated patients (65% to 97%) using retrospective cohort studies and found an incremental cost per death averted in the expanded scenario of 2009 US$147 (2020 US$176), as well as potential

cost savings in malaria and bacterial infection treatment [12]. However, this study only accounted for a limited number of undifferentiated bacterial infections and did not consider adverse reactions to CPT. Further, given the large number of conditions both potentially prevented and caused by CPT, the absence of outcomes presented in a common health utility measure (e.g., disability-adjusted life years averted, or DALYs) in previous studies limits the ability of policymakers to use evidence to make decisions across different health areas.

I carried out a trial-based health-economic evaluation of the discontinuation of CPT versus continuation of CPT. To my knowledge this is the first economic evaluation that uses RCT effectiveness data and real-world costs, accounts for a broad range of disease consequences from the use and discontinuation of CPT alongside ART, and reports outcomes using a common health utility measure.

Methods

Setting and Trial

Details of the trial design and outcomes have been published elsewhere [7, 13]. COSTOP assessed the safety of discontinuing CPT in patients stable on ART through a non-inferiority double-blind placebo-controlled trial. The trial was conducted in two research clinics of the Medical Research Council/Uganda Virus Research Institute and London School of Hygiene & Tropical Medicine (MRC/UVRI and LSHTM) Uganda Research Unit in Entebbe and Masaka, Uganda between 2011-2014.

Patients were recruited from nearby HIV care centres and were eligible if aged 18 years or older, had been on ART and daily CPT for at least 6 months, had a confirmed CD4 count of ≥250 cells/μL and no contraindication to cotrimoxazole. Participants were randomised to daily oral placebo (PLC) or cotrimoxazole 960 mg tablet (CPT). A total of 2180 participants (1091 PLC, 1089 CPT) completed the trial after 12 months of minimum follow up. The average number of months enrolled in the trial per participant was 26.4 in the PLC arm and 27.2 in the CPT arm.

The trial had two primary outcomes: time to first CPT-preventable event (or CPT-preventable death), and time to first severe CPT-related adverse event. CPT-preventable events were defined as those listed in the WHO surveillance clinical classification of HIV-related disease in adults against which cotrimoxazole has known biological activity [14]. Severe CPT-related adverse events were defined as grade 3 and 4 cases of anaemia, neutropenia and thrombocytopenia. Secondary outcomes included all-cause mortality, malaria episodes, and mean changes in CD4 count [7].

Costing Methods

Direct economic medical costs were collected from a provider's perspective for the trial duration.

I estimated the costs of (i) diagnosing and treating CPT-preventable events, (ii) malaria cases and (iii) severe CPT-related haematological adverse events in both trial arms, as well as the costs of (iv) delivering cotrimoxazole in the CPT arm. Costs were estimated for medications and other treatments (e.g., surgeries), diagnostics, medical consultations and hospitalisations including staff time, facility costs and overheads.

Patient-specific resource utilisation data (medications and diagnostics used, number of medical consultations and days of hospitalisation) were obtained from the individual patient medical records and trial dataset and extracted using a data collection tool which was piloted beforehand (see Appendix 4.1). The same basic format of data collection tool, considering the same inputs, was used

when collecting data for all clinical events, in both trial sites and for both arms of the trial to avoid bias.

Resource use data were collected for (i) all cases of diagnosing and treating CPT-preventable events observed in the trial (n=120). CPT-preventable events were defined in the trial based on biological plausibility: those infections listed in the WHO surveillance clinical classification of HIV-related disease in adults against which cotrimoxazole has known biological activity. An independent end-point review committee (blinded to treatment allocation) reviewed reported clinical events and adjudicated whether these events fulfilled WHO surveillance clinical staging definitive or presumptive diagnostic criteria and whether they could be defined as CPT-preventable events [7]. For the purposes of costing, CPT-preventable events were identified using the trial database. Each event was linked back to a patient number. That information was used to track each paper-based patient file at each of the trial sites. Information on diagnostics and treatments used, as well as on the number and type of consultations and hospitalisations used, were found in the files and recorded.

Resource use data on (ii) all malaria cases (n=453) observed in the trial were collected. For purposes of costing, all cases and resource use data were available from the trial dataset so patient record review was not necessary. Given the large number of (iii) CPT-related adverse events (n=1043), a stratified random sampling was carried out to estimate mean resource use (n=227). Possible determinants of resource use for CPT-related adverse events were initially discussed with trialists. All CPT-related adverse events were identified in the trial dataset and stratified across three relevant dimensions: event type (anaemia, neutropenia and thrombocytopaenia), event severity and trial site. Following randomisation, patient files were reviewed, and resource use data extracted. Yearly resource use data for (iv) cotrimoxazole delivery was consistent across all patients in the CPT arm over time (one dose delivered during a monthly meeting). Unit costs for each event for (i) and (ii) were added together to obtain a total per arm. Average unit costs per strata for (iii) were multiplied by the number of events in each stratum and then added up by arm. Unit costs for (iv) were multiplied by person-years of trial participation in the CPT arm.

Price data on medications and diagnostics used were representative of the prevailing market rate and obtained through the 2016 Joint Medical Stores Catalogue and Price Indicator and, in rare cases when a price was unavailable, from a local district hospital price list [15, 16]. The dataset of a recent health systems costing in Uganda was used to determine prices per medical consultations and per day of hospitalisation, which included staff costs [17].

Cost data were collected in 2016 Ugandan Shillings (UGX) and converted to 2016 US Dollars using an average exchange rate of 3400 UGX per 1 US$. Results were updated to 2020 US Dollars using gross domestic product (GDP) deflators [18].

Cost-effectiveness analysis

Individual trial participant data were used to determine the number of (i) CPT-preventable events, (ii) cases of malaria and (iii) CPT-related adverse events. DALYs were calculated for (i)-(iii) for both trial arms using a standard approach which includes accounting for morbidity (years lived with disability) and mortality (years of life lost) as explained below [19].

Length of illness was determined through patient records. Severity of illness was determined by a two-stage process. A clinician-led review of individual patient records was used to determine severity level (mild, moderate, severe) of every (i) CPT-preventable event and whether the acute event was followed by sequelae. For (ii) malaria, cases were considered mild unless they required hospitalisation, in which case they were determined to be severe. For (iii) CPT-related adverse events, grades 1-2 haematological events were considered mild and grades 3-4 were considered severe.

Given the wide range of symptoms across conditions, particularly of CPT-preventable bacterial infections, condition-specific and severity-specific DALY weights were applied for the 27 CPT-preventable conditions observed during the trial, malaria and three CPT-related adverse events. If available, DALY weights were obtained directly from Salomon et al. (2015) [20]. For conditions for which a DALY weight was not available, I carried out a process of expert elicitation to determine the main symptoms of each condition per level [21, 22]. Expert elicitation is a method to estimate values when there are uncertain model parameters, as well as to validate analytical assumptions. It is often used to quantify probabilities of outcomes in clinical settings when no data is available by having small groups of clinicians discuss their own clinical experiences and agree on a base case estimate and a range of possible values around that estimate [22]. I designed a modified version of the expert elicitation process to elicit inputs necessary to build DALY weights.

Five medical doctors with ample experience (5-20 years of clinical work) with PLHIV in Uganda were recruited. All had worked as clinicians in the COSTOP trial and therefore were familiar with the diagnosis and treatment of these 31 conditions in a Ugandan context. I facilitated the elicitation session, where clinicians were asked to draw from their clinical background, discuss and agree among themselves what the most salient symptoms (e.g., fever, headache) of each condition were at different levels of severity. As a group, the experts and the facilitator used this list of agreed

symptoms and compared it to the symptoms used to define health states in found in the Appendix of Salomon et al. (2015) [20] and tried to best match them to each of our study's 31 conditions across severity levels. The DALY weights of the matched health state were used in our study. In some instances the salient symptoms of one condition encompassed more than one of Salomon et al.'s (2015) health states (e.g., fever and temporary skin disfigurement). In those cases the DALY weights were combined. The experts were also asked to estimate an average number of days of symptoms per condition and per severity level (for cases where information may have been unavailable from patient files), as well as an average likely number of days of any post-acute effects.

Data on mortality from CPT-related causes and patient's age at death were obtained from trial records. Data on the expected life at the age of death were obtained from WHO's Global Health Observatory data repository [23]. A standard 3% discount rate was applied to both costs and effects [24]. Analysis was carried out using Microsoft Excel®. Further details on cost and health outcomes assumptions can be found in Appendix 4.2.

The primary outcome of the analysis is the incremental cost-effectiveness ratio (ICER) estimated by dividing the difference in costs between the PLC arm and the CPT arm by the difference in DALYs between the PLC arm and the CPT arm. Intermediate measures included total cost per trial arm, cost per person per arm, total DALYs per trial arm, and DALYs per person per arm.

$$\frac{COST_{PLC\ Arm} - COST_{CPT\ Arm}}{DALYs_{PLC\ Arm} - DALYs_{CPT\ Arm}}$$

To reflect the ongoing debates around appropriate country-specific cost-effectiveness thresholds [25], I compared our ICER to four thresholds values calculate through health opportunity-cost approaches as per Woods et al. (2016) and Ochalek et al. (2018) [26, 27]. Once updated to US$2020 values, using GDP deflators [18], these are: US$15 and US$393 per DALY averted according to Woods et al.'s lowest and highest estimates respectively, and US$142 and US$187 per DALY averted according to Ochalek's lowest and highest estimates, respectively. I assumed the threshold was the same across all quadrants in the cost-effectiveness plane.

Sensitivity Analyses

I carried out univariate deterministic sensitivity analysis to measure the effect of uncertainty on key parameters (e.g., price of cotrimoxazole and other medical commodities, health system costs and discount rates). A probabilistic sensitivity analysis, with a Monte Carlo simulation of 1000 iterations was carried out, randomly sampling combinations of all cost and DALY parameters using different distributions. A full list of parameter inputs can be found in Appendix 4.3. I plotted cost-effectiveness

acceptability curves to show the probability that CPT discontinuation would be cost-effective for the four cost-effectiveness thresholds explored, ranging from US$15 to US$393.

Ethical approvals were obtained from the London School of Hygiene & Tropical Medicine and the Research Ethics Committee of the Uganda Virus Research Institute. The clinical trial was registered (ISRCTN44723643). See Appendix 4.4.

Role of the funding source

The funders of the study had no role in study design, data collection and analysis, interpretation, preparation of the manuscript, or decision to publish. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The COSTOP trial found a statistically significant increase in CPT-preventable events in the PLC arm (n=72) compared with the CPT-arm (n=39). The trial reported 4 CPT-related deaths in the PLC arm and 2 in the CPT arm. Although there were 27 types of CPT-preventable events, almost half of all events (47.0%) were bacterial pneumonias [7]. A higher number of cases of malaria were also reported in the PLC arm: 350 v. 103 in the CPT arm [28]. However, there was also a higher number of CPT-related severe adverse events in the CPT arm: 616 v. 427 in the PLC arm [7].

Total costs were higher in the CPT arm ($43,300) than in the PLC arm ($23,643) resulting in an incremental cost of -$19,666 (or incremental savings of $19,666). The cost per participant per year was $17.50 in the CPT arm and $9.84 in the PLC arm. The mean cost of diagnosing and treating CPT-preventable events was $115, ranging widely from $4.69 to $2960. The mean cost for diagnosing and treating malaria was $17.35 ($7.33-$457) and $17.31 ($0.23-$901) for CPT-related adverse events. See Table 1.

The largest cost driver in the CPT arm was cotrimoxazole itself, accounting for 51.7% of costs ($22,368), followed by diagnosing and treating CPT-related adverse events (34.1%), CPT-preventable events (11.5%) and malaria (2.8%). Costs were more evenly distributed across the PLC arm: 44.7% for diagnosing and treating CPT-related adverse events, 33.4% CPT-preventable events, and 21.9% malaria. Cost drivers were different for each of the three disease areas examined and were consistent between trial arms. Hospitalisation costs made up the largest proportion of CPT-preventable events costs, and diagnostics were the largest cost for CPT-related adverse events. Costs for malaria were evenly distributed between treatment, diagnostics, consultations and hospitalisations. See Table 1.

Total DALYs were higher in the PLC arm (61.31) than in the CPT arm (34.87), with an incremental effectiveness of -26.43 DALYs averted (or 26.43 DALYs). The number of DALYs per patient per year was 0.03 in the PLC arm and 0.01 in the CPT arm. DALYs were mostly driven by mortality (97.8% in the PLC arm and 95.5% in the CPT arm). CPT-related severe adverse effects were the largest cause of morbidity, accounting for 1.3% and 3.3% of the DALYs in the PLC and CPT arms, respectively. Morbidity from malaria and CPT-related adverse events accounted for ≤1% of total DALYs. See Table 1.

Discontinuing CPT was found to be both less costly and less effective than providing CPT. The base-case ICER for CPT discontinuation was US$ 744 per DALY averted (Figure 1). Figure 2 shows that CPT

discontinuation is very likely (>89%) to be cost-effective with respect to any of the thresholds used (26, 27).

Our univariate sensitivity analysis suggests that the ICER was highly sensitive to the price of cotrimoxazole. A doubling of the price would lead to a 113.7% increase in the ICER (to US$1590 per DALY averted), making the withdrawal of CPT even more cost-effective. Halving the price would lead to a 56.9% reduction in the ICER (to US$320 per DALY averted), which would make the discontinuation of CPT less cost-effective, but it would still remain cost-effective according to three of the four thresholds used. The ICER was also sensitive to discount rates (variation between 1% and 10% led to a 65% decrease in the ICER and a 16% increase in the ICER, respectively) and to costs of consultations and hospitalisations (a halving or doubling of these costs led a 16% decrease in the ICER and a 25% increase in the ICER, respectively). The ICER was not sensitive to changes in the costs of medications, or diagnostics. See Figure 3.

Discussion

This study is the first health-economic evaluation of cotrimoxazole preventive therapy using patient-specific clinical RCT effectiveness data, accounting for a wide range of health consequences and using real world costs (i.e., reflecting actual resource use incurred and therefore accounting for health system constraints). I present the results using a common health utility measure (DALYs) which is appropriate for systems-wide decision-making, particularly in the case of an intervention that entails consequences across diseases areas, such as CPT. I find that it is cost-effective to discontinue CPT, meaning that, within current resources, discontinuation potentially could improve population health from a provider perspective, albeit with a negative impact in health outcomes on the individuals currently receiving CPT.

Total costs were higher in the CPT arm than in the PLC arm. The cost of cotrimoxazole delivery in the CPT arm alone was $22,368, almost as much as the total costs in the PLC arm. While more cases of bacterial infection and malaria were reported in the PLC arm, the additional costs from diagnosing and treating these were still substantially lower than the costs associated with CPT.

Discontinuing CPT was both less costly and less effective than the standard of care, with an ICER of US$744 per DALY averted, considered cost-effective by any of the thresholds used. Based on this assessment, policymakers should consider CPT discontinuation for HIV-positive ART-stable adults in Uganda. A substantial decrease in price would make CPT discontinuation less cost-effective, but not sufficiently so for it to not be considered cost-effective by three of the four thresholds used. It is difficult to situate our results with others evaluating the cost-effectiveness of CPT. The only comparable study did not include the costs and effects of CPT-related adverse events and reported findings in terms of costs per death averted. Further, only costs of medication were included [12].

There are complex ethical and policy-related considerations about the acceptability of discontinuing interventions that are both less costly and less effective, often known as ‘southwest interventions’ in relation to their location on the cost-effectiveness plane. There is considerable debate around whether the same cost-effectiveness thresholds should be applied for both northeast (more costly and more effective interventions) and southwest interventions. Philosopher and economist David Hume argued in the 18th Century that people place greater value on losing something they have than in not receiving something that was never theirs to begin with [29]. Some health economists have similarly made the case that acceptability thresholds should be higher for ‘decremental’ cost-effectiveness ratios than for incremental cost-effectiveness ratios [30], supported by empirical evidence suggesting that willingness to accept (WTA) monetary compensation to forgo a programme is greater than the willingness to pay (WTP) for the same benefit. In the health sector, others have

found that WTA is between two to six times greater than the WTP [31]. Conversely, some argue that there is no rational justification for the use of different thresholds in the southwest quadrants as additional resources freed up could be used to increase welfare more efficiently [32]. In the absence of context-specific preferences data on WTP and WTA for health in Uganda, I opted for applying the same thresholds across both the northeast and southwest quadrants.

A key policy question is how funds freed up from discontinuation should be reallocated. An ICER of US$744 per DALY averted represents savings of US$744 per DALY incurred. An extra-welfarist perspective may argue that they should be invested in whichever is the most cost-effective intervention across the health system. Others have made the case that savings made from investing in less effective interventions, for example in the case of PLHIV, should be reinvested into other areas within the HIV programme [33]. If the latter was the case, then discontinuation would only improve health if there were more cost-effective areas of HIV prevention, care and treatment that are not currently being funded.

A general reporting bias in publishing the results of interventions that fall in the southwest quadrant is well-documented. In framing an economic evaluation, authors generally classify an intervention as the option that is either more costly or more effective [34]. A systematic review of all cost-utility analyses between 2002-07 showed that out of 2128 cost-effectiveness ratios reported from 887 publications, only 0.4% described 'decrementally' cost-effective interventions [35]. Further, theoretical examples by health economists focus on short-term interventions for acute illness for a relatively small number of patients in high-income countries. Even those who advocate for more reporting and rational policy use of such studies concede that it may be politically unfeasible to discontinue an intervention mid-way through an individual's treatment. Instead, new patients from that decision point on should be initiated on the less costly and less effective alternative, while those already enrolled on treatment should be allowed to stay on [32].

There also may be spill-over effects of discontinuation. HIV is a lifelong, chronic condition requiring daily treatment. Uganda has one of the highest HIV prevalence rates in the world (5.4%), with 1.4 million adults living with HIV, of which 1.27 million are receiving ART [36]. Because of the sheer number of people on treatment, the discontinuation of CPT from those currently receiving the treatment may be attractive from a fiscal space perspective. However, discontinuation of CPT could shift the cost burden. Out-of-pocket expenditure for malaria is already considerable in certain LMICs [37]; an increase in the number of cases will only exacerbate this problem. Although a treatable condition, HIV is still a high-stigmatising disease and an emotive issue both for PLHIV and HIV-negative people [38]; if the discontinuation of CPT is abrupt, poorly understood by patients, and

leads to subsequent noticeable increases in acute bacterial conditions and malaria in the population at large, it could lead to long term mistrust of health institutions. Creating two cohorts (one where those who currently receive CPT stay on it and one where those newly diagnosed are not prescribed it) may be challenging in terms of long term administrative and logistical management of this arrangement. Also, such a set up may raise issues of social cohesion with patients wondering why those with similar clinical profiles are treated differently, which could lead to a further loss of trust in the health system. On the other hand, a reduction in the overall use of antibiotics prophylactically could reduce the risk of antimicrobial resistance. Future epidemiological studies may wish to model such scenarios.

Importantly, for CPT discontinuation to be cost-effective, a health system that diagnoses and treats additional cases of bacterial infections and malaria is essential. Without that care infrastructure in place, morbidity and mortality from these diseases could increase. The savings obtained from CPT could therefore be invested in strengthening the ability of health systems to respond to bacterial infections and malaria. This will not only ensure that those whose health could deteriorate as a result of CPT discontinuation receive prompt and adequate treatment but would also benefit HIV-negative people who also commonly suffer from the same diseases.

Ultimately, cost-effectiveness is one parameter among several that policymakers should consider when deciding whether to invest or disinvest in interventions. Other criteria include acceptability, equity, financial risk protection and political feasibility. In deciding whether or not to disinvest in CPT countries should consider all the above, as well as longer-term issues of trust in the health system and social cohesion and ensure that there is adequate engagement with patient groups as well as adequate communication campaigns.

This study is subject to a number of limitations. First, resource use data was collected from all CPT-preventable and malaria events, but I had to use a stratified random sample of CPT-related adverse events due to the high number of events and limited resources for data collection. While a large number of CPT-related adverse events were sampled, it is difficult to know whether our sample accurately represents the real distribution of costs and the degree to which a minority of high-cost patients may have right-skewed the results. More CPT-related adverse events were observed in the CPT arm; an under- or over-estimation of related costs could therefore bias the final results in favour or against CPT discontinuation. Further, a weakness inherent to stratified random sampling is the possibility of excluding a key stratum that could be a determinant of cost (e.g., sex).

One of the strengths of the study was the possibility of accessing patient-specific data across 31 different conditions. However, given the absence of publicly available validated DALY weights I had to estimate them using an expert elicitation panel. This was done in an exploratory manner and I encourage other researchers to repeat our method and share their experiences. The number of experts participating in the elicitation exercise was low. However, the process requires discussion and consensus between experts on specific parameters. Agreement amongst a larger number of experts, across 31 conditions, and several levels of severity per disease (mild, moderate and severe) would have been impractical.

Conclusion

I estimated the cost-effectiveness of discontinuation of CPT in HIV-positive ART-stable adults in Uganda.

A randomised-controlled trial found that discontinuation of CPT led to increased cases of bacterial infections and malaria and reduced cases of CPT-related adverse events. I costed the diagnosis and treatment of these three types of events in both trial arms, as well as the distribution of CPT. I found that, despite the increases in costs related to the diagnosis and treatment of bacterial infections and malaria in the trial arm where people stopped receiving CPT, overall costs were higher in the arm where people continued to receive CPT due to the recurrent costs of cotrimoxazole itself. I calculated the effectiveness of the intervention by estimating DALYs across both arms. I found that total DALYs were higher in the arm where patients stopped receiving CPT. Discontinuing CPT was therefore found to be both less costly and less effective than the standard of care. With a base case ICER of $744 per DALY incurred, the discontinuation of CPT appeared cost-effective in the Ugandan setting. Deterministic and probabilistic sensitivity analyses confirmed that CPT discontinuation is very likely to be cost-effective.

Discontinuing CPT can be considered a 'southwest' intervention, by its position in the cost-effectiveness plane (less costly and less effective). There are considerable theoretical debates on whether cost-effectiveness thresholds should be the same for interventions on the southwest quadrant and those in the northeast quadrant (interventions that are more costly and more effective). These debates are based on evidence that willingness to accept is higher than willingness to pay, particular in relation to non-market goods, such as health. However, in the absence of Uganda-specific preference data to indicate the ratio between willingness to pay and willingness to accept for health goods, I opted to use the same cost-effectiveness thresholds across the entire plane.

To my knowledge, this study is the first economic evaluation of CPT which accounts a wide range of health outcomes, and which presents results in DALYs, meaning that its value for money can be weighed against that of other interventions across different health areas. Importantly, this is, to my knowledge, the first 'decremental' cost-effectiveness analysis in a low- and middle-income setting. This is significant in the context of funding constraints. Interventions that lead to small reductions in health, but that can free up substantial levels of resources, could be used to leverage funds for the health system.

Policymakers in Uganda should therefore consider discontinuing CPT in ART-stable adults. However, disinvestment decisions can be politically difficult and can carry social implications. Further, a decision to disinvest may also require evidence beyond value for money from the health system's perspective. Discontinuing CPT may lead to a shift in expenditure from the health system to the patient; implications on financial risk need to be carefully assessed. Further, health system constraints need to be examined to ensure that the rise in cases of a range of bacterial infections and of malaria can be adequately treated beyond the trial sites. Adjustments to the economic evaluation may need to be made to account for poorer outcomes at scale or the costs of improving the health system to address this additional disease burden.

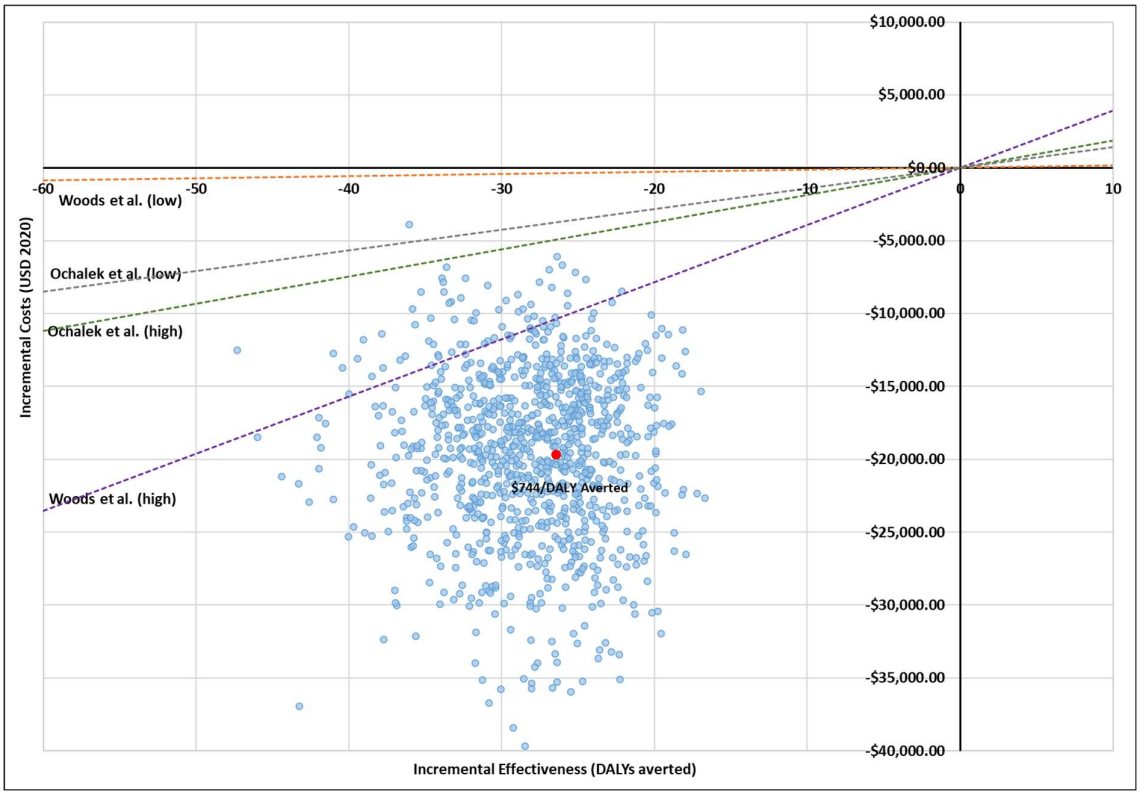
Tables and Figures

Table 1: Table of total costs and health outcomes by trial arm

	CPT arm					PLC arm				
	CPT-preventable events	CPT-related adverse effects	Malaria	CPT	Total	CPT-preventable events	CPT-related adverse effects	Malaria	CPT	Total
Total Costs (2020 US$)										
Diagnostics	$621	$9,664	$333	$0	$10,618	$931	$6,112	$1,206	$0	$8,250
Treatment	$118	$219	$115	$22,368	$22,819	$222	$174	$420	$0	$816
Medical Consultations	$216	$2,956	$472	$0	$3,644	$305	$1,925	$1,656	$0	$3,886
Hospitalisations	$4,011	$1,911	$297	$0	$6,219	$6,437	$2,364	$1,882	$0	$10,683
Total	**$4,965**	**$14,750**	**$1,217**	**$22,368**	**$43,300**	**$7,896**	**$10,574**	**$5,164**	**$0**	**$23,634**
Total Effectiveness										
Total cases	39	427	103	N/A	N/A	72	616	350	N/A	N/A
Total deaths	2	0	0	N/A	2	4	0	0	N/A	4
Morbidity (DALYs)	0.37	1.14	0.06	N/A	1.57	0.34	0.81	0.25	N/A	1.40
Mortality (DALYs)	33.30	0.00	0.00	N/A	33.30	59.90	0.00	0.00	N/A	59.90
Total (DALYs)	**33.67**	**1.14**	**0.06**	**N/A**	**34.87**	**60.24**	**0.81**	**0.25**	**N/A**	**61.31**
Incremental costs (2020 US$)										**-$19,666**
DALYs averted										**-26.43**
Incremental cost per DALY averted										**$744**

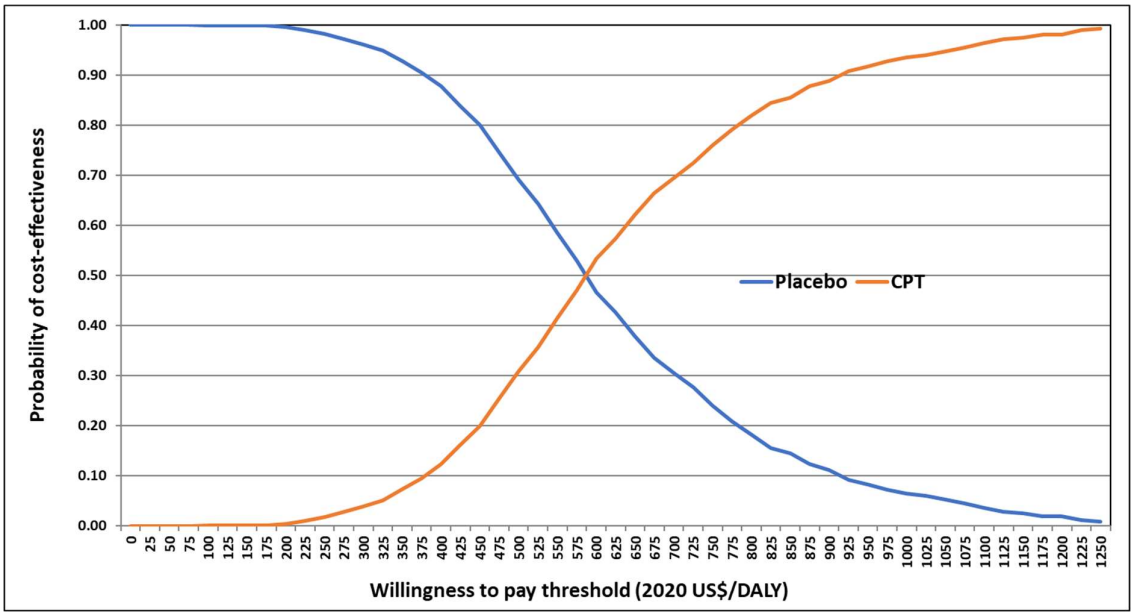
CPT: cotrimoxazole-preventive therapy. PLC: placebo. DALY: disability-adjusted life year. N/A: not applicable.

Figure 1: Cost-effectiveness plane of the incremental costs and incremental DALYs of discontinuing versus continuing cotrimoxazole preventive therapy prophylaxis (provider perspective)



DALY: disability-adjusted life year. USD: USD dollar.

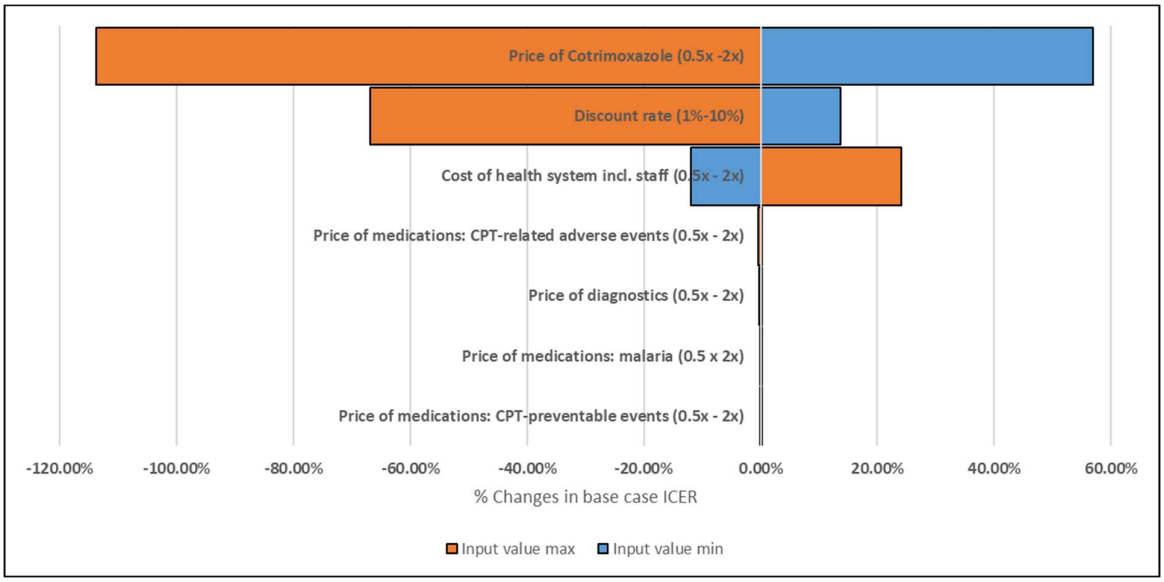
Figure 2: Cost-effectiveness acceptability curve of discontinuing cotrimoxazole preventive therapy (Placebo) versus continuing cotrimoxazole preventive therapy (CPT) from the provider perspective



CPT: cotrimoxazole-preventive therapy. DALY: disability-adjusted life year.

Figure 3: Univariate sensitivity analysis

Percentage changes to the base case ICER following changes in the values of some key parameters. Blue bars indicate the percentage change to the ICER from introducing the minimum numerical value of the input and orange bars indicate the percentage change to the ICER from introducing the maximum numerical value of the input.



ICER: incremental cost-effectiveness ratio.

4.4 Epilogue

The analysis presented above influenced the policy decision in Uganda: a partial disinvestment in cotrimoxazole preventive therapy (CPT) took place in August 2018. I provided support on the analytic side of process by carrying out a cost and cost-effectiveness analysis and sharing my findings with decisionmakers. However, I was not an observer nor was I personally involved in the decision-making process.

In the section below, I report on information informally gathered on the process, outcome and aftermath of the disinvestment decision through review of the online press, written notes and informal conversations with stakeholders involved in the process. While not collected systematically, and therefore not part of the formal peer-reviewed paper in this chapter, the information here presented provides key context around the decision, which guided the further development of this dissertation. Some of the issues raised below are discussed further in the Discussion.

Discontinuation of cotrimoxazole preventive therapy: in practice

I presented the results of our economic evaluation at the National ART Clinical Care Committee at end of 2017 at the request of the Ugandan Ministry of Health. The Ministry had previously reviewed the COSTOP trial findings and requested that these be supplemented by a cost and cost-effectiveness analysis. The findings presented to the Committee were largely the same as those reported in this chapter (in 2016 US$), except for the probabilistic sensitivity analysis which had not yet been carried out. My notes from the meeting highlight a few areas of interest for the Committee around heterogeneity and the costing perspective. Firstly, there was interest in understanding how the findings would vary in different regions of the country where the burden of bacterial infections and malaria, as well as health system capacity, may be different from those in Entebbe and Masaka. Secondly, Committee members were interested in how the analytical choice to carry out the costing from a provider's perspective could change the interpretation results. While HIV treatment is free in Uganda, the cost of addressing bacterial, malarial or haematological illness and complications may not be, and the out-of-pocket costs to the patient, including transport costs, may be considerable. Further, increased patient costs may affect care-seeking behaviour; patients, particularly in those with mild or moderate symptoms, may delay seeking care early, possibly increasing treatment costs and leading to detrimental health outcomes, further down the line.

Some of the Committee's concerns on the point on heterogeneity were addressed implicitly when carrying out the probabilistic sensitivity analysis which showed that even when assuming plausible ranges of uncertainty around costs and health outcomes the discontinuation of CPT is very likely

cost-effective. On the second point, an analysis on patient costs was not carried out as relevant patient data were not collected as part of the trial.

For about six months I had no news on the policy process. However, in May 2018, four months before the eventual formal discontinuation of CPT, large-scale stock outs of cotrimoxazole were widely reported in the national and international media. Septrin, the widely known branded name for cotrimoxazole in Uganda, was reported have run out in May 2018, alongside Dapson, an anti-leprotic drug [39, 40]. The language used in the media was categorical. Thousands of patients were said to "find themselves exposed to potentially life-threatening infections", according to Ugandan newspaper *The Observer* [39]. The British newspaper *The Guardian* wrote that the "drug shortage put hundreds of thousands of lives at risk" [40]. A district coordinator, himself living with HIV was quoted as saying that "without Septrin, the future looks bleak" and that "the moment you stop taking [it], the body cannot resist infections hence you develop chest pain and several fevers" [39]. It was reported that during the stockouts pregnant women and children and adolescent under 15 years of age were still provided with Septrin [41].

These news stories created sufficient momentum that they merited a public clarification from the Ministry of Health which was reproduced by several media outlets [42, 43]. A press release from the Office of the Director General of Health Services, clarified, firstly, that Septrin was not "an HIV drug", but rather antibiotic used to treat a range of bacterial infections. The supply of Septrin would be fully restored and distributed to all affected facilities by July 2018. According to the Director General, the stock-outs were blamed on challenges with the manufacturers although other government sources suggested the drugs had not been procured due to a funding gap which would be addressed once Uganda received money from the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) [40]. In the official press release, the Director General urged those affected to obtain Septrin from alternative sources. Lastly, and importantly, the Ministry stated that evidence for the continuous need for Septrin for all patients was under review, that those on ART and virally suppressed may not require continued use, and that, upon conclusion of the review, the Ministry may consider prioritising certain groups, such as pregnant women, children and those newly initiated on ART, in order "to ensure rational use of resources" [44]. This sentiment was echoed by others, such as the Uganda Network of AIDS Service Organisations (UNASO), whose policy officer stated that "in order to curb this problem…there is a need to revise the national test and treatment guidelines to streamline who should access Septrin, or not, at the health facilities" [40].

In August 2018, the Ministry of Health announced the discontinuation of CPT in the majority of patients. According to the national press, Dr. Joshua Musinguzi, Programme Manager of the AIDS

Control Programme, stated that the ART Committee made the decision based on "a meta-analysis of all studies that have been carried out by different researchers on the subject" [45]. The article reports that, according to Ministry of Health data, 29 billion Ugandan schillings (2020 US$ 8.3 million) were spent annually on procuring Septrin. Dr. Musinguzi added that "they decided to stop the compulsory use of Septrin drug because they were advised by doctors that it was a waste" (45). CPT would not be discontinued for all, however; more than 400,000 PLHIV would not be affected by the ban. This policy change would also reduce the risk of stock-outs according to Dr. Musinguzi, who was quoted as saying that "we now have enough drugs and since only a selected group of people will be taking the drugs, we shall not run out of the drugs" [45].

According to informal conversations with two stakeholders who were present during discussions on the evidence as part of the decision process, there were two key factors that drove the decision to disinvest: the fact that the trial did not report a statistically significant difference in deaths between the trial arms and the increased costs in the CPT arm. The data on costs were interpreted within a broader discussion on the fiscal space for HIV interventions at the time. In 2018 Uganda had shifted to a 'test and treat' strategy. Previously, people who had tested positive for HIV would largely be initiated on ART only after their CD4 counts (an indicator of the state of the immune system) dropped below a specific threshold. With a 'test and treat' strategy, all who test positive are initiated on treatment, which increases the number of people on treatment and drives up costs. At the time, the Ministry of Health was carrying out forecasting for the country's Global Fund grant. A quantification of the costs for ART was likely to put in context the value for money provided by CPT. Some argued that the shift towards 'test and treat' made the widespread distribution of CPT even more irrelevant; with more patients being initiated on ART early, fewer would have a weakened immune system susceptible to the kinds of opportunistic infections that CPT is supposed to prevent [41].

In September 2018 the Consolidated Guidelines for Prevention and Treatment of HIV in Uganda updated recommendations for the use of CPT. Certain groups of PLHIV would continue to receive CPT, namely those newly initiated on ART, pregnant women, children and adolescents under the age of 15 years and patients suspected of treatment failure. However, the guidelines stated that CPT would be discontinued in the majority of patients, specifically those who are not pregnant, over the age of 15 years, on ART for at least one year, with prior confirmation of viral suppression and not on treatment for, or suspected of, a stage 3 or 4 clinical event or other symptoms of advanced disease. The guideline does make clear, however, that CPT can be restarted in patients who are newly

pregnant, and in those who are suspected of treatment failure or who are undergoing treatment for a stage 3 or 4 clinical event [46].

The news of the stockouts, followed by the explicit disinvestment, caused a stir among patient advocates. In November 2018, newspapers reported that the Centre for Health Human Rights and Development (CEHURD) would sue the National Medical Stores at the High Court for a continuous failure to provide Septrin to PLHIV, claiming a violation to the right to health and dignity and a breach of the Government's core obligation to provide essential drugs contrary to the Constitution [47]. CEHURD would also ask that those going to court be paid damages for the violation of their rights [41]. The article on *The Observer* went on to quote an HIV activist who stated that since stockouts of Septrin started his viral load had increased, "he was psychologically tortured by the fear of stockouts of this kind", and he had "witnessed patients die and lose hope in coming to the facility since there are no drugs to sustain their lives" [47]. He added that in April 2018 they "buried one of [their] peers who couldn't afford Septrin in village at [UGX] 400 [equivalent to 2020 US$ 0.11] on a daily basis to supplement the [antiretroviral drugs]" [47]. News outlet *New Vision* quoted others whose Septrin had been discontinued. Describing herself as "healthy and happy" when taking both ART and Septrin, patient Florence Namuli stated that, following the discontinuation of the latter drug, she started getting "co-infections such as cough, malaria, joint and chest pain" despite being virally suppressed [48].

Some media outlets provided coverage that included the findings from the COSTOP trial to justify the disinvestment decision. An article in *The Independent* quoted Dr. Freddie Mukasa Kibengo, a scientist based at the Medical Research Council in Rakai, who said that two major studies have found that "the drug had no added value to those who have been virally suppressed" [41]. He recalled how, since the mid-1990s, about ten years prior to the arrival of ART, Septrin was the only drug available given to patients to stave off opportunistic infections and that people continued to receive the drug for a long time after being initiated on ART. Some called for the Government to offer greater sensitisation on the changes in policy as the lack of adequate communication had caused "confusion and tension among patients" [10]. Dr. Kibego suggested that part of the problem had been a lack of understanding from patients, as well as the media, on what Septrin is, as many had described it as an antiretroviral drug when the stockouts first began [41]. Peer-reviewed qualitative evidence collected prior to discontinuation (2008-2011) suggested that there were misunderstandings amongst the general population about the purpose and use of cotrimoxazole [49]. This perspective was echoed by local researchers with whom I spoke informally.

***

Reflections on disinvestment

The work I carried out on the economic evaluation of the discontinuation of CPT highlights a number of issues.

The first is whether the analytical requirements of an incremental decision on investment are adequate to carry out analyses on disinvestment. The economic evaluation I carried out as part of this project used standard cost and cost-effectiveness analysis methods (see the Global Health Costing Consortium Reference case and the Consolidated Health Economic Evaluation Reporting Standards, or CHEERS checklist). In my experience, the overall methodological principles used to understand the cost-effectiveness of investment decisions worked well for disinvestment.

There were however two areas that I think should have been explored in greater detail given the decision problem faced in Uganda, and which perhaps need to be built more systematically into economic evaluations of disinvestment going forward. The first is a detailed understanding of payers and patient costs for the intervention, the comparator and, importantly, any longer-term consequences of the policy change. While the costs of ART and CPT are covered by the national health system in Uganda, the costs of diagnosing and treating bacterial infections and malaria fall on the individual. In removing CPT, and therefore causing an increase in cases of bacterial infections and malaria, the cost burden is shifted from the health system to the patient. It is necessary here to consider how the shift may affect other priorities of the health system and of Universal Health Coverage, including protection against financial risk and equity in access. While neither financial risk protection nor equity are traditionally built into economic evaluations, they should be involved more systematically in priority setting discussions (see Figure 1 in Chapter 3) to ensure that decisions reflect societal values beyond efficiency.

Another area which is not generally included in economic evaluations of investment decisions is that of the broader costs of relaxing health system constraints. In discontinuing CPT nationwide, PLHIV are likely to experience a greater number of bacterial infections and cases of malaria. While the trial demonstrated that this increase in cases were clinically manageable and did not lead to statistically significant increases in deaths, this is likely a reflection of the strength of the health system in the locations where the trial was conducted. Inequalities in access to care are common in low- and middle-income countries. It is therefore not unreasonable to assume that curative services, particularly for some of the more complex bacterial infections seen in the trial, may be lacking in other parts of the country. This means that either CPT discontinuation could lead to even worse health outcomes, or that a larger amount of resources will need to be spent to strengthen health

systems elsewhere, with the acknowledgment that relaxing certain health system constraints (e.g., advanced staff training) requires time in addition to money. These two possible consequences should be incorporated more systematically in economic evaluations of disinvestment.

A second issue this study raises is the need to consider the breadth of the analysis performed. The decision to discontinue CPT was based on evidence of incremental cost-effectiveness. That means that the study informed on the costs and health outcomes that would be gained and lost, respectively. However, given its narrow perspective, the study fails to inform on what could be the most efficient uses of the resources released as a result of the disinvestment of CPT. This lack of clarity on the opportunities stemming from disinvestment (in addition to inadequate communication) may have been to blame the largely negative reaction recorded.

In Chapter 5 and 6 I discuss a health sector wide approach to investment and disinvestment through the process of health benefit package design. However, the case study of CPT in Uganda suggests that perhaps a more effective analysis to inform this type of decision could have been programme budgeting and marginal analysis (PBMA), which can be used to inform the maximisation of health-related impact of available resources in specific programmes. As informal conversations with those involved in the process showed, an incentive to disinvest from CPT was to increase coverage of ART. Both of these interventions would fall within the HIV programme. A broader but programme-specific perspective provided by PBMA would have compared interventions across the programme, considering interventions in the 'hit list', such as CPT discontinuation, and in the 'wish list', such as expanded ART. Trade-offs affecting the same population of patients could have been discussed more explicitly.

A third consideration stemming from this study was the use of thresholds to determine cost-effectiveness. As mentioned in Chapter 2, there is ongoing debate as to whether the thresholds used in the northeast and southwest quadrants should be the same. Some believe, abiding by an extra-welfarist framework, that the thresholds used for investment or disinvestment decisions should be the same as the priority ought to be to finance interventions that yield greater societal benefits. However, others argue that the thresholds should be different as, empirically, willingness to pay (WTP) and willingness to accept (WTA) differ. This 'WTP-WTA gap' shows that people tend to value that which they have more than that which they do not have and that the compensation required to forgo a good or service should be greater than that required to buy the good or service in the first place. Empirical evidence shows that this gap is particularly wide in relation to non-market goods, such as health.

I considered using different thresholds for the northeast and southwest quadrants in my study but ultimately decided against it. While the debate about thresholds is a legitimate one it currently has limited use in practice. Calculating a kink in the threshold would require eliciting societal preferences on WTP and WTA specific to health. As explained in Chapter 2, research on the endowment effect, which is most often used to explain the WTP-WTA gap suggests that the magnitude of the effect can be culturally specific and that most available research on the subject has been done on North American and Western European subjects. It therefore seemed inappropriate to apply a ratio derived from preferences from a completely different population and relating to different health interventions. More research in this area of preferences would be worthwhile.

The fourth issue this study raises relates to barriers and enablers of disinvestment, as summarised in Chapter 2. The broader literature suggests that a lack of evidence, decision-making processes and identification of disinvestment candidates were all barriers to disinvestment. In this case study I found that those three elements were indeed present in Uganda and a disinvestment decision took place and was implemented. Further, as noted earlier in this epilogue, a lack of appropriate communication and transparency in the process in Uganda led to a contentious disinvestment process; improved sensitisation may have aided in a smoother policy implementation.

This study fills a number of important gaps. First, it is the only study examining the cost-effectiveness of CPT accounting for the broad range of disease consequences stemming from the use and discontinuation of CPT alongside ART. It is also the first CPT study to report outcomes using DALYs, which means its cost-effectiveness can be compared to that of interventions across all parts of the health system. Importantly, to my knowledge, this is the first evaluation of a 'decrementally' cost-effective intervention carried out in a low- and middle-income country. This is important as alternative uses of savings stemming from the discontinuation can be substantial. This area is systematically understudied and is particularly important in severely resource-constrained settings.

***

Chapter 4 focused on an economic evaluation in the context of incremental decision-making. In the next two chapters I explore the issue of disinvestment more broadly by examining the process of disinvestment in a system-wide context through research carried out on the health benefit package design process in Pakistan

4.5 References

1. Anglaret X, Chêne G, Attia A, Toure S, Lafont S, Combe P, et al. Early chemoprophylaxis with trimethoprim-sulphamethoxazole for HIV-1-infected adults in Abidjan, Côte d'Ivoire: a randomised trial. Cotrimo-CI Study Group. Lancet. 1999;353(9163):1463-8.
2. Watera C, Todd J, Muwonge R, Whitworth J, Nakiyingi-Miiro J, Brink A, et al. Feasibility and effectiveness of cotrimoxazole prophylaxis for HIV-1-infected adults attending an HIV/AIDS clinic in Uganda. J Acquir Immune Defic Syndr. 2006;42(3):373-8.
3. World Health Organization. Provisional WHO/UNAIDS recommendations on the use of contrimoxazole prophylaxis in adults and children living with HIV/AIDS in Africa. Afr Health Sci. 2001;1(1):30-1.
4. Granich R, Gupta S, Hersh B, Williams B, Montaner J, Young B, et al. Trends in AIDS Deaths, New Infections and ART Coverage in the Top 30 Countries with the Highest AIDS Mortality Burden; 1990-2013. PLoS One. 2015;10(7):e0131353.
5. World Health Organization. Guidelines on post-exposure prophylaxis for HIV and the use of co-trimoxazole prophylaxis for HIV-related infections among adults, adolescents and children. Recommendations for a public health approach - December 2014 supplement to the 2013 consolidated ARV guidelines. 2014.
6. Gupta S, Granich R, Hersh B, Lepere P, Samb B. Global Policy Review of Recommendations on Cotrimoxazole Prophylaxis among People Living with HIV. J Int Assoc Provid AIDS Care. 2014;13(5):397-401.
7. Anywaine Z, Levin J, Kasirye R, Lutaakome JK, Abaasa A, Nunn A, et al. Discontinuing cotrimoxazole preventive therapy in HIV-infected adults who are stable on antiretroviral treatment in Uganda (COSTOP): A randomised placebo controlled trial. PLoS One. 2018;13(12):e0206907.
8. Medina Lara A, Kigozi J, Amurwon J, Muchabaiwa L, Nyanzi Wakaholi B, Mujica Mota RE, et al. Cost Effectiveness Analysis of Clinically Driven versus Routine Laboratory Monitoring of Antiretroviral Therapy in Uganda and Zimbabwe. PLOS ONE. 2012;7(4):e33672.
9. Pitter C, Kahn JG, Marseille E, Lule JR, McFarland DA, Ekwaru JP, et al. Cost-effectiveness of cotrimoxazole prophylaxis among persons with HIV in Uganda. J Acquir Immune Defic Syndr. 2007;44(3):336-43.
10. Yazdanpanah Y, Losina E, Anglaret X, Goldie SJ, Walensky RP, Weinstein MC, et al. Clinical impact and cost-effectiveness of co-trimoxazole prophylaxis in patients with HIV/AIDS in Côte d'Ivoire: a trial-based analysis. Aids. 2005;19(12):1299-308.
11. Goldie SJ, Yazdanpanah Y, Losina E, Weinstein MC, Anglaret X, Walensky RP, et al. Cost-Effectiveness of HIV Treatment in Resource-Poor Settings — The Case of Côte d'Ivoire. New England Journal of Medicine. 2006;355(11):1141-53.
12. Abimbola TO, Marston BJ. The cost-effectiveness of cotrimoxazole in people with advanced HIV infection initiating antiretroviral therapy in sub-Saharan Africa. J Acquir Immune Defic Syndr. 2012;60(1):e8-e14.
13. Anywaine Z, Abaasa A, Levin J, Kasirye R, Kamali A, Grosskurth H, et al. Safety of discontinuing cotrimoxazole prophylaxis among HIV infected adults on anti-retroviral therapy in Uganda (COSTOP trial): Design. Contemp Clin Trials. 2015;43:100-4.
14. World Health Organization. WHO case definitions of HIV for surveillance and revised clinical staging and immunological classification of HIV-related disease in adults and children. Geneva: World Health Organization; 2007.
15. Stores JM. Catalogue and Price Indicator. 2016.
16. Nel A, van Niekerk N, Kapiga S, Bekker L-G, Gama C, Gill K, et al. Safety and Efficacy of a Dapivirine Vaginal Ring for HIV Prevention in Women. New England Journal of Medicine. 2016;375(22):2133-43.

17. Settumba SN, Sweeney S, Seeley J, Biraro S, Mutungi G, Munderi P, et al. The health system burden of chronic disease care: an estimation of provider costs of selected chronic diseases in Uganda. Trop Med Int Health. 2015;20(6):781-90.
18. World Bank. Open Data. 2022.
19. Fox-Rushby JA, Hanson K. Calculating and presenting disability adjusted life years (DALYs) in cost-effectiveness analysis. Health Policy Plan. 2001;16(3):326-31.
20. Salomon JA, Haagsma JA, Davis A, de Noordhout CM, Polinder S, Havelaar AH, et al. Disability weights for the Global Burden of Disease 2013 study. Lancet Glob Health. 2015;3(11):e712-23.
21. Bojke L, Soares MO. Decision Analysis: Eliciting Experts' Beliefs to Characterize Uncertainties. Encyclopedia of Health Economics 2014.
22. Soares MO, Bojke L, Dumville J, Iglesias C, Cullum N, Claxton K. Methods to elicit experts' beliefs over uncertain quantities: application to a cost effectiveness transition model of negative pressure wound therapy for severe pressure ulceration. Stat Med. 2011;30(19):2363-80.
23. World Health Organization. Global Health Observatory Data Repository. 2017.
24. Wilkinson T, Sculpher MJ, Claxton K, Revill P, Briggs A, Cairns JA, et al. The International Decision Support Initiative Reference Case for Economic Evaluation: An Aid to Thought. Value Health. 2016;19(8):921-8.
25. Thokala P, Ochalek J, Leech AA, Tong T. Cost-Effectiveness Thresholds: the Past, the Present and the Future. Pharmacoeconomics. 2018;36(5):509-22.
26. Ochalek J, Lomas J, Claxton K. Estimating health opportunity costs in low-income and middle-income countries: a novel approach and evidence from cross-country data. BMJ Global Health. 2018;3(6):e000964.
27. Woods B, Revill P, Sculpher M, Claxton K. Country-Level Cost-Effectiveness Thresholds: Initial Estimates and the Need for Further Research. Value Health. 2016;19(8):929-35.
28. Kasirye RP, Baisley K, Munderi P, Levin J, Anywaine Z, Nunn A, et al. Incidence of malaria by cotrimoxazole use in HIV-infected Ugandan adults on antiretroviral therapy: a randomised, placebo-controlled study. Aids. 2016;30(4):635-44.
29. Hume D. A Treatise on Human Nature
30. Kent DM, Fendrick AM, Langa KM. New and dis-improved: on the evaluation and use of less effective, less expensive medical interventions. Med Decis Making. 2004;24(3):281-6.
31. O'Brien BJ, Gertsen K, Willan AR, Faulkner LA. Is there a kink in consumers' threshold value for cost-effectiveness in health care? Health Econ. 2002;11(2):175-80.
32. Dowie J. Why cost-effectiveness should trump (clinical) effectiveness: the ethical economics of the South West quadrant. Health Econ. 2004;13(5):453-9.
33. Walensky RP, Sax PE, Nakamura YM, Weinstein MC, Pei PP, Freedberg KA, et al. Economic savings versus health losses: the cost-effectiveness of generic antiretroviral therapy in the United States. Ann Intern Med. 2013;158(2):84-92.
34. Bell CM, Urbach DR, Ray JG, Bayoumi A, Rosen AB, Greenberg D, et al. Bias in published cost effectiveness studies: systematic review. Bmj. 2006;332(7543):699-703.
35. Nelson AL, Cohen JT, Greenberg D, Kent DM. Much cheaper, almost as good: decrementally cost-effective medical innovation. Ann Intern Med. 2009;151(9):662-7.
36. Country Factsheet: Uganda [Internet]. 2022 [cited 25 March 2022]. Available from: https://www.unaids.org/en/regionscountries/countries/uganda.
37. Haakenstad A, Harle AC, Tsakalos G, Micah AE, Tao T, Anjomshoa M, et al. Tracking spending on malaria by source in 106 countries, 2000-16: an economic modelling study. Lancet Infect Dis. 2019;19(7):703-16.
38. Chan BT, Weiser SD, Boum Y, Siedner MJ, Mocello AR, Haberer JE, et al. Persistent HIV-related stigma in rural Uganda during a period of increasing HIV incidence despite treatment expansion. AIDS (London, England). 2015;29(1):83-90.
39. Ochwo A. HIV patients at risk as septrin runs out. The Observer. 2018 23 May 2018.

40. Okiror S. HIV drug shortage puts hundreds of thousands of lives at risk in Uganda. The Guardian. 2018.
41. Nassaka F. The Septrin controversy. The Independent. 2018 11 December 2018.
42. Musinguzi B. Supply of Septrin will Resume in July- Ministry. Uganda Radio Network. 2018 25 May 2018.
43. Wandawa V. HIV: Govt speaks out on shortage of drugs. New Vision. 2018 25 May 2018.
44. Clarification on Stock Out of Septrin [press release]. 25 May 2018 2018.
45. Mawanda P. Health Ministry Stops Use of Septrin in HIV Management. Uganda Radio Network. 2018 31 August 2018.
46. Republic of Uganda Ministry of Health. Consolidated Guidelines for Prevention and Treatment of HIV in Uganda. 2018 September 2018.
47. Nakabugo Z. HIV patients sue gov't over Septrin stockout. The Observer. 2018 19 November 2018.
48. Agaba V. HIV/AIDS patients want more sensitization on new Septrin policy. New Vision. 2018.
49. Okwera A, Mafigiri DK, Guwatudde D, Whalen C, Joloba M. Level of understanding of co-trimoxazole use among HIV infected, recurrent pulmonary tuberculosis suspects at a national referral tuberculosis clinic in Kampala, Uganda: a qualitative analysis. Afr Health Sci. 2015;15(1):49-57.

Chapter 5: Disinvestment at the level of the healthcare system: the need for high quality cost data

5.1 Prologue

While this doctoral thesis has five results chapters (Chapters 4-8), the overall results can be grouped into three analytical sections. Together, Chapters 5 and 6 make up the second of the three analytical sections: an analysis to determine what decision criteria and intervention characteristics were prioritised during the health benefit package design process in Pakistan, which involved investment and disinvestment of interventions. Chapter 6 describes the health benefit package (HBP) design process and tracks interventions' inclusion and exclusion, which reveal how policymaker traded priorities.

In Chapter 5 I present the cost dataset that I developed which informed the HBP design process, and which is one of the main sources of data for the analysis presented in Chapter 6. The research paper in Chapter 5 aims to answer the following research question: for the purpose of informing investment and disinvestment decisions, what are the unit costs of interventions considered for Pakistan's health benefit package?

***

HBPs are widely seen as an essential component in the effort towards Universal Health coverage (UHC), defined as access to quality essential services for all without financial hardship [1-4]. Committed to achieving UHC, the Government of Pakistan began a process of HBP design in 2019 using Disease Control Priorities 3 (DCP3) as a framework of reference for the priority setting exercise [5].

DCP3 is a project that synthesised global evidence of cost and cost-effectiveness evidence across disease areas and proposed an Essential Universal Health Coverage (EUHC) package, composed of 218 interventions, as a template for low- and middle-income countries (LMICs) [6]. Given that the aim of the Government of Pakistan was to create an HBP actionable in the immediate future, and acknowledging a limited budget envelope, an evidence-based deliberative priority setting process was designed to assess and appraise interventions considered for inclusion in the package, using the 218 EUHC interventions as a starting point. Certain interventions would be prioritised for inclusion in the HBP while others, potentially some that were currently being delivered, would need to be

deprioritised and removed from the list of services provided by the public sector. In other words, decisionmakers could be faced with the choice to invest in new services and disinvest from existing healthcare services.

From 2019, I worked in the DCP3 UHC Country Translation project, along with a team of other researchers and public health professionals, which assisted the Government of Pakistan in the HBP design process. As part of the process, quantitative evidence on budget impact, cost-effectiveness and avoidable burden of disease of each intervention was produced. As a health economist my role was to generate evidence and facilitate its uptake among stakeholders involved in the decision-making process. However, unlike in Uganda where my sole role was that of analyst (see Chapter 4), in Pakistan I was also able to observe and analyse the different rounds (and different outcomes) of the evidence-based deliberative process. Chapters 5 and 6 explore the priority setting process in Pakistan both in terms of the analytics and the process.

In Pakistan, I was responsible for producing the data necessary to estimate budget impact, which involved calculating the unit costs of all interventions considered. As the case study in Uganda showed, high-quality and transparent cost data is an important input for decisionmakers considering disinvestment in healthcare interventions. In Chapter 5 I describe the methods I developed to estimate Pakistan-specific unit costs and present the cost dataset produced.

During the HBP design process, evidence on budget impact was presented and used alongside cost-effectiveness and burden of disease data. Cost-effectiveness data was collected by other members of the team (see Appendix 5.1 for a draft paper outlining that analytical process [7]) and data on avoidable burden of disease was sourced from the Global Burden of Disease database from the Institute of Health Metrics and Evaluation (IHME) and the Health Intervention Prioritisation (HIP) Tool [8, 9]. Chapter 6 describes how evidence was collated, explores the process of evidence uptake and analyses the trade-offs that took place as interventions were prioritised and deprioritised at different stages of the HBP design process, building, in part, on the data presented in Chapter 5.

Candidate's role in the research paper

This work was part of the Disease Control Priorities 3 (DPC3) Country Translation project, which provided technical assistance to the Ministry of National Health Services, Regulations & Coordination of Pakistan (MNHSR&C) with the design of a new health benefit package. Analytical approaches used in this project were proposed by the London School of Hygiene & Tropical Medicine and discussed with national stakeholders involved, namely the Health Planning, System Strengthening & Information Analysis Unit (HPSIU) of the MNHSR&C and the Aga Khan University.

The candidate, Sergio Torres-Rueda, reviewed and summarised costing approaches, and prepared a presentation which he co-presented to stakeholders in Pakistan. This presentation was part of a meeting to determine the overall analytical approaches used during the health benefit package design process. He reviewed the feedback from the meeting and designed a costing approach. He wrote up a research plan, and designed data collection and semi-automated analysis tools. He prepared submissions for ethical approval in Pakistan and the United Kingdom. The candidate liaised with the broader project to ensure coherence across and, specifically, with the HPSIU to ensure that intervention description sheets prepared were sufficiently disaggregated as to be appropriate for costing purposes. He supervised data extraction and collation and carried out several rounds of dataset review and cleaning. He carried out the analysis using the final dataset, and wrote an initial manuscript, which was included, in longer form, in a project report. The candidate, along with a colleague, edited the manuscript down to its current form and reviewed and integrated comments from the co-authors.

Full details of contributions of other authors can be found in 'Research Paper Cover Sheet'.

5.2 Cover sheet for Research Paper 2

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT

T: +44 (0)20 7299 4646
F: +44 (0)20 7299 4656
www.lshtm.ac.uk

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed for each research paper included within a thesis.

SECTION A – Student Details

Student ID Number	1702569	**Title**	Mr.
First Name(s)	Sergio		
Surname/Family Name	Torres-Rueda		
Thesis Title	Priority Setting and Disinvestment in Healthcare: Economic Evidence, Policy Processes and Potential Consequences		
Primary Supervisor	Prof. Anna Vassall		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Choose an item.	Was the work subject to academic peer review?	Choose an item.

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	BMJ Global Health
Please list the paper's authors in the intended authorship order:	Wajeeha Raza, Mashal Murad Shah, Wahaj Zulfiqar, Urooj Gul and Shehrbano Akhtar, Muhammad Khalid, DCP3 Country Translation Pakistan Group, Ala Alwan, Sameen Siddiqi, Anna Vassall, Sergio Torres-Rueda (corresponding

	author)
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	STR and AV summarised costing approaches which were presented to national stakeholders. STR and AV informed and moderated national government discussions on costing approaches, and designed final approach. STR designed data collection tools and supervised data extraction and collation. Data extraction and collation was led by WR and carried out by WR and MMS. Data collation was aided by WZ, UG, SA and MK. STR reviewed final data set. STR wrote the initial draft of the manuscript (in the form of project report). Report edited to manuscript format by STR and WR. All authors provided comments on the draft of the paper. Overall work was supervised by AV and SS.

SECTION E

Student Signature	Sergio Torres-Rueda
Date	05/04/22

Supervisor Signature	Anna Vassall
Date	05/04/22

5.3 Research Paper 2

Title

Costing Interventions for Developing a Health Benefit Package: Application of a Rapid Method and Results from Pakistan

Authors

Wajeeha Raza[1]

Mashal Murad Shah[1]

Wahaj Zulfiqar[2]

Urooj Gul[2]

Shehrbano Akhtar[2]

Muhammad Khalid[2]

DCP3 Country Translation Pakistan Group

Ala Alwan[3]

Raza Zaidi[2]

Sameen Siddiqi[1]

Anna Vassall[3]

Sergio Torres-Rueda[3]*

*Corresponding author

Institutional Affiliations

[1]Aga Khan University, Karachi, Pakistan

[2]Health Planning, System Strengthening & Information Analysis Unit, Ministry of National Health Services Regulations & Coordination, Islamabad, Pakistan

[3]London School of Hygiene & Tropical Medicine, London, United Kingdom

Abstract

Introduction: The Federal Ministry of National Health Services, Regulation & Coordination (MNHSR&C) in Pakistan has committed to progress towards Universal Health Coverage (UHC) by 2030 by providing a health benefit package (HBP). Starting in 2019, the Disease Control Priorities 3 (DCP3) evidence framework was used to guide the development of Pakistan's HBP. In this paper, I describe the methods and results of a rapid costing approach used to inform the HBP design process.

Methods: A total of 159 interventions were costed through a context-specific, normative, ingredients-based, bottom-up approach. Costs were constructed by determining resource use from descriptions provided by MNHSR&C and validated by technical experts. Price data from publicly available sources were used. Deterministic univariate sensitivity analyses were carried out.

Results: A total of 167 unit costs were calculated. Unit costs ranged from 2019 US$ 0.27 to 2019 US$ 1,478. Interventions in the cancer package of services had the highest average cost (2019 US$ 837) while interventions in the environmental package of services had the lowest (2019 US$ 0.68). Cost drivers varied by platform; the two largest drivers were drug regimens and surgery-related costs. Sensitivity analyses suggest our results are not sensitive to changes in staff salary but are sensitive to changes in medicine pricing.

Conclusion: I estimated a large number of context-specific unit costs, over a six-month period, demonstrating a rapid costing method suitable for HBP design.

Introduction

Countries around the world have strengthened their commitment to Universal Health Coverage (UHC) in recent years. UHC has been enshrined in Sustainable Development Goal target 3.8 and calls for access to quality essential healthcare services for all [1]. There are many types of health services that countries could potentially deliver but budgetary constraints require policymakers to limit the number or coverage of interventions financed through public expenditure. In order to set health sector priorities, many countries have embarked on health benefit package (HBP) design or revision exercises. This approach allows for explicit system-wide priority setting within a given budget envelope [10].

Pakistan's commitment to providing a UHC benefit package (UHC-BP) of health services was stated in its 12th Five-Year Plan (2018-23) and National Action Plan (2019-23) for the health sector [11]. The Federal Ministry of National Health Services Regulation & Coordination (MNHSR&C) decided to use Disease Control Priorities 3 (DCP3) as a starting point, and framework of reference, for the process of priority setting of health services provided by the public sector at the district level [5]. DCP3 is the third edition of a multi-year project funded by the Bill and Melinda Gates Foundation which sought to synthesise global evidence of cost and cost-effectiveness evidence across disease areas. Further, it suggested an essential universal health coverage (EUHC) package, composed of 218 interventions, as a guide for low- and middle- income countries (LMICs) [6].

In early 2019, the MNHSR&C, jointly with the provincial departments of health and key national stakeholders, compared the current scope of essential health services offered in Pakistan against the services covered by the EUHC. They recommended that a subset of EUHC interventions should be assessed for inclusion in Pakistan's UHC-BP [12]. This paper reports on the costing of this shortlist of DCP3 interventions, as part of a broader process of UHC-BP design in Pakistan.

This paper has two objectives: (i) to demonstrate a rapid costing methodology that can be used in the process of estimating unit costs for HBP design in LMICs, helpful for both investment and disinvestment decisions, and (ii) to present the first comprehensive dataset of unit costs for health interventions based on localised evidence in Pakistan. These unit costs are the building blocks needed to estimate the package's total cost, the relative budget impact of individual interventions and the affordability of the HBP given available fiscal space, which are key analytical components in the HBP design process.

Methods

The general guiding principles and priorities of the costing approach presented here were designed during a meeting with national and international stakeholders convened by the Health Planning, System Strengthening & Information Analysis Unit (HPSIU) of the MNHSR&C in Islamabad in July 2019. The meeting included 25-30 participants from three main sectors identified by HPSIU: academic partners (from the London School of Hygiene & Tropical Medicine and the Aga Khan University), international organisations (World Health Organization and UNICEF), and national government organisations (Health Services Academy and representatives from provincial Departments of Health). The meetings had two parts. In the first, the LSHTM team, including myself, prepared presentations on (i) overall costing approaches, (ii) factors to consider when costing a health benefit package, (iii) steps in the costing process, (iv) existing cost models, (v) data sources and data requirements. In the second part, stakeholders reacted to the presentations, posed questions and proposed priorities for costing, given the trade-offs between different approaches and the limitations of the project. A smaller group discussion followed, mostly between academic partners and the Ministry of Health, to iron out governmental priorities further and provide myself and other team members sufficient information to finalise a costing approach and develop related tools.

Ideally, cost estimation for HBP design would rely on local primary data collection. However, I used secondary data sources for several reasons. Firstly, costing current service provision would likely reflect service delivery of low quality; as HBPs aim to deliver high quality services, collecting primary data could lead to cost underestimation. Further, it was estimated that 62% of the interventions in DCP3's EUHC package were not carried out routinely in Pakistan's public sector [12]. Lastly, primary data collection is a resource-intensive exercise which was not feasible in the project timeframe.

Obtaining unit costs from the published global literature was also considered. However, a review of cost-effectiveness databases found a scarcity of high-quality costing estimates appropriate for Pakistan [7, 13]. Adapting and transferring cost data across settings can be misleading as resource use (such as lengths of patient consultations, health worker salaries and prices of medications and equipment) varies greatly between countries [14-16]. Further, variation in the context-specific service configuration can affect costs and efficiency [17]. Lastly, published data is often not sufficiently disaggregated and costing studies often employ different methodologies leading to evidence of varying levels of quality, a challenge when attempting comparability across many interventions.

Consequently, in line with priorities voiced by with stakeholders, I instead opted to develop a context-specific, rapid normative method to estimate the cost of DCP3 EUHC interventions. The costs were estimated by a joint team I led, with members from the Aga Khan University and the London School of Hygiene & Tropical Medicine, using data provided by the HPSIU and reviewed and validated by local technical experts. This rapid costing was conducted over a six-month period.

General approach

I carried out an ingredients-based costing (i.e., requiring the identification and subsequent valuing of all inputs needed to deliver the activity) taking an economic costing approach, which accounted for the value of all resources used, regardless of whether financial expenditure was expected. A bottom-up approach to costing was applied for most interventions. I assumed a provider's perspective and used a one-year time horizon. This approach followed the principles set in the Global Health Costing Consortium reference case [18], a gold standard for the costing of health interventions in LMICs.

I costed interventions across all five DCP3 EUHC delivery platforms: community-level, primary healthcare-level (PHC), first-level hospitals, referral hospitals and population-level. However, the priority setting exercise focused on a district package of services; population-level interventions were therefore excluded from the main analysis as they are operated and implemented at the national level, but their unit costs were still calculated. See Appendix 5.2 for further information.

The DCP3 EUHC contains 218 interventions [6]. Following a preliminary review carried out by MNHSR&C, as well as consultations with provincial-level stakeholders and within HPSIU, 47 interventions were eliminated as not deemed immediately relevant to Pakistan. As described, 12 population-level interventions were also excluded. Of the 159 remaining interventions considered for deliberation, three interventions were not costed as resource mapping was unfeasible (see Appendix 5.3). Consequently, I calculated unit costs for 156 DCP3 interventions. Finally, multiple unit costs were calculated for 9 interventions because either the scope of DCP3 interventions were deemed to be too broad and MNHSR&C preferred to divide them into sub-interventions, or the intervention could be delivered in multiple platforms, so a total of 167 unit costs were calculated.

The costing approach comprised several steps, specified in greater detail below: 1) development of a costing template, 2) development of intervention description sheets for each intervention, identification of intervention-specific inputs and validation by technical working groups (TWGs), and 3) identification and assessment of price sources and price data extraction.

I calculated unit costs by estimating the resources needed and relevant prices per beneficiary per year (e.g., cost per person treated for hypertension over a year). Costs were estimated in Pakistani rupees and converted to 2019 US dollars at an exchange rate of 155 PKR:USD.

Costing template

The stakeholders felt that a cost estimation tool for HBP design needed to show transparency, flexibility and ease of use, and should work across multiple platforms in the health system. As a result, the team designed a semi-automated user-friendly costing template in Microsoft Excel®. The template separated resource use data and prices and divided costs by input category. It allowed calculations of multiple unit costs per intervention (e.g., interventions carried out in multiple platforms or by multiple types of health workers). It also granted the flexibility of entering multiple price lists per input.

Determining resource use

To capture all resources used for each individual intervention, the HPSIU prepared intervention-specific description sheets detailing inputs necessary for service delivery: staff requirements (staff type and time), drug regimens, laboratory-based diagnostics, radiology, other supplies and equipment per patient/year. These descriptions were developed based on the latest existing national guidelines (or, in their absence, international guidelines) for each intervention and expert opinion from senior Pakistani clinicians.

Staff requirements were described in terms of staff type and duration of direct contact with the patient. Additional time was added to account for transportation for community-based interventions. Drug regimens were described by including the medication type, dose, frequency of use and duration of treatment. Weighted cost averages were used when multiple regimens could be used for the same intervention. Types and total number of diagnostic procedures were specified, as were other supplies used. Equipment resource use was quantified by the number of minutes used per intervention. Costs were annuitized and discounted. Equipment costs were treated as capital costs and were annuitized using a 3% discount rate. Building costs were quantified by estimating the rental costs of the room per minute and multiplying by the number of minutes required for each intervention.

For hospital-based interventions, the average number of inpatient bed-days, and whether the intervention involved surgery, were also specified by senior clinicians. A protocol-based cost would not have been appropriate given the large quantities of supplies and equipment generally used. The different inputs needed for inpatient bed-days and surgeries were obtained from the published sources. Relevant studies were identified through a literature review, including an activity-based

hospital costing carried out with a similar methodology to mine [19, 20]. Authors of these studies were contacted and they agreed to share their raw data. I disaggregated these data further and removed inputs irrelevant to our costing, arriving at a generic list of resources applicable to inpatient bed-days and surgeries across disease areas. These standard quantities of resources used for both bed-days and surgeries were used for all relevant DCP3 interventions.

Due to feasibility issues, MNHSR&C changed the delivery platform specified in 23 DCP3 interventions to better suit the national context; interventions were costed assuming resource use in the platform in which they would be delivered in Pakistan. See Appendix 5.4.

The first draft of the intervention description sheets was compiled by the HPSIU and revised and amended by experts during several rounds of disease-specific TWG consultations held in November 2019 and February 2020. Experts, all with ample clinical experience in Pakistan, were chosen by the MNHSR&C and grouped by broad disease area categories. They were tasked with reviewing resource use requirements suggested by HPSIU and to suggest changes when they believed original decisions did not sufficiently take into account health system constraints (e.g., if a particular type of required diagnostic equipment was unavailable in a specific platform). Final intervention descriptions were used for mapping individual interventions and compiling a list of resources used and quantities [21]. Further details on resource use quantification can be found in Appendix 5.4.

I only accounted for direct resource use in service provision. I did not include any indirect costs, above-service delivery costs or other overheads. I also do not include health system costs such as the cost of governance at the district level.

Determining prices

A variety of price sources were available for each input. An assessment of strengths and weaknesses of different price sources was conducted. The quality of sources was assessed using three main criteria shown in Table 1, namely how recently the source had been published, whether it referred to the public or private sector, and whether it was applicable across settings within Pakistan. A hierarchy of sources was then established.

Details on price sources assessed and used can be found in Appendix 5.5. In summary, Federal-level healthcare worker pay scales were used to determine average staff time pricing per health worker cadre [22] as the source was both recent and from the public sector. When an intervention could be delivered by different types of staff, I costed each configuration separately and presented an average unit cost.

The primary source for medication price data used was the Sindh Health Department Procurement Price list of 2018-19 [23], as it was both recent and listed public sector prices. However, this source did not contain prices of all medications used in the interventions costed. When a medication price was not found, three other sources were consulted (see Appendix 5.5). The first choice for supplies and equipment was a list of procurement prices from the Medical Emergency Resilience Fund 2019-2020 [24]. Building prices were obtained from Federal budgets (spaces) [25] and a costing study carried out in Khyber Pakhtunkhwa Province (utilities) [26]. A generic cost of furniture was added (10% of the building costs). I was unable to construct diagnostic and radiology costs through an ingredients-based approach due to time constraints and the complexity of supplies and equipment used. I used the 'Costing and Pricing of Services in Private Hospitals of Lahore: Summary Report' as a primary source for diagnostic prices as it also used an ingredients-based approach consistent with my methodology [27]. As with medication prices, alternative sources were consulted when prices for supplies, equipment and diagnostics could not be found in the preferred sources (see Appendix 5.5). Generic prices for surgery and inpatient bed-day were obtained from the same sources as the resource use data [19, 20].

Published unit costs and prices

In nine instances, unit costs or the price of the main input of an intervention were obtained from the peer-reviewed literature. These alternative options were used when the unit cost or main price estimated was grossly out of line with available global evidence and no Pakistan-specific reason for the discrepancy could be identified after consultation with health economists knowledgeable of the specific area. See Appendix 5.6.

Population-level interventions

Population-based interventions were categorised into three groups: mass media interventions, interventions related to the development of national-level protocols, and high-level training and other exercises. A top-down costing approach was used. Budget estimates of similar activities previously undertaken at the national level were reviewed. Input disaggregation was difficult as most budget estimates came from total fees charged for contracted services. Unit costs were estimated by dividing total national-level costs by an estimated population in need. See Appendix 5.2 for further details.

Sensitivity analysis

I carried out deterministic univariate sensitivity analyses for two key parameters. Staff salaries vary by province in Pakistan but, in our analysis, I used federal pay scale salaries for our base case unit

costs (which are used in Islamabad Capital Territory and Baluchistan province). I carried out a sensitivity analysis using pay-scales for Sindh and Khyber Pakhtunkhwa (KP) provinces, estimating percentage changes in average intervention costs per platform. I also examined the sensitivity of unit costs to different medicine prices for the ten most costly interventions. Using the different medicine price sources reviewed, I recalculated unit costs applying the lowest and highest medicine prices available and present those ranges in relation to the base case unit costs.

A summary of the costing approach can be found in Figure 1.

See Appendix 5.7 for ethical approval documents for the DCP3 Country Translation project from the Aga Khan University and the London School of Hygiene & Tropical Medicine.

Results

There is a high variation in the unit costs for interventions, ranging from 2019 US$ 0.27 to 2019 US$ 1,477.76. The top five highest unit costs observed were delivered in the referral hospital platform: treatment of early-stage childhood cancers (2019 US$ 1,477.76), treatment of early-stage breast cancer (2019 US$ 1,304.04), management of refractory illness (2019 US$ 673.43), repair of cleft lip and cleft palate (2019 US$ 515.11), and specialized tuberculosis services, including management of drug resistant tuberculosis (2019 US$ 493.21). The five lowest unit costs were delivered through the community-based platform: screening of hypertensive disorders in pregnancy (2019 US$ 0.27), providing guidance on early symptoms during emerging infectious outbreaks (2019 US$ 0.28), adolescent-friendly health service provision (2019 US$ 0.33), antenatal and post-partum education (2019 US$ 0.34) and larviciding and water management in high malaria transmission settings (2019 US$ 0.41). The full set of unit costs can be found in Table 2.

The mean unit costs varied increasingly by platform: 2019 US$ 5.12 (0.27 – 35.40) in the community-based platform, 2019 US$ 11.89 (0.42 – 110.25) for PHC, 2019 US$ 141.96 (1.16 – 387.77) in first-level hospitals, and 2019 US$ 402.56 (1.72 – 1,477.76) in referral hospitals. See Figure 2. The mean unit cost by disease area package (as defined by DCP3) also varied greatly. The packages with the highest mean unit cost per intervention were the cancer interventions (2019 US$ 837.37), musculoskeletal interventions (2019 US$ 167.90), and surgery (2019 US$146.71). Those with the lowest mean unit costs per intervention were environmental interventions (2019 US$ 0.68), pandemic-related interventions (2019 US$ 1.30) and adolescent health interventions (2019 US$ 2.03). See Figure 3.

The overall largest cost drivers of unit costs overall were drug regimens and surgery-related costs. However, there was great variation in cost drivers by platform. Staff costs were considerable for community and PHC interventions (21% and 25% respectively), but less significant for first-level and referral hospitals (4% and 3% respectively). Costs of medications made up a high percentage of total costs for community-level interventions (61%), referral hospitals (38%) and PHC interventions (34%). Surgery-related costs accounted for 34% and 19% of total costs in the first-level hospital and referral hospital interventions, respectively. Costs of inpatient bed-days made up 19% of total costs for first-level hospital interventions and 8% for referral hospitals. Supply costs were higher for community-level and PHC-interventions (10% and 24%, respectively) than for hospital-based interventions (3% at first-level hospitals and 2% at referral hospitals). Equipment costs were low in all platforms (<1%). See Figure 4.

Sensitivity analysis showed that replacing federal health worker staff salaries with KP Province salaries would alter the average unit costs by between a decrease of 0.03% for first-level hospitals and an increase of 1.82% at the PHC level. When using Sindh Province salaries, average unit costs increased by between 0.15% at the referral hospital level and 2.88% at the PHC level. Using alternative sources for medicine prices substantially changed unit costs for several of the highest unit cost interventions. Using the lowest price among the available medicine price sources led to moderate decreases in unit costs (by up to 7.13%, or 2019 US$ 62, for the treatment of early-stage childhood cancers). However, using the highest possible price available increased unit costs substantially in some interventions (by up to 370%, or 2019 US$ 4,831, for the treatment of early-stage breast cancer). See Figures 5 and 6.

Discussion

This paper presents the first comprehensive set of unit costs of health interventions in Pakistan estimated for the purposes of HBP design. These unit costs were subsequently used during the priority setting process to calculate total costs, intervention-specific budget impact and to assess package affordability [28]. I demonstrate a rapid method which could be implemented in other countries where context-specific and comparable unit costs are required for HBP design. In this Discussion, I reflect on the process and outcome.

Our costing method is appropriate for priority setting and is consistent with frameworks for fair decision-making, such as Accountability for Reasonableness (A4R) [29]. The dataset produced combines a large number of interventions, considers a comprehensive set of inputs per intervention and presents resource use and price data in a highly disaggregated manner and in a format that is highly accessible. Consequently, the data produced are transparent, relevant to the context and the decision problem faced by decisionmakers and would be accessible during any revision or reversal processes, such as disinvestment initiatives. Further, a lack of sufficient and appropriate evidence is commonly cited as a barrier to decision-making around health investment and disinvestment [30-33]; I address this gap by providing a broad set of country-specific cost estimates that could be referenced in future reviews of the package.

During the planning stages, a number of publicly available priority setting tools were reviewed, including, the Cost Revenue Analysis Tool Plus [34], the Health Interventions Prioritization (HIP) Tool [8] and the One Health Tool [35]. While these tools have important added value for other parts of the priority setting process stakeholders in Pakistan opted for developing semi-automated user-friendly costing templates in Microsoft Excel® for a number of reasons. Firstly, using a commonly available software that did not require extensive training was preferred in order to engage a broader set of stakeholders, both at national and provincial level, leaving the door open for regional adaptations or future package revisions. Secondly, a spreadsheet-based tool provided transparency in inputs and calculations which facilitate external validation of the data. Thirdly, it provided much-needed flexibility that allowed unit costs to be estimated for interventions with multiple service delivery configurations, different delivery platforms, as well as accounting for all intervention-specific fixed resources used. Microsoft Excel®-based tools have been used for HBP design in other LMIC settings [36].

HPSIU developed the service descriptions that served to determine resource use with a high-quality service in mind. This allowed for reflection on what constitutes a high-quality service and what aims the health system should strive towards. Although the process of cost calculation was carried out in

six months, it was labour intensive. It required considerable input from several clinically trained members of staff at HPSIU (working full-time on this specific task), and, importantly, the aid of a wide range of TWG experts whose input enhanced the accuracy of the service descriptions. For a similar process to be successful elsewhere a number of factors will be required: a high level of technical expertise within the Ministry of Health, the ability to convene a wide range of actors and a high degree of political commitment. This process could also be expedited by having an available inventory of interventions, guidelines and resource needs to form the basis for Microsoft Excel®-based templates that could be adjusted locally. Such an inventory is currently under development at the World Health Organization with the UHC Compendium [37].

Several price sources for different inputs, with different strengths and weaknesses, were identified. This prompted reflection on what constitutes desirable attributes of a price source when estimating costs for HBP design. With the input of all stakeholders, we settled on three main criteria: (i) using recent prices, important in settings like Pakistan with high price fluctuations, (ii) using prices of purchase from the public sector, as the exercise was framed around public provision of services, and (iii) using prices reflective of the entire country, a difficult task in a highly heterogeneous setting as Pakistan. Although we found it helpful to keep these criteria in mind, we did not come to a resolution on how these three criteria should be traded off when one source did not possess all three attributes. More work needs to be done to develop a validated rapid process for selecting local prices to cost HBP interventions.

It is key to draw a distinction between priority setting and budgeting; our costs were designed for priority setting and should not be directly translated into budgets without further adjustments. Our estimates will underestimate future financial expenditures in four ways. Firstly, our costs do not include indirect costs, above-service delivery costs or other overheads. Secondly, the approach does not capture health system inefficiencies or wastage. Thirdly, our estimates do not capture the costs incurred in carrying out initial consultations or diagnostics with patients whose conditions are not covered by the HBP. Lastly, we calculated economic costs instead of financial costs. As a result, increased expenditure needed to purchase fixed resources at scale (e.g., purchasing a dental chair for every PHC facility) will not be reflected. This highlights the importance, within the priority setting process, of thinking through issues of feasibility and implementation, such as the bundling of interventions, which would enable more efficient use of common inputs.

These under-estimations could be addressed by applying a mark-up, either a generic health system-wide one [38] or a context-specific one based on empirical evidence from primary costings, and by presenting economic and financial costs separately. Once the composition of the package has been

agreed, further work will be needed to better calculate incremental financial expenditure. Such exercises have been carried out elsewhere in the South Asian sub-continent and may be helpful in Pakistan [39].

On the other hand, our unit costs may overestimate future provider expenditure. Firstly, certain goods presently procured as donations from international donors are accounted for even if no financial costs are incurred by the public sector. Secondly, the service delivery descriptions capture a delivery of high quality. Therefore, compared to current provision, some inputs may be overestimated (although this overestimation is necessary to account for enhanced quality). Addressing these over-estimations may require reviewing costs as eligibility for donor funding schemes changes and as service delivery practices and guidelines are updated.

Our unit costs were not highly sensitive to variations in staff salaries and are therefore, in that respect, likely to be generalisable across provinces. Some of the more costly interventions were highly sensitive to changes in medicine costs, particularly, early-stage cancer treatment and treatment for drug-resistant tuberculosis. Further work to understand province-specific medication procurement sources is important to produce accurate estimates.

Limitations

Our study is subject to a number of limitations. Firstly, while I attempted to develop a method that could be used across all HBP cost calculations, I was not able to apply it consistently across inputs and intervention types. The methods used allowed for a rapid ingredients-based estimation of resource use. However, I found it difficult to apply this method when the inputs costed involved large numbers of components (generic inpatient bed-day and surgery costs) or complex diagnostic pathways and therefore had to rely on external estimates and prices. Secondly, our analysis shows that average cost drivers vary by platform. However, the averages here presented are unweighted (in other words, they don't reflect the frequency of each intervention). Therefore, the average proportion of inputs per platform presented in this analysis is not reflective of the actual proportion of inputs that that will be needed for implementation per platform. Such calculations require combining unit costs with target population data per intervention, which was outside the scope of this analysis. Thirdly, I was not able to adjust for within-country variation of resource use and prices (beyond our sensitivity analysis on staff salaries). Future exercise may want to use econometric or other methods to present a range of sub-national unit costs that better capture heterogeneity [40]. Lastly, additional data may be needed to inform disinvestment decisions; it may be necessary to account for additional training stemming from the disinvestment, to differentiate between fungible

and non-fungible inputs when thinking about how resources can be reallocated within the system, and to consider changes to economies of scale in existing services.

Conclusion

I estimated 167 unit costs for 156 interventions included in the DCP3 EUHC package. These costs were derived through a ingredients-based normative approach. Costs were constructed by determining resource use from descriptions provided by the Ministry of National Health Services Regulation & Coordination and validated by technical experts. Price data from publicly available sources were used. Deterministic univariate sensitivity analyses were carried out.

These unit costs have had multiple uses. First, and primarily, they were used to inform the process of designing Pakistan's health benefit package. They were also used in an analysis determining priorities within the decision-making process (see Chapter 6). More recently, they were used to build a disinvestment model for Pakistan (see Chapter 8).

The methods developed allowed for the rapid production of a large dataset of unit costs which were both context-specific and comparable. Unlike other costing efforts for health benefit package design, the data here presented is transparent and highly disaggregated, which can inform package adaptations. While helpful in informing disinvestment decisions, additional data may be needed. For example, it may be necessary to account for additional training, the relaxing of resource constraints and changes to economies of scale following a disinvestment decision.

Further refinements to these methods are needed to better estimate costs of diagnostics, inpatient bed-days and generic surgeries for future application in Pakistan and for similar projects in other settings. A global inventory of interventions and their resource needs would greatly enhance efforts by countries wishing to develop their own costing tools in Microsoft Excel®, rather than use programmed global ones. I have demonstrated that it is possible to estimate local costs, with expert validation and local acceptance, in rapid timeframes, rather than rely on extrapolated estimates from the limited global available costs from other settings.

Tables and Figures

Table 1: Hierarchy of price sources

Criteria	Rationale
Is the price recent?	Account for changes in inflation and use real prices
Is the source of price a public source?	This costing exercise uses a provider perspective for the public sector. The prices for inputs purchased by the public sector such as medicines and equipment can often differ substantially from private sector prices. We therefore attempted to use the purchase prices for public sector providers
Is the source nationally representative?	At this stage, the UHC benefit package and its unit costs are a national exercise therefore the price sources used were ranked higher if they were nationally representative

Table 2: Unit costs of DCP3 interventions in Pakistan by platform and by cluster (2019 US$)

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C1	Antenatal and postpartum education on family planning	$0.34
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C2	Counselling of mothers on providing thermal care for preterm new-borns (delayed bath and skin to skin contact)	$0.47
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C3a	Management of labour and delivery in low-risk women by skilled attendant	$14.46
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C3b	Basic neonatal resuscitation following delivery	$1.01
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C4	Promotion of breastfeeding or complementary feeding by lay health workers	$0.71
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C8	Detection and management of severe acute malnutrition and referral in the presence of complications	$12.53
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C9	Detection and treatment of childhood infections (iCCM), including referral if danger signs	$0.52
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C10	Education on handwashing and safe disposal of children's stools	$0.74
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C11	Pneumococcus vaccination	$11.46
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C12	Rotavirus vaccination	$5.66

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C14	Provision of vitamin A and zinc supplementation to children according to WHO guidelines, and provision of food supplementation to women and children in food insecure households	$13.00
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C16	Childhood vaccination series (diphtheria, pertussis, tetanus, polio, BCG, measles, hepatitis B, HiB, rubella)	$11.67
Community	Reproductive, maternal, new-born, child adolescent health/age related	Child health	C17	In high malaria transmission settings, indoor residual spraying (IRS) in selected areas with high transmission and entomologic data on IRS susceptibility	$1.05
Community	Reproductive, maternal, new-born, child adolescent health/age related	School-age health	C18	Education of school children on oral health	$0.84
Community	Reproductive, maternal, new-born, child adolescent health/age related	School-age health	C19	Vision pre-screening by teachers; vision tests and provision of ready-made glasses on-site by eye specialists	$1.84
Community	Reproductive, maternal, new-born, child adolescent health/age related	School-age health	C20	School based HPV vaccination for girls (Also included in RH, HIV and Cancer packages of services)	$26.11
Community	Reproductive, maternal, new-born, child adolescent health/age related	School-age health	C21	Mass drug administration for lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiases and trachoma, and food borne trematode infections (Also included in NTDs package of services)	$1.76
Community	Reproductive, maternal, new-born, child adolescent health/age related	Adolescent health	C23	Adolescent-friendly health services including provision of condoms to prevent STIs; provision of reversible contraception; treatment of injury in general and abuse in particular; and screening and treatment for STIs	$0.33
Community	Reproductive, maternal, new-born, child adolescent health/age related	Adolescent health	C24	Life skills training in schools to build social and emotional competencies	$4.47
Community	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	C27a	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households	$35.40
Community	Infectious diseases	HIV	C28	Community-based HIV testing and counselling (for example, mobile units and venue-based testing), with appropriate referral or linkage to care and immediate initiation of lifelong ART	$1.40

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
Community	Infectious diseases	HIV	C30a	Provision of condoms	$14.15
Community	Infectious diseases	HIV	C30b	Provision of disposable syringes	$5.03
Community	Infectious diseases	TB	C32	Routine contact tracing to identify individuals exposed to TB and link them to care	$8.67
Community	Infectious diseases	Adult febrile illness	C34	Conduct larviciding and water-management programs in high malaria transmission areas where mosquito breeding sites can be identified and regularly targeted	$0.41
Community	Infectious diseases	Adult febrile illness	C41	Mass drug administration in low malaria transmission settings (including high-risk groups in geographic or demographic clusters)	$0.84
Community	Infectious diseases	NTDs	C43	Early detection and treatment of Chagas disease, human African trypanosomiasis, leprosy, and leishmaniases	$7.94
Community	Infectious diseases	Pandemics	C45	Identify and refer patients with high risk including pregnant women, young children, and those with underlying medical conditions	$0.56
Community	Infectious diseases	Pandemics	C46	In the context of an emerging infectious outbreak, provide advice and guidance on how to recognize early symptoms and signs and when to seek medical attention	$0.28
Community	Non-communicable and injury prevention	CVD	C47	Exercise-based pulmonary rehabilitation for patients with obstructive lung disease	$2.01
Community	Non-communicable and injury prevention	Mental health	C48	Self-managed treatment of migraine	$0.42
Community	Non-communicable and injury prevention	Environmental	C51	WASH behaviour change interventions, such as community-led total sanitation	$0.68

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
Community	Health services	Rehabilitation	C53a	Identification of ECD rehabilitation interventions	$0.75
Community	Health services	Rehabilitation	C56	Pressure area prevention and supportive seating interventions for wheelchair users	$0.41
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC4a	Condoms and hormonal contraceptives	$9.50
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC5a	Counselling on kangaroo care for new-borns	$0.42
Community	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC9a	Screening of hypertensive disorders in pregnancy	$0.27
Community	Infectious diseases	TB	HC28	Screening for HIV in all individuals with a diagnosis of active TB; if HIV infection is present, start (or refer for) ARV treatment and HIV care	$1.53
Community	Non-communicable and injury prevention	Palliative care	HC66	Psychosocial support and counselling services for individuals with serious, complex, or life-limiting health problems and their caregivers	$4.47
Community	Infectious diseases	TB	P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkage to care (“active case finding”)	$0.49
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C3c	Management of labour and delivery in low-risk women by skilled attendant	$14.94
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C3d	Basic neonatal resuscitation following delivery	$1.09
PHC	Infectious diseases	Adult febrile illness	C33	For malaria due to P. vivax, test for G6PD deficiency; if normal, add chloroquine or chloroquine plus 14-day course of primaquine	$1.65

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	C5	Tetanus toxoid immunization among schoolchildren and among women attending antenatal care	$0.67
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households (PHC)	$35.68
PHC	Health services	Rehabilitation	C53b	ECD rehabilitation interventions	$8.10
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC1	Early detection and treatment of neonatal pneumonia with oral antibiotics	$3.41
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC2	Management of miscarriage or incomplete abortion and post abortion care	$18.09
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC3	Management of preterm premature rupture of membranes, including administration of antibiotics	$110.28
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC4b	Condoms and hormonal contraceptives	$9.50
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC5b	Counselling on kangaroo care for new-borns	$0.42
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC7	Pharmacological termination of pregnancy	$10.74
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC9b	Screening and management of hypertensive disorders in pregnancy	$4.44
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC11	Management of labour and delivery in low-risk women (BEmNOC), including initial treatment of obstetric or delivery complications prior to transfer	$19.92

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Child health	HC12	Detection and treatment of childhood infections with danger signs (IMCI)	$4.66
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Adolescent health	HC14	Psychological treatment for mood, anxiety, ADHD and disruptive behaviour disorders in adolescents	$1.28
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	HC16	Post-gender-based violence care, including counselling, provision of emergency contraception, and rape-response referral (medical and judicial)	$9.40
PHC	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	HC17	Syndromic management of common sexual and reproductive tract infections (for example, urethral discharge, genital ulcer, and others) according to WHO guidelines	$3.19
PHC	Infectious diseases	HIV	HC20	Hepatitis B and C testing of individuals identified in the national testing policy (based on endemicity and risk level), with appropriate referral of positive individuals to trained providers	$2.43
PHC	Infectious diseases	HIV	HC21	Partner notification and expedited treatment for common STIs, including HIV	$2.31
PHC	Infectious diseases	HIV	HC23	Provider-initiated testing and counselling for HIV, STIs, and hepatitis for all in contact with the health system in high prevalence settings, including prenatal care with appropriate referral or linkage to care including immediate ART initiation for those testing positive for HIV	$2.73
PHC	Infectious diseases	HIV	HC25	Provision of voluntary medical male circumcision in settings with high prevalence of HIV	$25.03
PHC	Infectious diseases	TB	HC26	For PLHIV and children under five who are close contacts or household members of individuals with active TB, perform symptom screening and chest radiograph; if there is no active TB, provide isoniazid preventive therapy according to current WHO guidelines	$12.62
PHC	Infectious diseases	TB	HC27	Diagnosis of TB, including assessment of rifampicin resistance using rapid molecular diagnostics (UltraXpert), and initiation of first-line treatment per current WHO guidelines for drug susceptible TB; referral for confirmation, further assessment of drug resistance, and treatment of drug-resistant TB	$57.97

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
PHC	Infectious diseases	TB	HC29	Screening for latent TB infection following a new diagnosis of HIV, followed by yearly screening among PLHIV at high risk of TB exposure; initiation of isoniazid preventive therapy among all individuals who screen positive but do not have evidence of active TB	$9.79
PHC	Infectious diseases	Adult febrile illness	HC30	Evaluation and management of fever in clinically stable individuals using WHO IMAI guidelines, with referral of unstable individuals to first-level hospital care	$2.62
PHC	Infectious diseases	Adult febrile illness	HC32	Provision of insecticide-treated nets to children and pregnant women attending health centres	$5.36
PHC	Infectious diseases	Pandemics	HC33	Identify and refer to higher levels of health care patients with sings of progressive illness	$3.06
PHC	Non-communicable and injury prevention	CVD	HC36	Long-term combination therapy for persons with multiple CVD risk factors, including screening for CVD in community settings using non-lab-based tools to assess overall CVD risk	$6.20
PHC	Non-communicable and injury prevention	CVD	HC37	Low-dose inhaled corticosteroids and bronchodilators for asthma and for selected patients with COPD	$1.59
PHC	Non-communicable and injury prevention	CVD	HC38	Provision of aspirin for all cases of suspected acute myocardial infarction	$0.56
PHC	Non-communicable and injury prevention	CVD	HC39a	Screening and management of albuminuric kidney disease with ACEi or ARBs, including targeted screening among people with diabetes	$6.29
PHC	Non-communicable and injury prevention	CVD	HC41	Secondary prophylaxis with penicillin for rheumatic fever or established rheumatic heart disease	$1.86
PHC	Non-communicable and injury prevention	CVD	HC42	Treatment of acute pharyngitis in children to prevent rheumatic fever	$3.04
PHC	Non-communicable and injury prevention	CVD	HC45	Opportunistic screening for hypertension for all adults and initiation of treatment among individuals with severe hypertension and/or multiple risk factors	$13.66

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
PHC	Non-communicable and injury prevention	CVD	HC46	Tobacco cessation counselling and use of nicotine replacement therapy in certain circumstances	$12.39
PHC	Non-communicable and injury prevention	Mental health	HC48	Interventions to support caregivers of patients with dementia	$5.43
PHC	Non-communicable and injury prevention	Mental health	HC49	Management of bipolar disorder using generic mood-stabilizing medications and psychosocial treatment	$56.89
PHC	Non-communicable and injury prevention	Mental health	HC50	Management of depression and anxiety disorders with psychological and generic antidepressant therapy	$20.36
PHC	Non-communicable and injury prevention	Mental health	HC53	Screening and brief intervention for alcohol use disorders	$7.98
PHC	Non-communicable and injury prevention	Musculoskeletal	HC55	Calcium and vitamin D supplementation for primary prevention of osteoporosis in high-risk individuals	$2.13
PHC	Non-communicable and injury prevention	Congenital disorders	HC56	Targeted screening for congenital hearing loss in high-risk children, using otoacoustic emissions testing	$8.76
PHC	Health services	Surgery	HC57a	Dental extraction	$12.11
PHC	Health services	Surgery	HC58a	Drainage of dental abscess	$9.10
PHC	Health services	Surgery	HC59	Drainage of superficial abscess	$10.02
PHC	Health services	Surgery	HC60	Management of non-displaced fractures	$8.42

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
PHC	Health services	Surgery	HC61	Resuscitation with basic life support measures	$1.03
PHC	Health services	Surgery	HC62	Suturing of lacerations	$1.77
PHC	Health services	Surgery	HC63a	Treatment of caries	$15.86
PHC	Health services	Rehabilitation	HC64	Basic management of musculoskeletal and neurological injuries and disorders, such as prescription of simple exercises and sling or cast provision	$5.48
PHC	Health services	Pathology	HC68	Health centre pathology services	$13.84
First-level hospital	Non-communicable and injury prevention	Injury	C50	Parent training of high-risk families, including nurse home visitation for child maltreatment	$1.93
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH1	Detection and management of foetal growth restriction	$321.46
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH2	Induction of labour post-term	$167.96
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH3	Jaundice Management of Phototherapy	$63.30
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH4	Management of eclampsia with magnesium sulphate, including initial stabilization at health centres	$106.79
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH5	Management of maternal sepsis, including early detection at health centres	$140.65

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH6	Management of new-born complications, neonatal meningitis, and other very serious infections requiring continuous supportive care (such as IV fluids and oxygen)	$79.06
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH7	Management of preterm labour with corticosteroids, including early detection at health centres	$157.66
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH8	Management of labour and delivery in high-risk women, including operative delivery (CEmONC)	$356.48
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH9	Surgery for ectopic pregnancy	$200.53
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	FLH10	Surgical termination of pregnancy by manual vacuum aspiration and dilation and curettage	$115.24
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Child health	FLH11	Full supportive care for severe childhood infections with danger signs	$166.84
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Child health	FLH12	Management of severe acute malnutrition associated with serious infections	$150.08
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	FLH13	Early detection and treatment of early-stage cervical cancer	$170.42
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	FLH14	Insertion and removal of long-lasting contraceptives (IUCDs and Implants)	$1.16
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	FLH15	Tubal ligation	$118.23
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Reproductive health	FLH16	Vasectomy	$115.60

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
First-level hospital	Infectious diseases	TB	FLH17	Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO guidelines (either short- or long-term regimen)	$373.39
First-level hospital	Infectious diseases	Adult febrile illness	FLH18	Evaluation and management of fever in clinically unstable individuals using WHO IMAI guidelines, including empiric parenteral antimicrobials and antimalarial and resuscitative measures for septic shock	$84.39
First-level hospital	Non-communicable and injury prevention	CVD	FLH20	Management of acute coronary syndromes with aspirin, unfractionated heparin and generic thrombolytic (when indicated)	$268.17
First-level hospital	Non-communicable and injury prevention	CVD	FLH22	Management of acute coronary exacerbations of asthma and COPD using systemic steroids, inhaled beta-agonists and if indicated oral antibiotics and oxygen therapy	$50.90
First-level hospital	Non-communicable and injury prevention	CVD	FLH23	Medical management of acute heart failure	$387.77
First-level hospital	Non-communicable and injury prevention	Cancer	FLH24	Management of bowel obstruction	$167.20
First-level hospital	Non-communicable and injury prevention	Musculoskeletal	FLH25	Calcium and vitamin D supplementation for secondary prevention of osteoporosis	$147.97
First-level hospital	Non-communicable and injury prevention	Musculoskeletal	FLH26	Combination therapy, including low dose corticosteroids and generic disease modifying anti-rheumatic drugs (including methotrexate) for individuals with moderate to severe rheumatoid arthritis	$273.01
First-level hospital	Non-communicable and injury prevention	Congenital disorders	FLH27	In settings where sickle cell disease is a public health concern, universal new-born screening followed by standard prophylaxis against bacterial infections and malaria	$9.31
First-level hospital	Non-communicable and injury prevention	Congenital disorders	FLH28	In setting where specific single-gene disorders are a public health concern (for example thalassemia), retrospective identification of carriers plus prospective (premarital) screening and counselling to reduce rates of conception	$71.29
First-level hospital	Non-communicable and injury prevention	Injury	FLH30	Management of intoxication/ poisoning syndromes using widely available agents e.g., charcoal, naloxone, bicarbonate, antivenin	$18.83

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
First-level hospital	Health services	Surgery	FLH31	Appendectomy	$172.07
First-level hospital	Health services	Surgery	FLH32	Assisted vaginal delivery using vacuum extraction or forceps	$166.39
First-level hospital	Health services	Surgery	FLH34	Colostomy (adult and paediatric)	$184.26
First-level hospital	Health services	Surgery	FLH35	Escharotomy or fasciotomy (adults)	$193.01
First-level hospital	Health services	Surgery	FLH36	Fracture reduction	$155.91
First-level hospital	Health services	Surgery	FLH37	Hernia repair including emergency surgery	$150.09
First-level hospital	Health services	Surgery	FLH38	Hysterectomy for uterine rupture or intractable postpartum haemorrhage	$204.52
First-level hospital	Health services	Surgery	FLH39	Irrigation and debridement of open fracture	$236.30
First-level hospital	Health services	Surgery	FLH40	Management of osteomyelitis, including surgical debridement	$254.37
First-level hospital	Health services	Surgery	FLH41a	Management of septic arthritis	$251.43
First-level hospital	Health services	Surgery	FLH41b	Placement of external fixation and use of traction for fractures	$214.64

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
First-level hospital	Health services	Surgery	FLH42	Relief of urinary obstruction by catheterization for fractures	$138.21
First-level hospital	Health services	Surgery	FLH43	Removal of gallbladder, including emergency surgery	$190.29
First-level hospital	Health services	Surgery	FLH44	Repair of perforations (for example perforated peptic ulcer, typhoid ileal perforation)	$240.26
First-level hospital	Health services	Surgery	FLH45	Resuscitation with advanced life support measures, including surgical airway	$50.13
First-level hospital	Health services	Surgery	FLH46	Basic skin grafting	$168.16
First-level hospital	Health services	Surgery	FLH48a	Trauma laparotomy	$221.35
First-level hospital	Health services	Surgery	FLH49	Trauma related amputations	$194.00
First-level hospital	Health services	Surgery	FLH50	Tube thoracostomy	$53.05
First-level hospital	Health services	Rehabilitation	FLH52	Compression therapy for amputations, burns, and vascular or lymphatic disorders	$5.43
First-level hospital	Health services	Rehabilitation	FLH53	Evaluation and acute management of swallowing dysfunction	$8.67
First-level hospital	Health services	Palliative care	FLH57	Prevention and relief of refractory suffering and acute pain related to surgery, serious injury or other serious, complex or life-limiting health problems	$1.40

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
First-level hospital	Health services	Pathology	FLH58	First level hospital pathology services	N/A
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC6	Management of neonatal sepsis, pneumonia, and meningitis using injectable and oral antibiotics	$41.32
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	HC10	Screening and management of diabetes in pregnancy (gestational diabetes or pre-existing type II diabetes)	$15.96
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Child health	HC13	Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load	$197.22
First-level hospital	Infectious diseases	HIV	HC19	For individuals testing positive for hepatitis B and C, assessment of treatment eligibility by trained providers followed by initiation and monitoring of ART when indicated	$188.69
First-level hospital	Infectious diseases	HIV	HC24	Hepatitis B vaccination for high-risk populations, including healthcare workers, IDU, MSM, household contacts and partners with multiple sex partners	$1.67
First-level hospital	Health services	Surgery	HC57b	Dental extraction	$13.93
First-level hospital	Health services	Palliative care	HC67	Expanded palliative care and pain control measures, including prevention and relief of all physical and psychological symptoms of suffering	$1.40
First-level hospital	Reproductive, maternal, new-born, child adolescent health/age related	Maternal and new-born health	RH1	Full supportive care for preterm new-borns	$24.14
First-level hospital	Health services	Surgery	RH14	Cataract Extraction and Insertion of Intraocular Lens	$151.84
Referral hospital	Health services	Surgery	FLH33	Craniotomy for trauma	$311.03

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
Referral hospital	Infectious diseases	TB	RH2	Specialized TB services, including management of MDR- and XDR-TB treatment failure and surgery for TB	$493.21
Referral hospital	Infectious diseases	Adult febrile illness	RH3	Management of refractory illness including etiological diagnosis at reference microbial laboratory	$673.43
Referral hospital	Non-communicable and injury prevention	CVD	RH4	Management of acute ventilator failure due to acute exacerbations of asthma and COPD	$30.11
Referral hospital	Non-communicable and injury prevention	CVD	RH5	Retinopathy screening via telemedicine, followed by treatment using laser photocoagulation	$1.72
Referral hospital	Non-communicable and injury prevention	CVD	RH6	Use of percutaneous coronary intervention for acute myocardial infarction where resources permit	$257.14
Referral hospital	Non-communicable and injury prevention	Cancer	RH7	Treatment of early-stage breast cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination at health centres and first level hospitals	$1,304.04
Referral hospital	Non-communicable and injury prevention	Cancer	RH8	Treatment of early-stage colorectal cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination at health centres and first level hospitals	$400.46
Referral hospital	Non-communicable and injury prevention	Cancer	RH9	Treatment of early-stage childhood cancers (such as Burkitt and Hodgkin lymphoma, acute lymphoblastic leukaemia, retinoblastoma and Wilms tumour) with curative intent in paediatric cancer units or hospitals	$1,477.76
Referral hospital	Non-communicable and injury prevention	Musculoskeletal	RH10	Elective surgical repair of common orthopaedic injuries (for example meniscal and ligamentous tears) in individuals with severe functional limitation	$239.90
Referral hospital	Non-communicable and injury prevention	Musculoskeletal	RH11	Urgent, definitive surgical management of orthopaedic injuries (for example open reduction and internal fixation)	$176.50
Referral hospital	Non-communicable and injury prevention	Congenital disorders	RH12	Repair of cleft lip and cleft palate	$515.11

Platform	Cluster	Package	Intervention Code DCP	Intervention Name	Unit Cost (2019 US$)
Referral hospital	Non-communicable and injury prevention	Congenital disorders	RH13	Repair of club foot	$95.16
Referral hospital	Health services	Surgery	RH15	Repair of anorectal malformations and Hirschsprung's disease	$230.76
Referral hospital	Health services	Surgery	RH16	Repair of obstetric fistula	$252.62
Referral hospital	Health services	Surgery	RH17	Ventriculoperitoneal shunt	$247.84
Referral hospital	Health services	Surgery	RH18	Surgery for trachomatous trichiasis	$136.67
Referral hospital	Health services	Pathology	RH19	Referral level hospital pathology services	N/A
Referral hospital	Health services	Pathology	RH20	Speciality pathology services	N/A

Figure 1: Summary of costing approach

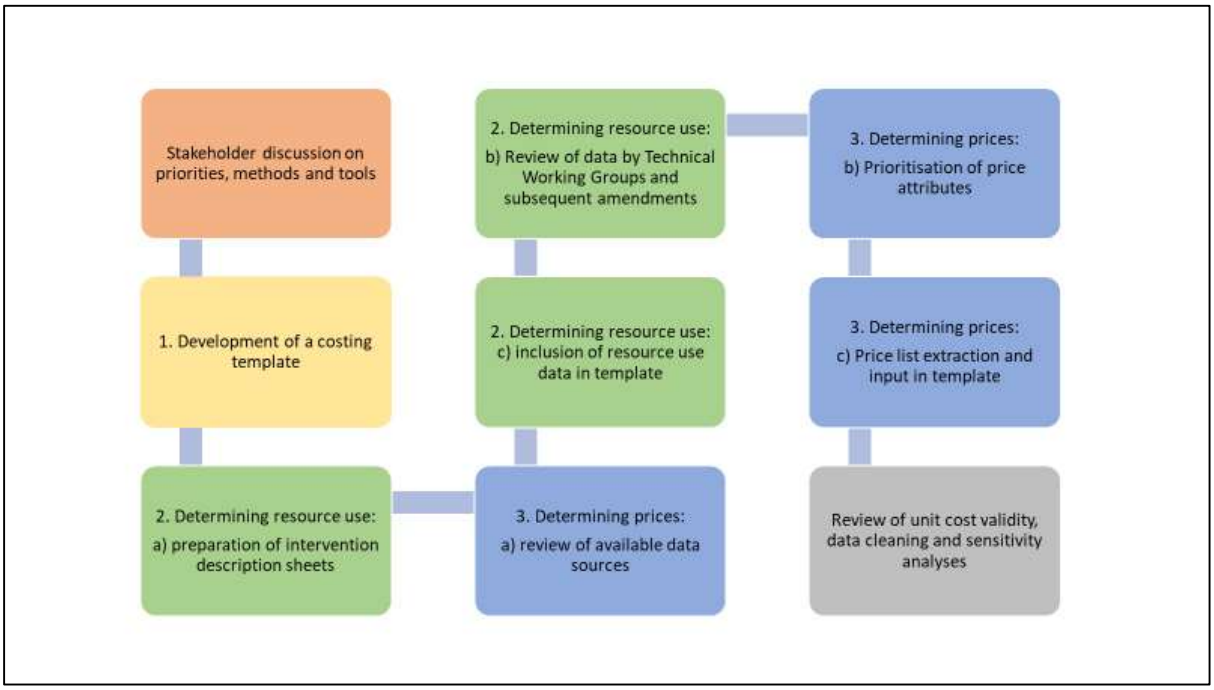


Figure 2: Distribution of unit costs and mean unit costs by platform (2019 US$)

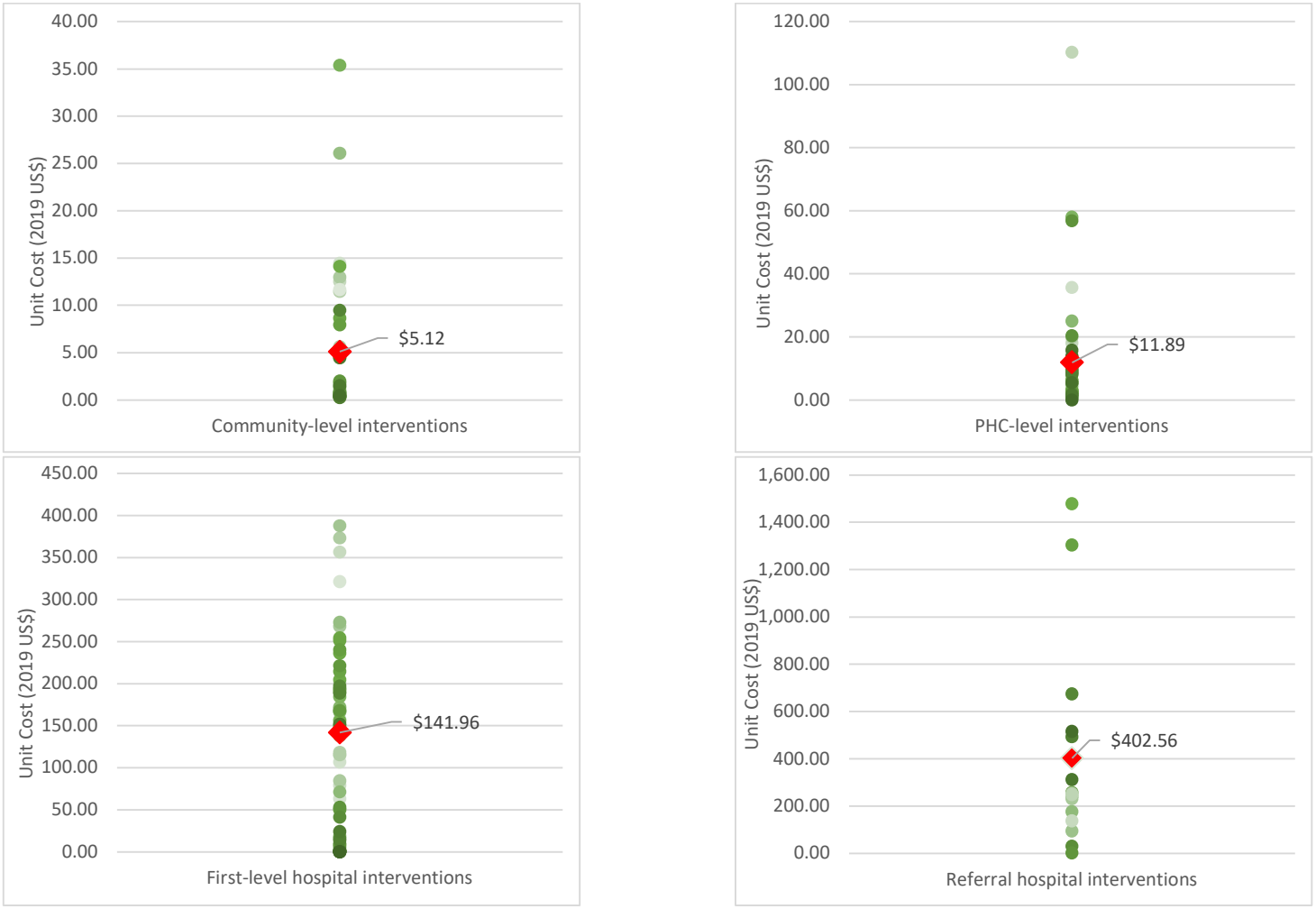


Figure 3: Mean unit cost per health package (2019 US$)

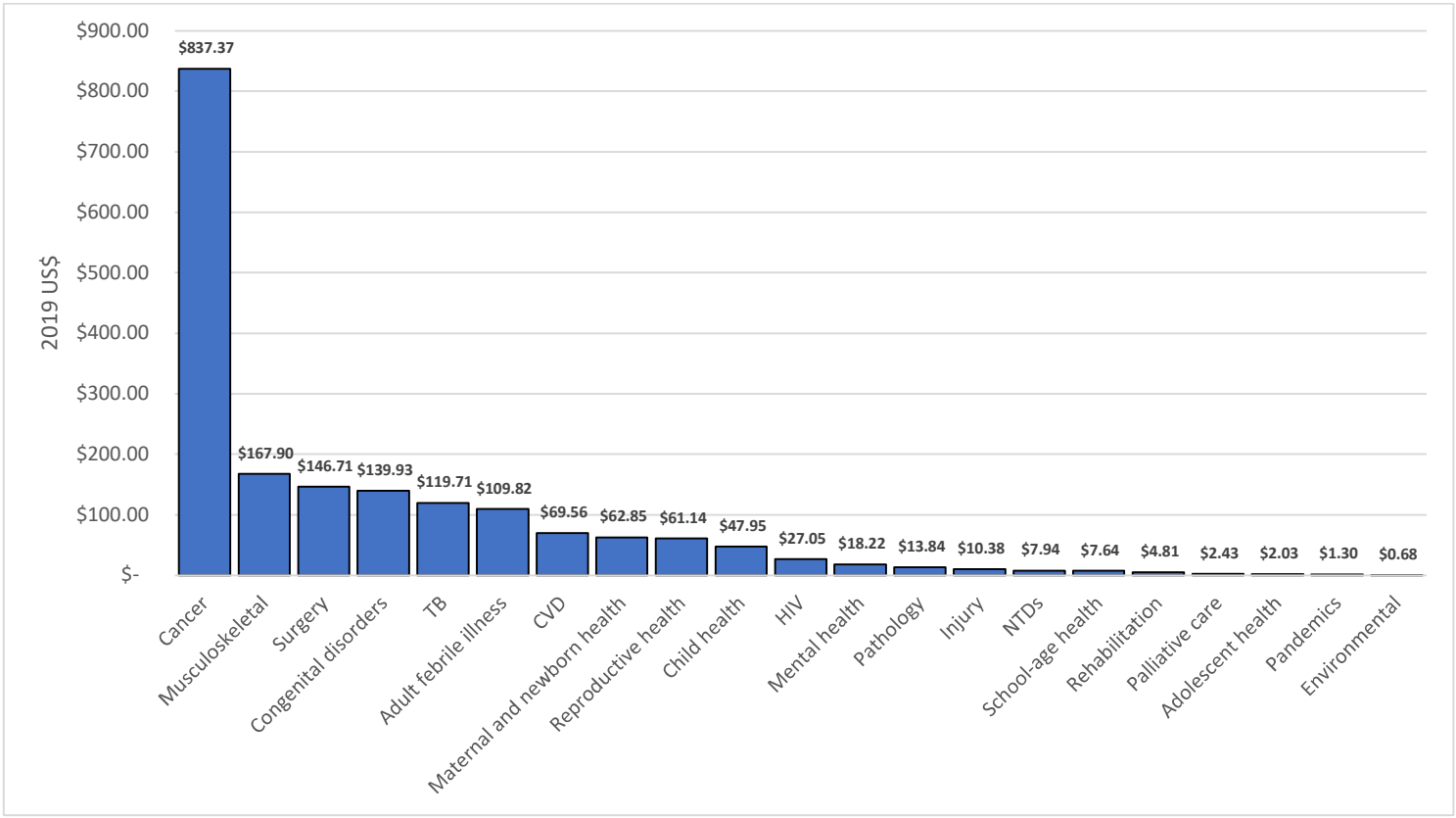


Figure 4: Cost drivers by platform

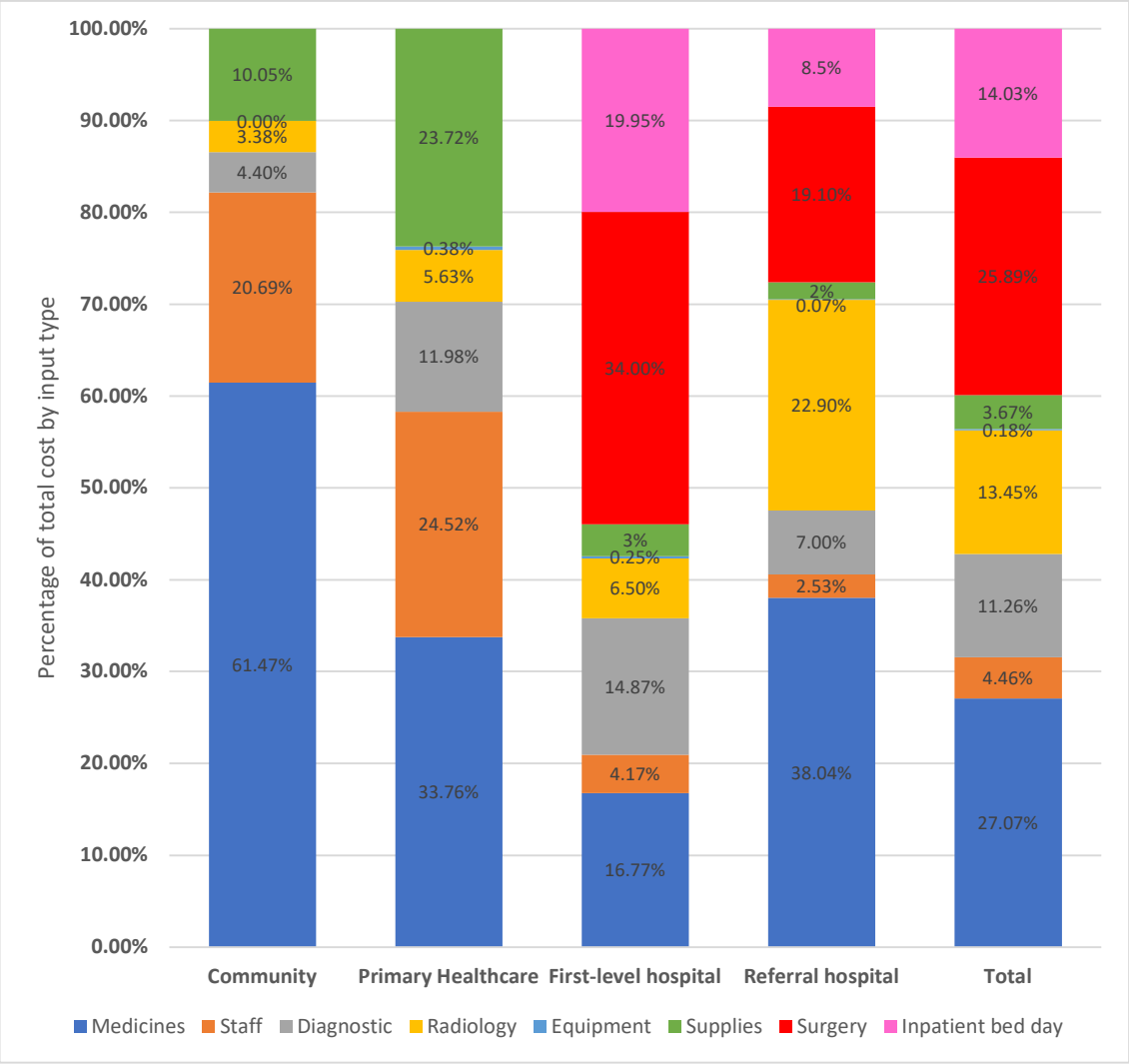


Figure 5: Tornado diagram of provincial staff salaries by platform

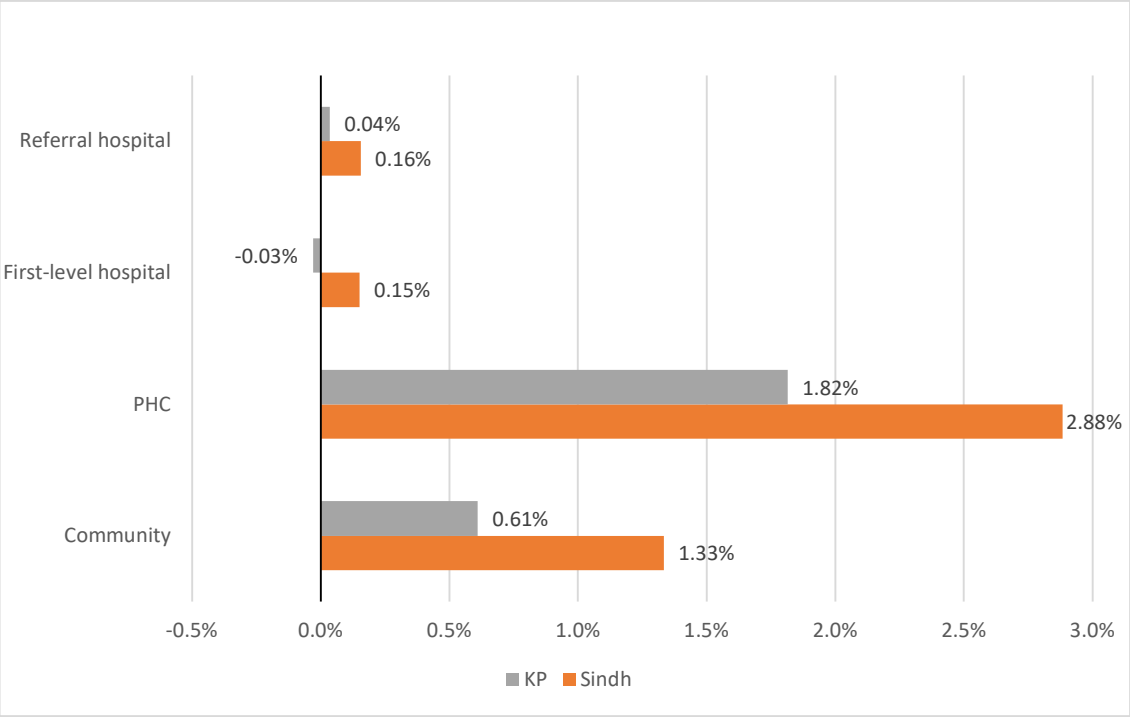
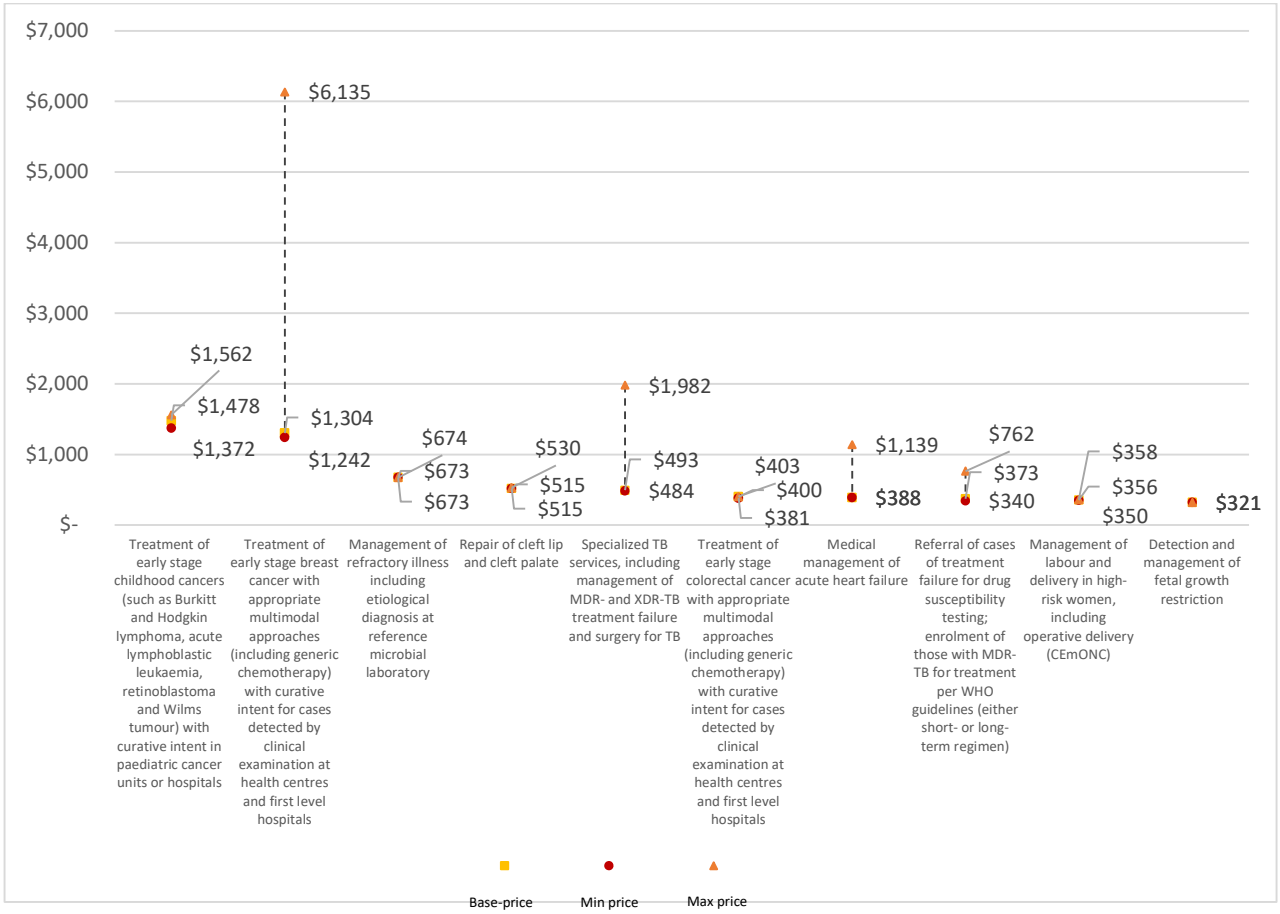


Figure 6: Sensitivity analysis of interventions with 10 highest unit costs using a range of medicine prices



5.4 Epilogue

Chapter 5 showed how a comprehensive context-specific cost dataset, used for investment and disinvestment decisions in the context of health benefit package design, can be estimated rapidly. These data are then used in Chapter 6 to determine what decision criteria (including budget impact) and intervention characteristics were prioritised during the health benefit package design process in Pakistan. Chapters 5 and 6 should be considered jointly as part of the second analytical section in this dissertation.

The cost dataset presented in Chapter 5 is also used later in Chapter 8 where I propose a disinvestment model to reach a 'smart, temporary and reduced' health benefit package for use during health system shocks, such as those experienced during pandemics.

I would argue that the work presented in Chapter 5 shows a novel, rapid costing method because it strikes an adequate balance between transparency, flexibility, accuracy, adaptability, comparability, expediency, and feasibility which other approaches does not. This was achieved through a combination of creating a new semi-automated template for analysis, as well choosing a normative, ingredients-based bottom-up approach that reflected the aims of the costing exercise, which included supporting both investment and disinvestment decisions, and took into account data availability as well as staff capability and time constraints.

A recently published review of health benefit package costing in five countries (Afghanistan, Ethiopia, Pakistan, Somalia and Sudan), as well as experience from other settings, such as Cote d'Ivoire and Armenia, [41,42] reveals that most countries used pre-set software (e.g., One Health Tool, Core Plus or HIP Tool), at least partially, to carry out health system wide costing exercises given the size of the task and the number of interventions involved. Users of these tools have reported that, while effective in providing estimates, these tools often lack transparency both in terms of pre-set inputs and calculations, can be data-demanding and require substantial amounts of training before use.

The model I set up, on the other hand, is in Microsoft Excel®, a commonly used software globally. The model separates input types (e.g., staff type and time required, medications, etc) and requires that input types and quantities be entered. All inputs listed link to a dataset on prices which includes multiple price sources. The model is semi-automated and chooses prices per inputs based on a hierarchy I set up given attributes of different price sources available and analysis priorities. This hierarchy can easily be modified to test the sensitivity of costs to differences in prices of certain

inputs. All calculations are shown transparently, and every single assumption or piece of data entered can be traced back to a source.

The approach set out allowed for direct comparability of interventions, which is essential to the aim of health benefit package design. Other countries designing health benefit packages carried out primary costing (which is limited to existing interventions) or used local studies to obtain unit costs (which are limited to a narrow range of interventions in most low- and middle-income settings). Therefore, the costs produced using my approach are highly comparable.

Further, my approach was also considerably less time consuming. Countries like Ethiopia, Somalia and Sudan report having taken longer (18 to 20 months) and requiring a larger team (between 8 and 12 people). My approach allowed the team to cost the entire health benefit package in 12 months (with most work being done in the first 6 months) by a team of five people.

Reflections on disinvestment

In Chapter 5 I present a rapid method to determine the unit costs of a large number of interventions in the context of the health benefit package design process in Pakistan, during which decisions to invest and disinvest in interventions were made. This chapter does not explicitly report on a disinvestment decision or outcome, but rather it feeds into the analysis presented in Chapter 6 which explores the types of interventions (including the decision criteria and characteristics they exemplify) prioritised and deprioritised. However, it is important to reflect on the costing methods used and their suitability for analyses of disinvestment.

The costing I designed is highly disaggregated and is presented in a transparent way. It allows for the specification of resource type, resource use and prices in a manner that is flexible and can be easily changed. While an ingredients-based costing is evidently not exclusive to my approach in Pakistan, the combination of having chosen this approach with a transparent model, means that all assumptions can be easily modified as future interventions are introduced or removed from the package. As I go on to show in later chapters (see Chapters 7 and 8), the decision to disinvest is better informed with an understanding of what could be the alternative uses of newly available financial resources. Having a health system-wide data set, including on unit costs, in a format that allows simple manipulation, would lead to better calculations of opportunity cost and, hopefully, decisions that include considerations of both financial optimisation and equity.

The cost estimates (and budget impact implications) included in my approach take into account, and differentiate, both fungible inputs (e.g., clinical staff that can be deployed to perform a range of activities) and non-fungible inputs (e.g., highly specialised equipment). When disinvestment occurs,

the costs related to non-fungible inputs could potentially be redeployed elsewhere whereas those of non-fungible activities may not (as they can become sunk costs). This differentiation built into the model is helpful for disinvestment decisions. Policymakers or planners could quickly calculate, for example, the number of staff hours (and related costs) that would be freed up if an intervention is discontinued. They would be able to differentiate that cost from, for example, the costs of capital items that could not be easily redeployed.

However, it is important to acknowledge that there are limitations to the types of information this model can produce in relation to informing disinvestment decisions and that further analyses may be needed. First, as highlighted in Chapter 2, there may be a considerable lag between disinvestment decisions and their complete implementation. Evidence suggests that some clinical staff have an aversion towards the withdrawal of services and are known to continue offering services for some time after they have been formally withdrawn. Sensitisation and the development of guidelines can help in ensuring staff accept and embrace disinvestment decisions. The additional costs incurred from both the 'inefficiencies' of offering services that have been withdrawn, and of sensitising clinical staff, need to be accounted for. Secondly, I would argue that, other than money, no inputs are entirely fungible. For example, some clinical staff could be relocated from one activity to another. However, the activities to which staff can be relocated will be limited to those activities which require similar skills to those the staff already has. If the activity requires additional skills, retraining will be necessary, which requires both time and additional financial resources. Also, even if the skills required are the same, there is no guarantee that the demand for the new service to which staff is relocated is delivered at the same level of the health system, or in the same geographical areas. These changes will require planning and incur costs. Lastly, the delivery of service often occurs in bundles of interventions with shared costs. This means that certain interventions benefit from economies of scale. For example, a primary care facility may deliver three types of dental services, requiring a dental assistant and a dental chair. If two of those services are withdrawn, the unit costs of the remaining intervention will change as the costs of the capital goods will be allocated entirely to one intervention and, assuming that the demand for services for the remaining intervention stay the same, so will the costs associated with the dental assistant. These areas should be considered in further iterations of models like the one presented in this chapter.

5.5 References

1. United Nations Economic and Social Council, *Progress towards the Sustainable Development Goals*. 2017: New York.
2. Glassman, A., et al., *Defining a Health Benefits Package: What Are the Necessary Processes?* Health Systems & Reform, 2016. **2**(1): p. 39-50.
3. Pillay, Y., et al., *Health benefit packages: moving from aspiration to action for improved access to quality SRHR through UHC reforms.* Sex Reprod Health Matters, 2020. **28**(2): p. 1842152.
4. World Health Organization, *Principles of Health Benefit Packages*. 2021.
5. Jamison, D.T., et al., *Universal health coverage and intersectoral action for health: key messages from Disease Control Priorities, 3rd edition.* Lancet, 2018. **391**(10125): p. 1108-1120.
6. Watkins, D.A., et al., *Universal Health Coverage and Essential Packages of Care*, in *Disease Control Priorities: Improving Health and Reducing Poverty*, rd, et al., Editors. 2017: Washington (DC).
7. Huda, M., et al., *Assessing global evidence on cost-effectiveness to inform Pakistan's Essential Health Benefit Package* 2021.
8. Health Interventions Prioritization Working Group. *Health Interventions Prioritization (HIP) Tool* 2019; Available from: http://hiptool.org/.
9. Institute for Health Metrics and Evaluation (IHME), *Global Burden of Disease, Pakistan Profile*. 2019, IHME, University of Washington: Seattle, WA,.
10. Glassman A, Giedion U, and Smith P, *What's in and what's out: designing benefits for universal health coverage.* 2017, Center for Global Development: Washington DC.
11. Government of Pakistan and Ministry of National Health Services Regulation & Coordination, *National Discourse on the Development and Implementation of Universal Health Coverage Benefit Package of Pakistan*. 2019.
12. Government of Pakistan and Ministry of National Health Services Regulation & Coordination, *Review of Essential Health Services in Pakistan Based on Disease Control Priorities 3.* 2019.
13. Tufts Medical Centre. *Global Health Cost-Effectiveness Analysis Registy*. 2019; Available from: http://ghcearegistry.org/ghcearegistry/.
14. Irving, G., et al., *International variations in primary care physician consultation time: a systematic review of 67 countries.* BMJ Open, 2017. **7**(10): p. e017902.
15. Tijdens, K., D.H. de Vries, and S. Steinmetz, *Health workforce remuneration: comparing wage levels, ranking, and dispersion of 16 occupational groups in 20 countries.* Hum Resour Health, 2013. **11**: p. 11.
16. Cameron, A., et al., *Medicine prices, availability, and affordability in 36 developing and middle-income countries: a secondary analysis.* Lancet, 2009. **373**(9659): p. 240-9.
17. Watson, S.I., et al., *Cost-effectiveness of health care service delivery interventions in low and middle income countries: a systematic review.* Glob Health Res Policy, 2018. **3**: p. 17.
18. Vassall A, et al., *Reference Case for Estimating the Costs of Global Health Services and Interventions.*, G.H.C. Consortium, Editor. 2017.
19. Khan, R.M., et al., *Time-driven activity-based costing of total knee replacements in Karachi, Pakistan.* BMJ Open, 2019. **9**(5): p. e025258.
20. Sagheer U., et al., *Cost of establishing and maintaining a bed in a tertiary care hospital in Pakistan*, in *Leadership in Health Services*. 2000.
21. Government of Pakistan and Ministry of National Health Services Regulations & Coordination, *Interventions' Description of Essential Package of Health Services/IHC Benefit Package of Pakistan*. 2020.

22. Ministry of National Health Services, R.a.C., *Federal Pay Scales for Health Workers Islamabad Capital Territory*. 2019.
23. Government of Sindh, H.D., *Procurement of Drugs, Medicines, Surgical and Disposable Items, Xray files, Chemicals & Allied Items Under Rate Contract Basis During the Year*. 2019.
24. Medical Emergency Resilience Fund, *Procurement Prices.* 2019.
25. Ministry of National Health Services Regulation and Coordination, *Islamabad Capital Territory Health Infrastructure 2020-2021 PC-1.* 2020.
26. Ministry of National Health Services Regulation & Coordination, *Khyber Pakhtunkhwa Province Hospital Costing*.
27. Punjab Healthcare Commission, *Costing and pricing of services in private hospitals of Lahore.* 2018.
28. Torres-Rueda, S. and N. Kitson, *Combining evidence to design a health benefit package in Pakistan: a review and analysis of decisions at different stages of the process.* 2022.
29. Daniels, N., *Accountability for reasonableness.* BMJ (Clinical research ed.), 2000. **321**(7272): p. 1300-1301.
30. Elshaug, A.G., et al., *Challenges in Australian policy processes for disinvestment from existing, ineffective health care practices.* Aust New Zealand Health Policy, 2007. **4**: p. 23.
31. Lim, B.P., et al., *Health Technology Disinvestment in Singapore.* Ann Acad Med Singap, 2018. **47**(8): p. 338-344.
32. Mayer, J. and A. Nachtnebel, *Disinvesting from Ineffective Technologies: Lessons Learned from Current Programs.* Int J Technol Assess Health Care, 2015. **31**(6): p. 355-62.
33. Polisena, J., et al., *Disinvestment Activities and Candidates in the Health Technology Assessment Community: An Online Survey.* Int J Technol Assess Health Care, 2019. **35**(3): p. 189-194.
34. Medical Sciences for Health. *Cost Revenue Analysis Tool Plus*. 2017; Available from: https://www.msh.org/resources/cost-revenue-analysis-tool-plus.
35. World Health Organization. *One Health Tool*. 2019; Available from: https://www.who.int/choice/onehealthtool/en/.
36. Eregata, G.T., et al., *Revision of the Ethiopian Essential Health Service Package: An Explication of the Process and Methods Used.* Health Syst Reform, 2020. **6**(1): p. e1829313.
37. World Health Organization, *The UHC Compendium: Health interventions for Universal Health Coverage*. 2021.
38. Sachs, J., *Macroeconomics and Health: Investing in Health for Economic Development*, in *Report of the Commission on Macroeconomics and Health*. 2001, World Health Organization: Geneva.
39. Singh, D., et al., *Cost of scaling-up comprehensive primary health care in India: Implications for universal health coverage.* Health Policy Plan, 2021. **36**(4): p. 407-417.
40. Zeng, W., et al., *Costing essential services package provided by a non-governmental organization network in Bangladesh.* Health Policy Plan, 2017. **32**(10): p. 1375-1385.
41. Gaudin S., et al. Using costing to facilitate policy making towards Universal Health Coverage: findings and recommendations from country-level experiences. BMJ Glob Health. 2023;8(Suppl 1).
42. Fraser-Hurt N, et al. Using allocative efficiency analysis to inform health benefits package design for progressing towards Universal Health Coverage: Proof-of-concept studies in countries seeking decision support. PLoS One. 2021;16(11):e0260247.

Chapter 6: Evidence uptake in health sector-wide priority setting processes of investment and disinvestment

6.1 Prologue

While this doctoral thesis has five results chapters (Chapters 4-8), the overall results can be grouped into three distinct analytical sections. In Chapter 4, the first of these three analytical sections, I presented the economic evidence produced for the incremental disinvestment decision of cotrimoxazole preventive therapy in Uganda, which took place between 2017-18.

In 2019-20 I was again able to contribute to national-level decision-making as an analyst but this time in the context of a broader, health system-wide priority setting exercise in Pakistan, namely the health benefit package (HBP) design process. In addition to my role in evidence generation, I was also able observe and analyse the different rounds in the evidence-based deliberative process of the HBP design process.

Chapters 5 and 6 jointly make up the second of the three analytical sections which explores the HBP process in Pakistan. The research paper in Chapter 6 aims to answer the following research question: what decision criteria and intervention characteristics were prioritised by policymakers when choosing which interventions to invest in and disinvest from during the health benefit package deliberation process in Pakistan?

In Chapter 6 I describe how data, including on budget impact (as developed and explained in Chapter 5), were presented to, and used by, relevant stakeholders. I review the stages of the appraisal process and describe how the composition of the proposed HBP changed throughout. I examine which types of decision criteria and intervention characteristics were prioritised by different sets of stakeholders and reflect on some of the trade-offs made when considering investment and disinvestment decisions, particularly between current coverage and efficiency. By taking a longitudinal perspective on the priority-setting process, I was also able to reflect on some of the barriers and facilitators to disinvestment discussed in Chapter 2.

Candidate's role in the research paper

This work aims to evaluate the health benefit package design process in Pakistan. The candidate, Sergio Torres-Rueda, reviewed the existing literature on the influence of different decision criteria (e.g., cost-effectiveness, burden of disease) on health technology assessment decision-making. He designed the evaluation framework, which included making decisions on which decision criteria

appraised during the design process, as well as intervention characteristics, would be evaluated. The analysis collated a range of data sources and set them against the outcome of different stages of the process. The candidate was in charge of producing the cost dataset (see Chapter 5), which was used for one of the criteria evaluated (budget impact), as well as classifying over 150 interventions across a number of characteristics, such as whether the intervention could be defined as involving the 'rule of rescue' (which at times required getting acquainted with intervention implementation through the literature). The analysis also required keeping track of how interventions were appraised through the different stages of the process. The candidate created the outcome dataset tracing the progression of each intervention by reviewing documents prepared at each stage of the process and extracting relevant data on inclusion and exclusion. He conducted several rounds of cleaning and double-checking data sources with members of HPSIU and other partners. The candidate carried out the analysis presented in the paper, including formulating figures and tables, and drafted the manuscript. He also reviewed comments from co-authors and edited the manuscript accordingly.

Full details of contributions of other authors can be found in 'Research Paper Cover Sheet'.

6.2 Cover sheet for Research Paper 3

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT

T: +44 (0)20 7299 4646
F: +44 (0)20 7299 4656
www.lshtm.ac.uk

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed for each research paper included within a thesis.

SECTION A – Student Details

Student ID Number	1702569	**Title**	Mr.
First Name(s)	Sergio		
Surname/Family Name	Torres-Rueda		
Thesis Title	Priority Setting and Disinvestment in Healthcare: Economic Evidence, Policy Processes and Potential Consequences		
Primary Supervisor	Prof. Anna Vassall		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Choose an item.	Was the work subject to academic peer review?	Choose an item.

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	BMJ Global Health
Please list the paper's authors in the intended authorship order:	Sergio Torres-Rueda (corresponding author), Nichola Kitson, Wahaj Zulfiqar, Maarten Jansen, Wajeeha Raza, Maryam Huda, Sameen Siddiqi, Muhammed Khalid, DCP3 Country Translation Pakistan Group, Frank Sandmann, Rob

	Baltussen, Ala Alwan, Raza Zaidi, Anna Vassall
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	STR developed the concept for the paper. The data used was collected by WR, MH, MJ and STR. Data was collated by NK, WZ during HBP deliberations. Analysis in the paper was carried out by STR. Paper was drafted by STR. All authors reviewed the paper and provided feedback. AV, AA, RB, SS and RZ provided guidance.

SECTION E

Student Signature	Sergio Torres-Rueda
Date	05/04/22

Supervisor Signature	Anna Vassall
Date	05/04/22

6.3 Research Paper 3

Title

The use of decision-criteria and evidence to design a health benefit package in Pakistan: a review and analysis of prioritisation decisions at different stages of the appraisal process

Authors

Sergio Torres-Rueda*[1]

Nichola Kitson[1]

Wahaj Zulfiqar[2]

Maarten Jansen[3]

Wajeeha Raza[4]

Maryam Huda[4]

Sameen Siddiqi[4]

Muhammed Khalid [2]

DCP3 Country Translation Pakistan Group

Frank Sandmann[1]

Rob Baltussen[3]

Ala Alwan[1]

Raza Zaidi[2]

Anna Vassall[1]

*Corresponding author

Institutional Affiliations

[1]London School of Hygiene & Tropical Medicine, London, United Kingdom

[2]Health Planning, System Strengthening & Information Analysis Unit, Ministry of National Health Services Regulations & Coordination, Islamabad, Pakistan

[3]Radboud University, Nijmegen, Netherlands

[4]Aga Khan University, Karachi, Pakistan

Abstract

Introduction: Pakistan embarked on a process of health benefit package (HBP) design as a pathway towards universal health coverage culminating in the introduction of the country's essential package of health services (EPHS) in 2020. The HBP design followed an evidence-informed deliberative process; evidence on 170 possible interventions was introduced along multiple stages of the appraisal process engaging different sets of stakeholders whose task was to prioritise interventions for inclusion. As the ultimate aim was to produce an actionable HBP within realistic budget constraints, stakeholders had to restrict the final list of interventions prioritised. In this paper I describe how evidence was collated and collected during the EPHS design process. I report on the composition of the package at different stages, analyse trends of prioritised and deprioritised interventions and reflect on the trade-offs made, particularly between efficiency and disinvestment.

Methods: Quantitative evidence on cost-effectiveness, budget impact, avoidable burden of diseases, as well as qualitative evidence on feasibility, was presented to stakeholders throughout a series of stages. I recorded which interventions were prioritised and deprioritised at each stage of the appraisal process and carried out three analyses: (1) a review of total number of interventions prioritised at each stage, along with associated costs per capita and DALYs averted, to understand changes in affordability and efficiency in the package, (2) an analysis of interventions prioritised broken down by decision criteria ranking and intervention characteristics to analyse prioritisation trends across different stages, and (3) a description of the trajectory of interventions broken down by current coverage and cost-effectiveness to highlight trade-offs.

Results: At the start of the process 170 interventions were considered, with a total cost per capita of US$57.41 and averting 52.28 million DALYs. At the end of the process two packages were presented: a full EPHS that included 117 interventions at a cost per capita of US$29.70 averting 46.75 million DALYs, and an immediate implementation package with 88 interventions at a cost per capita of US$12.98 averting 40.37 million DALYs. Efficiency and affordability generally increased throughout the process, although not uniformly. Stakeholders largely prioritised interventions with low budget impact and those preventing a high burden of disease. Highly cost-effective interventions were also prioritised, but less consistently. Interventions with high current coverage were overwhelmingly prioritised for inclusion, even when they provided low value for money.

Conclusion: Evidence-informed deliberative process can produce actionable and affordable health benefit packages. While cost-effective interventions are generally preferred, an aversion to disinvest from existing interventions can limit efficiency.

Introduction

Establishing health benefit packages (HBPs) is a critical part of the pathway towards Universal Health Coverage (UHC) [1]. A large number of low- and middle-income countries (LMICs) have revised or developed new HBPs in recent years [2, 3]. The composition of some of these packages can be found in the public domain [4-6]. While approaches vary, the process often involves the review of intervention-specific evidence, across several decision criteria, by groups of stakeholders in a sequenced manner [7-9]. Pakistan embarked on a process of HBP design, producing an Essential Package of Health Services (EPHS) focused on district-level services in 2020.

In the context of large numbers of potential health interventions, as well as fixed budgets and other resource constraints, HBP design processes require prioritising certain interventions and considering trade-offs across several decision criteria (e.g., cost-effectiveness or budget impact) and intervention characteristics (e.g., delivery platform or target population). A body of evidence from high-income countries (HICs) has quantitatively explored the relative importance of decision criteria in incremental health technology assessment (HTA) outcomes, suggesting cost-effectiveness is a highly influential decision criteria [10-18], among several [11-14, 16-18]. However, little is known about the influence of specific decision criteria and intervention characteristics in broader HBP design process generally, and in LMICs specifically.

Further, different decision criteria may be influential at different stages of the appraisal process. Designing HBPs often involves stepwise deliberative approaches that engage different groups of stakeholders; packages are typically reviewed by technical experts and national and provincial actors within the health system and later approved and adopted by decisionmakers. While the importance of understanding the process outcomes is evident, analysing the trajectory of individual interventions appraised throughout the HBP design process is also key as it reveals how evidence is appraised and what decision criteria are ultimately prioritised by different types of stakeholders.

For a public sector package to be actionable, as opposed to aspirational, a final list of interventions must be specified which may entail reducing or altogether suspending the public provision of existing services. Evidence shows explicit disinvestment decisions are comparatively rare, particularly in LMICs [6]. Studies from HICs suggest disinvestment decisions are hindered by a number of barriers in policy and practice [19-26]. As a result, inefficient interventions may not be explicitly removed from HBPs, further limiting the fiscal space available to introduce more cost-effective interventions [27]. However, little is known on what factors facilitate or hinder disinvestment in LMICs.

In this paper I describe how evidence was collated and presented during the different stages in the EPHS design process in Pakistan. I report on the composition of the package at each stage in the appraisal process and analyse trends in the interventions prioritised and deprioritised by different stakeholders. The aim of this paper is to explore which decision criteria and intervention characteristics were valued as important, reflecting both on the outcomes of each appraisal stage and on how the design of the appraisal process may have influenced them. I do so through three analyses: (i) a review of the total number of interventions, costs and health outcomes (i.e., disability-adjusted life years, or 'DALYs', averted) per appraisal stage to understand HBP optimisation throughout the decision-making process, (ii) an analysis of interventions prioritised broken down by decision criteria ranking and intervention characteristics to analyse prioritisation trends across different appraisal stages, and (iii) a description of the trajectory of interventions broken down by cost-effectiveness and current coverage to highlight patterns in investment and disinvestment decisions and key trade-offs. The final packages are reported in detail in Alwan et al. (2022) [28].

Methods

In this Methods section I start by presenting the study context and background. I go on to describe the evidence-based deliberative process that took place as part of the HBP design exercise, which covers the evidence used and its assessment and appraisal. Lastly, I describe the three analyses I carried out in this paper to understand the use of evidence throughout the different stages of the HBP design process.

Study context and background

Disease Control Priorities 3 (DCP3) was used as the starting point and framework of reference for the process. DCP3 synthesises global evidence on cost and cost-effectiveness across disease areas and suggests an essential universal health coverage (EUHC) model package composed of 218 interventions [29].

The Ministry of National Health Services, Regulations & Coordination (MNHSR&C) of Pakistan carried out a scoping review, as well as consultations with provincial-level stakeholders and within the Health Planning, System Strengthening & Information Analysis Unit (HPSIU), to compare the composition of EUHC interventions to existing services in Pakistan and discuss their relevance to the Pakistani context. An initial shortlist of 170 EUHC interventions was suggested for further assessment, and inclusion in the prioritisation process.

EUHC interventions are delivered in five delivery platforms: community-level, primary healthcare-level (PHC), first-level hospitals, referral hospitals and population-level. Early in the process the MNHSR&C decided to focus on a district package of services. Consequently, nearly all population-level interventions were also excluded, as they are largely operated and implemented at the national level (one was adapted for delivery at the community level in Pakistan). Of the remaining 159 interventions, nine were broken down into multiple interventions because either the scope of the EUHC interventions were deemed to be too broad to assess, or the intervention could be delivered in multiple platforms. Consequently, a final shortlist of 170 Pakistan-adapted interventions was recommended for formal assessment and appraisal.

An evidence-informed deliberative process was used to discuss the prioritisation of these 170 Pakistan-adapted interventions with an explicit aim of defining an actionable publicly funded package within fiscal space. Eight decision criteria to assess these interventions were selected in November 2019 by the MNHSR&C and other key stakeholders: cost-effectiveness, budget impact, avoidable burden of disease, feasibility, equity, financial risk protection, and socio-economic impact. Effectiveness was also selected but not considered explicitly during the process as DCP3 EUHC

interventions are widely proven to be effective. While formal techniques such as quantitative multi-criteria decision analysis (MCDA), aim to weigh decision criteria (vis-à-vis one another) explicitly [30], the EPHS process in Pakistan employed more qualitative approaches in interpreting each intervention's performance in each criterium.

Evidence-informed deliberative processes

Evidence and assessment of criteria

Evidence on the decision criteria was collected, collated and presented as described below, and is outlined in detail in Huda et al. (2022) and Raza et al. (2022) [31, 32].

Cost-effectiveness: Data on incremental cost-effectiveness ratios (ICERs) were largely sourced from the Tufts Medical School Global Health Cost-Effectiveness Analysis (GHCEA) registry and localised, covering 88 interventions. The remaining ICERs were sourced from HIP Tool default values, which in turn were sourced from DCP3 [33]. ICER values extracted and further details on methods used can be found elsewhere [31]. The ICERs of each individual intervention were ranked from high to low and categorised evenly: the bottom third were classified as having high cost-effectiveness, the middle third medium cost-effectiveness and the top third low cost-effectiveness). Their applicability to the Pakistani setting was rated on a scale of 1 (lowest applicability) to 3 (highest applicability) [31].

Budget impact: The unit costs of DCP3 interventions considered were calculated through a normative, ingredients-based, bottom-up costing approach and used to determine budget impact. Further details can be found in Chapter 5 and elsewhere [32]. A mark-up factor of 1.6 was applied to unit costs to account for above-service delivery costs [34]. A total national cost per intervention per year was then calculated by multiplying the marked-up unit costs by the estimated population in need provided by the health management system and other health sector reporting systems. Total costs were then divided by the total population of Pakistan to calculate a cost per capita per intervention. This figure was then compared to health spending per capita and presented as a percentage of the health budget. As with ICERs, interventions were categorised evenly between those with high, medium and low budget impact.

Avoidable burden of disease: Pakistan-specific data, in the form of disability-adjusted life years (DALYs), were obtained from the Global Burden of Disease database from the Institute of Health Metrics and Evaluation (IHME) [35]. The number of DALYs averted assigned to each intervention were obtained from the HIP Tool [33].

Feasibility: The HPSIU prepared detailed descriptions of the resources used for each intervention. No scoring was done of feasibility, but it was qualitatively assessed by the technical working groups (TWGs) supporting the appraisal process. Full summary sheets are presented elsewhere [32].

Equity, financial risk protection and socio-economic impact: Criteria were not quantified as sufficient intervention-specific data were unavailable. However, during the appraisal process the Committee used a definition of equity as prioritising interventions for vulnerable groups, and highlighted where interventions reached those groups, as part of their deliberations.

Three evidence products combining the abovementioned evidence, where available, were produced: (a) intervention descriptions sheets detailing intervention-specific resource use of high-quality service provision across a number of inputs (staff level and time, medicines, diagnostics, and other supplies and equipment) [36], (b) evidence sheets containing intervention-specific data on cost-effectiveness, budget impact, avoidable burden of disease [37], and (c) presentations of package 'scenarios', which were initially produced using the HIP Tool [33] and, later, on a Microsoft Excel®-based model to allow for visual representation of multiple optimisation scenarios simultaneously.

Package scenarios examined varied four key parameters. First, to explore affordability, the EPHS under two different fiscal space scenarios was explored, reflecting approximate current health expenditure at the district level (US$ 8 per capita) and a less financially constrained scenario (US$16 per capita). Secondly, multiple payer options were explored by modelling scenarios where 80% of the costs of first-level hospital interventions were covered by the public sector and 20% by patient co-payments. Thirdly, different time horizons were considered to examine both short-term affordability of an immediately actional HBP within available fiscal space (2-year time horizon), as well as a more aspirational HBP leading to a progressive realisation of UHC over the long term (5- and 10-year time horizons). Lastly, target coverages were adjusted; while an ultimate target intervention coverage of 80% of the population in need across all interventions was modelled, several intermediate coverage targets, which varied by interventions, were also included in the optimisation models and compared to current coverage rates.

Overall, all the above evidence was prepared and presented in a manner consistent with principles of fair policymaking, such as those established in the accountability for reasonableness (A4R) framework [38]: evidence was presented in a transparent manner, across criteria relevant to the local decision problem, and in manner that could be used for eventual revision processes.

See Table 1 for a summary of the three evidence products, including criteria addressed and stages of the appraisal process where used.

Appraisal of evidence process

The appraisal process has been described in detail by Baltussen et al. (2022) and Alwan et al. (2022) [28, 37] and is summarised below and in Figure 1.

Following an initial (i) shortlisting from DCP3 EUHC interventions, described above, evidence was reviewed and appraised by different stakeholders, in a sequential process. At each stage of the appraisal process, a recommendation on whether to prioritise or deprioritise an intervention was agreed upon and documented. Recommendations at each stage were non-binding; a recommendation to prioritise or deprioritise an intervention at one stage could be reversed at a subsequent stage.

For appraisal purposes, intervention platforms were grouped in two categories: community-based and PHC interventions, and first-level hospital and referral hospital interventions. An initial (ii) TWG review of community-based and PHC interventions (henceforth TWG1) was carried out by technical experts who prioritised interventions into three categories (high-priority, medium priority or not prioritised), followed by a (iii) National Advisory Council (NAC) meeting (henceforth NAC1), where stakeholders reviewed the recommendations from the TWG and proposed a list of prioritised interventions.

A (iv) second TWG reviewed evidence on first-line hospital and referral-hospital interventions (henceforth TWG2) following the same processes as TWG1. Then, a (v) second NAC (henceforth NAC2) meeting was convened with a broader remit: reviewing both the recommendations from NAC1 and the list of prioritised interventions from TWG2, hence covering interventions in all four platforms.

Two key distinctions about NAC2 merit highlighting. Firstly, for the first time in the process, stakeholders had to simultaneously consider interventions across all platforms in the health system within a given fiscal. As outlined above, several scenarios, including those which were budget constrained were introduced to crystalise trade-offs. Stakeholders were presented with scenarios prioritising all high priority interventions (P1) and high and medium priority interventions (P2) (as defined by the TWGs), as well as six implementation scenarios, highlighting different fiscal space constraints, time horizons, co-payments, and coverage rates (IS1-IS6). See Appendices 6.1 and 6.2 containing visual representations of the eight modelled scenarios. Further, a key decision around the objective of the process, which emerged during NAC2, was to proceed with the design of two health benefit packages, reflecting different time horizons and fiscal space challenges: a reduced immediate

implementation packaged (IIP) to be rolled out over 2 years, and the full EPHS, to be implemented in stepwise manner over the following decade as health budgets expand.

Following the NAC2, the two recommended packages were reviewed by (vi) the International Advisory Group (IAG) and, lastly, reviewed and approved by (vii) the UHC EPHS Steering Committee (SC).

Analysis of costs, outcomes and prioritised criteria during the process

I trace the trajectory of interventions prioritised throughout the process and carry out three types of analyses to understand, respectively: the general composition of prioritised interventions, the decision criteria and intervention characteristics prioritised at different stages, and the trade-offs made between maintaining current coverage and foregone package efficiency at each stage. For each of the three analyses, I present two set of results to account for both the process leading to the full EPHS and the IIP. For analytical purposes I do not include the results of NAC1, and instead focus only on NAC2, as the latter considered the entire package and prioritisation among all 170 interventions. I also present the outcomes of TWG1 and TWG2 in a combined manner (henceforth 'combined TWG').

It is important to note that the definition of a 'prioritised intervention' varies between appraisal stages and reflects the aim of each stage. Stakeholders in the initial shortlisting from DCP3 EUHC were asked to remove interventions not relevant to Pakistan and those in the TWGs were asked to group interventions by levels of priority. While the aim of these stages was not to propose a full implementable package (contrary to the NAC2, the IAG and the SC), I include all five stages in the analysis to examine broad patterns in how different stakeholders prioritise and deprioritise interventions over time.

The first analysis is (i) an overall review of the total number of interventions prioritised in each stage of the appraisal process, along with the associated total costs per capita and total DALYs averted of prioritised interventions, as well as a calculation of total DALYs averted per dollar per capita spent. To carry out this analysis I reviewed records compiled at each stage of the decision-making process (e.g., logs detailing decisions on each intervention) in order to co-produce a Microsoft Excel®-based dataset on interventions included and excluded. I then combined that dataset with data I produced on budget impact (as described in Chapter 5) as well as data produced by colleagues in the HBP design process on effectiveness (i.e., DALYs averted per intervention).

The second analysis (ii) traces the trajectory of prioritised interventions grouped by decision criteria and intervention characteristics. To decide which criteria and characteristics to include in the

analysis, I reviewed the peer-reviewed literature on factors influencing priority setting decisions (as presented in the Introduction), as well as other key intervention characteristics. I arrived at ten decision criteria and characteristics that were (a) highlighted in the literature, (b) present in the decision-making process in Pakistan, and (c) measurable in the context of our study. Firstly, I grouped interventions together by how they fared on three decision criteria as per evidence presented during the appraisal ((1) cost-effectiveness, (2) budget impact, (3) burden of preventable disease) as well as on (4) quality of available evidence on cost-effectiveness (ICER quality), and (5) current coverage, defined as an estimated percentage of the target population receiving the intervention at the time of the HBP design process. I also grouped interventions by their stated delivery characteristics: (6) delivery platform, (7) intervention cluster, and (8) intervention purpose, and also if they could be defined as (9) addressing the health needs of a vulnerable population (here defined as involving reproductive, maternal, neonatal and child health, as agreed by the NAC due to equity implications), or where (10) the 'rule of rescue' (defined as the imperative to rescue identifiable individuals facing avoidable death) [39]) was expected to apply.

I compiled a Microsoft Excel®-based dataset which listed how each intervention scored (or was categorised) in each decision criteria or intervention characteristic. I sourced information on (1) cost-effectiveness, (3) burden of preventable disease and (4) ICER quality from databases produced by colleagues (with my assistance), which I verified using the Tufts Medical School Global Health Cost-Effectiveness Analysis (GHCEA) registry [33], the Global Burden of Disease database from IHME [35] and the HIP Tool [33]. As described in Chapter 2, I carried out the analysis to arrive at (2) budget impact of each intervention. I obtained data on (5) current coverage by intervention for 2019 from the health management system and other reporting systems in the MNHSR&C. I assembled and reviewed the data and categorised coverage by level. I also extracted data on stated delivery characteristics (i.e., (6) delivery platform, (7) intervention cluster and (9) whether the intervention covered vulnerable populations) from the DCP3 EUHC literature [29]. Lastly, I had to review the intervention descriptions and aims of all interventions to be able to determine their (8) purpose (e.g., curative, preventive, etc) as well as whether the (10) 'rule of rescue' applied. This dataset was combined with the dataset assembled for analysis (i), which tracked which interventions were included and excluded at which stage, in order to understand which interventions, exhibiting particular decision criteria scores, or characteristics, were prioritised at different points of the process.

The third analysis describes the trajectory of interventions broken down by current coverage combined with cost-effectiveness. I categorised data on current intervention coverage into four

categories: high, medium, low and no coverage. Intervention cost-effectiveness was categorised as high, medium, and low cost-effectiveness and no cost-effectiveness evidence. I combined the two criteria to create sixteen joint indicators to describe each intervention (e.g., high coverage + high cost-effectiveness; high coverage + medium cost-effectiveness, etc). I then combined this dataset with data used for (i) in Microsoft Excel® to understand which types of interventions were included and excluded vis-à-vis their cost-effectiveness and coverage, simultaneously.

Appendix 6.3 contains a review of decision criteria and intervention characteristics analysed. Appendices 6.4 and 6.5 contains the categories used for each intervention and Appendix 6.6 has specific current coverage rates. Appendix 6.7 contains information on intervention inclusion and exclusion at each stage.

Results

Figure 1 shows the number of interventions prioritised at each stage of the appraisal process, concluding in two final packages: the full EPHS, composed of 117 interventions, and an IIP with 88 interventions. Details on the interventions included in the two final packages are presented in full in Alwan et al. (2022) [28].

Size, costs and effects at different stages of the appraisal process

Figure 3 shows how the total costs per capita and DALYs averted of the prioritised set of interventions changed throughout the different steps of the appraisal process. Following the initial assessment for relevance to the Pakistani context, 170 interventions were prioritised with a cost per capita of US$57.41, which was expected to avert 52.28 million DALYs. After the TWG meetings, 129 interventions were considered high priority, at a cost of US$48.97 per capita and which would avert 48.92 million DALYs. At NAC2, a full EPHS was proposed, composed of 117 interventions at US$29.70 per capita and averting 46.74 million DALYs. This package was supported by the IAG and endorsed by the SC. A subset of interventions from the EPHS were then selected to make up the IIP, composed of 76 interventions, at US$10.20 and averting 44.01 million DALYs. The IAG reviewed the proposed IIP, increasing the number of interventions to 81, at a cost of US$13.07 per capita and averting 44.20 million DALYs. Finally, the SC revised the IIP, increasing it in size to 88 interventions at a cost of US$12.97 per capita and averting 40.37 million DALYs, and endorsed it.

The efficiency of the package evolved throughout the process. The first two stages, the DCP3 shortlisting and TWGs, yielded the least efficient set of prioritised interventions, averting 0.91 million and 1.00 million DALYs per dollar per capita spent, respectively. However, it is important to highlight that the aim of these two appraisal stages was not to prioritise within a budget constraint. The most efficient packages were those proposed for the IIP in NAC2 and IAG, which were projected to avert 4.31 and 3.38 million DALYs per dollar per capita spent, respectively, which is higher than the efficiency of the full EPHS and the final IIP, which are expected to avert 1.57 and 3.11 million DALYs per dollar per capita spent, respectively.

Figure 2 shows the trajectory of interventions in the IIP design process. The initial iteration of the IIP during NAC2 contains 76 interventions, a subset of the 117 interventions from full EPHS in NAC2. The IIP iteration from the IAG retains the 76 interventions from the NAC2 IIP and adds 5 interventions excluded from the NAC2 full EPHS, for a total of 81 intervention. At the last IIP appraisal stages, the SC eliminates 14 out of 81 interventions from the previous iteration of the package and adds 21 from the NAC2 full EPHS. As a result, the eventual IIP has 88 interventions.

Composition of the package throughout the appraisal process

Figure 3 breaks down aggregated interventions included in the package by the decision criteria and intervention characteristics prioritised throughout the different stages of the appraisal process.

The share of interventions classified as highly cost-effective increased moderately in the initial part of the process: between 28% in the DCP3 shortlisting phase to 34% in the full EPHS. However, highly cost-effective interventions made up a substantially higher share of interventions in the IIP, up to 54% of the package in the first iteration of the IIP at the NAC2, then decreasing to 39% once the SC approved the final package. The share of interventions classified as having low budget impact remained constant (60%-63%) between the first stage and the full EPHS. They increased in the IIP, making up 74% of the IIP at the NAC2 and decreasing to 68% in the final iteration approved by the SC. Interventions preventing a high burden of disease made up the largest share of the package in all stages: from 35% in the initial shortlisting to 41% in the final EPHS. The share was highest in the first iteration of the IIP in NAC2 (47%) and dropped to 42% by the final package approved at the SC.

The proportion of interventions with low ICER quality made up more than half of interventions in all stages of the appraisal process, except in the first and second stages of appraisal around the IIP (NAC2 and IAG, where the figure dropped to 46% and 47%, respectively). Interventions with high current coverage increased from 20% in the shortlist stage to 29% in the final EPHS and further to 32% in the IIP.

The share of primary health care interventions increased throughout the process, from making up 29% of the initial shortlist to 38% in the final EPHS and increasing to 42% in the final IIP. Interventions based at referral hospitals made up 11% of prioritised interventions at the start of the process but were removed at NAC2 as the emphasis was on designing a district-level package of services. The proportion of interventions in the reproductive, maternal, neonatal and child health (RMNCH) cluster also increased steadily: from 31% in the initial shortlisting to 40% and 41% in the final EPHS package and IIP, respectively.

The proportion of interventions aimed at vulnerable populations increased steadily throughout the process: from 35% in the initial shortlisting, to 43% in the final EPHS and 48% in the final IIP. The proportion of interventions involving the rule of rescue remained between 26%-35% throughout the process, reaching the highest level during IAG appraisal of the IIP. Curative and preventive interventions made up the majority of prioritised interventions and their share remained steady through the process: 69%-74% and 17%-20%, respectively. Only 4% of shortlisted interventions were classified as rehabilitative or palliative; all were eliminated during the IIP appraisal stages.

Distribution of interventions by current coverage and cost-effectiveness

Figure 4 shows the distribution of interventions broken down by cost-effectiveness and current coverage, divided between stages leading to (a) full EPHS and (b) the final IIP. In both stages, nearly all interventions with high coverage were included in the package, regardless of cost-effectiveness; (34/34) for the full EPHS and (29/34) for the final IIP, including 8/8 interventions with low cost-effectiveness in the full EPHS and 5/8 in the final IIP. In the final EPHS, 31/46 interventions with medium coverage and 52/80 with low coverage were included in the package. The figure was 22/46 and 50/80, respectively for the final IIP. About two-thirds (8/11) of highly cost-effective interventions with medium coverage and half (9/17) of those with low coverage were included in the final IIP. The figure was higher in the full EPHS: 9/11 and 13/17, respectively. Over one-third of interventions with low coverage were excluded (28/80 in the full EPHS and 30/80 in the IIP), regardless of cost-effectiveness. None of the interventions without current coverage were included in either the full EPHS or the IIP.

Discussion

I have analysed the composition of the interventions included in the health benefit package in Pakistan throughout five stages in the appraisal process. To my knowledge, this is the first study of its kind in either HIC or LMIC settings.

I found that the evidence-informed deliberation process improved affordability and efficiency as the appraisal process progressed. The process started from an initial list of 170 interventions at a cost per capita of US$57.41 and ended with two packages: an EPHS that included 117 interventions at a cost per capita of US$29.70, and an immediate implementation package with 88 interventions at a cost per capita of US$12.98. I found that cost-effectiveness was not always prioritised by stakeholders. The final EPHS and IIP were more efficient than the initial list of prioritised interventions (1.57, 3.11 and 0.91 million DALYs per dollar per capita spent, respectively). However, intermediate iterations of the package, particularly the IIP proposed at NAC2 and IAG, were more efficient than the final packages, averting 4.31 and 3.38 million DALYs per dollar per capita spent, respectively.

In respect to achieving the goal of efficiency in the package, our findings suggest that evidence uptake worked most effectively during the NAC2 IIP and IAG IIP appraisal stages. During the NAC2 IIP stage the share of highly cost-effective interventions prioritised was the highest in the process (53%), as was the share of interventions with low budget impact (75%) and share of interventions preventing a high burden of disease (47%). The lowest share of interventions whose cost-effectiveness evidence was considered of low quality was observed in the IAG IIP (46%), followed by NAC2 IIP (47%).

However, it is important to note that the NAC and IAG were composed of primarily technical stakeholders whose task was to propose an efficient, affordable, and equitable package of health benefits. In comparison, the mandate of the SC was to consider fully whether the final packages were political acceptable to policymakers, and, importantly, to the constituents who elect them. Important changes were made by the SC at the final stage of the IIP appraisal process; 24% of interventions in the final IIP package are not included in the immediately prior iteration of the IIP (IAG). These changes made the final IIP comparatively less efficient, but potentially more politically viable and, importantly, implementable within the two-year time frame specified. Further, other important decision criteria in priority setting, such as equity and financial risk protection were not quantified. Informal knowledge and deliberation of these criteria may have played a role in the different stages, including in the final stages of the appraisal process.

The TWGs were provided with intervention-specific evidence on budget impact and cost-effectiveness, but not a budget constraint for each cluster or disease area. They produced a list of high priority interventions which, in the aggregate, would have been unaffordable. Substantial reductions in the size and cost of the package were only achieved at the NAC stages, once an explicit budget envelope was stipulated and stakeholders forcibly began to engage with the more difficult trade-offs of the process. However, the TWG process played a role in defining the scope of the key package scenarios considered at the NAC stages. This initial broad prioritisation of interventions with clinical experts, who understand real-world service delivery well, was an essential part of eventually arriving at packages that are not only efficient and affordable, but also feasible, and altered the mix of interventions finally selected. It is also possible that, as clinical experts, TWG members have closer proximity to the patient and may have been more averse to recommend discontinuation of specific interventions; clinician's aversion to the withdrawal of existing services is well documented in other settings [19, 20, 24, 26, 40].

Evidence from priority setting and health technology assessment from HICs have found that cost-effectiveness is the key predictor of the decision to adopt a new intervention [10-12, 14-18, 41]. In all cases this evidence comes from incremental priority setting, rather than whole sector package revision. Other factors also appear to predict adoption (albeit to a lesser degree), including burden of disease [12, 17, 18], the availability of alternative interventions targeting the same disease [41], the quality, volume and recency of evidence available [11, 14, 16], the level of uncertainty of the evidence [17] and affordability [18]. It is challenging to directly compare our findings with these results from HICs; in my analysis I do not compare the relative importance of different criteria in one stage of the process but rather explore the importance of a criterion across appraisal stages.

However, our findings suggest both similarities and differences. Stakeholders appeared to favour highly cost-effective interventions, but not uniformly, with highly cost-effective interventions making up between 28% and 53% of the IIP at different stages and improving when budget constraints were introduced. Stakeholders appeared to consistently favour interventions with low budget impact and those which prevented a high burden of disease (making up 35%-47% and 60%-75% of the IIP at different stages, respectively) and increasingly favoured interventions delivered through primary health care and those addressing health needs of vulnerable populations, as the process progressed.

Barriers to disinvestment in healthcare are well documented. The evidence points towards both political barriers [22, 24, 40, 42] as well as barriers related to the unavailability of structured decision-making processes, the difficulty to identify potential candidates for disinvestment, and the lack of relevant evidence with which to make informed decisions [19-23]. However, the EPHS design

process, using the DCP3 framework, provided a formal process, a list of candidate interventions and relevant evidence yet disinvestment from comparatively less cost-effective interventions was not achieved. The reasons for this are not clear. It is possible that adequate processes and evidence may be necessary but not sufficient conditions for disinvestment to take place in practice and that the trade-offs observed between current intervention coverage and value for money made by the NAC and SC point towards political barriers to disinvestment.

However, it is also possible that concerns about feasibility played a role in stakeholders' reticence to disinvest. Stakeholders appeared to prioritise interventions with high current coverage rather than those representing comparatively better value for money. For example, all interventions with high levels of current coverage (34/34) were included in the full EPHS as well as a substantial majority (29/34) of those in the final IIP, including many with comparative low cost-effectiveness. This pattern could, on the one hand, suggest an aversion to disinvestment at the expense of efficiency; in other words, averting fewer DALYs appears to have been preferred over the withdrawal of existing services. However, it could also reveal legitimate concerns about feasibility and a certain degree of risk aversion. Interventions with high current coverage have already proven to be feasible at scale, those with low or no coverage have not. It remains hard to disentangle whether the primary consideration in these cases is an aversion to disinvestment or concerns about intervention feasibility.

The aim of the EPHS design process in Pakistan was to arrive at an actionable HBP. This requires linking decisions to investment plans and financing systems and providing operational guidance on how existing expenditures can be allocated within the available fiscal space [43]. As a result, the evidence-informed deliberation process was framed largely around considerations of cost- and cost-effectiveness. The use of scenarios in the latter appraisal stages highlighted the real trade-offs faced at a health system level, forcing stakeholders to confront the value for money of interventions prioritised and deprioritised. However, it remains unclear whether the relative importance of cost-effectiveness seen here is an artifact of how the process was framed or whether it reflects the values by policymakers involved in health in priority setting.

The relative importance of decision criteria and intervention characteristics in the HBP design processes and appraisal is largely understudied, particularly in LMICs. Stakeholders, and members of society as a whole, have different interests and as such may reasonably have differing views on which values should guide priority setting [30]. It is then not surprising that the decisions made by different sets of stakeholders in the process in Pakistan reflect different priorities, such as feasibility, technical efficiency and political acceptability. While formal techniques such as MCDA aim to weigh

decision criteria explicitly and quantitatively, it is not clear whether more qualitative methods, such as the ones in employed in Pakistan, result in health benefit packages that more accurately reflect the values of the population (vis-à-vis those of stakeholders). I encourage others to carry out studies such as ours through the HBP design process in other LMIC settings and to further reflect on how both the framing of the process and involvement of different stakeholders in different parts of the process influence the decision criteria prioritised and, ultimately, the shape of the package.

This study has several limitations. I was not able to analyse the complete process as I did not have all the assessment criteria for all 218 DCP3 EUHC package interventions, given the initial scoping reduced the assessment to 159 of those interventions (170 including the split interventions). While I was able to examine some of the potential drivers of decision-making, such as cost-effectiveness or budget impact, other drivers, such as feasibility could not be quantitatively included in our analysis. Future analyses should consider a broader set of drivers of adoption and methodological work should be developed to facilitate their assessment. Further, as I summarise the results along different stages of the process, it should be noted that our cost and cost-effectiveness data have limitations [31, 32], including that values used are point estimates and do not contain information on the range of uncertainty around the parameter means. Data on current coverage was compiled by members of HPSIU and only available during the latter stages of the appraisal; however, broad estimates of coverage were also included in a mapping exercise available to stakeholders prior to the appraisal [44]. Lastly, our analysis does not statistically ascertain the correlation between specific decision criteria and the decision outcome, due to the overlap between the different criteria and other confounding factors.

Conclusion

I summarise the process used to collate and present evidence during the health benefit package design process in Pakistan. Evidence was arranged into evidence products which stakeholders used to prioritise and deprioritise interventions during different stages of the process. The composition of the package changed at different stages; efficiency and affordability generally increased throughout the process, although not uniformly. The share of primary health care interventions increased throughout as did the proportion of interventions in the reproductive, maternal, neonatal and child health cluster. Curative and preventive interventions made up the majority of prioritised interventions and their share remained steady through the process. Overall, by involving different types of stakeholders in the process, a range of criteria and values were considered such as efficiency, feasibility and acceptability.

Technical stakeholders, involved in intermediate stages of the process, tended to prioritise interventions with higher cost-effectiveness, as well as those with low budget impact; the package was most efficient during those intermediate stages. The final iterations of the package were comparatively less efficient. Almost a quarter of interventions were replaced at the last stage and, notably, interventions with high current coverage appeared to be prioritised for inclusion, even when they provided low value for money. The reasons for this are unclear. While this trade-off may point towards an aversion to disinvest, it may also signal concerns about feasibility and risk; interventions that have high current coverage, for better or for worse efficiency-wise, have proven themselves feasible and acceptable. Further research in this area should attempt to systematically and quantitatively ascertain the relationship between a greater rage of decision criteria and the likelihood of inclusion in a health benefit package.

Tables and Figures

Table 1: Evidence Products. Types of evidence included and stage of the appraisal process used.

		EVIDENCE PRODUCTS		
		EVIDENCE SHEETS	**INTERVENTION DESCRIPTION SHEETS**	**OPTMISATION MODELS**
EVIDENCE TYPE COLLECTED OR COLLATED	**Cost-effectiveness**	ICERs were ranked and categorised into low, medium and high cost-effectiveness, or no cost-effectiveness evidence. ICER applicability to Pakistan was assessed on a scale of 1 (lowest) to 3 (highest).	Intervention descriptions sheets were used to describe service delivery and to consequently compare with interventions found in the global cost-effectiveness literature in order to select relevant ICERs.	Selected ICERs were used in the HIP Tool-based and Microsoft Excel®-based optimisation models.
	Budget impact	Costs per capita were presented as an absolute figure and percentage of total health spending per capita. Budget impact was categorised as low, medium and high.	Intervention descriptions sheets were used to understand resource use and consequently to calculate unit costs per intervention.	Unit costs were used in HIP Tool-based optimisation models. Costs per capita were used in Microsoft Excel®-based optimisation models.
	Avoidable burden of disease	Avoidable burden of disease was presented was categorised as low, medium and high.	N/A	DALYs averted per intervention were included in the HIP Tool-based and Microsoft Excel®-based optimisation models.
	Feasibility	No data were collated/collected but the criterion was listed in evidence sheet to elicit expert opinions during deliberations.	Resource use was described across a number of inputs (staff level and time, medicines, diagnostics, supplies and equipment).	N/A
	Equity	No data were collated/collected but the criterion was listed in evidence sheet to elicit expert opinions during deliberations.	N/A	N/A
	Financial risk protection	No data were collated/collected but the criterion was listed in evidence sheet to elicit expert opinions during deliberations.	N/A	N/A
	Socio-economic impact	No data were collated/collected but the criterion was listed in evidence sheet to elicit expert opinions during deliberations.	N/A	N/A
	Fiscal space	No data were collated/collected but the criterion was listed in evidence sheet to elicit expert opinions during deliberations.	N/A	Assumptions included in the Microsoft Excel®-based optimisation models.
	Co-payments	N/A	N/A	Assumptions included in the Microsoft Excel®-based optimisation models.
	Time horizon	N/A	N/A	Assumptions included in the HIP Tool-based and Microsoft Excel®-based optimisation models.
	Coverage	N/A	N/A	Data on coverage were used in the HIP Tool-based and Microsoft Excel®-based optimisation models.
APPRAISAL PROCESS STAGE WHERE EVIDENCE PRODUCT WAS USED		TWG1, NAC1, TWG2, NAC2, IAG, SC	TWG1, NAC1, TWG2, NAC2, IAG, SC	NAC1, NAC2, IAG, SC

Figure 1: Timeline of appraisal process and number of interventions prioritised by stage. Stages marked with an 'X' indicate the aim of prioritising interventions within a specified budget constraint. Except for the DCP3 EUHC stage, number of interventions cited refers to Pakistan-adapted interventions.

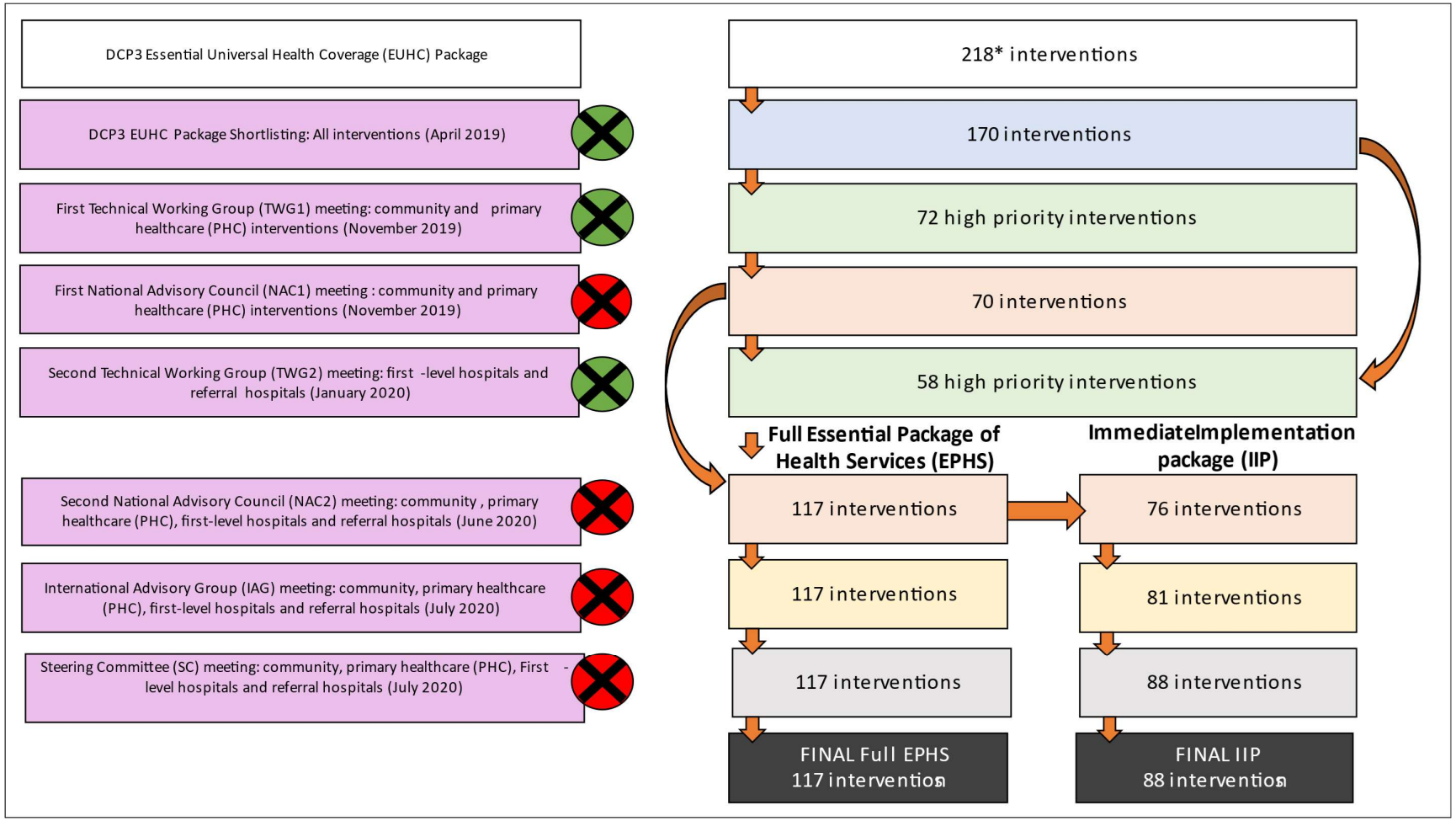
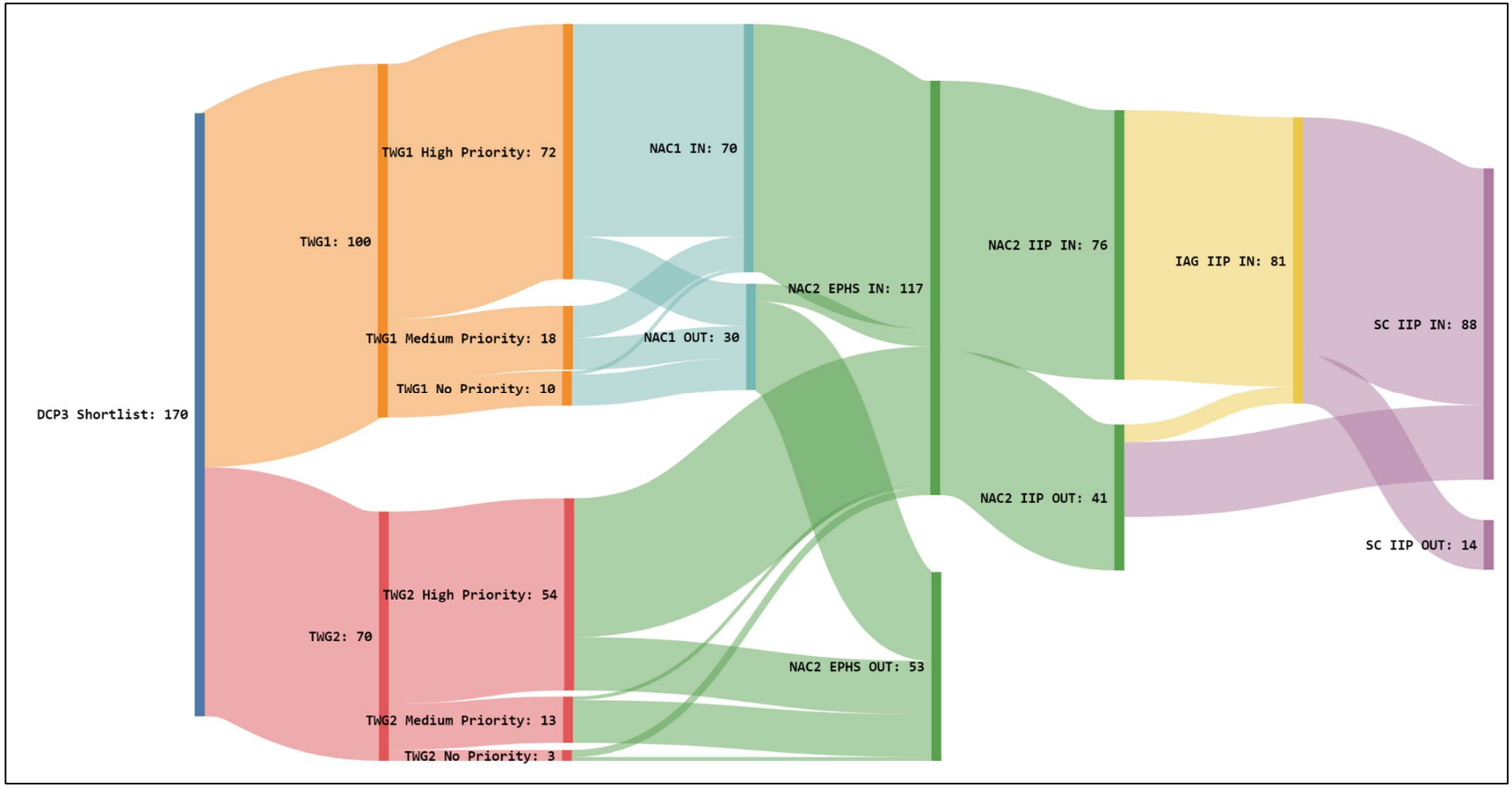
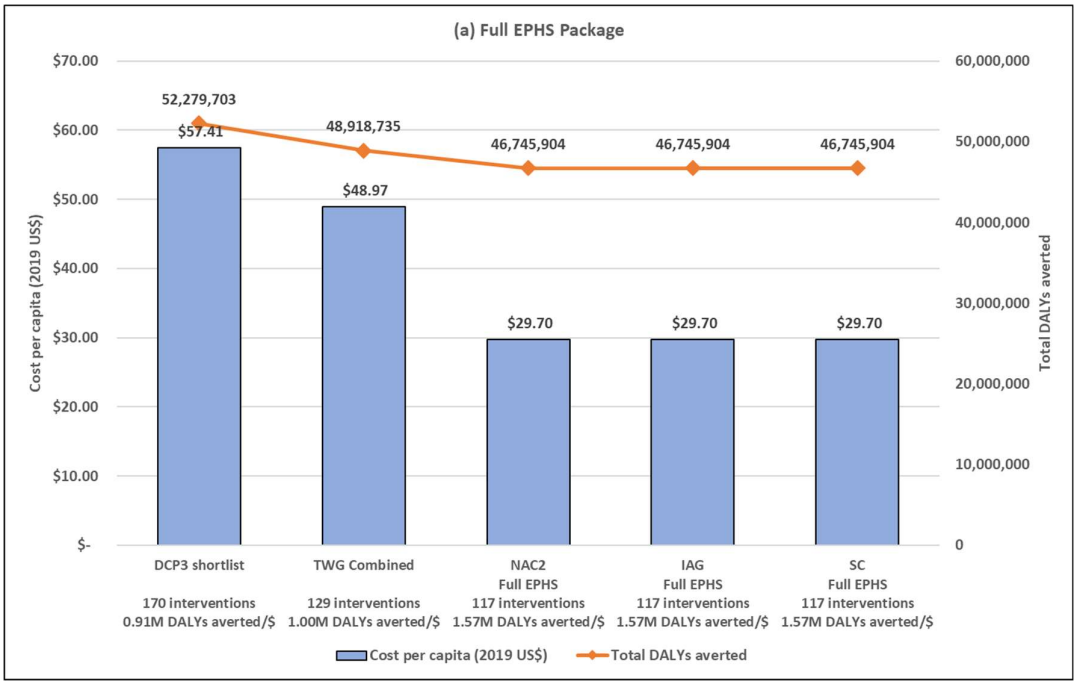


Figure 2: Trajectory of interventions throughout the stages of the IIP appraisal process



Note: The number of interventions labelled as high priority in TWG2 differ between Figures 1 and 2 because four interventions that were initially assessed in TWG1 were reassessed in TWG2 (and chosen as high priority). For illustrative purposes, these 4 interventions are accounted for in TWG1 but not in TWG2.

Figure 3: Costs per capita, DALYs averted and millions of DALYs averted per US$ dollar spent by stage in the deliberation process for (a) full EPHS package and (b) immediate implementation package



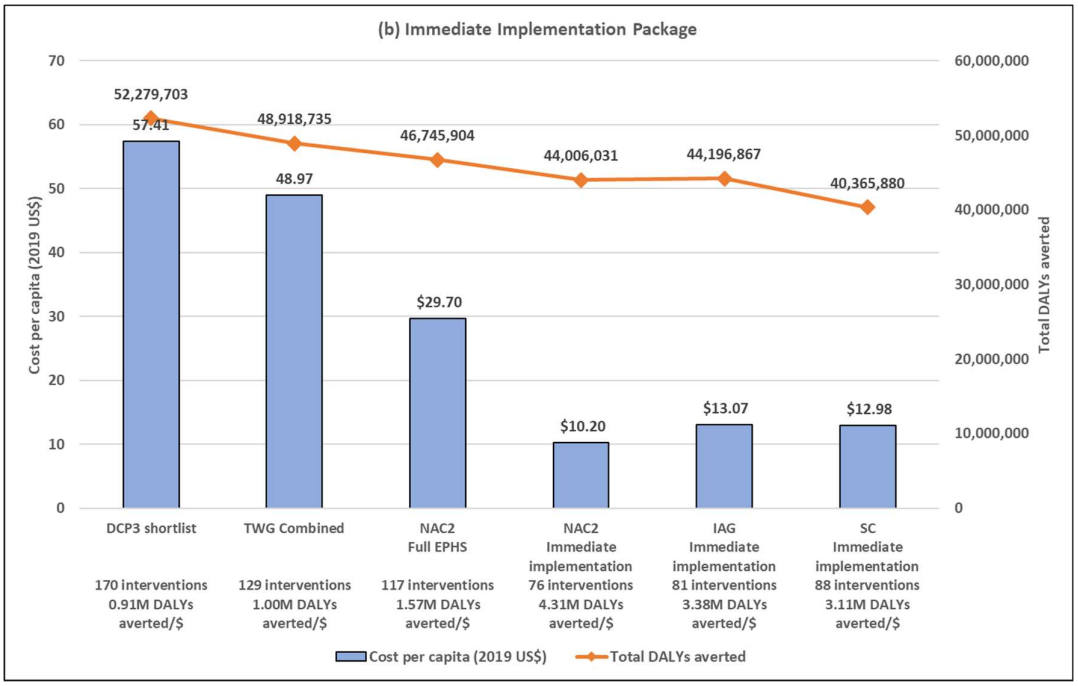


Figure 4 (a): Pathway to full EPHS package: Distribution of included interventions by stage in the appraisal process broken down by (1) cost-effectiveness, (2) budget impact, (3) burden of disease, (4) ICER quality, (5) current coverage), (6) platform, (7) cluster, (8) vulnerable populations, (9) rule of rescue, and (10) intervention purpose

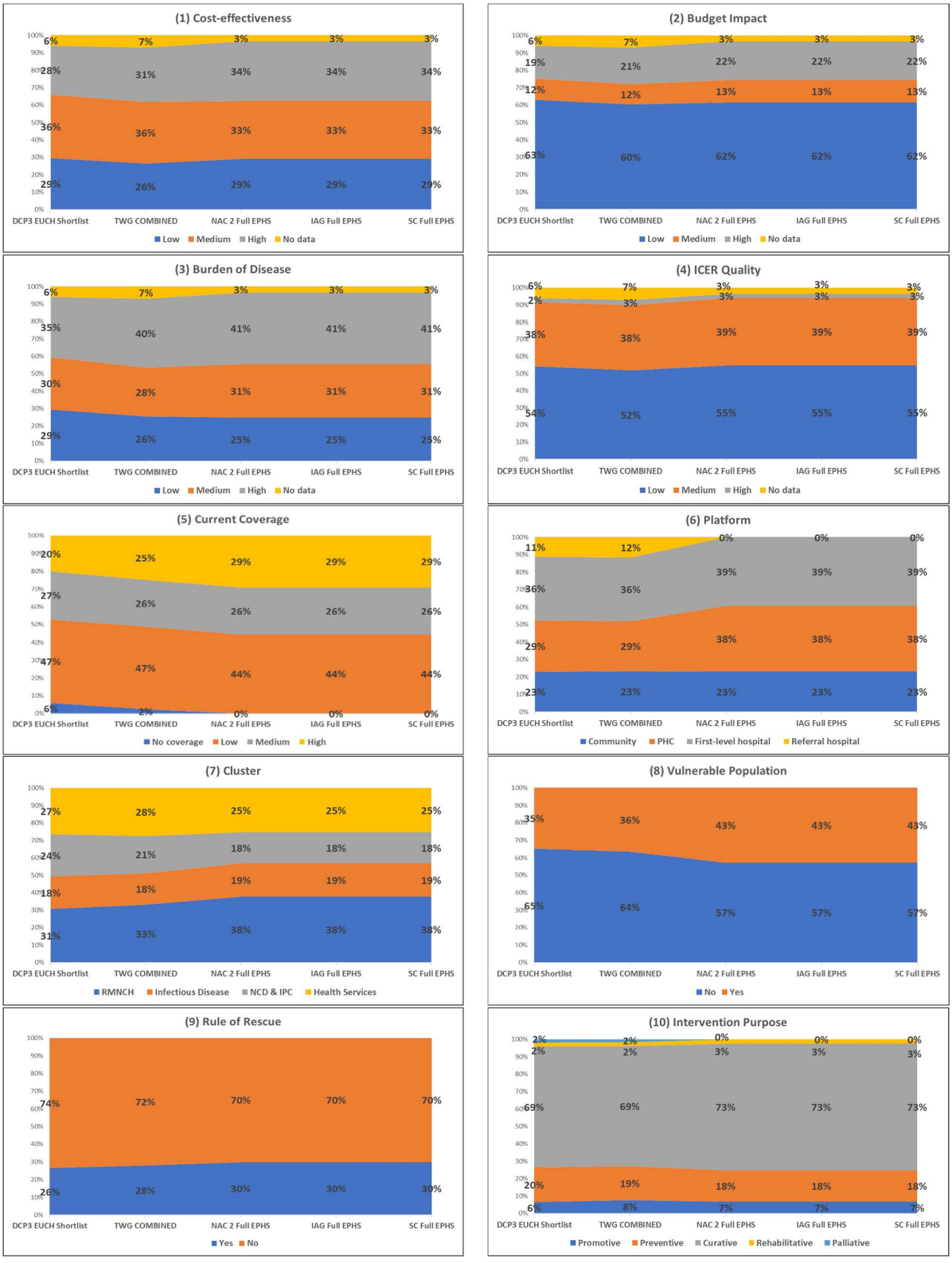


Figure 4 (b): Pathway to immediate implementation package: Distribution of included interventions by stage in the appraisal process broken down by (1) cost-effectiveness, (2) budget impact, (3) burden of disease, (4) ICER quality, (5) current coverage), (6) platform, (7) cluster, (8) vulnerable populations, (9) rule of rescue, and (10) intervention purpose

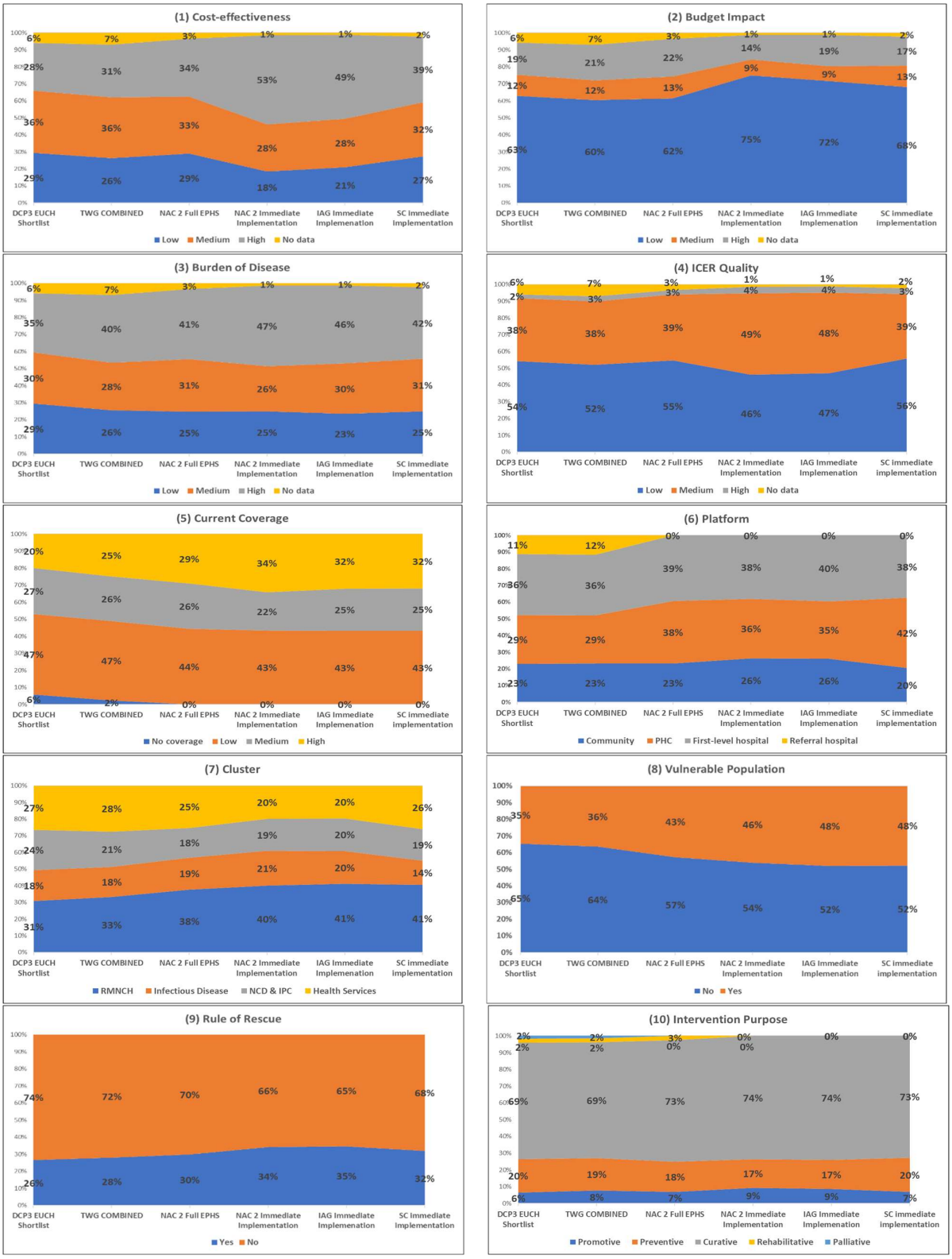
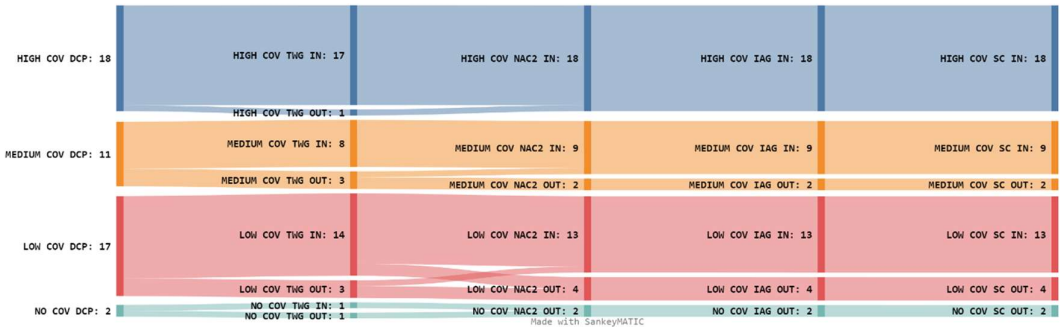
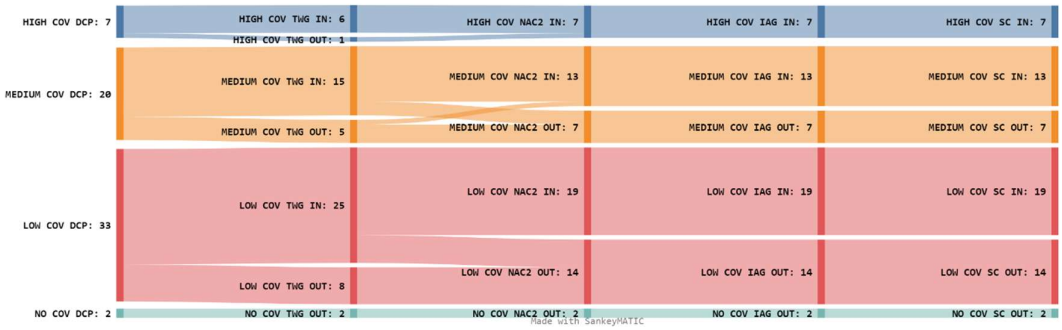


Figure 5 (a): Distribution of interventions throughout the process by current coverage and cost-effectiveness for the full EPHS

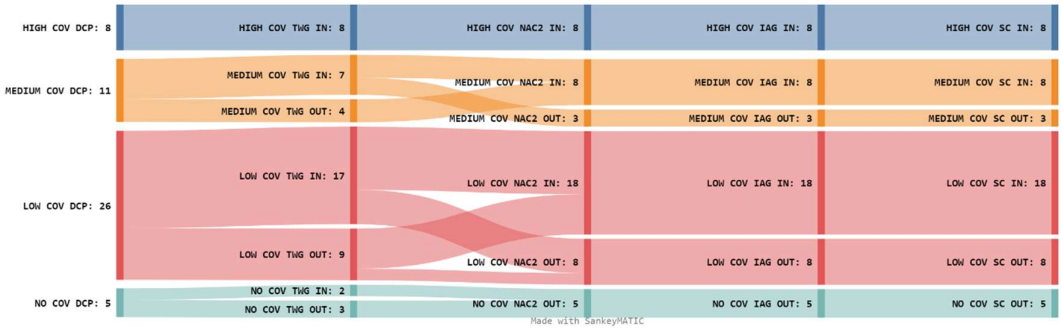
(i) Interventions with high cost-effectiveness



(ii) Interventions with medium cost-effectiveness



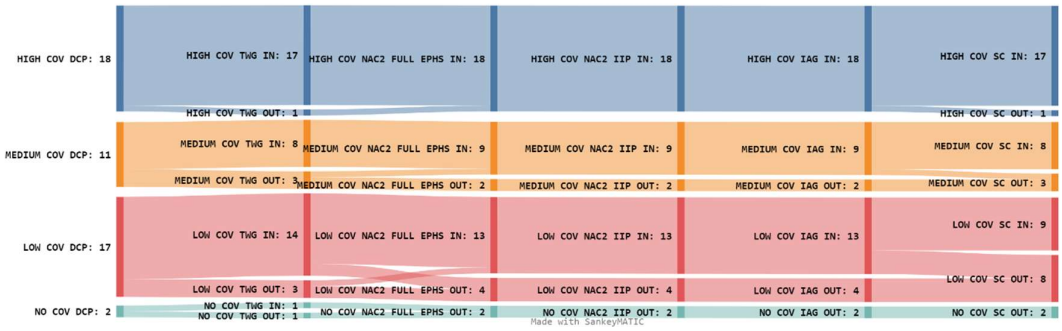
(iii) Interventions with low cost-effectiveness



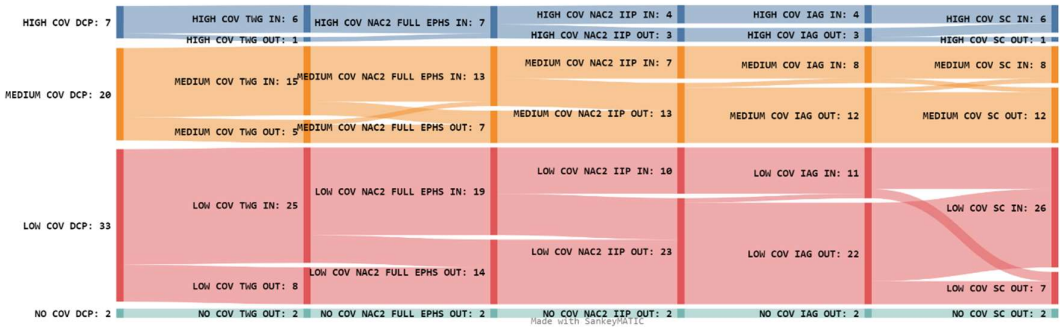
(iv) Interventions with no cost-effectiveness evidence

Figure 5 (b): Distribution of interventions throughout the process by current coverage and cost-effectiveness for the IIP

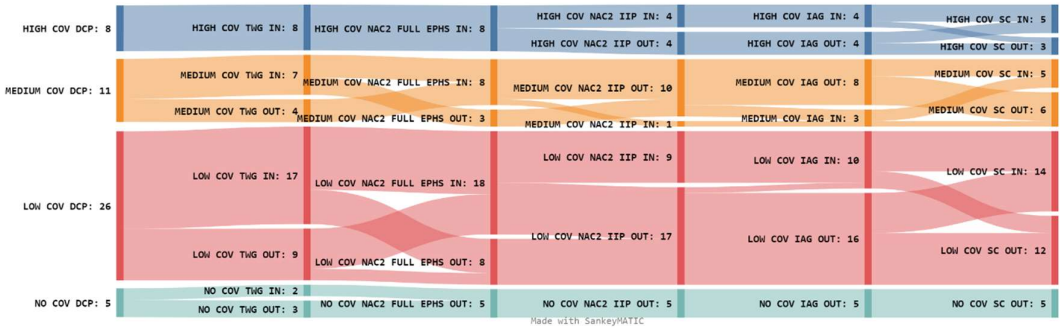
(i) Interventions with high cost-effectiveness



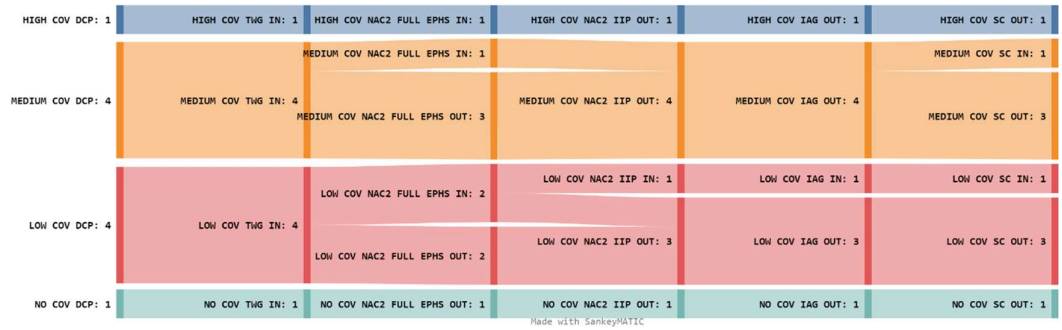
(ii) Interventions with medium cost-effectiveness



(iii) Interventions with low cost-effectiveness



(iv) Interventions with no cost-effectiveness evidence



6.4 Epilogue

In Chapter 4 I presented the evidence and outcome of an incremental disinvestment decision. In Chapter 6 (building on work from Chapter 5), I broadened the scope and examined the uptake of evidence during a health system wide HBP design process in Pakistan, which included decisions on investment and disinvestment. This study is the first of its kind. While there is a body of literature on the types of decision criteria and intervention characteristics that are prioritised, to my knowledge all of it comes from high-income settings and is focused entirely on incremental decision-making. This paper examines the decision criteria and intervention characteristics prioritised in a systems-wide priority setting process in a low- and middle-income setting.

I found that the evidence-based deliberative process was successfully used to narrow down a list of 170 interventions to 88 which were implementable within the immediately available budget envelope. However, it must be noted that the final iteration of the package is moderately less efficient than intermediate iterations. Cost-effectiveness was prioritised but not uniformly; technical stakeholders in intermediate stages tended to favour package efficiency more so than stakeholders tasked with producing a final, politically acceptable package. Interventions with high coverage rates were rarely deprioritised, even if they produced little value for money. It is difficult to disentangle whether this reflects an aversion to disinvestment or concerns with intervention feasibility.

Reflections on disinvestment

The findings from Chapter 6 suggest that decisionmakers designed a package that, in the aggregate, was less efficient than alternative options. While it is difficult to ascertain the reasons why (at least using the data available), I suggest that decisionmakers traded off cost-effective interventions for interventions with current high coverage. The reasons for this are unclear. Such a choice may have stemmed from an aversion to disinvest. It may have also stemmed from the fact that, for better or for worse, currently available interventions with high coverage have already shown to be acceptable and feasible in the Pakistani context, whereas those with no or low coverage have not.

Chapter 2 reviews some of reasons different economists and behavioural scientist have posited in order to explain endowment effects. While loss aversion is one of the most common explanations, others, such as Gal (2006) have suggested that endowment effects are instead linked to a propensity towards maintaining the status quo (i.e., inertia). This is particularly the case when preferences are often fuzzy and ill defined, which lead individuals to prefer the status quo over an uncertain option. It is possible that a tendency towards inertia also played a role in the preference towards interventions with high current coverage in our study in Chapter 6. While individual interventions

(and their scores and characteristics) were, per se, precise and well-defined, it is possible that the choices around different iterations of the HBP as a whole, composed of dozens of interventions, were indeed ill defined or fuzzy, and that decisionmakers suffered, to some degree, from cognitive overload and erred on the side of inertia. Understanding the cognitive overload of complex decision-making around health benefits packages may be a worthwhile research endeavour.

It is important to note, however, that not all stakeholders involved in the process shied away from disinvestment. Stakeholders in the NAC2 and IAG, mostly from technical backgrounds, prioritised interventions that were most cost-effective, regardless of their current coverage. It was at the last stage of the process, once political and other considerations were included by the Committee that the package became relatively less efficient. This suggests that some of the barriers identified in high-income settings (and summarised in Chapter 2) may also be present in Pakistan, namely fears of negative public perceptions on disinvestment, including that of waste within the public purse.

As opposed to the case study described in Chapter 4, the work described in Chapters 5 and 6 presents a broader health systems approach to priority settings. One of the key differences, and benefits, of using a broader perspective is that there is greater explicitness in both what is withdrawn and what is inserted. This may help in terms of planning for possible contingencies, such as strengthening specific services, or creating other mitigating social structures.

While systems wide analyses are in some ways preferable, they are also very data heavy and, while there is methodological guidance on how to assess certain criteria, particularly cost-effectiveness, there is little by way of methods of other criteria that may be influential, such as feasibility. While the predominance of cost-effectiveness as the most important criteria has been recorded in incremental decision-making (see Chapter 2), Chapter 6 interrogates whether that is the case across the entire HBP process in Pakistan. When the ICERs of interventions included in the final package are benchmarked against commonly used cost-effectiveness thresholds, it is notable that a large proportion of interventions would not be classified as cost-effective: between 59%-70% are above the Ochalek et al. thresholds and between 9%-47% are above the Woods et al. thresholds [45, 46]. This suggests that there are other key values at play and current ways of quantitatively assessing different criteria are inadequate to capture what may also be important for decisionmakers. Further methodological development in this area would be a worthwhile effort.

Lastly, the work in Chapter 6 questions whether some of the enablers of disinvestment, identified in Chapter 2, do indeed facilitate disinvestment. The absence of formal decision-making processes and explicit guidance, inadequate evidence and a lack of a list of candidate interventions for

reassessment and disinvestment have all been cited as reasons impeding successful disinvestment. However, all of these factors were present during the HBP process and in fact were designed at the heart of it. Yet disinvestment leading to a more efficient package of services did not take place.

***

Chapter 7 and 8 will revisit HBPs in the context of system-wide disruptions, such as those experienced during the COVID-19 pandemic. I reflect on the processes used for HBP design, as well as other findings from Chapters 4, 5 and 5, to propose a schematic disinvestment model to design 'smart, temporary and reduced' HBPs that explicitly take into account opportunity cost.

6.5 References

1. World Health Organization, *Principles of health benefit packages*. 2021: Geneva.
2. Bank, T.W., *Universal Health Coverage Study Series (UNICO)*. 2017.
3. Glassman, A. and K. Chalkidou, *Priority-setting in health: building institutions for smarter public spending*. 2012: Washington D.C.
4. Eregata, G.T., et al., *Revision of the Ethiopian Essential Health Service Package: An Explication of the Process and Methods Used.* Health Systems & Reform, 2020. **6**(1): p. e1829313.
5. Islamic Republic of Afghanistan Ministry of Public Health, *Integrated Package of Essential Health Services*. 2019.
6. World Health Organization, *Health Technology Assessment and Health Benefit Package Survey 2020/2021*. 2021.
7. Hayati, R., et al., *Scoping literature review on the basic health benefit package and its determinant criteria.* Globalization and Health, 2018. **14**(1): p. 26.
8. Mohamadi, E., et al., *Stakeholders Analysis of Health Insurance Benefit Package Policy in Iran.* Health Scope, 2018. **7**(2): p. e63165.
9. Glassman, A., et al., *Defining a Health Benefits Package: What Are the Necessary Processes?* Health Systems & Reform, 2016. **2**(1): p. 39-50.
10. Dakin, H., et al., *The Influence of Cost-Effectiveness and Other Factors on Nice Decisions.* Health Econ, 2015. **24**(10): p. 1256-1271.
11. Dakin, H., N. Devlin, and I. Odeyemi, *"Yes", "No" or "Yes, but"? Multinomial modelling of NICE decision-making.* Health policy (Amsterdam, Netherlands), 2006. **77**(3): p. 352-367.
12. Svensson, M., F.O. Nilsson, and K. Arnberg, *Reimbursement Decisions for Pharmaceuticals in Sweden: The Impact of Disease Severity and Cost Effectiveness.* Pharmacoeconomics, 2015. **33**(11): p. 1229-36.
13. Karikios, D.J., et al., *Is it all about price? Why requests for government subsidy of anticancer drugs were rejected in Australia.* Intern Med J, 2017. **47**(4): p. 400-407.
14. Chen, G., V. Peirce, and W. Marsh, *Evaluation of the National Institute for Health and Care Excellence Diagnostics Assessment Program Decisions: Incremental Cost-Effectiveness Ratio Thresholds and Decision-Modifying Factors.* Value in Health, 2020. **23**(10): p. 1300-1306.
15. Trenaman, L., S.D. Pearson, and J.S. Hoch, *How Are Incremental Cost-Effectiveness, Contextual Considerations, and Other Benefits Viewed in Health Technology Assessment Recommendations in the United States?* Value in Health, 2020. **23**(5): p. 576-584.
16. Cerri, K.H., M. Knapp, and J.L. Fernandez, *Decision making by NICE: examining the influences of evidence, process and context.* Health Econ Policy Law, 2014. **9**(2): p. 119-41.
17. Devlin, N. and D. Parkin, *Does NICE have a cost-effectiveness threshold and what other factors influence its decisions? A binary choice analysis.* Health Econ, 2004. **13**(5): p. 437-52.
18. Harris, A.H., et al., *The Role of Value for Money in Public Insurance Coverage Decisions for Drugs in Australia: A Retrospective Analysis 1994-2004.* Medical Decision Making, 2008. **28**(5): p. 713-722.
19. Elshaug, A.G., et al., *Challenges in Australian policy processes for disinvestment from existing, ineffective health care practices.* Aust New Zealand Health Policy, 2007. **4**: p. 23.
20. Lim, B.P., et al., *Health Technology Disinvestment in Singapore.* Ann Acad Med Singap, 2018. **47**(8): p. 338-344.
21. Mayer, J. and A. Nachtnebel, *Disinvesting from Ineffective Technologies: Lessons Learned from Current Programs.* Int J Technol Assess Health Care, 2015. **31**(6): p. 355-62.
22. Polisena, J., et al., *Disinvestment Activities and Candidates in the Health Technology Assessment Community: An Online Survey.* Int J Technol Assess Health Care, 2019. **35**(3): p. 189-194.

23. Elshaug, A.G., J.E. Hiller, and J.R. Moss, *Exploring policy-makers' perspectives on disinvestment from ineffective healthcare practices.* Int J Technol Assess Health Care, 2008. **24**(1): p. 1-9.
24. Rooshenas, L., et al., *"I won't call it rationing...": an ethnographic study of healthcare disinvestment in theory and practice.* Soc Sci Med, 2015. **128**: p. 273-81.
25. Lim, B.P., et al., *Health Technology Disinvestment in Singapore.* Ann Acad Med Singapore, 2018. **47**(8): p. 338-344.
26. Mitchell, D., et al., *Understanding Health Professional Responses to Service Disinvestment: A Qualitative Study.* Int J Health Policy Manag, 2019. **8**(7): p. 403-411.
27. Leech, A.A., et al., *Are low and middle-income countries prioritising high-value healthcare interventions?* BMJ Glob Health, 2020. **5**(2): p. e001850.
28. Alwan, A. and et al, *Addressing the UHC Challenge Using the Disease Control Priorities-3 Approach: Learning from the Pakistan Experience.* 2022.
29. Watkins, D.A., et al., *Universal Health Coverage and Essential Packages of Care*, in *Disease Control Priorities: Improving Health and Reducing Poverty*, rd, et al., Editors. 2017: Washington (DC).
30. Baltussen, R., et al., *Multicriteria Decision Analysis to Support Health Technology Assessment Agencies: Benefits, Limitations, and the Way Forward.* Value in Health, 2019. **22**(11): p. 1283-1288.
31. Huda, M., et al., *Assessing global evidence on cost-effectiveness to inform Pakistan's Essential Health Benefit Package* 2022.
32. Raza, W., et al., *Costing Interventions for Developing a Health Benefit Package: Application of a Rapid Method and Results from Pakistan.* 2022.
33. Group, H.I.P.W., *Health Intervention Prioritizaion Tool*. 2019.
34. Sachs, J., *Macroeconomics and Health: Investing in Health for Economic Development*, in *Report of the Commission on Macroeconomics and Health*. 2001, World Health Organization: Geneva.
35. Institute for Health Metrics and Evaluation (IHME), *Global Burden of Disease, Pakistan Profile*. 2019, IHME, University of Washington: Seattle, WA,.
36. Government of Pakistan Ministry of National Health Services Regulations & Coordination, *Interventions' Description of Essential Package of Health Services/IHC Benefit Package of Pakistan*. 2020.
37. Baltussen, R., et al., *The use of evidence-informed deliberative processes for designing the universal health coverage benefit package in Pakistan.* 2022.
38. Daniels, N., *Accountability for reasonableness.* BMJ (Clinical research ed.), 2000. **321**(7272): p. 1300-1301.
39. McKie, J. and J. Richardson, *The rule of rescue.* Soc Sci Med, 2003. **56**(12): p. 2407-19.
40. Robinson, S., et al., *Priority-setting and rationing in healthcare: evidence from the English experience.* Soc Sci Med, 2012. **75**(12): p. 2386-93.
41. Skedgel, C., D. Wranik, and M. Hu, *The Relative Importance of Clinical, Economic, Patient Values and Feasibility Criteria in Cancer Drug Reimbursement in Canada: A Revealed Preferences Analysis of Recommendations of the Pan-Canadian Oncology Drug Review 2011–2017.* PharmacoEconomics, 2018. **36**(4): p. 467-475.
42. Garpenby, P. and A.C. Nedlund, *Political strategies in difficult times - The "backstage" experience of Swedish politicians on formal priority setting in healthcare.* Soc Sci Med, 2016. **163**: p. 63-70.
43. Aman, A., et al., *Financing universal health coverage: four steps to go from aspiration to action.* Lancet, 2019. **394**(10202): p. 902-903.
44. Government of Pakistan Ministry of National Health Services Regulation & Coordination, *Review of Essential Health Services in Pakistan Based on Disease Control Priorities 3.* 2019.

45. Ochalek J, Lomas J, Claxton K. Estimating health opportunity costs in low-income and middle-income countries: a novel approach and evidence from cross-country data. BMJ Global Health. 2018;3(6):e000964.
46. Woods B, Revill P, Sculpher M, Claxton K. Country-Level Cost-Effectiveness Thresholds: Initial Estimates and the Need for Further Research. Value Health. 2016;19(8):929-35.

Chapter 7: Disinvestment during shocks to the health system: estimating costs of care and treatment

7.1 Prologue

While this doctoral thesis has five results chapters (Chapters 4-8), the overall results can be grouped into three analytical sections. In Chapter 4, the first of these analytical sections, I presented the economic evidence produced for the incremental disinvestment decision of cotrimoxazole preventive therapy in Uganda and described the subsequent popular reaction. Together, Chapters 5 and 6 made up the second of the three analytical sections: an analysis to determine prioritised decision criteria and intervention characteristics during the health benefit package (HBP) design process in Pakistan, where both investment and disinvestment decisions took place. The third analytical section, composed of Chapters 7 and 8, incorporates lessons from the previous two sections, and proposes an analytical model quantifying the potential consequences of different explicit approaches to health system wide disinvestment following health system shocks.

The idea behind this third analytical section stemmed from the COVID-19 pandemic. The disruption and high costs caused by COVID-19 highlighted the need to think about HBP adaptations during health system-level shocks. In the absence of substantial additional resources, COVID-19 care and treatment at a large scale will necessitate disinvestment from existing interventions in the HBP. The key policy questions are: what interventions should be disinvested from (even if temporarily), what criteria should be used to make these disinvestment decisions, and what are the consequences of these decisions on the overall package. However, to understand the magnitude and shape of the potential disinvestment from existing services, it first is necessary to estimate the costs caused by the health shock, a question which is not simple to answer at the early stages of a crisis. Consequently, the research question of paper in Chapter 7 is as follows: For the purpose of understanding possible resource reallocation (and consequent disinvestment) during health system shocks, what are the costs of COVID-19 care and treatment in Pakistan and other low- and middle-income countries?

The costs estimated in Chapter 7 are then used in Chapter 8 to propose a 'smart, temporary and reduced' HBP adequate for use during pandemics using Pakistan as a case study. While the data from Chapter 7 that is used in Chapter 8 only pertains to Pakistan, I decided to calculate the costs of care and treatment of COVID-19 across a larger number of low- and middle-income countries, as these data may have been helpful for other countries experiencing similarly difficult decisions.

Candidate's role in the research paper

The candidate, Sergio Torres-Rueda, developed the concept for the paper. He surveyed guidance to understand the different components of the response. The candidate reviewed the overall structure of the COVIDM epidemiological model and made decisions around which scenarios would be used, reviewing data extraction. He co-designed the analysis tool where the analysis was carried out. He reviewed available datasets from other projects to obtain resource and unit cost data and reviewed literature on other COVID-19 related parameters (e.g., length of stay, supplementary oxygen use). He extracted data and populated the analysis sheets. He designed the method of data extrapolation from base countries to other countries and sourced required data (e.g., data on gross domestic product). He carried out several rounds of data cleaning. The candidate wrote the manuscript and incorporated comments from co-authors. He submitted the paper to *BMJ Global Health* and responded to peer-review comments prior to publication. He has also presented results of this study at an international conference as well to funders (Global Fund to Fight AIDS, Tuberculosis and Malaria) and to the faculty at the London School of Hygiene & Tropical Medicine. Full details of contributions of other authors can be found in 'Research Paper Cover Sheet'. The paper here presented differs slightly to the published version in that the former incorporates comments from the doctoral examiners.

7.2 Cover sheet for Research Paper 4

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT

T: +44 (0)20 7299 4646
F: +44 (0)20 7299 4656
www.lshtm.ac.uk

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed for each research paper included within a thesis.

SECTION A – Student Details

Student ID Number	1702569	**Title**	Mr.
First Name(s)	Sergio		
Surname/Family Name	Torres-Rueda		
Thesis Title	Priority Setting and Disinvestment in Healthcare: Economic Evidence, Policy Processes and Potential Consequences		
Primary Supervisor	Prof. Anna Vassall		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?	BMJ Global Health		
When was the work published?	Dec 2021		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	**No**	Was the work subject to academic peer review?	**Yes**

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	

Stage of publication	Choose an item.

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	STR developed the concept for the paper. Data was collated by STR, SS, FB. STR carried out the analysis. STR wrote the manuscript. All authors provided feedback during the analysis and on manuscript. AV provided supervision.

SECTION E

Student Signature	Sergio Torres-Rueda
Date	05/04/22

Supervisor Signature	Anna Vassall
Date	05/04/22

7.3 Research Paper 4

Title

Stark Choices: Exploring health sector costs of policy responses to COVID-19 in low- and middle-income countries

Authors

Sergio Torres-Rueda*[1]

Sedona Sweeney[1]

Fiammetta Bozzani[1]

Nichola R. Naylor[2]

Tim Baker[3,4,5]

Carl Pearson[2]

Rosalind Eggo[2]

Simon R. Procter[2]

Nicholas Davies[2]

Matthew Quaife[2]

Nichola Kitson[1]

Marcus R. Keogh-Brown[1]

Henning Tarp Jensen[1]

Nuru Saadi[1]

Mishal Khan[1,6]

Maryam Huda[6]

Angela Kairu[7]

Raza Zaidi[8]

Edwine Barasa[7,9]

Mark Jit[2]

Anna Vassall[1]

*Corresponding author

Affiliations

[1]Department of Global Health and Development, London School of Hygiene & Tropical Medicine, London, United Kingdom

[2]Department of Infectious Disease Epidemiology, London School of Hygiene & Tropical Medicine, London, United Kingdom

[3]Department of Clinical Research, London School of Hygiene & Tropical Medicine, London, United Kingdom

[4]Muhimbili University of Health & Allied Sciences, Dar es Salaam, Tanzania

[5]Ifakara Health Institute, Dar es Salaam, Tanzania

[6]Aga Khan University, Karachi, Pakistan

[7]Health Economics Research Unit, KEMRI-Wellcome Trust Research Programme, Nairobi, Kenya

[8]Health Planning, System Strengthening and Information Analysis Unit, Ministry of National Health Services Regulations & Coordination, Islamabad, Pakistan

[9]Nuffield Department of Medicine, University of Oxford, Oxford, United Kingdom

Abstract

Objectives: COVID-19 has altered health sector capacity in low- and middle-income countries (LMICs). Cost data to inform evidence-based priority setting are urgently needed. Consequently, in this paper I calculate the full economic health sector costs of COVID-19 clinical management in 79 LMICs under different epidemiological scenarios.

Methods: I used country-specific epidemiological projections from a dynamic transmission model to determine number of cases, hospitalisations and deaths over one year under four mitigation scenarios. I defined the health sector response for three base LMICs through guidelines and expert opinion. I calculated costs through local resource use and price data and extrapolated costs across 79 LMICs. Lastly, I compared cost estimates against gross domestic product (GDP) and total annual health expenditure in 76 LMICs.

Results: COVID-19 clinical management costs vary greatly by country, ranging between <0.1% –12% of GDP and 0.4%–223% of total annual health expenditure (excluding out-of-pocket payments). Without mitigation policies COVID-19 clinical management costs per capita range from US$43.39–US$75.57; in 22 of 76 LMICs these costs would surpass total annual health expenditure. In a scenario of stringent social distancing, costs per capita fall to US$1.10–US$1.32.

Conclusions: I present the first dataset of COVID-19 clinical management costs across LMICs. These costs can be used to inform decision making on priority-setting. Our results show that COVID-19 clinical management costs in LMICs are substantial, even in scenarios of moderate social distancing. Low-income countries are particularly vulnerable and some will struggle to cope with almost any epidemiological scenario. The choices facing LMICs are likely to remain stark and emergency financial support will be needed.

Introduction

Coronavirus disease 2019 (COVID-19) was declared a public health emergency of international concern by the World Health Organization (WHO) in January 2020 [1]. By the end of January 2021, nearly 100 million SARS-CoV2 confirmed infections and over 2.1 million associated deaths had been reported globally [2]. All-cause excess mortality data in some settings suggests the true figure could be substantially higher [3, 4]. Although clinical data from early in the pandemic suggested only a minority of cases will experience severe (~15%) or critical (~5%) disease that requires hospitalisation [5], the estimated resources needed to implement WHO pandemic response guidelines are substantial, particularly for more resource-constrained health systems in low- and middle-income countries (LMICs) [6]. Although the COVID-19 disease burden in 2021 and beyond is uncertain, particularly with the advent of highly efficacious vaccines, it is unlikely that the disease will be eradicated entirely, so such costs continue to be important for planning and resource allocation.

A limited number of studies have explored country-specific unit costs and total costs of COVID-19 clinical management in high-income settings [7, 8] and LMICs [9-11]. There have been two efforts to estimate global financing needs, including LMICs. The first was done for 214 countries and territories and costed clinical management, excluding testing, through a financial costing approach. Under different scenarios, the additional yearly health spending at the global level ranged from US$130-231 billion to US$ 0.6-1 trillion [12]. A second study, which calculated incremental costs of a health sector-wide response across 73 LMICs (accounting for 95% of the overall population of LMICs), found total recurring financial costs of between US$ 33-61 billion per month [13]. Additionally, there are financial costing tools and catalogues available for countries to budget incremental short-term resource requirements [14-16].

While the abovementioned global studies are key to mobilising resources for COVID-19, they either present incremental financial costs, exclude broader health systems costs, or assume a normative approach to resource use unlikely to be followed in LMICs faced with severe resource constraints. Full economic costs of a broader COVID-19 health system response, including 'real world' plausible estimates of service delivery in LMICs under different mitigation scenarios, are urgently needed to inform the priority-setting process. These costs will be required to understand the cost-effectiveness of novel COVID-19 curative and preventive interventions, including those focused on vaccination, as well as to define the extent to which essential services can be maintained during the pandemic. Further, full economic cost data are needed to inform policy choices seeking to balance the broader macro-economic costs of mitigation strategies against the costs to the health system from the disease. Lastly, country-specific resource estimates are needed to highlight the gaps between

currently available financial resources and those which would be required for adequate care and treatment of COVID-19 in LMICs. Such estimates may further contribute to country-specific resource mobilisation efforts.

This paper presents the first estimates of full economic costs of the COVID-19 response to health systems in LMICs taking a 'real world' approach under different pandemic mitigation scenarios over a 12-month period.

Methods

In summary, I used country-specific epidemiological projections from a dynamic transmission model which estimated total numbers of cases, days of hospitalisations and deaths under different mitigation scenarios. I defined the health sector response for three different LMICs in detail (Ethiopia, Pakistan and South Africa), using a combination of guidelines and expert opinion. I used local resource use and price data from a range of primary and secondary data sources. I then extrapolated costs across LMICs at similar income levels. Lastly, I compared cost estimates against country-specific measures of gross domestic product (GDP) and health expenditure. Greater details on the methods are found below and in the Supplementary Methods Appendix (Appendix 7.1).

Epidemic mitigation scenarios

Estimates of COVID-19 cases for different scenarios come from the publicly available COVIDM epidemiological model, produced by the Centre for the Mathematical Modelling of Infectious Diseases at the London School of Hygiene & Tropical Medicine. COVIDM is a compartmental model with four compartments (Susceptible, Exposed, Infectious and Removed) which projects the health impact of COVID-19 in LMICs (https://cmmid.github.io/topics/covid19/LMIC-projection-reports.html). The model is age-structured (five-year bands). Susceptible individuals acquire infection at a given rate. Age-specific mixing patterns of individuals alter their likelihood of exposure to the virus. The model was calibrated using country specific age structures for 92 countries. For each country, the model produces different projections of the number of clinical cases, number of required days in hospital for severe cases (general ward) and critical cases (intensive care unit, or ICU), and deaths, for 57 distinct mitigation scenarios that may occur over a one-year period [17].

I chose four scenarios for the costing. Scenario 1 represents an unmitigated epidemic. While it is unlikely that an epidemic will be completely unmitigated, it serves as an epidemiological counterfactual to estimate the full costs of COVID-19. Scenarios 2-4 represent a range of plausible levels of mitigation achieved through different policy options: Scenario 2, a high level of reduction in contacts among symptomatic people and low levels of reduction in contacts in the general population; Scenario 3, a high level of reduction in contacts among symptomatic people and the general population; and Scenario 4, a 30-day lockdown followed by low levels of reduction in contacts in the general population for the remainder of the year. The Supplementary Methods Appendix (Appendix 7.1) contains further descriptions of the scenarios (Table SM3) and the numbers of cases, days in hospital and deaths for each country and scenario (Table SM4).

Defining the COVID-19 health sector response

In line with the WHO guidelines I defined activities for seven priority areas of health sector response to COVID-19 (including both direct service delivery and broader prevention and management strategies): a) emergency response mechanisms at the national level; b) risk communication and community engagement; c) case finding, contact tracing and management; d) surveillance; e) public health measures (hygiene education); f) screening and diagnosis (using polymerase chain reaction (PCR) tests) and, g) case management [18]. I estimated a unit cost per country for each of these activities. The COVIDM model was used to identify the number of cases, hospitalisations and deaths in each scenario per country in order to calculate costs associated with (f) and (g).

Estimating unit costs per activity

I calculated full economic costs from a health system perspective over a 12-month time horizon. To estimate the average unit costs for each activity I used an ingredients-based costing approach (i.e., identifying and subsequently valuing all inputs needed to deliver an intervention) [19]. For each input I estimated quantities needed and a country-specific price per quantity. For example, in the case of (a) emergency response mechanism (national level), I aimed to calculate a cost per day. I assumed that the three inputs required per day were: (i) 10 junior level government officials, (ii) 10 senior level government officials, as well as (iii) meeting space and equipment for those 20 people. The salary for one day of work for a junior level government official in Ethiopia was calculated at US$12.27, for one senior level government official at US$17.29 and the cost of one day's worth of space and equipment necessary for meetings was estimated at US$13.18 per person. I multiplied inputs by prices: (10 x US$12.27) + (10 x US$17.29) + (20 x US$13.18), which equals US$559.26. This represented the cost per day of the emergency response mechanism at the national level. Detailed inputs costed in each priority area can be found in Table SM6 in the Supplementary Methods Appendix (Appendix 7.1).

I used recent local cost and resource use data from three base countries: Ethiopia (low-income country, or 'LIC'), Pakistan (lower middle-income country, or 'lower-MIC') and South Africa (upper middle-income country, or 'upper-MIC'). As primary data collection from COVID-19 service delivery points was not feasible, I selected countries where I, and other members of my research team, had recently conducted large scale costing exercises around either tuberculosis (TB) or general health services. These provided current local data on actual resource use, input prices and health system unit cost data for activities such as outpatient consultations, inpatient bed-days, a range of laboratory tests including PCR tests and contact tracing. In the case of Ethiopia and South Africa, I

had recent primary data from TB studies (2017-18) [20-22]. In the case of Pakistan, I worked with the Ministry of National Health Services, Regulation & Coordination in 2019-20 to calculate ingredients costs for all essential services as part of the Disease Control Priorities 3 project (DCP3) [23]. Although secondary local cost data were used for Pakistan, all costs were subjected to a review by technical working groups as part of DCP3 that included practitioners at all levels of the health system.

Adapting resource use assumptions to LMICs

I conducted our costing based on global guidelines. However, I adapted the level of COVID-19 specific resource needs to take into account feasibility in LMIC contexts by a combination of reviewing COVID-19 resource planning tools and budgets and scoping literature searches for primary data on clinical care practices in LMICs. Clinical management resource use estimates were adapted based on informal consultation with co-authors with experience in clinical work in emergency settings in LMICs. In certain areas of clinical practice, I costed low-cost critical care options deemed more feasible in LMICs, including a reduced clinician-to-patient ratio and an estimation of oxygen therapy needs that depended more heavily on low-flow oxygen options. See Table SM10 in the Supplementary Methods Appendix (Appendix 7.1). While I had access to and reviewed local COVID-19 data on length of stay in hospital from different settings, this revealed either exceptionally long (early cases) or short (during surge) lengths of stay, and therefore I used data from China and the United Kingdom [24], in line with the data used in the underlying epidemiological model.

Extrapolating unit costs from base countries to other LMICs

To generate costs for other LMICs, I extrapolated our detailed unit cost estimates for Ethiopia, Pakistan and South Africa to LICs, lower-MICs, and upper-MICs, respectively, based on country specific epidemiological and health systems data, and standard approaches to adjusting prices. In effect, the one constant element between countries is the model of care, with all other aspects of costs adjusted using national-level data in each of the 79 countries.

Each cost input in the ingredients costing was classified as a tradeable good, non-tradeable good, or staff cost [25]. Tradeable goods are generally defined as those that can easily be traded in the international market and include goods such as medical or other supplies and medications. To convert costs of tradeable goods from the base country (e.g., Ethiopia) to a 'second' country (e.g., Afghanistan) I first converted the prices from local currency to 2019 US$ and then apportioned the percentage of the unit cost that was composed of tradeable goods in 2019 US$ from the base country to the second country.

Non-tradeable goods cannot be easily traded in international markets and generally need to be consumed in the country where they have been produced (e.g., buildings and utilities). To convert these, I multiplied the proportion of the unit cost that was defined as non-tradeable (in 2019 US$) by the ratio between the 2019 GDP per capita (adjusted for PPP) of the second country and the 2019 GDP per capita (adjusted for PPP) of the base country. Data on GDP per capita (adjusted for PPP) were found in the World Bank database [26].

To convert staff costs from a base country to a second country I used conversion rates from a regression analysis on wages of health workers for 193 countries to predict wages by country income category relative to GDP per capita. I estimated the number of working hours for nurses, doctors, and other medical staff and applied GDP per capita multipliers in order to value their time [27].

I calculated unit costs per activity for a total of 129 LMICs, as well as a mean unit cost per activity per country income category (LICs, lower-MICs, and upper-MICs) weighted by population.

Calculating total costs

Unit costs per activity were multiplied by the number of activities expected in each country, in some cases driven by the epidemiological estimates (e.g., per days in hospital for critical cases) and in others by fixed time and geographical area (e.g., per country per day). Since Scenario 1 models an unmitigated epidemic only clinical management costs were included. See Table SM12 in the Supplementary Methods Appendix (Appendix 7.1) on the number of units used for each activity.

While an effort was made to ensure that the resource use costed is feasible in LMICs, our total cost estimates assume that every patient with severe or critical disease will be hospitalised regardless of existing hospital bed capacity. In other words, I estimate total resource needs regardless of current country-specific non-financial constraints.

Total country-level costs were estimated for 79 LMICs where I had epidemiological estimates. The 79 countries have a combined population of more than 3.98 billion people, which accounts for 60% of the total population of LMICs [26]. Some LMICs were excluded from our analysis due to the lack of epidemiological estimates or suitable data on GDP with which to make price adjustments.

Comparing costs

Estimates of annual cost per capita of each scenario in each country were estimated by dividing total costs by the population of each country. These were compared against: (i) country-specific GDP per capita, (ii) national health spending (excluding out-of-pocket, or OOP, expenditure) per capita, (iii)

national health spending (including OOP expenditure) per capita, and (iv) government health expenditure per capita in 76 LMICs where relevant data were available [26, 28]. See Table SM14 in the Supplementary Methods Appendix (Appendix 7.1). I also present a mean cost per capita per country income category weighted by population.

Sensitivity analysis

Data on the percentage of symptomatic cases tested with PCR were unavailable and so the assumed base case estimate (10%) was considered highly uncertain. Consequently, I performed a deterministic sensitivity analysis by increasing this value between 20%-100%.

Patient and Public Statement

While there was no patient involvement in our research, I consulted several actors involved in policymaking in LMICs to ensure our work was useful in national-level decision making.

Results

Unit costs in base countries

Table 1 shows the unit costs per activity in our three base countries. Daily case management costs ranged from US$33.32 (Pakistan) to US$105.88 (South Africa) for severe cases and from US$221.18 (Pakistan) to US$1081.94 (South Africa) for critical cases. Costs per case treated ranged from US$266.59 (Pakistan) to US$847.03 (South Africa) for severe cases and from US$2211.83 (Pakistan) to US$10,819.42 (South Africa) for critical cases, assuming eight days of hospitalisation for severe cases and ten days for critical cases [24]. The costs for screening and diagnosis (using PCR) ranged from US$26.98 (Pakistan) to $73.12 (South Africa) per person tested. Unit costs were highest across all activities in South Africa (upper-MIC base country). They were lowest in Pakistan (lower-MIC base country) for activities whose inputs are largely composed of clinical staff time, and in Ethiopia (LIC base country) for activities requiring limited or no clinician involvement. The ratios between the highest and lowest unit costs were greatest for non-clinical activities.

Extrapolated global unit costs

Table 1 also shows our estimates of the mean unit costs per activity by country income category weighted by population size. Across all activities, unit costs are highest in the upper-MIC category and lowest in the LIC category, except in costs per death where I assume the same costs across all countries. Daily costs for management of severe cases and critical cases ranged from US$35.37 to US$140.53, and from US$310.67 to US$ 1417.30, respectively. Costs per case treated ranged from US$282.91 to US$1124.24 for severe cases, and from US$3106.70 to US$14,172 for critical cases, assuming eight days of hospitalisation for severe cases and ten days for critical cases [24]. The cost person tested with PCR ranged from US$31.35 to US$63.30.

Country-specific unit costs can be found in Table SR1 in the Supplementary Results Appendix (Appendix 7.2). Malaysia had the highest unit costs for the hospital-based case management activities (US$ 206.38 per day in hospital for severe cases and US$ 2011.43 for per day in hospital for critical cases) and for testing (US$86.58), while Burundi had the lowest across all three unit costs (US$ 28.43, US$ 189.56 and US$25.93 respectively).

Total costs and costs per capita

Tables SR2 and SR3 in the Supplementary Results Appendix (Appendix 7.2) show the total costs per country and cost per capita per country, by scenario. Across all scenarios, the total costs per country are highest in India (US$ 113.70 billion – US$ 2.10 billion) and lowest in in São Tomé and Príncipe (US$ 863,111 – US$ 10.04 million). It is important to note that the simulation time-horizon is 12

months, and the epidemic may continue beyond that point so total costs of managing the epidemic in the long term will most likely be higher.

Mean costs per capita per country income group weighted by population are presented in Table 2. Costs per capita were similar between Scenario 1 (no mitigation) and Scenario 4 (30-day lockdown followed by low contact reduction in the general population): between US$43.19 – US$75.57 and US$45.73 – US$71.62, respectively. Highest costs per capita were observed in Scenario 1 in upper-MICs, and in Scenario 4 for LICs and lower-MICs. Scenario 3 (high levels of contact reduction in symptomatic people and general population) had the lowest costs per capita across all income groups (US$1.10 – US1.32).

In all scenarios, the largest cost drivers were screening and diagnosis and case management. Costs of screening and diagnosis were particularly substantial for LICs, accounting for 51.62% - 59.47% of total costs, and less substantial for upper-MICs (20.10% - 26.45% of total costs). Conversely, the costs of case management were particularly substantial for upper-MICs (62.03% - 79.90% of total costs), and less so for LICs (37.75% - 48.38%). Most of the costs of case management are related to hospital-based critical care (>76% across country income groups and scenarios). Case finding, contact tracing and surveillance, and public health measures in contrast made up less than 4% of the total response costs (in Scenarios 2-4). See Table 3.

Costs as percentage of economic metrics

The maps in Figures 1a-d (and underlying data in Tables SR4-SR7 in the Supplementary Results Appendix (Appendix 7.2)) illustrate and compare the costs per capita of COVID-19 management as a percentage of GDP per capita and of total health spending per capita, using different metrics of health expenditure.

COVID-19 costs per capita as a percentage of GDP per capita are highest in Scenario 1 (unmitigated epidemic) and Scenario 4 (30-day lockdown and low contact reduction in the general population) across all countries, ranging from 1.43% in Eswatini to 11.85% in Burundi (both Scenario 4). They were consistently lowest in Scenario 3 (high levels of contact reduction in symptomatic people and general population): between 0.03% in Angola, Bolivia and Ghana and 0.83% in Zimbabwe.

Likewise, COVID-19 costs as a percentage of health expenditure were highest in all countries in Scenarios 1 and 4: 23.35% - 216.36% and 23.42% - 222.34% of total national health spending excluding OOP payments, respectively; 14.68% - 171.29% and 15.68% - 183.51% of total national health spending including OOP payments, respectively; and 35.15% - 1344.28% and 38.24% - 1451.34% of government health spending, respectively. Lowest proportions were observed in

Scenario 3: 0.38% - 18.96% of total national health spending excluding OOP payments, 0.26% - 15.64% of total national health spending including OOP payments, and 0.68% - 40.78% of government health spending.

Sensitivity Analysis

I found that estimates were highly sensitive to assumptions on the number of symptomatic cases tested (see Table SR8 in the Supplementary Results Appendix (Appendix 7.2)) for Scenarios 2-4. Increasing the number of symptomatic cases tested from 10% to 20% increased the cost per capita estimates by 8% - 18%. Assuming that all symptomatic cases would be tested increased the cost per capita estimates by 73% - 164%. A sensitivity analysis was not deemed necessary for the unmitigated scenario (Scenario 1) as only tests carried out in hospital-based cases were included in the base case.

Discussion

I provide the first set of country-specific full economic cost estimates of COVID-19 management in LMICs, from a health sector perspective. The countries included in our study account for 60% of the total population of LMICs [26]. This information can assist policymakers to better understand trade-offs across all health sector resources and offers an estimate of the scale of financial resources that would be needed for clinical management. Our data may be used for cost-effectiveness analyses of future treatment and prevention strategies, notably vaccines, and to weigh the broader macro-economic costs of mitigation strategies against the costs to the health system. Additionally, I provide country-specific unit cost estimates for specific COVID-19 related activities that could be useful for planning purposes and to inform disinvestment decisions.

I find that the costs to the health sector of responding to COVID-19 are substantial in LMICs, even when assuming lower-cost critical care options. High levels of social distancing by the general population throughout the year (Scenario 3) would greatly reduce costs compared to a policy of allowing the pandemic to proceed unmitigated (Scenario 1), but also, importantly, compared to scenarios leading to moderate levels of social distancing (Scenarios 2 and 4).

Our findings suggest that the total number of cases is highest in a policy scenario of no mitigation (Scenario 1). However, the highest total costs vary by country between Scenario 1 and Scenario 4 (30-day lockdown followed by minor reductions in contacts). While Scenario 4 has a lower number of total cases, costs are comparable to those in Scenario 1 because Scenario 1 only accounts for clinical management costs and excludes the costs of any mitigation strategies, including testing beyond severe and critical cases in hospital. These results should not be taken as an endorsement that it is preferable, from a financial perspective, to have no mitigation strategy over a strategy of limited social distancing. A no mitigation strategy may result in slightly lower costs of COVID-19 management in some settings but would have substantial knock-on effects on costs and outcomes for other health interventions not quantified in our study.

I compared total COVID-19 costs per country across the four epidemiological scenarios against GDP per capita and three metrics of national-level health expenditure per capita: total national health expenditure with and without OOP payments, and government health expenditure. I found that, while some countries are likely able to absorb the costs (particularly in Scenario 3), even moderate levels of social distancing would lead to high levels of the health spending being directed towards COVID-19 in nearly all countries. In Scenario 2, for example, 74 out of 76 countries would need to direct more than 20% of their total national health expenditure (excluding OOP costs) to COVID-19.

COVID-19 related costs would exceed total health spending in several countries, although this varies by expenditure metric examined and epidemiological scenario. COVID-19 costs could exceed total expenditure in between 8 to 11 countries out of 76 when compared against total national health expenditure including OOP. This figure increases to 18 to 23 countries when compared against total national health expenditure excluding OOP and to 52 to 54 countries when compared against government health expenditure only. This highlights that in many countries, OOP expenditure and non-government sources of health expenditure, such as donor funding, may play a critical role in covering the costs of the COVID-19 pandemic. As the global macro-economic situation deteriorates due to the pandemic and overseas development aid is reduced, international agencies and donor nations need to be aware of the potentially catastrophic consequences of reducing funding towards health services in LMICs and the consequent impact on out-of-pocket expenditure.

No country is expected to exceed total health expenditure under Scenario 3. However, in eight countries, COVID-19 costs are projected to exceed spending across all three health expenditures metrics for Scenarios 1, 2 and 4: Burundi, Central African Republic, Democratic Republic of Congo, Ethiopia, The Gambia, Madagascar, Mozambique and Tanzania. These countries, all LICs located in sub-Saharan Africa, are therefore particularly vulnerable and will likely require considerable financial support.

Further research is required to better understand the effect that shocks of this magnitude have on the health system, and, particularly, on essential services. It is crucial to understand which services are most vulnerable to being displaced and the levels of funding required to ensure their continued provision, as well as identifying which non-urgent services can be temporarily delayed without causing lasting impact [29]. While additional funding may aid in ensuring the continuation of some of these services, it may not be possible to relax some of the required infrastructural and human resource constraints in the short-term, so the capacity of the health system to absorb additional funding should also be examined.

I carried out a costing from the perspective of the health sector focusing exclusively on COVID-19. I have not quantified the health impacts or costs of discontinuing (even temporarily) other key health sector activities. Further, while high levels of social distancing would lead to better COVID-19-related health outcomes and lower health sector costs, they may also imply economic losses in other sectors as well as social and other non-economic consequences. Decisionmakers should consider all these factors when debating COVID-19 mitigation policies.

Our unit cost estimates per day of hospitalisation for severe and critical cases are broadly in line with those published in the literature for LMICs [9-11]. Our total LMIC costs are lower than those published by Edejer et al. (2020) [13], although they are not entirely comparable due to the sizes of the population studied, the scope of the costing activities included, and some key assumptions on resource use, particularly around staff costs. Edejer et al. included a larger population in their analysis (countries accounting for 95% of the total population of LMICs, as opposed to 60% in our paper). While the scope of our costing was narrow and focused largely on clinical activities, Edejer et al. also included non-clinical interventions (e.g., surveillance at points of entry in the country). Lastly, Edejer et al. assumed higher remuneration of staff during the pandemic by including hazard pay as per international guidelines whereas I assumed staff salaries would remain constant with pre-pandemic salaries.

The two activities with highest proportion of costs in our analysis were screening and diagnosis and case management. Screening and diagnosis costs accounted for a particularly high percentage of total costs in LICs (over 50% of in some scenarios). I assumed all testing across all settings would be PCR-based, which led to relatively high unit costs. As the pandemic evolves, I expect less resource intensive diagnostic technologies with adequate accuracy to replace PCR, leading to lower overall costs. Our total costs were highly sensitive to variations in testing scale-up: a 10% increase in the proportion of symptomatic cases tested led to increases of up to 18% in total costs. Country-specific data on numbers of people tested are needed to better calibrate our cost model.

Case management costs were high across settings, particularly in upper-MICs. Healthcare staff salaries made up a large proportion of the costs per day in hospital, particularly for critical cases; higher unit costs in upper-MICs are a product of comparatively higher staff salaries in these settings. Our cost model already assumes a conservative staff-to-patient ratio. I do not expect costs per day of hospitalisation to drop considerably unless this ratio is further reduced. With the advancement of new therapeutics, costs per day of hospitalisation may increase; however, the costs per case treated may decrease if new therapeutics allow for faster patient recovery and reduce length of hospital stay required.

I aimed to calculate overall resource needs, so the total costs assume that all severe and critical patients will be hospitalised. However, this is currently unlikely in certain settings, particularly in LICs, as not all those who need care will be able to access it; ICU capacity remains extremely limited in many settings [30]. Our costs should therefore not be interpreted as forecasting expenditure, but rather indicative of the scale of financial resources required to provide adequate care at scale.

I did not account for country-specific short-run health system constraints. Accurately quantifying resources constraints, particularly those related to critical care at a global level, is difficult as many components are required (e.g., mechanical ventilators, anaesthesiologists, sufficient high-flow oxygen capacity and high clinician-to-patient ratios). It is important for policymakers to measure and consider these constraints in a country-specific manner when making allocative decisions between different health needs, acknowledging that some resources (e.g., human resources) cannot normally be relaxed at scale in the short term, even with additional funding.

While I did not factor access to care in the calculations, I did estimate resource use levels that were considered feasible in LMICs: I assumed, for example, that only one-third of critical cases would receive mechanical ventilation and the other two-thirds would receive other methods of oxygen supplementation. However, such respiratory support is complex and many LMICs may struggle to provide it even in lower quantities. What constitutes a 'feasible strategies of service delivery' will inevitably vary between LMICs, but our estimates suggest that, in many settings, even service delivery that is comparatively less resource intensive would lead to very high health sector costs.

Other essential (and less costly) critical care options may be more realistic in certain settings [31, 32]. However, there is scant evidence at present on the effect of different types of critical care pathways, particularly low-cost critical care options, on COVID-19-related mortality. Future work should explore the relationship between costs and outcomes in a more dynamic fashion.

Limitations

The methods used in this study are subject to several important limitations. Firstly, I rely on epidemiological projections modelled at the start of the epidemic. However, recent data from several settings, notably sub-Saharan Africa, suggests lower numbers of cases and fewer deaths than projected by models (see Table SM15 in the Supplementary Methods Appendix (Appendix 7.1)) [2]. The extent to which differences are due to under-ascertainment of real cases and deaths or to actual differences in epidemic dynamics is unclear. If the former is correct, I would expect numbers of true cases and deaths across LMICs to fall between Scenarios 1 and 4, and Scenario 3. However, if the latter is correct, our total costs would be largely over-estimated. It is important to note, however, that a direct comparison between our modelled estimates and total cases reported to end January 2021 (one year after the WHO declared COVID-19 a public health emergency of international concern) could also be misleading in some settings. Our modelled data covers a 12-month period per country from the start of the epidemic in each country. However, the epidemic started and accelerated at different times in different countries, so the time horizons considered will differ.

Further, the case numbers that our estimates rely upon cover a range of possible epidemic dynamics; one given scenario is unlikely to match the real case numbers currently being observed across all LMICs. Differences between reported and modelled estimates may also be explained by the fact that mitigation policies in place through the pandemic have varied over time in most countries [33], they may not have led to comparable levels of contact reduction as in our model, nor have they been implemented for the same amount of time as in the model (one year from the start of the epidemic).

Secondly, 'real world' costs are ideally estimated by collecting extensive primary cost data on actual service delivery. I have not been able to do this for COVID-19, and therefore relied on data collected for other purposes and on expert opinion from LMICs to make key assumptions on how services may be delivered. I only used three country estimates to extrapolate to other settings.

The length of hospital stays necessary for severe and critical cases used in the epidemiological models were based on evidence from early in the pandemic. As more data become available on length of stay and treatment options improve, epidemiological and costing models should be revisited. Service uptake and health-seeking behaviour may also differ by setting and should be considered in further work.

Thirdly, this work focuses on a narrow set of health sector COVID-19 interventions. I do not include the costs of protecting healthcare workers delivering other essential services outside the COVID-19 response (i.e., PPE for routine activities), or COVID-19 related costs beyond the health sector (e.g., police enforcing social distancing policies), which may be considerable but were beyond the scope of our analysis.

Despite these limitations, this paper provides several critical qualitative recommendations for those working in COVID-19 policymaking. First, it is imperative that global agencies and funders continue to ensure sufficient targeted resources are available for LMICs to respond as the pandemic evolves, with most LMICs expected to shift substantial amounts of funding to COVID-19, even with policies of moderate social distancing in place. While much of the focus is on the macro-economic impact and mortality impact of COVID-19, the fiscal impact on the health sector is likely to be substantial. LICs are particularly vulnerable and some will struggle to cope with almost any COVID-19 scenario. When thinking through mitigation strategies, decisionmakers should consider the macroeconomic implications alongside associated potential reductions in healthcare-related costs, including patient costs.

Secondly, in thinking through resource needs, it is important for countries to re-evaluate interventions and adapt response measures in ways that are context appropriate, affordable and sustainable, particularly in relation to high-cost activities, namely screening and testing and hospital-based care. This could include intervention delivery re-design and adaptations such as integration of care, leveraging of community health workers and home-based care, better targeting of interventions such as testing, and lower cost diagnostic approaches and critical care, among other ideas.

Finally, while the results of this paper reflect the myriad decisions about care, protection and patient experience that are required to plan resource use, there is little discussion or data on what is feasible in LMICs. This is a task that cannot be met using a global perspective but needs country-specific inputs to reflect the health system characteristics of each country. I therefore also call for urgent support to encourage interaction of economists, planners, service managers and epidemiological modellers to inform COVID-19 policy at the country level across LMICs.

Conclusion

I present the first dataset of COVID-19 clinical management costs across LMICs. These can be used for cost-effectiveness analyses of prevention strategies, notably vaccines, and can assist policymakers understand trade-offs between essential services as well as inform discussions on the balance between broader macro-economic costs of mitigation strategies and health sector costs. I find that COVID-19 clinical management costs are substantial in LMICs, even in scenarios of moderate social distancing and assuming lower-cost critical care options. LICs are particularly vulnerable and some will struggle to cope with almost any COVID-19 scenario. As social distancing is relaxed, emergency financial support will be needed. The choices facing LMICs are likely to remain stark.

The costs presented in this paper can also be used to inform disinvestment decisions. The magnitude of the COVID-19 pandemic in most countries meant that, in order to provide COVID-19-related care and treatment, resources in the health sector had to be reallocated. In some cases, disinvesting from other interventions took place (at times in a temporary manner). To better plan for explicit disinvestment decisions, it is first necessary to understand the level of resources that will be required to manage the health shock. While the costs presented in Chapter 7 can inform such decisions, it is important to note that these costs have limitations. In particular, they do not account for country-specific resource constraints, which could lead to overestimating the amount of actual resources that need to be found through disinvesting from other interventions.

The methods here presented did not include primary data collection. As the pandemic subsides, and primary costing exercises can resume, it would be important to evaluate whether accurate estimates can indeed be obtained through normative, ingredients-based methods and through between-country extrapolations. If the validation yields encouraging results, methods like mine could be used for the collection of costs of future health shocks.

Tables and Figures

Table 1: Unit Costs per Activity for (a) Base Countries and (b) Country Income Category (population-weighted mean) (2019 US$)

Activity	Unit Type	(a) Base countries			(b) Country income category (population-weighted mean)		
		Ethiopia	Pakistan	South Africa	Low Income Countries (LIC)	Lower-Middle Income Countries (Lower-MIC)	Upper-Middle Income Countries (Upper-MIC)
1.a. Emergency Response Mechanisms: National level	Per country per day	$559.26	$778.90	$7,697.16	$1,197.74	$2,697.57	$6,317.51
1.b. Emergency Response Mechanisms: Training of health staff	One-off per site	$4,813.58	$8,096.53	$68,141.36	$8,231.26	$17,600.99	$44,990.67
2. Risk communication & community engagement	Per country per day	$74.14	$91.67	$1,133.44	$105.87	$240.57	$558.54
3.a. Case finding, contact tracing and management: Contact tracing	Per person contacted	$3.48	$2.54	$26.23	$3.07	$9.84	$19.68
3.b. Case finding, contact tracing and management: Quarantine of contacts	Per person quarantined	$1.72	$2.35	$29.22	$2.95	$6.36	$16.02
4.a. Surveillance: Case notification	Per positive case	$1.72	$2.35	$29.22	$2.95	$6.36	$16.02
4.b. Surveillance: Reporting (national level)	Per country per week	$3.69	$6.52	$68.26	$7.30	$14.89	$41.07
5. Public health measures: Hygiene education	Per education campaign per month	$44.58	$54.66	$682.05	$63.97	$145.81	$338.43
6. Screening and diagnosis	Per person screened and tested	$36.97	$26.98	$73.12	$31.35	$37.86	$65.30
7.a. Case Management: Home-based care	Per person requiring home-based care	$22.90	$12.45	$146.57	$18.55	$51.53	$210.14
7.b. Case Management: Hospital-based (severe case)	Per day of hospitalisation (severe case)	$35.29	$33.32	$105.88	$35.37	$42.68	$140.53
7.c. Case Management: Hospital-based (critical case)	Per day of hospitalisation (critical case)	$505.56	$221.18	$1,081.94	$310.67	$329.75	$1,417.30
7.d. Case Management: Death	Per COVID-related death	$64.52	$64.52	$64.52	$64.52	$64.52	$64.52

Table 2. Mean Cost per Capita by Country Income Category Weighted by Population (2019 US$)

Scenario	Low Income Countries (LIC)	Lower-Middle Income Countries (Lower-MIC)	Upper-Middle Income Countries (Upper-MIC)
Scenario 1: No mitigation	$43.19	$52.63	$75.57
Scenario 2: Contact reduction: high symptomatic cases/low general population	$38.52	$45.96	$58.08
Scenario 3: Contact reduction: high symptomatic cases/high general population	$1.32	$1.10	$1.29
Scenario 4: 30-day lockdown + low contact reduction general population	$45.73	$54.98	$71.62

Table 3. Average % of Total Costs by Activity by Country Income Category by Scenario

Activity	Scenario 1: No mitigation			Scenario 2: Contact reduction: high symptomatic cases/low general population			Scenario 3: Contact reduction: high symptomatic cases/high general population			Scenario 4: 30-day lockdown + low contact reduction general population		
	LIC	Lower-MIC	Upper-MIC	LIC	Lower-MIC	Upper-MIC	LIC	Lower-MIC	Upper-MIC	LIC	Lower-MIC	Upper-MIC
1.a. Emergency Response Mechanisms: National level	0.00%	0.00%	0.00%	0.04%	0.01%	0.02%	1.04%	0.62%	0.99%	0.03%	0.01%	0.02%
1.b. Emergency Response Mechanisms: Training of health staff	0.00%	0.00%	0.00%	0.08%	0.16%	0.26%	2.19%	6.65%	11.77%	0.06%	0.13%	0.21%
2. Risk communication & community engagement	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.13%	0.08%	0.12%	0.00%	0.00%	0.00%
3.a. Case finding, contact tracing and management: Contact tracing	0.00%	0.00%	0.00%	0.98%	2.27%	1.29%	0.91%	2.00%	1.09%	0.96%	2.22%	1.24%
3.b. Case finding, contact tracing and management: Quarantine of contacts	0.00%	0.00%	0.00%	0.94%	1.21%	1.07%	0.91%	1.11%	0.91%	0.93%	1.18%	1.03%
4.a. Surveillance: Case notification	0.00%	0.00%	0.00%	0.13%	0.17%	0.15%	0.13%	0.16%	0.13%	0.13%	0.17%	0.15%
4.b. Surveillance: Reporting (national level)	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.10%	0.28%	0.56%	0.00%	0.01%	0.01%
5. Public health measures: Hygiene education	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6. Screening and diagnosis	51.62%	42.40%	20.10%	59.47%	50.07%	26.45%	56.84%	44.98%	22.39%	58.54%	48.91%	25.36%
7.a. Case Management: Home-based care	1.46%	2.85%	2.86%	1.23%	2.45%	2.75%	1.14%	2.15%	2.32%	1.21%	2.39%	2.63%
7.b. Case Management: Hospital-based (severe case)	8.07%	10.21%	11.86%	6.39%	8.14%	10.47%	6.62%	7.88%	9.19%	6.55%	8.39%	10.68%
7.c. Case Management: Hospital-based (critical case)	38.37%	44.03%	64.98%	30.36%	35.10%	57.34%	29.59%	33.69%	50.36%	31.18%	36.16%	58.49%
7.d. Case Management: Death	0.49%	0.52%	0.20%	0.39%	0.41%	0.18%	0.40%	0.40%	0.15%	0.40%	0.42%	0.18%

Figure 1(a): Health System Costs of COVID-19 Response per Capita as % of GDP per Capita (Nominal)

Scenario 1: No mitigation; **Scenario 2:** Contact reduction: high symptomatic cases/low general population; **Scenario 3:** Contact reduction: high symptomatic cases/high general population; **Scenario 4**: 30-day lockdown + low contact reduction general population

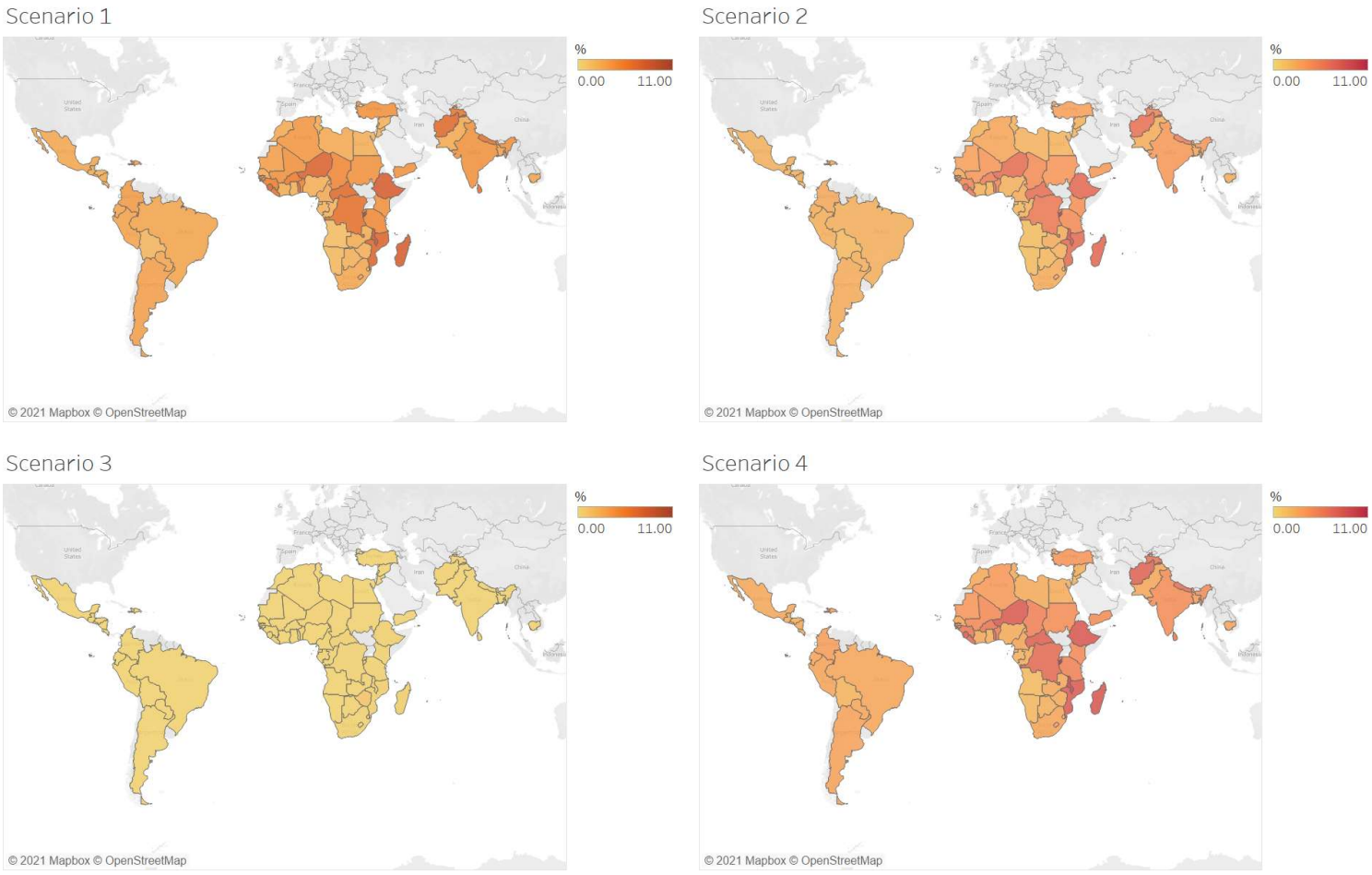


Figure 1(b): Health System Costs of COVID-19 Response per Capita as % of Total Health Spending (excl. OOP) per Capita

Scenario 1: No mitigation; **Scenario 2:** Contact reduction: high symptomatic cases/low general population; **Scenario 3:** Contact reduction: high symptomatic cases/high general population; **Scenario 4**: 30-day lockdown + low contact reduction general population

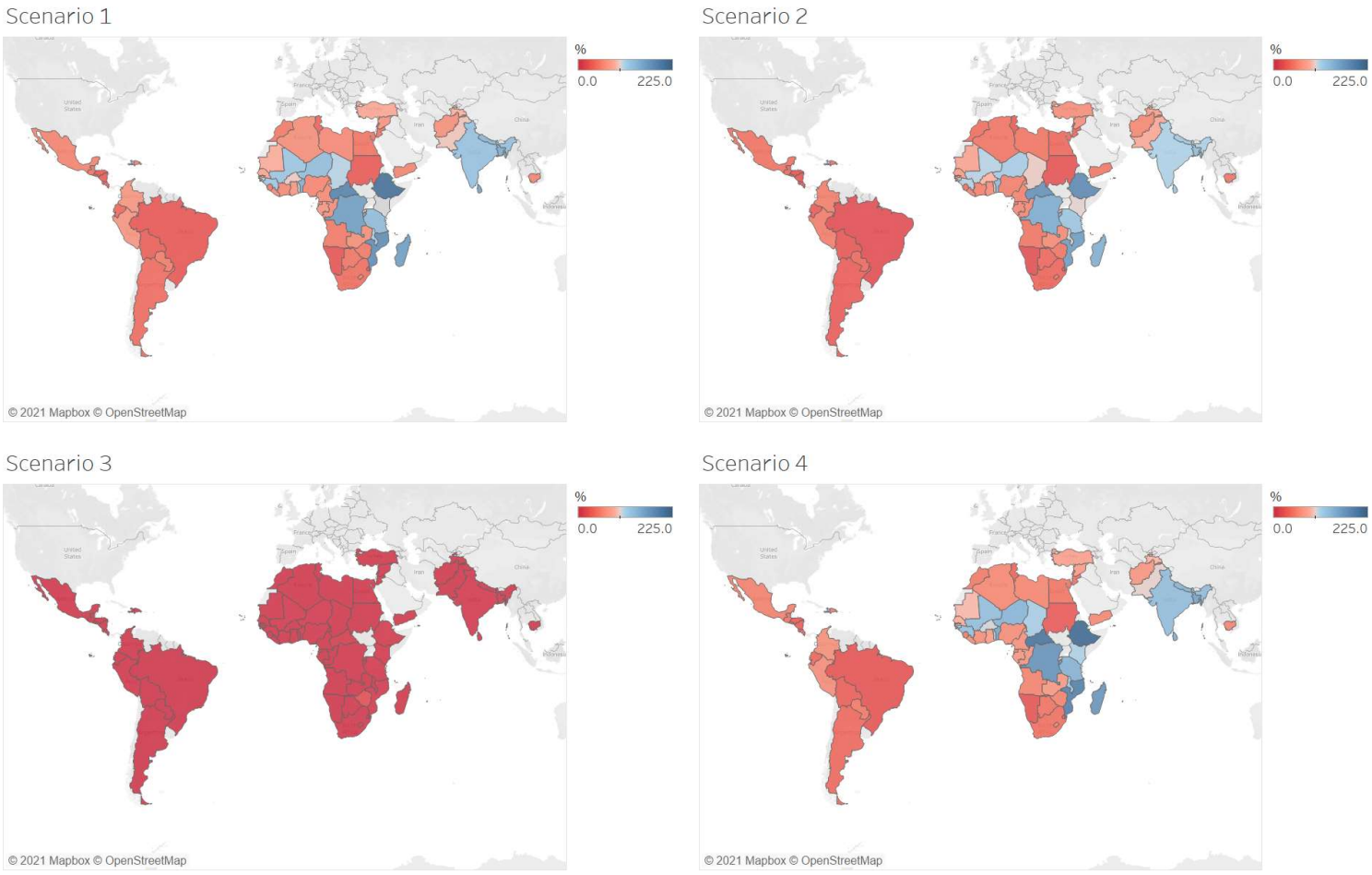


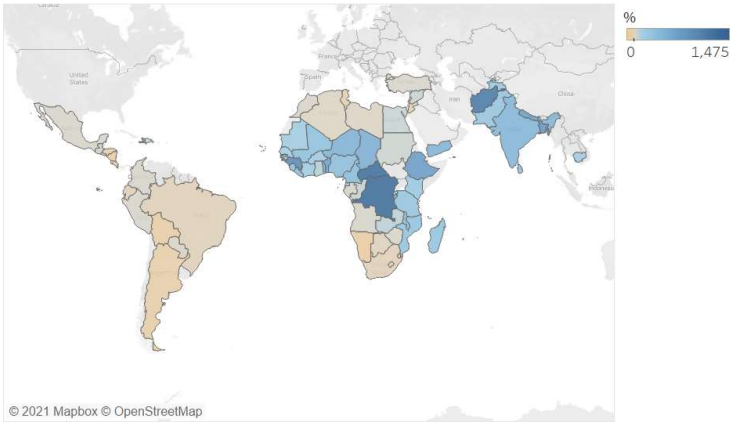
Figure 1(c): Health System Costs of COVID-19 Response per Capita as % of Total Health Spending (incl. OOP) per Capita

Scenario 1: No mitigation; **Scenario 2:** Contact reduction: high symptomatic cases/low general population; **Scenario 3:** Contact reduction: high symptomatic cases/high general population; **Scenario 4**: 30-day lockdown + low contact reduction general population

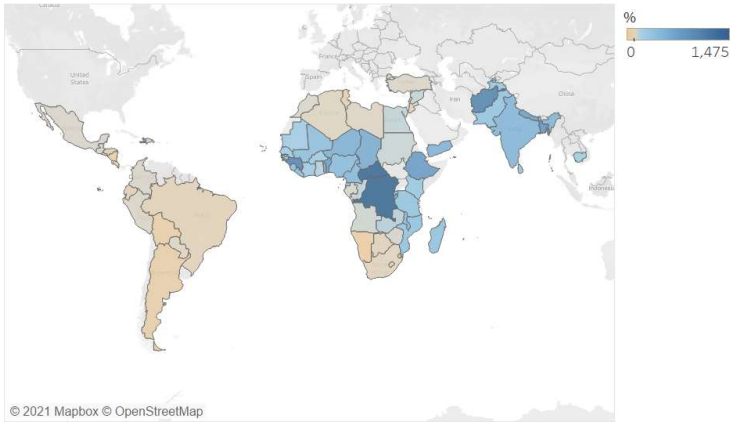
Figure 1(d): Health System Costs of COVID-19 Response per Capita as % of Government Health Spending per Capita

Scenario 1: No mitigation; **Scenario 2:** Contact reduction: high symptomatic cases/low general population; **Scenario 3:** Contact reduction: high symptomatic cases/high general population; **Scenario 4**: 30-day lockdown + low contact reduction general population

Scenario 1

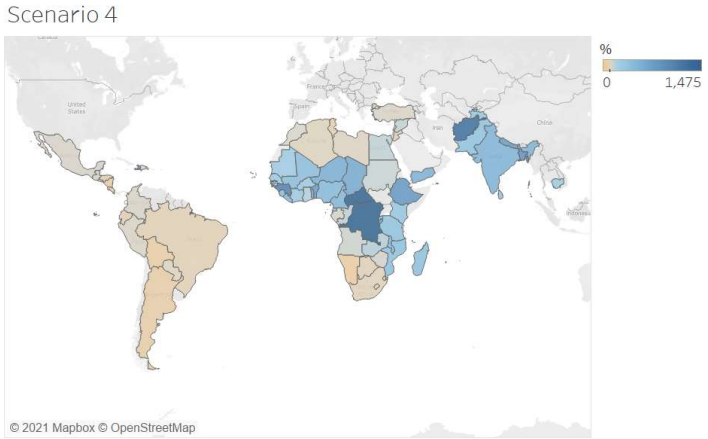


Scenario 2



Scenario 3

Scenario 4



7.4 Epilogue

The subject of this doctoral dissertation is disinvestment. As such, a costing study like the one presented in Chapter 7 may seem out of place. However, to understand the shape and magnitude of a disinvestment decision following a health system shock, it is essential to understand the costs involved. This is a particularly tricky question in the context of a global shock like the COVID-19 pandemic. Consequently, in Chapter 7, I carried out a normative, ingredients-based costing and estimated the unit costs of COVID-19 care and treatment in 129 low- and middle-income countries and total costs in 79 of them where epidemiological data were available, including Pakistan.

In Chapter 8 I will use the estimated costs of COVID-19 care and treatment in Pakistan from Chapter 7, combined with data presented in Chapters 5 and 6 from the HBP design process in Pakistan, to propose a 'smart, temporary and reduced' HBP adequate for use during pandemics.

Reflections on disinvestment

Understanding the costs of a health shock, such as those involved in the COVID-19 pandemic, is crucial to inform cross-sectoral policy decisions which include leveraging of government and donor funds, budgeting and balancing the costs of care and treatment versus those incurred by mitigating strategies. Additionally, the estimation of such costs, and in particular of the resource use involved, is essential within the health sector to understand the possible scale and nature of disruption to regular service provision.

The COVID-19 pandemic disrupted health service worldwide, particularly in the short- and medium-term, as financial and other resources were re-directed towards the care and treatment response, particularly in the months prior to the arrival of safe and effective vaccines. The estimates presented in Chapter 7 estimate the costs involved through a normative, ingredients-based manner. Under different circumstances, the costs of a new intervention would likely be obtained using primary data collection. However, given the contagious nature of COVID-19 and the strict lockdowns and restrictions on international travel, collecting primary cost data was not an option.

As described in Chapter 5, in 2019 I carried out a costing in Pakistan using a similar methodological approach. It was a welcome coincidence; when the pandemic started, I based some of my initial thinking on how to carry out the costing presented in Chapter 7 on the methods I developed and carried out in Pakistan.

The costing presented in Chapter 7 provides solid evidence on the scale of resources needed and therefore on the possible magnitude of the subsequent disinvestment. However, in retrospect, I

think it lacks some additional elements to be more useful to specific disinvestment decisions. As was the case with the costs presented in Chapter 5, the costs in Chapter 7 are also highly disaggregated by input type, which can be used to differentiate between fungible and non-fungible inputs. However, the costs presented in Chapter 7 do not take into account resource constraints. The total costs assume that all who need treatment will receive it. However, the pandemic showed that even high-income settings failed to provide high-quality treatment at all times.

While understanding the total costs of care and treatment is important in relation to leveraging funds for the respond, the absence of incorporating constraints may overestimate the magnitude of the resources required, and therefore of the subsequent level of disinvestment. For example, the costing model may estimate that the total cost of intensive care in a given country will be US$ 2 million over a 12-month period and will necessitate a maximum use of 2500 ICU beds during an epidemic peak. However, if the number of ICU beds in the country is below 2500 (and building capacity in the short-term is not possible), the actual costs incurred will be lower (as patients will be placed in lower levels of care), and therefore the resources that need to be displaced (and their associated costs) will be lower. Further development of costing models incorporating country-specific constraints would be worthwhile but, as explained in the research paper, obtaining information on the total number of key clinical inputs in low- and middle-income settings is often difficult.

7.5 References

1. WHO. *Fact Sheet 15A. Addendum to Fact Sheet 15 on National Implementation Measures for the International Health Regulations 2005 (IHR). COVID-19 as a Public Health Emergency of International Concern (PHEIC) under the IHR*. May 2020; Available from: https://extranet.who.int/sph/sites/default/files/document-library/document/FS15A_IHR_COVID19_EN_MAY_2020.pdf.
2. Dong, E., H. Du, and L. Gardner, *An interactive web-based dashboard to track COVID-19 in real time.* Lancet Infect Dis, 2020. **20**(5): p. 533-534.
3. Piccininni, M., et al., *Use of all cause mortality to quantify the consequences of covid-19 in Nembro, Lombardy: descriptive study.* BMJ, 2020. **369**: p. m1835.
4. Ricoca Peixoto, V., C. Nunes, and A. Abrantes, *Epidemic Surveillance of Covid-19: Considering Uncertainty and Under-Ascertainment.* Portuguese Journal of Public Health, 2020. **38**(1): p. 23-29.
5. WHO. *COVID-19 STRATEGY UPDATE. April 14 2020*. Available from: https://www.who.int/docs/default-source/coronaviruse/covid-strategy-update-14april2020.pdf.
6. Davies, N., et al. *The impact of Coronavirus disease 2019 (COVID-19) on health systems and household resources in Africa and South Asia*. 2020. DOI: https://doi.org/10.1101/2020.05.06.20092734.
7. Kompas, T., et al., *Health and Economic Costs of Early, Delayed and No Suppression of COVID-19: The Case of Australia.* medRxiv, 2020: p. 2020.06.21.20136549.
8. Lim, J.T., et al., *The costs of an expanded screening criteria for COVID-19: A modelling study.* Int J Infect Dis, 2020. **100**: p. 490-496.
9. Barasa, E. and A. Kairu. *What does it cost to treat a COVID-19 patient in Kenya? KEMRI Wellcome Trust Health Economics Research Unit, July 2020.* . 21 August 2020]; Available from: https://kemri-wellcome.org/zp-content/uploads/2020/07/HERU-Policy-brief-Treatment-costs-for-COVID-19-patients-in-Kenya.pdf.
10. Li, X.Z., et al., *Treatment of coronavirus disease 2019 in Shandong, China: a cost and affordability analysis.* Infect Dis Poverty, 2020. **9**(1): p. 78.
11. Jin, H., et al., *Estimating the cost-of-illness associated with the COVID-19 outbreak in China from January to March 2020.* medRxiv, 2020: p. 2020.05.15.20102863.
12. Dudine, P., K.-P. Hellwig, and S. Jahan, *A Framework for Estimating Health Spending in Response to COVID-19.* IMF Working Papers, 2020(Working Paper No. 20/145).
13. Tan-Torres Edejer, T., et al., *Projected health-care resource needs for an effective response to COVID-19 in 73 low-income and middle-income countries: a modelling study.* Lancet Glob Health, 2020. **8**(11): p. e1372-e1379.
14. WHO. *COVID-19 Essential Supplies Forecasting Tool. 29 April 2020*. Available from: https://www.who.int/publications/m/item/covid-19-essential-supplies-forecasting-tool#.
15. WHO. *Emergency Global Supply Chain System (COVID-19) catalogue. August 14 2020*. Available from: https://www.who.int/publications/i/item/emergency-global-supply-chain-system-(covid-19)-catalogue.
16. WHO. *Health Workforce Estimator (HWFE). May 15 2020*. Available from: https://www.euro.who.int/en/health-topics/Health-systems/pages/strengthening-the-health-system-response-to-covid-19/surge-planning-tools/health-workforce-estimator-hwfe.
17. Pearson, C., et al. *Projections of COVID-19 epidemics in LMIC countries. Update: June 2020.* 2020; Available from: https://cmmid.github.io/topics/covid19/LMIC-projection-reports.html.
18. World Health Organization, *COVID-19 Strategic Preparedness and Response Plan: Operational Planning Guidelines to Support Country Preparedness and Response*. 2020.

19. Vassall A, et al., *Reference Case for Estimating the Costs of Global Health Services and Interventions*. 2017.
20. Vassall, A., et al., Cost-effectiveness of Xpert MTB/RIF for tuberculosis diagnosis in South Africa: a real-world cost analysis and economic evaluation. Lancet Glob Health, 2017. **5**(7): p. e710-e719.
21. Chatterjee, S., et al., Examining the cost of delivering TB prevention, diagnosis and treatment in India, 2018 in 51st Union World Conference on Lung Health. 2020.
22. Kairu, A., et al., The costs of providing TB services in healthcare facilities in Kenya, in 51st Union World Conference on Lung Health. 2020.
23. Phase, D.C.T., *Universal Health Coverage: Essential Package of Health Services for Pakistan: A report for review by the International Advisory Group*. 2020, Ministry of National Health Services, Government of Pakistan and World Health Organisation,.
24. Davies, N.G., et al., *Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study.* Lancet Public Health, 2020. **5**(7): p. e375-e385.
25. Turner, H.C., et al., *Adjusting for Inflation and Currency Changes Within Health Economic Studies.* Value Health, 2019. **22**(9): p. 1026-1032.
26. World Bank, *World Bank Open Data*. 2020.
27. Serje, J., et al., *Global health worker salary estimates: an econometric analysis of global earnings data.* Cost Eff Resour Alloc, 2018. **16**: p. 10.
28. WHO, *Global Health Expenditure Database*.
29. Blanchet, K., et al., *Protecting essential health services in low-income and middle-income countries and humanitarian settings while responding to the COVID-19 pandemic.* BMJ Glob Health, 2020. **5**(10).
30. Craig, J., E. Kalanxhi, and S. Hauck, *National estimates of critical care capacity in 54 African countries.* medRxiv, 2020: p. 2020.05.13.20100727.
31. Schell, C.O., et al., *The global need for essential emergency and critical care.* Crit Care, 2018. **22**(1): p. 284.
32. Baker, T., et al., *Essential care of critical illness must not be forgotten in the COVID-19 pandemic.* Lancet, 2020. **395**(10232): p. 1253-1254.
33. Hale, T., et al., *Oxford COVID-19 Government Response Tracker*, B.S.o. Government, Editor. 2020.

Chapter 8: Proposing an analytical approach for disinvestment during health system shocks

8.1 Prologue

The scale and severity of the COVID-19 pandemic caused disruption in health systems across the world. As health centres and hospitals struggled to meet demand, essential services were displaced. In the absence of additional resources, some service displacement may be inevitable in times of severe shocks. However, to ensure that the displacement creates a reduced package of services that is most socially desirable, it is necessary to explicitly consider the opportunity costs of prioritising COVID-19 care and treatment over other services.

The third and final analytical section in this dissertation, composed of Chapters 7 and 8, proposes a model quantifying the potential consequences of different explicit approaches to health system wide disinvestment following health system shocks. In Chapter 8 I combine the costs of COVID-19 care and treatment presented in Chapter 7, as well as data from Pakistan's health benefit package process (Chapters 5 and 6) to propose a schematic disinvestment model that could be useful to low- and middle-income countries during pandemics, using Pakistan as a case study. Consequently, the research paper in Chapter 8 aims to answer the following research question: what are the potential consequences (in terms of costs, health outcomes and health benefit package composition) of different approaches to disinvestment following health system shocks?

Candidate's role in the research paper

The candidate, Sergio Torres-Rueda, developed the concept for this paper and set up the analytical framework. He developed the research question based on his experience working on the health benefit package design project in Pakistan and set up the scenarios according to findings from the dissertation's literature review and from the results of Chapters 4-7 of his dissertation. He collated data used in Chapters 5 and 6 (e.g., budget impact and cost-effectiveness data per intervention) and Chapter 7 (costs of COVID-19 care and treatment). He surveyed the literature to gather evidence to conduct two 'desk-based' economic evaluations to understand the value for money of two care and treatment options. He carried out the analysis in Microsoft Excel®. He wrote the initial draft of the manuscript and incorporated comments from co-authors.

Full details of contributions of other authors can be found in 'Research Paper Cover Sheet'.

8.2 Cover Sheet for Paper 5

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT

T: +44 (0)20 7299 4646
F: +44 (0)20 7299 4656
www.lshtm.ac.uk

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed for each research paper included within a thesis.

SECTION A – Student Details

Student ID Number	1702569	**Title**	Mr.
First Name(s)	Sergio		
Surname/Family Name	Torres-Rueda		
Thesis Title	Priority Setting and Disinvestment in Healthcare: Economic Evidence, Policy Processes and Potential Consequences		
Primary Supervisor	Prof. Anna Vassall		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Choose an item.	Was the work subject to academic peer review?	Choose an item.

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	Value in Health
Please list the paper's authors in the intended authorship order:	Sergio Torres-Rueda (corresponding author), Frank Sandmann, Raza Zaidi, Muhammed Khalid, Anna Vassall

Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	STR developed the concept for the paper. STR carried out the analysis. Data was collated by STR with input from MK and RZ. STR wrote the paper. FS and AV provided supervision and gave feedback on the paper.

SECTION E

Student Signature	Sergio Torres-Rueda
Date	05/04/22

Supervisor Signature	Anna Vassall
Date	05/04/22

8.3 Research Paper 5

Title

Disinvestment during system-wide supply and demand shocks: an approach to reaching a 'smart, temporary and reduced' health benefit package in pandemic times

Authors

Sergio Torres-Rueda*[1]

Frank Sandmann[1]

Raza Zaidi [2]

Muhammed Khalid[2]

Anna Vassall[1]

*Corresponding author

Institutional Affiliations

[1]London School of Hygiene & Tropical Medicine, London, United Kingdom

[2]Health Planning, System Strengthening & Information Analysis Unit, Ministry of National Health Services Regulations & Coordination, Islamabad, Pakistan

Abstract

Introduction: The disruption and high costs caused by the COVID-19 pandemic have highlighted the need to think about health benefit packages (HBP) adaptations during health system-level shocks. In the absence of substantial additional resources, COVID-19 care and treatment will displace existing interventions from the HBP. The key policy questions are what interventions should be disinvested from (even if temporarily), what criteria should be used to make these disinvestment decisions and what are the consequence of these decisions on the HBP. This paper aims to contextualise the level of resources needed to provide COVID-19 care and treatment, using Pakistan as a case study, and explore the possible outcomes of different approaches to prioritisation. In doing so, I propose an approach to examine trade-offs between prioritisation criteria which can inform the rapid design of a 'smart, reduced and temporary' HBPs during health system-level shocks. This approach may be particularly useful and feasible for countries that have recently undergone Universal Health Coverage HBP design processes.

Methods: I use data on cost, cost-effectiveness and preventable burden of disease to re-assess and reprioritise interventions in relation to incoming interventions. Data from the recent HBP design process in Pakistan is used for 88 existing interventions. I estimate the cost and cost-effectiveness of care and treatment for severe COVID-19 cases in regular hospital wards and critical cases in intensive care units (ICU) using secondary data. I explore five scenarios that exemplify different prioritisation options, including prioritising COVID-19 interventions, interventions involving the 'rule of rescue' (defined as the imperative to rescue identifiable individuals facing avoidable death), and curative interventions, as well as prioritising by cost-effectiveness, budget impact and avoidable burden of disease. I also explore the effects of the random selection of interventions for inclusion and exclusion, reflecting a situation of health system turmoil, as well as examining the consequences of relaxing the budget constraint. I compare these five scenarios with the existing HBP in terms of numbers of interventions included/excluded, total disability-adjusted life years (DALYs) averted, and breakdown of interventions included/excluded by broad disease areas.

Results: The estimated total costs and incremental cost-effectiveness ratios of providing care and treatment for severe cases and critical care in Pakistan are US$104 million and US$307 million and US$24 per DALY averted and US$865 per DALY averted, respectively. COVID-19 care and treatment interventions costs represent 17% of the total cost of the package; their introduction would displace between 9-14 interventions, depending on the method of prioritisation. Prioritising 'rule of rescue' interventions in addition could displace up to a further 20 interventions and would take up 54% of the existing budget. In nearly all scenarios the overall effectiveness of the package increases with the

introduction of COVID-19 care and treatment interventions, but the random selection of interventions has the potential to substantially reduce package efficiency. Reproductive, maternal, neonatal and child health (RMNCH) interventions are displaced in every scenario. In one scenario, disinvestment would occur in over one of every three RMNCH interventions.

Conclusion: The prioritisation approach used for disinvestment can have a wide range of consequences. Prioritising COVID-19 care and treatment interventions, as well as interventions involving the rule of rescue would consume over half of all financial resources allocated to the HBP. While the overall package efficiency is likely to improve, disinvestment will likely occur in interventions targeting the most vulnerable.

Introduction

In 2019 Pakistan embarked on a process of health benefit package (HBP) revision and design to progress towards Universal Health Coverage (UHC). A stepwise evidence-based deliberation process was followed; evidence on a wide range of candidate interventions was assessed and appraised by a series of stakeholders in a sequential manner [1, 2]. The process culminated in October 2020 with the ratification of two HBPs focused on district-level services. Due to budget constraints, a full Essential Package of Health Services (EPHS) composed of 117 interventions is expected to be introduced incrementally over the next decade. An immediate implementation package (IIP), encompassing a subset of 88 interventions from the full EPHS, was also approved and expected to be rolled out within two years. A detailed description of both packages can be found elsewhere [3].

In February 2020, approximately midway through the HBP design process, Pakistan reported the first confirmed infections of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV2) [4]; by March 2020, the World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) a global pandemic [5]. Global resource needs for COVID-19 care and treatment have been substantial [6, 7]. In addition, the pandemic has caused unprecedented pressure on health systems. Disruption to the delivery of essential services, including routine immunisation and outpatient paediatric clinic visits, were reported in Pakistan [8-10]. While the situation began to improve in late 2020 with the introduction and uptake of safe and effective COVID-19 vaccinations, cumulative morbidity and mortality outcomes have been substantial; by the end of February 2022 over 460 million recorded cases and 6 million COVID-19-associated deaths had been reported worldwide [11]. Pakistan has officially reported 1.5 million cases and 30,000 deaths, but excess mortality data suggests the number is likely to be ten times higher [11, 12].

The disruption caused by the COVID-19 pandemic, as well as the costs of care and treatment, have highlighted the need to think about how HBPs should be adapted during system-level healthcare supply and demand shocks. Despite uptake of COVID-19 vaccination, further waves associated with new variants have occurred and continue to be possible and future respiratory illness pandemics remain likely. Regretfully, expert opinion suggests that many countries remain largely unprepared for another global pandemic [13]. Preparing for disruption in HBP services in the context of pandemics therefore remains an important public health goal.

In the absence of additional funding for the health sector, the resources needed for COVID-19 care and treatment, and, more recently, vaccination, will displace other activities within the HBP. The key policy questions are what interventions should be disinvested from (even if temporarily), what criteria should be used to make these disinvestment decisions and what are the consequence of

these decisions on the HBP. In an economic sense, the optimal type of disinvestment would occur if, to create fiscal space for COVID-19 interventions, the least cost-effective interventions are removed from the package. See Figure 1 for a schematic example of optimal displacement within the healthcare budget. However, the reality is more complex. Evidence suggests that cost-effectiveness considerations are not always of paramount importance in decision-making [2]. Priority setting, whether related to investment or disinvestment decisions, involves a range of values and priorities [14].

In the context of emergency care, for example, the 'rule of rescue', defined as "the imperative to rescue identifiable individuals facing avoidable death" may trump other factors, including allocative efficiency [15, 16]. This may explain why cases of COVID-19, seen as potentially life-threatening emergencies would be treated preferentially and that, in conditions of reduced service provision, other emergency services would continue to be offered, regardless of the opportunity cost.

This paper aims to contextualise the level of resources needed to provide COVID-19 care and treatment within Pakistan's immediate implementation package. I examine the types of decisions on service prioritisation likely to have been encountered by policymakers and clinicians during the first phase of the pandemic (prior to the introduction of vaccines). I explore how different approaches to prioritisation could have led to disinvestment from different sets of interventions across disease areas and estimate changes to overall package efficiency. In doing so, I propose a method to examine trade-offs between prioritisation approaches to inform the rapid design of a 'smart, reduced and temporary' HBP during system-level healthcare supply and shocks, such as those caused by pandemics.

Methods

General approach

To arrive at a reduced 'smart, reduced and temporary' HBP adequate for shocks to the health system, such as that experienced during the COVID-19 pandemic, existing HBP interventions need to be re-assessed and re-prioritised in relation to newly incoming or reallocated interventions.

My approach is similar to that employed during deliberations of the HBP in Pakistan [2]: I assume a fixed budget envelope, based on available fiscal space and, consequently, that a limited number of interventions can be included. As a result, as new interventions, such as those addressing the COVID-19 pandemic, are added to the package, other interventions need to be withdrawn once the budget constraint is reached. To arrive at an acceptable package within a budget constraint, and to quantify trade-offs and account for opportunity costs of different alternatives, intervention effectiveness, budget impact and cost-effectiveness need to be quantified as part of an assessment process for HBP inclusion.

Contrary to the HBP design process, in preparing a 'smart, reduced and temporary' package, I assume, a priori, that certain interventions will be fixed in the package. I present a range of scenarios that fix different types of interventions to the package, which represent five principles and priorities. These are: budget impact, burden of disease, cost-effectiveness, applying the 'rule of rescue' and intervention purpose. I decided to use these five as they were (i) highlighted in the literature as important to decision-making in disinvestment (see Chapter 2 and 5), (ii) present in the priority setting process in Pakistan (see Chapter 5), and (iii) measurable in the context of our study. Through my modelling approach, I highlight the opportunity cost of prioritising different values in priority setting.

Scenario 1 is the immediate implementation package for district level services, which was developed independent of COVID-19. It contains 88 interventions and is projected to avert 40.37 million DALYs for a cost per capita of US$ 12.98 [2, 3]. I then explore four broad scenarios, all over a time horizon of 12 months.

Scenario 2 examines the introduction of hospital-based COVID-19 care and treatment (for severe and critical cases), in two situations: (a) where all interventions, including COVID-19 care and treatment, are prioritised by cost-effectiveness and no interventions are fixed to the package and (b) where COVID-19 care and treatment is prioritised and fixed to the package and all other interventions are chosen at random until the budget constraint is reached. Scenario (2a) represents the most efficient allocation of resources possible during the pandemic, and Scenario (2b)

represents a situation of health system turmoil, likely experienced by health systems around the world in the early days of the pandemic, where resources were diverted to addressing a new and urgent health challenge without proper consideration of opportunity costs.

Scenario 3 explores the principle of the 'rule of rescue' and assumes that all non-COVID-19 interventions where there was an imminent risk to life would be prioritised, alongside COVID-19 care and treatment. Once COVID-19 care and treatment and other 'rule of rescue' interventions are fixed to the package, the remaining interventions are chosen (a) by cost-effectiveness, (b) at random, (c) by budget impact (from lowest to highest) to model the impact of including the highest number of additional interventions possible, and (d) by preventable burden of disease (highest to lowest) to model the effects of attempting to maximise DALYs averted irrespective of costs, which could reflect a clinician perspective.

Scenario 4 fixes COVID-19 care and treatment, adds in 'rule of rescue' interventions in the package, and then prioritises curative interventions by cost-effectiveness, as these interventions are likely to get priority over promotive or preventive medicine. If all curative interventions fit within the package before the budgetary limit is reached, other non-curative interventions are included, prioritised by cost-effectiveness.

In Scenarios 2-4 I assume the same budget constraint as the existing IIP: US$12.98 per capita. In Scenario 5 I model a relaxation of the budget, assuming additional funding is allocated to the health sector to cover the costs of COVID-19 care and treatment. Pakistan received a US$ 200 million aid package from the World Bank as part of the Pandemic Response Effectiveness Project [17], which could be expected to increase the fiscal space for the HBP to US$ 13.88 per capita. In Scenario 5 COVID-19 care and treatment and 'rule of rescue' interventions are fixed in the package and all other interventions are prioritised according to cost-effectiveness.

For each scenario I present the total number of interventions included in the package, and the total number of DALYs averted in relation to the IIP to understand possible changes to the overall composition and efficiency of the package. I also present the number of interventions, percentage of total cost, and percentage of total DALYs averted broken down by 'cluster' by scenario to understand what approaches to prioritisation would have greatest consequences on particular types of patients. In line with Disease Control Priorities 3 (DCP3), Pakistan grouped interventions into four disease area clusters: reproductive, maternal, neonatal and child health (RMNCH), infectious diseases, non-communicable diseases and injury prevention and care (NCD & IPC), and health services [18].

Data

To model a 'smart, reduced and temporary' package in a manner that allows for the exploration of the cost-effectiveness of different combination of interventions within a certain budget envelope it was necessary to understand the cost per capita, and incremental cost-effectiveness ratios (ICERs) and DALYs of each intervention. Data on interventions currently in the IIP were collected as part of the DCP3 project [2]. Data on the cost, cost-effectiveness and burden of disease of the COVID-19 vaccination were calculated separately.

Cost, cost-effectiveness, and burden of disease of existing interventions in the IIP (excluding COVID-19 care and treatment)

All scenarios use Pakistan's existing IIP, which includes 88 interventions, as their baseline. The data were obtained from the database prepared as part of the DCP3 Country Translation project, described in detail elsewhere [2]. How these data were obtained has been described at in detail in Chapters 5 and 6. In brief, unit costs for each intervention were estimated through a normative, ingredients-based bottom-up approach. An ingredients-based costing requires the identification and subsequent valuation of all inputs needed to deliver an intervention. A cost is constructed by calculating the quantity of an input and multiplying that by the price (which stands in contrast to a top-down approach whereby overall costs or expenditures are divided by a number of outputs to calculate a unit cost). A normative approach to costing refers to an analytical choice to calculate costs of interventions 'as they ought to be' rather than as they actually are. Under a normative approach, resource use data may be obtained from guidelines or expert opinion rather than from direct observation. A normative approach may be appropriate when attempting to understand the costs of high-quality service delivery, when interventions do not yet exist in a particular setting, or when data collection is otherwise unfeasible.

The costing was carried out from a provider's perspective and calculated full economic direct costs per beneficiary per year. The list of interventions to be costed was obtained from the Disease Control Priorities 3 Essential Universal Health Coverage package. Unit costs were estimated using resource use data descriptions broken down by inputs (provided by the Ministry of National Health Services Regulation & Coordination of Pakistan) which were validated through several rounds of consultation with disease area-specific technical experts. Publicly available price data sources, assessed for appropriateness were used. See Chapter 5 and Raza et al. (2022) for further details [19].

A multiplicative factor was applied to all unit costs to account for above-service delivery costs. Unit costs were then multiplied by intervention-specific population in need data and estimated

intervention coverage. Total costs were then divided by the total population of Pakistan to calculate costs per capita per intervention. See Chapter 6 and Torres-Rueda et al. (2022) for further details [2].

Pakistan-specific data on avoidable burden of disease, in the form of disability-adjusted life years (DALYs), were obtained from the Global Burden of Disease database from the Institute of Health Metrics and Evaluation (IHME) [20]. The number of DALYs averted assigned to each intervention were obtained from the Health Interventions Prioritisation (HIP) Tool [21, 22]. To estimate cost-effectiveness, ICERs were largely sourced from the Tufts Medical School Global Health Cost-Effectiveness Analysis (GHCEA) registry and localised (see Appendix 5.5). Remaining ICERs were extracted from the HIP Tool, which were in turn sources from DCP3. Further details can be found elsewhere [2, 23].

Cost, cost-effectiveness, and burden of disease of COVID-19 care and treatment

Unit costs of hospital-based care and treatment were calculated per day of hospitalisation for severe cases and critical cases. Severe cases were assumed to be treated in general hospital wards and critical cases in intensive care units (ICUs). Costs were calculated through a normative, ingredients-based approach using secondary data. The health sector response by activity was initially defined using international guidelines. Some activities were adapted to reflect 'real-world' resource use in low- and middle-income countries (LMICs). Resource use estimates and price data were obtained from the DCP3 project and validated by Ministry of Health Services, Regulation & Coordination in Pakistan. The costing approach is described in detail in Chapter 7 and in Torres-Rueda et al. (2021) [6]. I assumed the length of stay in hospital was 8 days for severe cases and 10 days for critical cases [24]. I multiplied the unit cost per day of hospitalisation by severity by the number of days of hospitalisation to obtain the cost per severe case and per critical case.

Epidemiological outcomes in Pakistan over the initial 12-month period were estimated using modelling projections for the COVID-19 pandemic from the COVIDM model produced by the Centre for Mathematical Modelling of Infectious Diseases (CMMID) at the London School of Hygiene & Tropical Medicine (LSHTM) [25]. The model projects the numbers of severe and critical cases, and deaths under 57 different mitigation scenarios combining a range of non-pharmaceutical interventions (NPIs), such as physical distancing and isolating of positive cases. COVIDM is a compartmental model with four compartments (Susceptible, Exposed, Infectious and Removed) and it is age-structured (five-year bands). Susceptible individuals acquire infection at a given rate. Age-specific mixing patterns of individuals alter their likelihood of exposure to the virus. The model was calibrated using country specific age structures for 92 countries.

It is difficult to determine which of the COVIDM scenarios, published in June 2020, proved to be most accurate in predicting true cases and deaths; the number of official cases and deaths reported in most countries is likely to have been under-ascertained, particularly in the early days of the pandemic when testing was not widely available. To guide our decision on which COVIDM scenario to use, I cross referenced the COVIDM estimates with a systematic analysis on excess mortality per country (the COVID-19 Excess Mortality study) which estimates the excess mortality during the COVID-19 pandemic in 191 countries from January 2020 to December 2021. Researchers collected all-cause mortality reports in 74 countries during the pandemic and over a decade earlier. Excess mortality was calculated by estimating expected mortality and mortality linked to anomalies (e.g., heat waves), and removing these estimates from estimates on all-cause mortality during the pandemic. A regression model was built to estimate COVID-19 mortality in countries where all-cause mortality data were not available using 15 covariates pertaining to each setting's health system indicators, population health indicators and COVID-19-specific parameters.

The COVID-19 Excess Mortality Study suggested that the true number of deaths in Pakistan in 2020-2021 was 664,000 [12]. I consequently chose Scenario 21 in the COVIDM model, as it most closely matched this projection numerically. The total number of severe and critical cases in Scenario 21 were then multiplied by the unit cost per hospitalisation for severe and critical cases and by the estimated intervention coverage to obtain the total cost of COVID-19 care and treatment. These total costs were then divided by the population of Pakistan to obtain costs per capita.

To estimate the burden of disease, I obtained the number of deaths from Scenario 21 in the COVIDM model, broken into 15-year age bands. I then divided the number of deaths further, into 5-year age bands, weighting them proportionally using demographic data [26]. DALYs for premature deaths by 5-year age bands were obtained from Pearson et al (2021) [27], following the approach of Briggs et al. (2021) [28]. See Appendix 8.1 for further information on the total number DALYs per age. Number of deaths per age group were multiplied by average DALYs for premature deaths to obtain the total number of DALYs in the country. See Appendix 8.2 for the number of estimated deaths per age range by level of care provided. Disability due to COVID-19 was not incorporated in the DALY calculations as not expected to vary substantially between interventions and comparators.

The above data was used to estimate two ICERs: (1) ICU care for critical COVID-19 cases (with general ward hospital care as a comparator) and (2) general ward care for severe COVID-19 cases (with no hospital care as a comparator). The probabilities of death per severity and level of care were obtained from various sources as applied in a recent cost-effectiveness study of hospital-based COVID-19 care and treatment in Kenya [29-31]. This study was chosen as both Kenya and Pakistan

are lower-middle income countries and therefore it is plausible their quality of care at the hospital level is comparable.

Table 2 summarises key parameters used in the cost-effectiveness models.

Results

Appendix 8.3 has data on the cost per capita, DALYs averted and ICER values of the 88 IIP interventions, as well as information on cluster, rule of rescue status and intervention purpose per intervention.

Costs, burden of disease and cost-effectiveness of COVID-19 care and treatment interventions

The estimated total costs of providing hospital-based care and treatment for 391,367 severe COVID-19 cases in Pakistan was US$104.32 million, amounting to a cost per capita of US$0.47. The intervention was expected to avert 4.31 million DALYs across the country, compared to 43,160 thousand DALYs in the absence of any hospital-based care. The ICER of care and treatment for severe cases in general ward was estimated at US$24.41 per DALY averted. When compared to interventions in the IIP, the intervention ranks as the 11th most cost-effective intervention in the package.

The total cost of providing hospital-based care and treatment in ICU for 167,346 critical cases was estimated at US$370.14 million, amounting to a cost per capita of US$1.68, and expected to avert 1.47 million DALYs. The comparator, the care and treatment of critical cases in regular wards, was estimated to cost US$55.76 million and to avert 1.10 million DALYs. The ICER for care and treatment for critical cases in ICU was estimated at US$864.86 per DALY averted, the 73rd most cost-effective intervention in the package.

Number of interventions included/excluded and changes in DALYs averted in each scenario

Appendix 8.4 contains the list of 88 IIP interventions detailing which intervention was included and displaced in each scenario. Figure 2 shows the number of interventions included and excluded in each scenario. Figure 3 shows the differences in DALYs averted between each scenario and the IIP.

The IIP contains 88 interventions. COVID-19 adds two interventions to the package: care and treatment of severe cases in regular hospital wards and care and treatment of critical cases in ICU at a total cost per capita of US$2.15, representing 17% of the total cost per capita of the IIP.

Assuming a fixed budget of US$12.98 per capita, the introduction of care and treatment would require the full withdrawal of 9 interventions when prioritisation is done by cost-effectiveness (Scenario 2a), and 14 interventions if there is no prioritisation for non-COVID care and treatment interventions (i.e., with interventions effectively chosen at random) (Scenario 2b). The effect of disinvestment of these interventions on the total effectiveness on the package is substantial: when prioritising by cost-effectiveness the number of DALYs averted by the package increases by 4.90

million in relation to the IIP. In the scenario where prioritisation happens at random, the number of DALYs averted by the package instead decreases by 4.82 million.

The 28 'rule of rescue' interventions in the IIP have a combined total cost of US$5.74 per capita, representing 44% of the costs per capita of the package. Once they are fixed to the package, alongside the two care and treatment interventions, the remaining fiscal space for all other interventions totals US$5.09 per capita (39% of the total fiscal space available). The number of interventions that would need to be fully withdrawn varies greatly depending on the method of prioritisation of remaining interventions: 26 if prioritisation is carried out by cost-effectiveness (Scenario 3a), 21 if remaining interventions are chosen at random until fiscal space is saturated (Scenario 3b), 4 if prioritisation takes place budget impact (from low to high) (Scenario 3c) and 34 if prioritisation is done by preventable burden of disease (high to low) (Scenario 3d). The impact of prioritising COVID-19 care and treatment and 'rule of rescue' interventions on the effectiveness of the package is positive: the package averts an additional 4.83 million when remaining interventions are prioritised by cost-effectiveness, 3.97 million DALYs when no prioritisation criterion is used, 3.77 million DALYs when interventions are prioritised by budget impact and 4.80 million when prioritisation is done according to burden of disease.

Curative interventions not classified as involving the 'rule of rescue' account for 30 of the 88 interventions in the IIP, with a total cost per capita of US$3.51. Once they are included in the package, alongside COVID-19 care and treatment and 'rule of rescue' interventions (Scenario 4), the remaining fiscal space is US$1.58 (12% of the total package) for a possible 30 remaining interventions. Once these 30 interventions are ranked by cost-effectiveness, 16 need to be withdrawn from the package, resulting in an increase in efficiency in the package of 4.28 million DALYs averted.

Finally, the relaxation of the budget constraint, made possible by donor aid, increases the fiscal space of the IIP by US$0.90 (or 7%) per capita. Once care and treatment and 'rule of rescue' interventions are fixed to the package, 52 additional interventions can be included in the package, leading to the exclusion of 8 interventions, as seen in Scenario 5. This relaxation of the budget constraint increases the number of DALYs averted by 4.96 million.

Variation in displacement by cluster

Figure 4 shows (a) the number of interventions, (b) the percentage of total cost per capita, and (c) the percentage of total DALYs averted broken down by cluster by scenario. The RMNCH cluster accounts for 42 of the 88 interventions in the IIP, as well as for 50% of the total costs per capita and

68% of total DALYs averted in the IIP. Once COVID-19 care and treatment interventions are introduced, the number of RMNHC interventions decrease in all scenarios. Nearly one out of every four RMNHC interventions are displaced from the package in Scenarios 3a, 3b and 4, once 'rule of rescue' and curative interventions are fixed to the package. In Scenario 3d, once interventions are prioritised by burden of disease, over one in every three RMNHC interventions are displaced. This displacement leads to a decrease in the relative spending on RMNCH interventions in the package from 50% in IIP to 39%-43%, as well as a decrease in the total number of DALYs averted by cluster, from accounting for 68% of DALYs averted down to 60%. The random allocation of interventions into the package in Scenario 2b disfavours the infectious disease cluster; while only 3 out of 12 interventions in the infectious disease cluster are removed, the percentage of DALYs averted decreased from 26% to 5% of the total DALYs in the package.

Discussion

This paper aimed to contextualise the level of resources needed to provide COVID-19 interventions within Pakistan's health benefit package when faced with unprecedented interruptions to healthcare delivery. I propose a simple and pragmatic method to arrive at a 'smart, reduced and temporary' package that could be used for rapid decision-making on disinvestment during system-wide shocks, such as during pandemics, to accommodate health needs within the realities of financial constraints. This method is particularly useful and feasible for countries that have recently undergone Universal Health Coverage HBP design processes as these countries should have most of the relevant data required.

During the HBP design process in Pakistan all candidate interventions were assessed and appraised. In our model, however, I use the existing assessment of interventions from the HBP design process and limit the number of interventions that need to be appraised as I assume that the there are certain types of interventions that policymakers and clinicians will not disinvest from in practice, such as 'rule of rescue' interventions, including COVID 19 care and treatment interventions. By a priori accepting that some interventions will be fixed in the package, and quantifying the consequently available fiscal space, the decision-making process is simplified, and the trade-offs will be fewer. Importantly, by using such a method, the disinvestment choice is made explicitly, transparently and with a clear understanding of opportunity costs.

I find that the costs of only two COVID-19 care and treatment interventions make up a considerable proportion of the total costs of the IIP (17%). In the absence of additional funding for the health sector, the inclusion of these two interventions will force disinvestment from other interventions and displace them from the package. While the costs of COVID-19 care and treatment interventions are considerable, they also avert a large number of DALYs and are comparatively cost-effective.

In our scenarios I fix certain interventions in the package (COVID-19 care and treatment, 'rule of rescue' interventions and curative interventions) and then use different prioritisation criteria to determine which other interventions remain in the package up until the point when the budget constraint is reached. When I prioritise by cost-effectiveness, I find that the overall efficiency of the package increased, which is to be expected as the cost-effectiveness of the COVID-19 care and treatment interventions is within the range of existing IIP interventions. Consequently, interventions displaced will be comparatively less cost-effective than COVID-19 care and treatment. However, when no criteria were used to prioritise interventions, and in effect interventions were chosen at random, the overall efficiency of the package increased in one scenario and decreased in another. The package in Scenario 2b lost nearly 5 million DALYs (12% of total DALYs) because, in the

aggregate, the interventions that were removed from the package were more cost-effective than those being introduced. There is no reason why the selection of interventions for inclusion and exclusion in the real world would mimic the selection in Scenario 2b. However, the point here illustrated is that packages can become substantially less efficient at a time of turmoil in the health system if disinvestment decisions are not evidence informed.

In this analysis I show both the number of interventions displaced and the changes in DALYs averted as a result. While from a point of view of efficiency it is better to maximise the number of DALYs within the budget constraints, there may be reasons why policymakers may not want to reduce the total number of interventions, particularly if those interventions are situated within key flagship programmes, or address important priority areas, such as RMNCH.

During the first year of the COVID-19 pandemic, some advocated for the protection of the most essential non-COVID services to ensure continued access. Blanchet et al. (2020), for example, proposed a list of 120 highest priority interventions, based on DCP3, to be delivered without interruptions during the pandemic [32]. However, severely resource constrained settings such as Pakistan had even fewer interventions (only 88) in its HBP before the COVID-19 pandemic began. The choices faced in deciding what interventions to disinvest from are all the harder in these settings as opportunity costs are higher. Actionable quantitative rankings of intervention urgency (defined as impact of delaying access to a service) would be a useful addition to the work by Blanchet and colleagues; it could facilitate evidence-based disinvestment decision-making and be integrated into a simple model like ours.

In this paper I estimate that COVID-19 care and treatment interventions are within the bound of cost-effectiveness of the IIP in Pakistan. As a result, strictly from a position of efficiency, the trade-offs of including COVID-19 care and treatment interventions are straightforward. COVID-19 interventions appear to satisfy both an ethical imperative to "not stand idly by when an identified person's life is visibly threatened if rescue measures are available" [33], therefore abiding by the 'rule of rescue', and the utilitarian principle to maximise health utility with available resources as, overall, no DALYs averted were foregone. However, care and treatment may be less cost-effective in other settings (or in future pandemics), or the number of cases that require hospitalisation may be even higher. In those circumstances, the trade-offs between saving an identifiable life and the value of alternative uses for those resources will be all the more stark and complex. Therefore, quantifying the opportunity cost of different available options in preparation for such an eventuality, and collecting and collating relevant criteria for decision-making beforehand, is important. Further, even if comparatively cost-effective, fixing COVID-19 care and treatment and other 'rule of rescue'

interventions to the package will displace interventions which address maternal, neonatal and child health. Equity considerations should also be raised in the disinvestment decision-making process and the question of whether a package where more than half of resources go towards COVID-19 care and treatment and 'rule of rescue' interventions, at the expense of reduced access to healthcare for the most vulnerable, accurately reflects societal values. To better incorporate equity considerations into decision-making, greater strides should be made to quantitatively score the equity impact of interventions in specific settings.

Limitations of the model

This model has several limitations and could be improved by adding complexity in five areas that better reflect real world conditions. First, I assumed that once an intervention was prioritised for inclusion, it would be funded so that the target coverage set in the IIP would be met. While in the process of HBP design it was important to set ambitious target coverages to ensure equity and financial risk protection [3], in a pandemic situation decisionmakers may choose to temporarily reduce target coverage rates in order to use available resources across a greater number of interventions. This was evidenced in Chapter 4, where cotrimoxazole preventive therapy in Uganda was not discontinued altogether but rather its access was restricted to certain populations (e.g., pregnant women, people suffering from treatment failure).

Second, our analysis assumed a one-year time horizon. However, the disinvestment of certain interventions can increase costs (and worsen health outcomes) in subsequent implementation years. For example, interruption of HIV/AIDS or TB treatment can lead to treatment failure which necessitate more aggressive and costly treatment. I do not account for the medium- and long-term consequences of disinvestment, including higher future costs, which could be substantial. While adding both considerations would make our model more realistic, it would also add a level of analytical complexity that may delay rapid decision-making.

Third, this study is highly stylised. It does not acknowledge that not all constraints can be relaxed with increased funding in the short-term. For example, highly skilled human resources often need years of training, hospitals cannot be built and equipped in a matter of weeks, and, in the context of a global pandemic, shortages of key equipment, such as mechanical ventilators, may limit in-country service delivery. Conversely, complete displacement of all input used in interventions is unlikely to happen in practice. While some inputs are fungible (e.g., clinical staff who can be redeployed to perform a range of activities), others are not (e.g., highly specialised equipment). The cost estimates (and budget impact implications) included in my model take into account both fungible and non-

fungible inputs. If an intervention is displaced, it is therefore unlikely that the entirety of the cost assumed for that intervention could reallocated to a different intervention.

Fourth, the model does not incorporate health system constraints and treats interventions as independent of one another, which is not always the case. COVID-19 interventions, such as treatment for severe and critical cases, may put significant pressure on first-level hospitals. It may therefore not be feasible to prioritise other first-level hospitals concurrently and a better use of resources may be to focus resources on other delivery platforms.

Lastly, the criteria that were used to determine which interventions should be fixed to the package were derived from the published literature and from research presented in Chapters 4 and 6. Ideally, however, these prioritised criteria should be derived through elicitation with both policymakers and clinicians in the study settings to better understand 'red lines' (i.e., a realistic, context-specific sense of which interventions are unlikely to be discontinued).

Future iterations of this work should try to build a more complex model that accounts for variation in coverage rates, longer time horizons, fungibility of inputs and health system constraints, as well as context-specific decision criteria for both policymakers and clinicians.

Limitations on data used

It is important to analyse and acknowledge limitations with the data used in this analysis. First, I use cost and cost-effectiveness data on IIP interventions estimated prior to COVID-19. However, the pandemic has changed service delivery for non-COVID interventions in many settings: additional levels of personal protective equipment has been mandated, organization changes have been put in place, and telemedicine approaches have gained traction [34-36]. Whether these changes will be long-lasting is unclear. If they are, cost and cost-effectiveness estimates will need to be adjusted to reflect the different opportunity costs of non-COVID-19 interventions.

Second, my cost-effectiveness estimates are based on epidemiological data from other settings, both for COVID-19 interventions and non-COVID-19 ones. While efforts were made to find data relevant and from similar settings, there is uncertainty around these parameters in the Pakistani context.

Lastly, there are difficulties in using modelled projections of transmission, as well as combining projections from different models, in this case the COVIDM model and the COVID-19 Excess Mortality data. The COVIDM model was parameterised in the early months of the pandemic when certain key factors about transmission were misunderstood or unknown. Notably, there was

considerable uncertainty on the effect of infection on immunity, on the probability of reinfection, on the extent of asymptomatic or pre-symptomatic transmission, and on whether the main mode of transmission was through fomites or aerosols. Further, the model was developed before the appearance of more contagious and virulent variants. If models of these kind are used to inform resource allocation decisions early in pandemics, it is inevitable that certain key parameters will be uncertain. Sensitivity analyses should be incorporated systematically.

In terms of the suitability of the model to specific contexts, the COVIDM also has limitations. While the model was developed using country-specific age structures, contact pattern data were not available from every setting. Therefore, the contact patterns used to populate the model for Pakistan were obtained from a different setting. While it is perhaps unreasonable to assume that a model covering a large number of countries would have country-specific data for all parameters (particularly at a moment of uncertainty such as the first year of the COVID-19 pandemic), using contact pattern data from a different country could bias results. Social contact can vary dramatically between settings [37]. Differences in socio-economic factors (e.g., size of household), cultural factors (e.g., intergenerational households) and religious factors (e.g., interaction between men and women outside the household) will lead to different overall contact patterns. The need for data, evidenced during the COVID-19 pandemic should be used as a call for donors and funders to invest in research on social contact patters in a wide range of settings.

Further, it is important to emphasise that COVIDM estimates transmission in relation to specific mitigation scenarios assuming specific reductions in contact within and between age groups (e.g., assuming school closures mean 100% reduction in contact between children). What the model cannot do is predict whether, in the real world, specific mitigation policies lead to specific reductions in contact. Populations in different countries complied differently to similar mitigations measures, these measures were policed more or less stringently in different settings, and compliance and policing varied in individual settings over time [38]. These is why it is important for these kinds of models to not be seen as strictly predictive, but rather as suggestive of a range of possible outcomes.

The COVID-19 Excess Mortality model is also subject to a number of limitations. First, there are often long lags between deaths and registration of deaths. Therefore, all-cause mortality data, particularly for the final months of 2021 may be incomplete (the work was done in early 2022). Secondly, while studies in selected high-income countries suggest that excess mortality during the COVID-19 pandemic can largely be attributed to COVID-19, this may not be the case everywhere. Excess mortality in other settings could also be attributable to spill over effects from the health system

response to the pandemic (i.e., displacement of other services). Conversely, social distancing mitigation strategies may have also led to changes in all-cause mortality (e.g., fewer deaths due to reduction in traffic accidents and more deaths due to intimate partner violence). Therefore, it is unlikely that all excess mortality reported can be attributed to COVID-19 across all settings, particularly those with weaker health systems which struggled to cope with provision of regular services during the pandemic. Lastly, disaggregation of national-level data on all-cause mortality by age and gender varies greatly by country; extrapolating COVID-19 mortality in the base 74 countries is difficult, and therefore building predictive models across other countries taking into account national age structure and gender balance is not possible. Lastly, Pakistan was not one of the 74 countries where all-cause mortality prior to the COVID-19 pandemic were available. All-cause mortality prior to the pandemic was modelled using data from other settings and therefore estimates carry a greater degree of uncertainty. Direct observation data would have been preferable.

In addition to the limitations of the individual models, an important limitation of trying to combine data from these two models relates to different time horizons used. The estimates in the COVID-19 Excess Mortality study are reported over a 24-month period (from 1 January 2020 to 31 December 2021) whereas those of the COVID-M model refer to a 12-month period from the point of the start of the epidemic in each country (which, in reality, varied by country with some reaching their first epidemic peaks earlier in 2020 than others). The COVID-19 Excess Mortality study only reports base case estimates per country while the COVIDM model reports deaths, cases and hospitalisations over 57 mitigation scenarios.

In my analysis, I needed to use an estimate of deaths, as well as total cases and hospitalisations. The COVIDM model contained these estimates, but it was difficult to decide which mitigation scenario best represented what had actually happened in Pakistan. Given global under ascertainment of deaths and cases, I did not want to use official government data. I decided to use the estimates of COVID-19 deaths from the COVID-19 Excess Mortality model, and then match that number to a COVIDM scenario. However, given the COVID-19 Excess Death model expressed deaths over a 24-month period, and COVIDM over 12 months, I divided the total number of deaths in COVID-19 Excess Death model equally between the two years. This is problematic because deaths are unlikely to be evenly distributed across the 24-month period, given the dynamics of the epidemic, with peaks at different points in time, as well the introduction of variants with greater associated mortality.

Conclusions

I present an approach that could be used for rapid decision-making on disinvestment during system-wide shocks. This approach requires using data on intervention budget impact, cost-effectiveness and preventable burden of disease, both for interventions currently delivered and those related to the system shock. For existing interventions these data can be leveraged from datasets prepared for health benefit package design processes (see Chapters 5 and 6). Rapid estimation methods may be used for interventions related to the system shock (see Chapter 7 for budget impact).

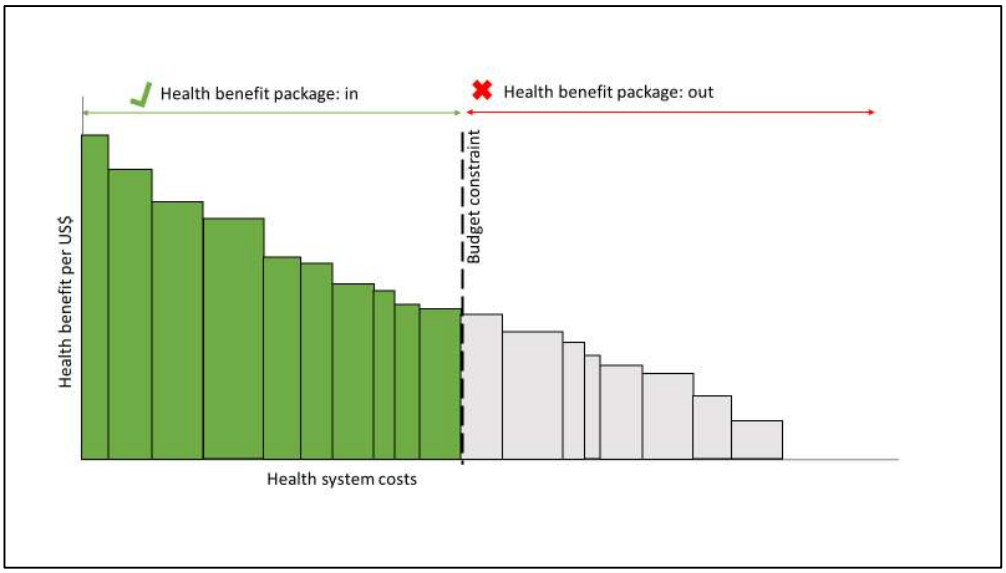
The findings suggest that different prioritisation approaches used for disinvestment can have a wide range of consequences on health benefit package composition and efficiency. Prioritising COVID-19 care and treatment interventions, as well as interventions involving the 'rule of rescue', would consume over half of all financial resources allocated to the package in Pakistan. The overall package efficiency is likely to improve in most of the scenarios where an explicit criterium was prioritised. However, if remaining interventions were selected at random (emulating a situation of disorder likely experienced at the start of a crisis), there is a potential for a substantial reduction in package efficiency. Across scenarios disinvestment will likely occur in interventions targeting the most vulnerable. RMNCH interventions are displaced across, and, in one scenario, disinvestment would occur in over one of every three RMNCH interventions. Additional work should be carried out to define and quantify intervention urgency as an explicit decision criterium to further inform policymakers. Further, it should be noted that COVID-19 interventions in this model were more cost-effective than the least cost-effective intervention in the package. Should interventions for future pandemics or crises be less cost-effective, the choices policymakers will have to make will be more stark as they will be confronted more directly with whether prioritising the 'rule of rescue' is socially desirable in all situations, which may require reflection on what are acceptable opportunity costs.

While this model should be regarded as a proof of concept, several alterations could allow it to be more useful in decision-making in practice. These include flexibility on target coverage rates, longer time horizons for certain interventions (especially those involving infectious disease), more conservative assumptions on input fungibility, resource reallocation and relaxation of resource constraints, and, finally, the development of context specific 'red lines' for disinvestment elicited from local policymakers and clinicians to develop analytical scenarios.

Tables and Figures

Figure 1: Schematic representation of optimal displacement. Each bar represents an intervention. Interventions are arranged by cost-effectiveness (with the most cost-effective intervention at the far left and the least cost-effective on the far right). Bars to the left of the budget constraint are included in the health benefit package (green) and those to the right (grey) are excluded.

(a) Health benefit package prior to COVID-19: The budget constrain allows for the inclusion of ten interventions in the health benefit package.



(b) Health benefit package prior to COVID-19: Once COVID-19 care and treatment are included in the health benefit package, and in the absence of additional funding, three interventions are displaced (blue). In an optimal situation, those interventions displaced would be the least cost-effective of those previously included.

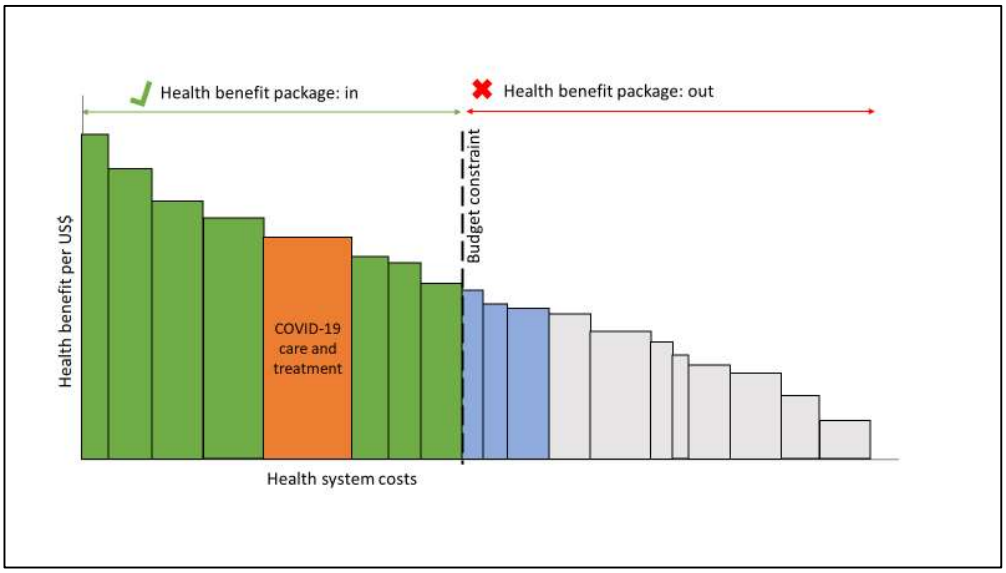


Table 1: Prioritisation scenarios modelled

Scenario name	Fiscal space	Care and treatment for severe cases in general ward	Care and treatment for critical cases in ICU	Prioritisation for non-fixed interventions	Rationale
(1) IIP	Current	No	No	N/A	Base case: Represents the benefit package designed without COVID-19 interventions.
(2a) IIP + CT (CE prioritisation)	Current	Yes (not fixed)	Yes (not fixed)	By CE	Scenarios represent the beginning of the COVID-19 pandemic (before the arrival of vaccines). Scenario (a) captures a situation where COVID-19 care and treatment is not prioritised and all interventions are prioritised according to cost-effectiveness. Scenario (b) represent a scenario of turmoil in the health system: COVID-19 care and treatment is prioritised; there is no other prioritisation criteria for all other interventions in the package (random selection).
(2b) IIP + CT (no prioritisation)	Current	Yes (fixed)	Yes (fixed)	Random	
(3a) IIP + CT + RR (CE prioritisation)	Current	Yes (fixed)	Yes (fixed)	By CE	Scenarios represent the implementation of both COVID-19 and care and treatment and all rule of rescue interventions. Remaining interventions are prioritised by (a) cost-effectiveness, (b) random selection, (c) budget impact (low to high) and (d) preventable burden of disease (high to low).
(3b) IIP + CT + RR (no prioritisation)	Current	Yes (fixed)	Yes (fixed)	Random	
(3c) IIP + CT + RR (by budget impact: low)	Current	Yes (fixed)	Yes (fixed)	By budget impact	
(3d) IIP + CT + RR (by preventable burden of disease: high)	Current	Yes (fixed)	Yes (fixed)	By preventable burden of disease	
(4) IIP + CT + RR + curative (CE prioritisation)	Current	Yes (fixed)	Yes (fixed)	By CE	Scenarios explore, in addition to COVID-19 care and treatment and 'rule of rescue' interventions, the prioritisation of curative interventions.
(5) IIP + CT + RR: expanded fiscal space (CE prioritisation)	Expanded	Yes (fixed)	Yes (fixed)	By CE	Assumes an increase in total fiscal space of US$200 million as per World Bank assistance package in 2020.

IIP= immediate implementation package, CT= COVID-19 care and treatment interventions, RR= 'rule of rescue' interventions, CE=cost-effectiveness, ICU= intensive care units.

Table 2: Parameters used to estimate ICERs of care and treatment of severe cases in general ward and care and treatment of critical cases in ICU

	Value	Source
Costs		
Severe cases: general ward		
Cost per day of hospitalisation (US$)	33.32	Torres-Rueda et al. (2021) [6]
Mean number of days of hospitalisation per severe case	8	Davies et al. (2020) [24]
Severe cases: no care		
Cost per day of hospitalisation (US$)	0	Assumption
Mean number of days of hospitalisation per severe case	0	Assumption
Critical cases: ICU		
Cost per day of hospitalisation (US$)	221	Torres-Rueda et al. (2021) [6]
Mean number of days of hospitalisation per case	10	Davies et al. (2020) [24]
Critical cases: general ward		
Cost per day of hospitalisation (US$)	33.32	Torres-Rueda et al. (2021) [6]
Mean number of days of hospitalisation per case	10	Davies et al. (2020) [24]
Effectiveness		
Severe cases		
Total cases (12 months)	1,223,021	COVIDM model (Scenario 21) [25]
Intervention coverage (general ward)	32%	Average coverage of first-level hospital interventions; Torres-Rueda et al. (2022) [2]
Proportion of surviving cases (general ward)	0.99	Liu et al (2020) [31]; Kairu et al. (2021) [29]
Proportion of surviving cases (no access to care)	0.01	Kairu et al. (2021) (inferred) [29]
Critical cases		
Total cases	522,956	COVIDM model (Scenario 21) [25]
Intervention coverage (general ward)	32%	Average coverage of first-level hospital interventions; Torres-Rueda et al. (2022) [2]
Proportion of cases that progress to death(ICU)	0.604	Elhadi et al. (2021) [30], Kairu et al. (2021) [29]
Proportion of cases that progress to death (general ward)	0.80	Assumption; average of % of surviving critical cases between access to ICU (0.604) and no access to care (1.0), as per Kairu et al. 2021 [29])
Cost-effectiveness		
DALYs due to premature death by age band	Variable	Pearson et al. (2021) [27]; see Appendix 8.1
Number of deaths by age band, severity and care type	Variable	World Population Prospects 2019 [26], COVIDM model [25]; see Appendix 8.2

Figure 2: Number of interventions included/excluded in each scenario

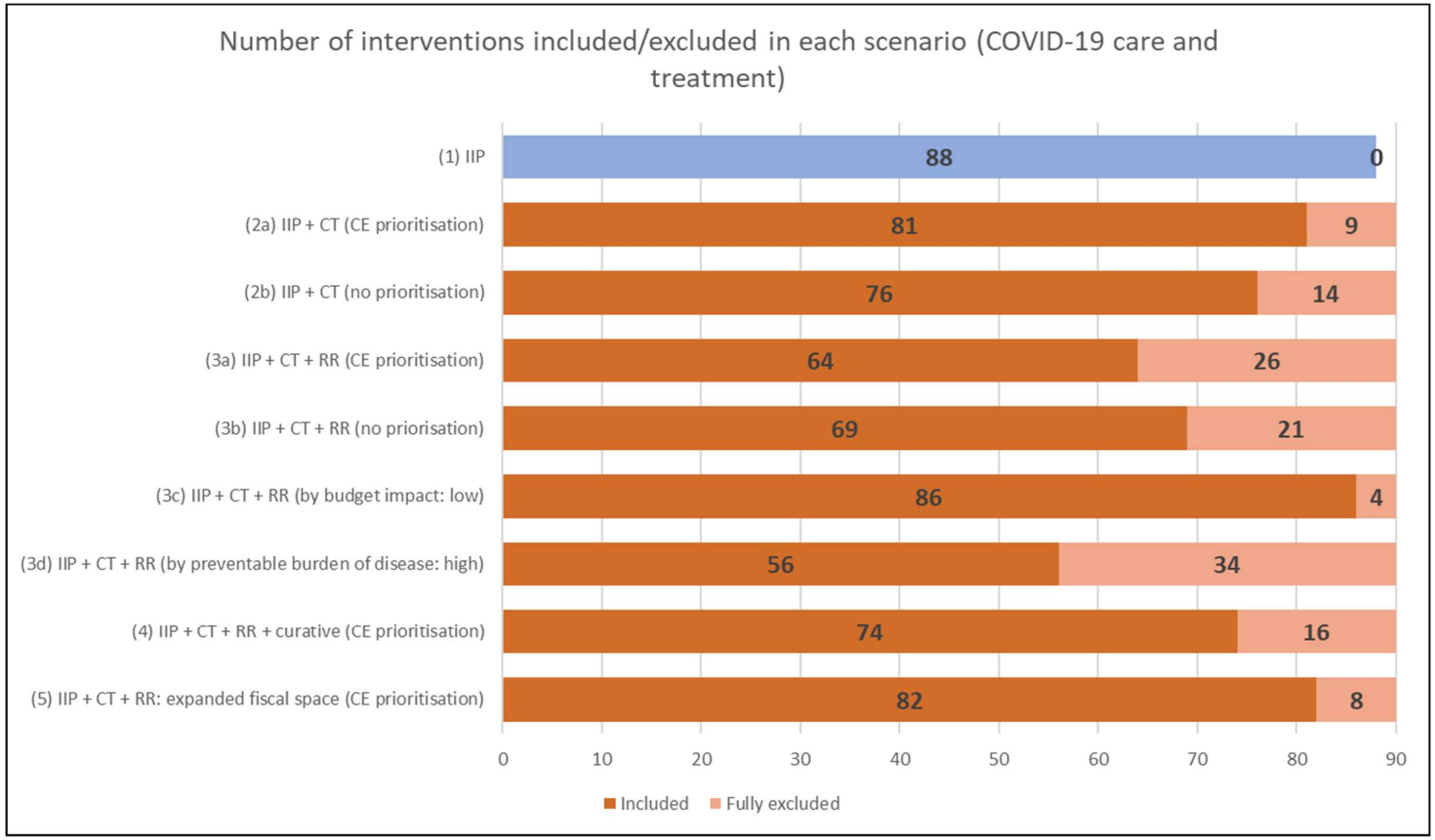


Figure 3: Difference in DALYs averted between scenario and base case (immediate implementation package)

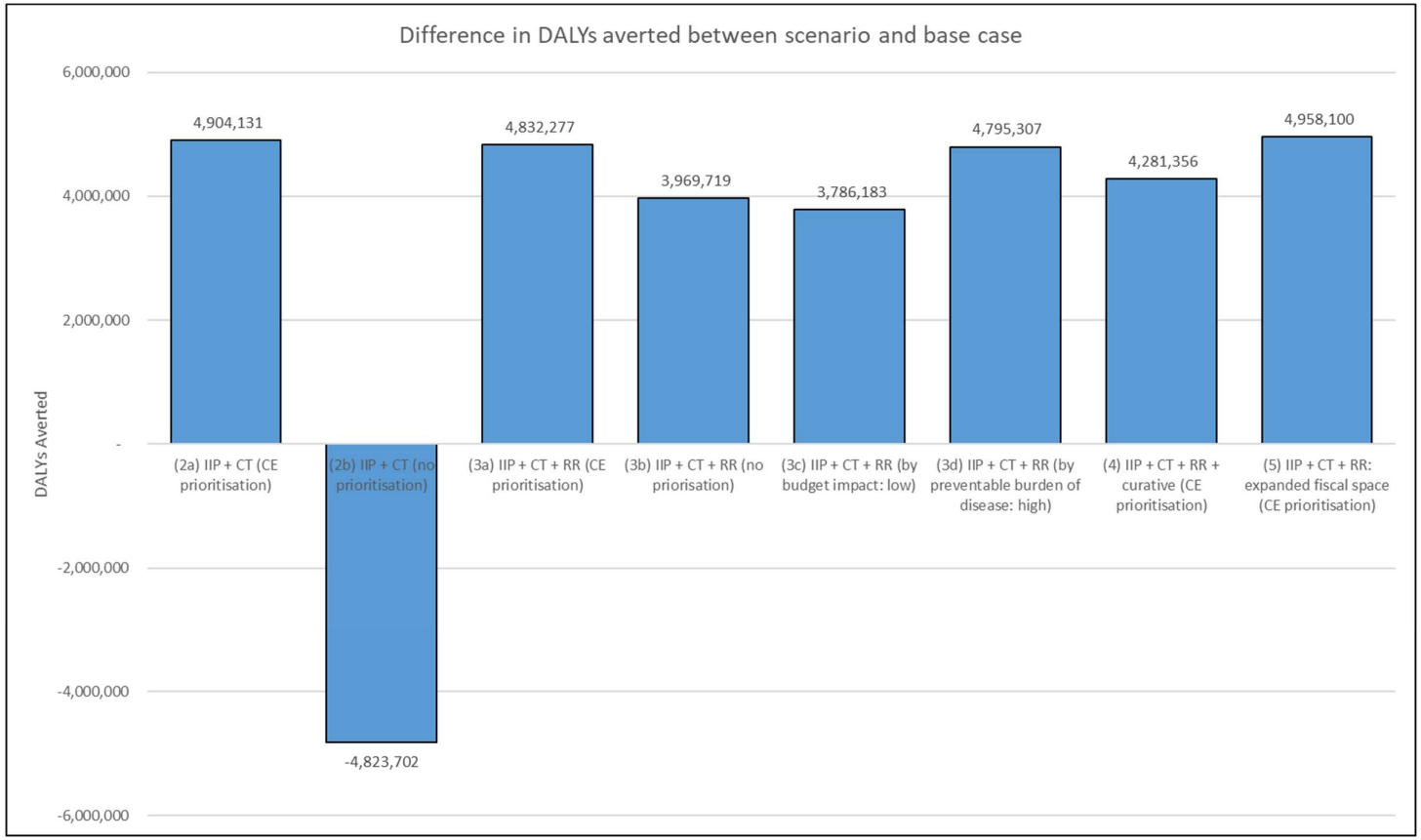
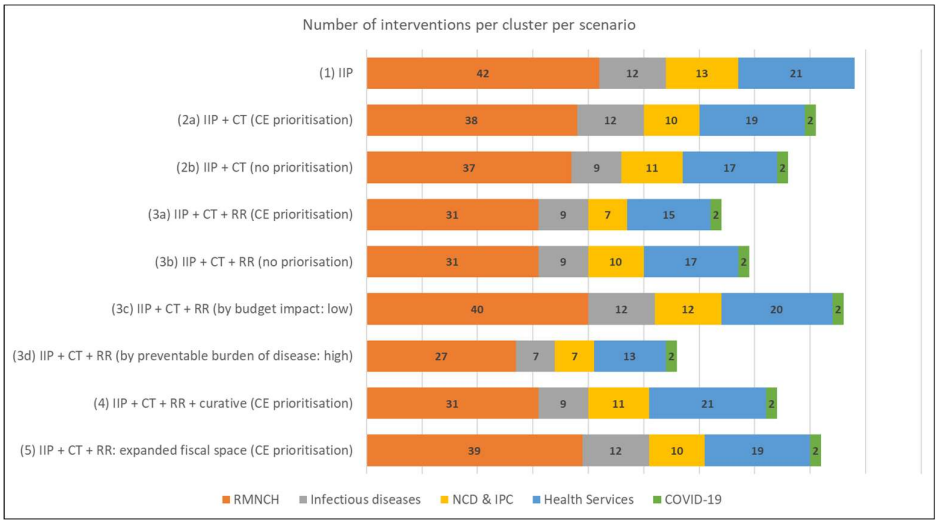
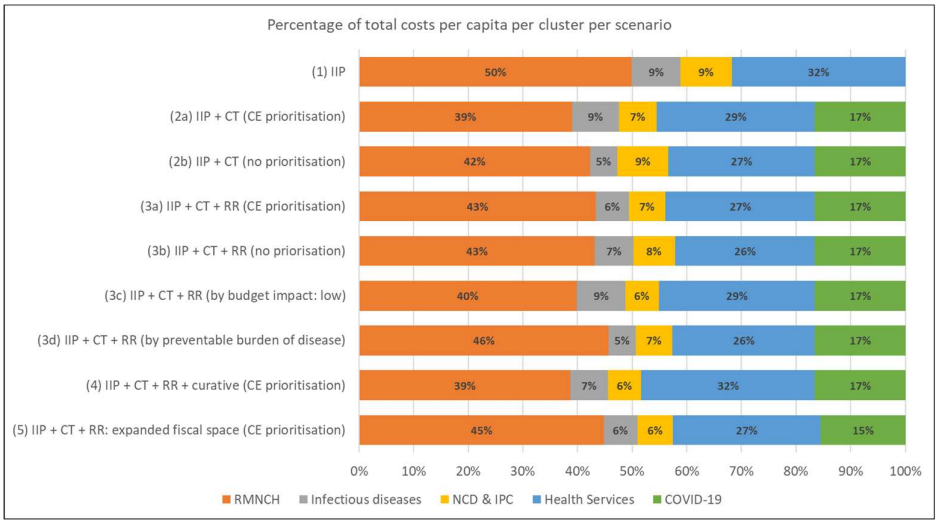
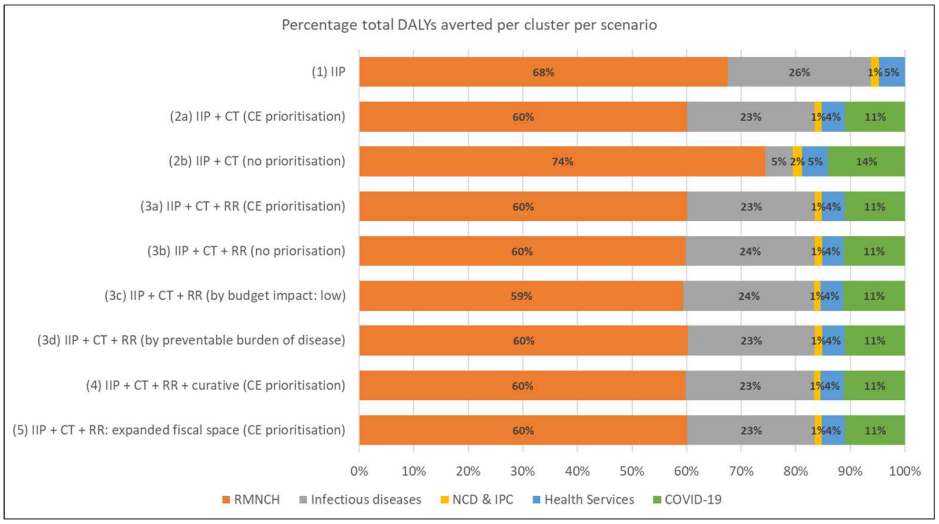


Figure 4: Inclusion/exclusion by cluster: (a) number of interventions, (b) the percentage of total cost per capita, and (c) the percentage of total disability-adjusted life years (DALYs) averted broken down by cluster by scenario







8.4 Epilogue

In Chapter 8 I propose an approach to examine trade-offs between prioritisation criteria which can inform the rapid design of 'smart, reduced and temporary' HBPs during health system-level shocks. Chapter 8 builds on work from the preceding analytical sections. One of the lessons from the first analytical section (Chapter 4) is that using an incremental approach to a disinvestment decision leaves out a key component, namely what the alternative use from newly available financial resources should be and whether those uses are socially and politically acceptable. The second analytical section (Chapters 5 and 6) examines disinvestment from a broader perspective, that of a health systems wide priority setting exercise. The work carried out in Chapter 6 traces the interventions that were included and excluded at different stages of the health benefit package design process and examines which decision criteria and intervention characteristics were prioritised at which point. However, while the health benefit package design process is an open and transparent one (and one with a tangible outcome), there is little clarity, both within the policy process and within the analysis of the process, on what the trade-offs between different decision criteria and intervention characteristics were. The work done in the third analytical section (Chapters 7 and 8) takes these ideas a step further and models the alternative uses of financial resources released through disinvestment and presents the trade-offs and opportunity costs of prioritising different decision criteria and intervention characteristics in an explicit manner. As far as I am aware, this is the first paper of its kind.

Another novel contribution of this paper is that it introduces the idea of quantifying the opportunity cost of implementing the 'rule of rescue'. As a concept, the 'rule of rescue' presents an imperative to rescue identifiable individuals facing avoidable death. Some would argue that, as it is an imperative, there is a moral obligation that needs to be honoured regardless of the opportunity cost. However, I would argue that the sheer scale of the COVID-19 pandemic forces a re-valuation of this principle, or at least necessitates a discussion of the opportunity costs involved and a debate as to whether those opportunity costs are societally acceptable in terms of costs, health outcomes forgone and potential regressions in equity.

Reflections on disinvestment

In Chapter 2 I define disinvestment as the withdrawal of health resources from an existing healthcare practice. This withdrawal can be complete or partial (e.g., restricting eligibility criteria) and can also have a temporal component, as the withdrawal can be either temporary or permanent. In relation to COVID-19 related disinvestment, in Chapter 8 I frequently use the term displacement,

which connotes a transfer or a change in position. Within the context of this dissertation, I interpret displacement to assume a temporal dimension and, more specifically, a temporary change which, in this case, has occurred due to force majeure. While the short-term consequences of displacement and disinvestment may be the same (i.e., the withdrawal of a services) the temporary nature in the latter suggests that there may be difference in the magnitude and characterisation of endowment effects as concerned individuals may hold some expectation of recuperating the good or service lost. While the focus of this dissertation is not behavioural economics or psychology, I think it would be interesting to ascertain empirically how endowment effects change depending on the belief that the separation from the health good or service will be temporary, and to measure that across different disease areas with different patient and prognosis profiles.

Further, as summarised in Chapter 2, research on the gap between willingness to pay and willingness to accept has focused on the loss of a good or service to the individual him or herself, or in one case, to a family member close to the individual. These situations would most resemble the loss of a health good or service to a patient. However, as shown in Chapter 3, there are other important actors to consider, namely policymakers and clinicians. Future extensions of the studies on endowment effects could consider exploring the values placed on the loss of health goods and services to patients from the perspective of the clinicians who have an obligation of care towards a patient, and of the policymakers who have an obligation to advocate and defend their constituents and, more broadly, social interests.

8.5 References

1. Baltussen, R., et al., *The use of evidence-informed deliberative processes for designing the universal health coverage benefit package in Pakistan.* 2022.
2. Torres-Rueda, S., et al., *The use of decision-criteria and evidence to design a health benefit package in Pakistan: a review and analysis of prioritisation decisions at different stages of the appraisal process.* 2022.
3. Alwan, A. and e. al., *Addressing the UHC Challenge Using the Disease Control Priorities-3 Approach: Learning from the Pakistan Experience.* 2022.
4. France 24. *Pakistan confirms first two cases of coronavirus*. 2020 26 February 2020; Available from: https://www.france24.com/en/20200226-pakistan-confirms-first-two-cases-of-coronavirus.
5. World Health Organization, *WHO Director-General's opening remarks at the media briefing on COVID-19 – 11 March 2020*. 2020.
6. Torres-Rueda, S., et al., *Stark choices: exploring health sector costs of policy responses to COVID-19 in low-income and middle-income countries.* BMJ Glob Health, 2021. **6**(12).
7. Tan-Torres Edejer, T., et al., *Projected health-care resource needs for an effective response to COVID-19 in 73 low-income and middle-income countries: a modelling study.* Lancet Glob Health, 2020. **8**(11): p. e1372-e1379.
8. Chandir, S., et al., *Impact of COVID-19 lockdown on routine immunisation in Karachi, Pakistan.* Lancet Glob Health, 2020. **8**(9): p. e1118-e1120.
9. Rahman, S.U., et al., *Impact of the COVID-19 lockdown on routine vaccination in Pakistan: a hospital-based study.* Hum Vaccin Immunother, 2021. **17**(12): p. 4934-4940.
10. Kirmani, S. and A. Saleem, *Impact of COVID-19 pandemic on paediatric services at a referral centre in Pakistan: lessons from a low-income and middle-income country setting.* Archives of Disease in Childhood, 2021. **106**(7): p. 627.
11. Dong, E., H. Du, and L. Gardner, *An interactive web-based dashboard to track COVID-19 in real time.* Lancet Infect Dis, 2020. **20**(5): p. 533-534.
12. *Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020-21.* Lancet, 2022.
13. Commission, T.L.C.-. *Global diplomacy and cooperation in pandemic times: Lessons and recommendations from COVID-19.* 2021.
14. Tromp, N. and R. Baltussen, *Mapping of multiple criteria for priority setting of health interventions: an aid for decision makers.* BMC Health Serv Res, 2012. **12**: p. 454.
15. Jonsen, A.R., *Bentham in a box: technology assessment and health care allocation.* Law Med Health Care, 1986. **14**(3-4): p. 172-4.
16. McKie, J. and J. Richardson, *The rule of rescue.* Soc Sci Med, 2003. **56**(12): p. 2407-19.
17. World Bank, *World Bank Fast-Tracks Support for COVID-19 (Coronavirus) Response to Pakistan*. 2020.
18. Watkins, D.A., et al., *Universal Health Coverage and Essential Packages of Care*, in *Disease Control Priorities: Improving Health and Reducing Poverty*, rd, et al., Editors. 2017: Washington (DC).
19. Raza, W., et al., *Costing Interventions for Developing a Health Benefit Package: Application of a Rapid Method and Results from Pakistan.* 2022.
20. Institute for Health Metrics and Evaluation (IHME), *Global Burden of Disease, Pakistan Profile*. 2019, IHME, University of Washington: Seattle, WA,.
21. Health Intervention Prioritization Working Group, *Health Intervention Prioritization Tool*. 2019.
22. Fraser-Hurt, N., et al., *Using allocative efficiency analysis to inform health benefits package design for progressing towards Universal Health Coverage: Proof-of-concept studies in countries seeking decision support.* PloS One, 2021. **16**(11): p. e0260247.

23. Huda, M., et al., *Assessing global evidence on cost-effectiveness to inform Pakistan's Essential Health Benefit Package* 2022.
24. Davies, N.G., et al., *Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study.* Lancet Public Health, 2020. **5**(7): p. e375-e385.
25. Pearson, C., et al., *Projections of COVID-19 epidemics in LMIC countries*. 2020.
26. Affairs, U.N.D.o.E.a.S., *World Population Prospects 2019*. 2019.
27. Pearson, C.A.B., et al., *COVID-19 vaccination in Sindh Province, Pakistan: A modelling study of health impact and cost-effectiveness.* PloS Med, 2021. **18**(10): p. e1003815.
28. Briggs, A.H., et al., *Estimating (quality-adjusted) life-year losses associated with deaths: With application to COVID-19.* Health Econ, 2021. **30**(3): p. 699-707.
29. Kairu, A., et al., *Modelling the cost-effectiveness of essential and advanced critical care for COVID-19 patients in Kenya.* BMJ Glob Health, 2021. **6**(12).
30. Elhadi, M., et al., *Epidemiology, outcomes, and utilization of intensive care unit resources for critically ill COVID-19 patients in Libya: A prospective multi-center cohort study.* PloS One, 2021. **16**(4): p. e0251085.
31. Liu, D., et al., *Risk factors for developing into critical COVID-19 patients in Wuhan, China: A multicenter, retrospective, cohort study.* EclinicalMedicine, 2020. **25**: p. 100471.
32. Blanchet, K., et al., *Protecting essential health services in low-income and middle-income countries and humanitarian settings while responding to the COVID-19 pandemic.* BMJ Glob Health, 2020. **5**(10).
33. Hadorn, D.C., *Setting health care priorities in Oregon. Cost-effectiveness meets the rule of rescue.* JAMA, 1991. **265**(17): p. 2218-25.
34. Hincapié, M.A., et al., *Implementation and Usefulness of Telemedicine During the COVID-19 Pandemic: A Scoping Review.* J Prim Care Community Health, 2020. **11**: p. 2150132720980612.
35. Ting, C., et al., "Well, I Signed Up to Be a Soldier; I Have Been Trained and Equipped Well": Exploring Healthcare Workers' Experiences during COVID-19 Organizational Changes in Singapore, from the First Wave to the Path towards Endemicity. Int J Environ Res Public Health, 2022. **19**(4).
36. Furman, E., et al., Prediction of personal protective equipment use in hospitals during COVID-19. Health Care Manag Sci, 2021. **24**(2): p. 439-453.
37. Mousa A, Winskill P, Watson OJ, Ratmann O, Monod M, Ajelli M, et al. Social contact patterns and implications for infectious disease transmission - a systematic review and meta-analysis of contact surveys. Elife. 2021;10.
38. Dabla-Norris E, Khan H, Lima F. What Determines Social Distancing? Evidence from Advanced and Emerging Market Economies. International Monetary Fund; 2021.

9. Discussion

In the past five chapters I have examined disinvestment using two case studies in low- and middle-income country (LMIC) settings. In this Discussion, I briefly summarise the findings from each research chapter and highlight themes across chapters.

Chapter 4

I carried out an economic evaluation of cotrimoxazole preventive therapy (CPT) discontinuation in clinically stable adults on antiretroviral treatment in Uganda. In doing so, I examined the cost-effectiveness of the disinvestment of an intervention in the context of incremental decision-making. Discontinuing CPT was both less costly and less effective than providing CPT. With an incremental cost-effectiveness ratio (ICER) of US$744 per disability-adjust life year averted (DALY) in our base case, CPT withdrawal would most likely be cost-effective in the Ugandan setting according to all thresholds used. This means that the money saved from not spending on CPT could be invested in interventions that yield better value for money.

The information on the costs and cost-effectiveness of CPT discontinuation, alongside with effectiveness data from the COSTOP trial, was presented to decisionmakers. Based on that evidence, decisionmakers opted to partially disinvest from CPT by restricting the eligibility criteria for access. Changes in the guidance meant that CPT was no longer provided to all people on antiretrovirals but only to a smaller subset, including pregnant women, children and adolescents under 15 and people experiencing treatment failure. According to media reports, the decision caused concern amongst patients. Many did not know that the cotrimoxazole received was an antibiotic taken prophylactically rather than an antiretroviral drug. Stockouts of cotrimoxazole, which took place shortly before the official decision to discontinue cotrimoxazole was announced, caused unease as people were advised to buy their own cotrimoxazole out-of-pocket until supplies were restocked. Further, the short period of time between the stockouts and the changes in guidance led to further confusion about the reason behind the lack of access to the drug: the unplanned stockouts pointed towards financial or logistical failures while the change in guidance was justified as being solidly based in scientific evidence.

The economic evaluation used similar methods to those carried out for the evaluation of the introduction of, and investment in, new technologies. However, in retrospect, having now carried out work in health benefit package (HBP) design and thought more deeply about disinvestment issues, I would have produced two additional analyses to present to national decisionmakers. The

first would be linked to heterogeneity, in particular to recalculating cost-effective under a range of malaria incidence assumptions. While the probabilistic sensitivity analysis suggests that CPT discontinuation is likely cost-effective, understanding the cost-effectiveness according to malaria may have also informed the decision on how the money that is now available due to CPT discontinuation could be used. Secondly, I would have added an analysis that considered a patient or societal perspective. An increase in malaria cases could lead to higher out of pocket expenditures. Further, some may choose to purchase cotrimoxazole from private facilities or pharmacies following discontinuation. While this may not have changed the decision outcome, it would have highlighted a negative externality of the disinvestment decision.

In Chapters 5 and 6 I examined disinvestment in the broader context of HBP design process using Pakistan.

Chapter 5

Chapter 5 describes a rapid method for costing interventions appraised for inclusion in the health benefit packages. I developed a rapid, ingredients-based normative bottom-up method that allowed us to cost 167 interventions across different platforms in the health system, in a manner that allowed for comparison between interventions and therefore could be used for priority setting in both investment and disinvestment. I found that hospital-based interventions and interventions in the cancer package of services had the highest unit costs. I carried out limited sensitivity analyses and found that unit costs do not vary substantially by adjusting salaries to regional pay scales. However, the prices of medications can greatly increase unit costs, particularly in cancer interventions.

Economic costs were calculated from a provider's perspective. Similar to the reflection on Chapter 4, capturing costs only from a provider's perspective, while adequate for the aims set out at the beginning of the HBP design process, misses the component of potential cost redistribution, from the public health system to the individual patient, when interventions are discontinued. Given that financial risk protection was not explicitly considered in the HBP process, a measure of changes in patient costs could have been helpful in informing disinvestment decisions.

The costs calculated fed into the appraisal process, described in Chapter 6, in two main ways. Unit costs per intervention were used to assess the cost per capita. These costs per capita were then, in turn, used to ensure that considered iterations of the packaged remained within a set budget, to ensure that the HBP was operational, rather than only aspirational. The costs also fed into the model developed in Chapter 8 directly and indirectly.

The budget impact of the 88 HBP interventions was directly used to determine which interventions were outside the budget constrain. By having a high-quality cost dataset at hand, I was able to model different disinvestment scenarios in situations of system-wide supply and demand shocks to the system. Further, some of the disaggregated cost ingredients from the HBP costing were used to build the costs of COVID-19 care and treatment early in the pandemic (in lieu of primary data collection). This highlights the advantage of having highly disaggregated cost data available.

The multiple uses of cost data for purposes of assessing disinvestment suggests that countries that have recently undergone an HBP design process have the necessary tools to make evidence-informed disinvestment decisions. This should be kept in mind when intervention assessments are planned as part of HBP design exercises, remembering that policies should ideally be revisited and reversed as may be necessary in times of shocks to the health system.

Chapter 6

The HBP design process in Pakistan was informed by the cost data calculated in Chapter 5, as well as other data collated on cost-effectiveness and avoidable burden of disease. In Chapter 6 I describe the stages of the HBP appraisal process, analysing the composition of the package at each stage and examining how different interventions travelled in and out of the package through the process. I also examine the uptake of different types of evidence by different stakeholders and study the trade-off between cost-effectiveness and intervention coverage.

I found that the evidence-based deliberative process was successfully used to narrow a list of 170 interventions down to 88 which fit within the immediately available fiscal space. While this is a success in and of itself, it must be noted that the final iteration of the package is moderately less efficient than intermediate iterations; the highest share of highly cost-effective interventions included in the package was observed in intermediate stages and decreased in the final stage. Interventions with high current coverage were overwhelmingly prioritised in the final package, regardless of cost-effectiveness. Conversely, a large number of highly cost-effective interventions, with low current coverage, were excluded. This pattern suggests a possible aversion to disinvest. However, the reason remains unclear.

In Chapters 7 and 8 I build on lessons from the previous three chapters and use some of the data produced to propose a model for designing ‘smart, temporary and reduced’ health benefit packages during system-wide supply and demand shocks, such as those experienced during the COVID-19 pandemic. In Chapter 7 calculate unit costs and total cost for COVID-19 care and treatment in 129

and 79 LMICs, respectively, including Pakistan. These costs were then fed into the disinvestment model explained in Chapter 8.

Chapter 7

COVID-19 care and treatment costs were calculated early in the pandemic to assist in decision-making and to produce inputs for cost-effectiveness models. In order for our findings to have the greatest possible use, I extrapolated cost estimates across a large proportion of LMICs. Costs were built by combining country-specific epidemiological projections and a cost model of the health sector response. Given the impossibility of collecting primary data, the costs were calculated through a desk-based approach and validated locally.

Chapter 8

In Chapter 8 I propose a model for designing 'smart, temporary and reduced' health benefit packages during system-wide supply and demand shocks such as those experienced during the COVID-19 pandemic. I contextualise the level of resources needed to provide COVID-19 care and treatment, using Pakistan as a case study, and explore the possible outcomes of different approaches to prioritisation.

The model is novel in that it considers the opportunity costs of disinvestment explicitly. I find COVID-19 care and treatment costs would displace at least 10% of interventions in the package. If, in addition, interventions related to the 'rule of rescue' are prioritised, the remaining fiscal space of the package would be reduced by more than half. When no prioritisation criteria were used, I find that the package has the potential to lose considerable efficiency, resulting in a substantial decrease in DALYs averted. Further, I find that in nearly all scenarios reproductive, maternal, neonatal and child health (RMNCH) interventions will be displaced out of the package. In some scenarios, nearly one in three RMNCH interventions would be displaced. Disinvesting without evidence can lead to both inefficient and inequitable outcomes.

***

In general terms, the work here presented contributes to the evidence base on disinvestment in low- and middle-income countries. At the time when I carried out my scoping literature review (late 2020), I could not find a single study outlining barriers and facilitators to disinvestment or presenting case studies based in any low- and middle-income setting.

Specifically, however, the three analytical sections address three gaps that were presented in Chapter 2 (and Chapter 6). The first analytical section carries out a 'decrementally cost-effectiveness'

analysis. As mentioned in the Background section, 'decrementally cost-effectiveness' analyses make up a tiny minority of economic evaluations and, to my knowledge, none have been conducted in low-income settings. The second analytical section, a health system-wide analysis on the types of interventions prioritised during the health benefit package design, is also novel. To my knowledge, the body of work examining the types of decision criteria that influence investment and disinvestment decisions has been done entirely on incremental health technology assessment, and never on a health benefits package process (or, again, in an low- or middle-income setting). Lastly, the third analytical section, the model of disinvestment assuming explicit decision criteria, fills a gap on the quantification of opportunity costs of implementing 'decrementally-cost effective' interventions, and other disinvestment decisions, an areas that is highly understudied. My model proposes for an approach towards filling in this gap.

***

A number of common and connected themes emerged across the five chapters. They are outlined below.

The importance of health systems-wide approaches: analytics and the implementation

Incremental approaches to disinvestment, and specifically cost-effectiveness analyses examining the discontinuation of an intervention, are useful to determine whether the intervention is cost-effective in relation to a cost-effectiveness threshold. If the threshold is based on the productivity of the health system, then whether the discontinuation is cost-effective or not, represents whether there are more efficient uses for that money elsewhere in the health system. However, incremental approaches to disinvestment don't give an indication on what the alternative uses for the freed funds could be, whether they may benefit those who have lost out due to the discontinuation of the intervention, or, more broadly, whether the money is reinvested in a way that is acceptable to society. The Uganda case study in Chapter 4 highlights this well.

A broader health systems approach to priority setting allows for the disinvestment decision to happen explicitly as the decisionmaker knows what will be removed from the package. Chapter 6 shows how the process of HBP review and design attempted that, and Chapter 8 shows a way to make rapid decisions around the opportunity costs of disinvestment, both in terms of net gains or losses to health, but also in terms of the number and types of interventions that would need to be displaced in order to include new or expanded interventions.

There are benefits to explicit priority setting in disinvestment. It allows for transparency, which may improve trust in the health system. It can allow the creation of mitigating social care structures. It

may relieve clinicians from having to make difficult resource allocation decisions at triage. It may also allow for more explicit consideration of other criteria, such as equity. While system-wide analyses may be preferable, they also require more data. Countries without these data may struggle to build datasets at speed. However, those that have recently undergone an UHC HBP design processes will benefit, as shown in Chapter 8.

It is important for the priority setting process to explore the broader health system when considering broader consequences of the disinvestment decision. A key question is whether the health system has the ability to cope with potential negative externalities stemming from the disinvestment decision, such as shifts in burden of disease to other areas of the health system. The COSTOP trial showed that discontinuing CPT led to a higher number of cases of bacterial infections and malaria. Our economic evaluation showed that, in the aggregate, diagnosing and treating these additional cases was better value for money than attempting to prevent them at scale, which goes against conventional wisdom ('prevention is better than cure'). However, it is important to understand whether the health system has the capacity to deal with the externalities of the disinvestment decision, in this case a shift towards managing a higher burden of bacterial infections and cases of malaria.

The COSTOP trial identified a range of bacterial infections which can be prevented by CPT. They range from some common ailments, such as bacterial diarrhoea, to other more complex ones, like endocarditis, which are more difficult to diagnose and which may require transferring the patient to a higher level of care. In order for a shift to take place towards a successful 'post-CPT' health system, a number of things need to happen. Clinical staff at primary facilities across the country need to be trained in identifying these bacterial infections and treating these infections, additional medicines, supplies and diagnostics need to be procured in a timely manner, and funding will need to be reallocated between programmes (or donors). These considerations, in terms of assessing whether the health systems can cope with externalities, are all the more complex in the context of transferring findings from one national setting to another.

The importance of cost-effectiveness

In Chapter 6 I discussed how evidence from incremental decision-making in HICs suggests that cost-effectiveness is a highly influential parameter in incremental decision-making around intervention adoption. While not strictly comparable, our work interrogates whether cost-effectiveness is as important a factor in the decisions to invest and disinvest in our case studies. The analysis carried out on the HBP process in Pakistan showed how the proportion of highly cost-effective interventions

varied at various points during the appraisal stages. However, the importance of cost-effectiveness decreased in the last stage, once decisionmakers had to make final decisions to produce a final package that was politically acceptable. When the ICERs of interventions included in the final package are bench-marked against commonly used cost-effectiveness thresholds, it is striking to see that a large proportion of interventions would not be defined as cost-effective: between 59%-70% of interventions included in the package are above the Ochalek et al. thresholds, and between 9%-47% are above the Woods et al thresholds.

Our cost-effectiveness analysis in Uganda showed that CPT discontinuation was cost-effective. The Uganda government decided to discontinue CPT as a result of evidence evaluation. While the result of the economic evaluation supported the government's decision, I informally learnt that the two components that resonated the most with decisionmakers were the higher costs in the CPT arm and the lack of evidence of additional mortality between the two arms of the trial.

The fact that not only many highly cost-effective interventions were not included in the HBP in Pakistan (Chapter 6), but that also over half of interventions included were at that time not considered cost-effective, gives a sense that there are important other values at play which policymakers are willing to prioritise over overall package efficiency. Cost-effectiveness only takes us so far. Considerations such as the 'rule of rescue' show that priority setting involves tensions between conflicting values. The COVID-19 pandemic demonstrated that people will be treated when at risk of imminent death, regardless of the opportunity cost and without an explicit consideration of who, as a result, will not receive their health benefits due to service displacement.

Data needs

The development of standardised, easily accessible quantitative indicators for both the feasibility and the urgency of interventions could improve transparent and explicit priority setting on disinvestment and shine light on decisionmaker preferences. Ideally, these indicators would broadly be calibrated to local contexts.

I developed a rapid costing method and produced cost estimates for a large number of interventions considered in the HBP design process in Pakistan (Chapter 5). Colleagues produced a set of incremental cost-effectiveness ratios (ICERs) for the same interventions also needed for the process. Datasets and tools that estimate the avoidable burden of disease per intervention are also available (IHME, HIP Tool). These three types of data were used in the appraisal stages of the HBP design process in Pakistan (Chapter 6) which allowed for explicit priority setting on what would be included and excluded from the package. I repurposed these data in Chapter 8 to propose a rapid

disinvestment model that could be used at time of system-wide demand and supply-side shocks, such as that experienced during pandemics. In the model I grouped and prioritised interventions that address the 'rule of rescue'.

While this exercise was helpful, quantifying the concept of urgency would have also been better. Urgency, which can be defined as the impact of delaying access to a service, could be a broader measure that introduces a temporal component to the decision-making. It would allow decisionmakers to understand what the future consequences are in terms of additional costs and DALYs, of discontinuing interventions today. This would apply to interventions that have immediate consequences, such as those exemplified in the rule of rescue, emergency medicine and palliative care, but importantly, other types of interventions. Additional costs and DALYs of postponement of interventions vary in scale. Delaying an elective surgery may increase DALYs for the patient but may not necessarily increase costs. Interrupting treatment for non-communicable diseases, such as diabetes or blood pressure, may lead to accelerated disease progression and increased treatment costs. Interruption of treatment for infectious diseases, such as HIV or TB, can lead to treatment failure which would not only increase DALYs and costs for the infected individual but may increase the risk of transmission events again, and it also could exacerbate the risk of antimicrobial resistance, which has extremely serious health and economic consequences. The costs and DALYs involved in delays vary due to the epidemiology of the disease and the available to provide care and treatment at different stages. Having comparable, intervention-specific quantifications would be help improve the quality of the disinvestment decision.

It must be acknowledged, however, that the inclusion of a measure of urgency would not come without its own problems. Different people value the present and the future differently. This would open up the debate around whether averting DALYs in the future should be prioritised equally to averting them in the present. However, using different discount rates in analyses to explore different scenarios or prioritising by urgency would help bring some empirical perspective to the process.

Additionally, decision-making is bound by political realities. Democratic governments are normally elected in fixed-term cycles. In order to be re-elected, governments generally aim to show results of how their policies have improved the lives of constituents in the immediate or short terms. Even if evidence-based projections showed that the most rational use of resources, assuming a long time horizon, was to disinvest from interventions that improve health now to move towards interventions whose benefits will arrive far in the future, it seems unlikely that politicians would act accordingly. Of course long-term investment decisions are made by governments (e.g., building a new damn to improve irrigation and water access in the long-term). However, investment issues are not as

emotive and psychologically complex as disinvestment. Again, a measure of urgency may bring some of these questions to the foreground but will not resolve an issue that is ultimately about social and political acceptability.

In Chapter 6 I examine the trade-offs between cost-effectiveness and current coverage. I find that interventions with high current coverage are most likely to be included in the package regardless of cost-effectiveness. However, given our data and approach it is difficult to interpret these findings. On the one hand this could point towards an aversion to disinvestment at the expense of lower efficiency in the package. Policymakers may prefer to avoid the social and political problems of withdrawing public interventions even if it means that the package produces less value for money than other alternatives. However, that may not be the only factor in play. Feasibility is an important concept in priority-setting, which takes into account the ease of introducing an intervention into a local context. Interventions with high current coverage have by definition already proven themselves feasible. In including interventions with low and no current coverage in the package, policymakers may think of themselves as taking a risk that may not pay off, as there may be characteristics of the interventions (known or unknown) that do not lend themselves to high uptake in the national context. In a highly-resource constrained settings like Pakistan, policymakers may not perceive this risk as worth taking.

Feasibility was not quantitatively assessed in the HBP package process in Pakistan. However, the resource use necessary for each intervention was summarised and compiled in intervention description sheets which were available for stakeholders to review. Anecdotal evidence suggests that technical working group members considered these resource requirements to inform their opinion as to whether an intervention should be included or not in the district package of services; some interventions, which involved higher levels of technology or equipment were excluded for feasibility reasons. This suggests that, broadly, the concept of feasibility played a role in decision-making. Introducing quantifications would serve two purposes. It would help the decisionmakers consider this factor explicitly and make comparisons accordingly. It would also help researchers disentangle if and how feasibility plays a role in disinvestment.

Barriers and facilitators

The peer-reviewed literature on the barriers and facilitators of disinvestment is limited and focusses almost entirely on a small number of high-income settings. At the policy level, a set of barriers to disinvestment were identified and expanded in detail in the Introduction. These include: the lack of appropriate evidence, processes and guidance with which to make disinvestment decisions,

difficulties in identifying candidates for disinvestment, adequate fiscal and human resources to assist in the process, a disconnect between decision making and implementation, competing interests among actors, and negative connotations and public perceptions.

Our cases studies allow us to reflect on the roles that some of these barriers may have played in the two priority setting processes analysed. Disinvestment occurred in Uganda by the discontinuation of CPT in certain groups. In Pakistan disinvestment occurred for some interventions, but generally those that had low coverage to begin with. As previously mentioned, it is difficult to disentangle whether the decisions in Pakistan were based on genuine feasibility concerns or on an aversion to disinvest.

Provision of appropriate evidence as well as identification of candidates for disinvestment, occurred in both Uganda and Pakistan. In Pakistan, there was a structured process, guidance and adequate financial and human resources allocated to the process. Chapter 6 describes the stages and actors involved in the process. Chapter 5 gives an idea of the resource intensity that was necessary to prepare relevant evidence. I cannot comment on the resource and general process that took place in Uganda. It is difficult to ascertain whether a lack of structure and resources around candidate identification, evidence, processes and guidance hinders disinvestment. It appears however that the availability of these structures and processes does not necessary guarantee that policymakers will arrive at disinvest decisions. These factors may therefore be necessary but not sufficient conditions for disinvestment decisions to be made. Although not studied systematically, the anecdotal evidence from the Ugandan case study suggested that there was some level of disconnect between decisionmakers and implementation challenges, as well as negative connotations and public perceptions about disinvestment. Nonetheless, disinvestment occurred.

The case study in Pakistan suggests that competing duties and aims, more so than interests, played a role in slowing down disinvestment from interventions that provided low value for money. Cost-effectiveness evidence tended to be more important for technical stakeholders who were tasked with proposing an efficient and equitable package within budget constraints. However, at the final stage, government stakeholders reversed some of those decisions to ensure that the package was also politically acceptable.

The peer-reviewed literature on facilitators of disinvestment was limited and only a few factors were identified, including the explicit use of empirical evidence, transparency in the process and appropriate communication were identified as key facilitators. Empirical evidence was present in the processes in both Uganda and Pakistan. The process in Pakistan was transparent; I do not know

about the Ugandan process. Appropriate communications did not seem to be in place in Uganda. It is difficult to know whether these facilitators played a role in the two countries studied. Explicit use of empirical evidence was witnessed in both settings; successful disinvestment was observed in Uganda more so than in Pakistan. A lack of appropriate communication did not hinder the decision-making process in Uganda, although it appears to have caused problems with clinicians and beneficiaries.

A number of worthwhile areas of future research have been identified. These include:

- The qualitative exploration of barriers and facilitators of disinvestment LMICs. There is currently minimal work that explores this topic. It would be worthwhile to understand whether barriers are similar to those from high-income settings. Such research may aid in developing strategies to overcome barriers in settings where efficient allocation is lacking.
- Work should be done on developing and validating quantitative indicators of intervention feasibility. These will need to be grounded in empirical data and will likely vary substantially between settings. However, their development may aid decisionmakers, as well as shed light on the question of the importance of feasibility as a factor that hinders disinvestment.
- Econometric work should be carried out to test the correlation between decision criteria in HBP process in LMICs as it has been done in high-income settings. Potential difficulties due to confounders have been noted in Chapter 6.
- Disinvestment models, like the one in Chapter 8, could be grounded on resource availably on the ground. The lack of fungibility of certain inputs was not quantified in this dissertation. It is no good to suggest that, for example, optimal reduced package of services should prioritise hospital-based interventions if all hospital capacity is utilised in care and treatment during pandemics. Constraints need to be quantified locally and included in models.
- Work from high-income settings suggests that clinicians may be unwilling to implement interventions decisions. Just as the model presented in Chapter 8 assumed certain interventions would remain fixed in the package (‘rule of rescue’), models understanding and accounting for clinicians’ ‘red lines’ would be useful.
- Just as I developed rapid methods to calculate unit costs of health interventions from a provider’s perspective in the HBP process in Pakistan, it may be useful to develop rapid methods to account for intervention-specific patient costs to add a dimension of financial risk protection to intervention-specific discussions.

10. Conclusion

The aim of this dissertation was to explore economic evidence requirements and uses, policy processes and potential consequences of disinvestment in healthcare in the context of priority setting. The first analytical section (Chapter 4) uses an incremental approach to a disinvestment decision in Uganda. The case study shows, however, that such an approach leaves out a key component, namely what the alternative use from newly available financial resources would be and whether those uses are socially and politically acceptable. The second analytical section (Chapters 5 and 6) examines disinvestment from a broader perspective, that of a health systems wide priority setting exercise. Through this work I trace the interventions that were included (i.e., invested in) and excluded (i.e., disinvested from) at different stages of the health benefit package design process and examine which decision criteria and intervention characteristics were prioritised at which point. However, while the health benefit package design process is an open and transparent one, and the end result is available for all to see, there is little clarity, both within the policy process and within the analysis of the process, on what the trade-offs between different decision criteria and intervention characteristics were. The work done in the third analytical section (Chapters 7 and 8) takes these ideas a step further and models the alternative uses of funds released through disinvestment intervention by presenting the trade-offs and opportunity costs of prioritising different decision criteria and intervention characteristics in an explicit manner.

I found that high quality economic evidence can be instrumental for successful decision-making in disinvestment, informing decisions during incremental priority setting in Uganda and, to a lesser extent, in a health systems wide effort in Pakistan. Standard economic evaluation approaches can be applied to incremental disinvestment decisions. However, it is important incorporate additional analyses exploring heterogeneity and to account for patient and societal costs. Further, while the cost-effectiveness analysis of the discontinuation of a single intervention will inform on value for money, it will not suggest alternate uses for money saved, nor whether those uses are acceptable to society. The work carried out in Uganda, and particularly observing the aftermath of the decision-making process, highlights the need for considering multiple decision criteria, both in quantitative and qualitative ways.

HBP design processes can offer transparent and explicit ways of making decisions on investment and disinvestment. The outcome of the process is a tangible and public good. However, the openness of the process itself doesn't necessary guarantee clarity on how different priorities are traded off. Uptake of cost-effectiveness evidence is not necessarily uniform across stakeholders involved in

health benefit package design. A tendency towards maintaining existing interventions with high coverage at the cost of not introducing new interventions that provide better value for money was observed. However, whether this reflects an aversion to disinvest, concerns about intervention feasibility, or risk aversion, remains unclear. As a result, the final iteration of the benefit package in Pakistan was, from an efficiency perspective, sub-optimal. Whether this inefficiency comes at the cost of greater acceptability or feasibility (or is due to political considerations that do not further societal interests) is an important question that should be investigated further.

Shocks to the health system, such as those observed worldwide during the COVID-19 pandemic may result in substantial intervention displacement. Without evidence-based approaches to disinvestment, intervention displacement can lead to inefficient and inequitable outcomes. Further, explicit prioritisation of criteria in modelling studies can be useful in creating policy conversations to understand the opportunity costs of prioritising specific values. The model I present in this dissertation can quantify those opportunity costs. However, it is highly schematic; adding complexity along certain dimensions (e.g., specifications on resource fungibility, changes to coverage levels, longer time horizons) may present a more accurate idea of trade-offs and opportunity costs.

Rapid, normative costing methods were employed to feed into two of the disinvestment analyses here presented. I show that these types of approaches to costing can be effectively used in system-wide priority setting exercises and in situations where primary data collection is not feasible. The availability of high-quality highly disaggregated data for health benefit package exercises could greatly aid the process of efficient and equitable disinvestment during health system shocks.

The work carried out in this dissertation also allowed me to reflect on what other kinds of data could further the study of disinvestment decision-making and better inform policy-makers. A system of scoring on intervention feasibility may shed light on stakeholder preferences and help differentiate implementation concerns from stakeholder aversions to disinvestment. Quantitative data on intervention urgency may be an important criterion in prioritising essential interventions during shocks to health systems.

Generalisability

The work developed as part of this doctoral dissertation was carried out using two case studies from two low- and middle-income settings: Uganda and Pakistan. The level of generalisability of each results chapter varies. The economic evaluation in Chapter 4 finds that discontinuing cotrimoxazole-preventive therapy is cost-effective in Uganda. Whether that may be the case in other settings will depend on contextual factors, such as the incidence of bacterial infections and malaria, as well as

the availability of health systems to cope with increases in cases of said illnesses. Chapter 5 presents a costing of a large number of health interventions in the Pakistani context. While the unit costs may not be generalisable in other settings, some of the work products produced (e.g., intervention descriptions sheets and the costing tool in Microsoft Excel®) could be used to replicate the effort elsewhere. Chapter 6 shows how stakeholders prioritised certain types of interventions when making decisions to invest and disinvest within the context of the health benefit package process in Pakistan. It is difficult to say whether these findings are generalisable to other settings; evidence from high-income countries suggests that cost-effectiveness is the most important determinant of adoption. This did not appear to be the case in Pakistan but additional analyses using other indicators are necessary to prove that more robustly. Chapter 7 is a cross-country costing of COVID-19 care and treatment. I used disaggregated data from three settings to extrapolate costs to a large number of countries. These estimates have already been used in analyses in other settings. However, validation through primary data collection would be recommended. Lastly, Chapter 8 presents an approach to model disinvestment in cases of health system shocks. While the approach used could be applied elsewhere, my model used data estimated and assembled from the health benefit package design process in Pakistan. Countries that have not gone through such exercises, and which do not have such datasets available, may struggle to populate the model without substantial human and financial resources.

Appendices

Chapter 4

Appendix 4.1: Data collection forms (resource use)

(a) Cotrimoxazole Preventive Treatment (CPT) preventable event

	Patient number	Event date	Site	CPT preventable event type	CPT preventable event-specific treatment (including dose and frequency)	Treatment for alternative diagnoses (including dose and frequency)	Other treatment (including dose and frequency)	Specify other treatment type: self-medication, supplements, co-morbid condition	Cotrimoxazole preventable event-specific diagnostic tests	Alternative diagnostic	Did patient have a malaria diagnosis at the same time as the event diagnosis? (Y/N)	Number of consultations related to the cotrimoxazole preventable specific event	Hospitalisation due to cotrimoxazole-preventable event? (Y/N)	Number of days in hospital (if available)	Event severity as classified in records (mild, moderate, severe)
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

(b) Malaria

	Patient number	Event date	Site	Treatment type (including dose and frequency)	Diagnostic type and number of tests	Number of consultations related to malaria	Hospitalisation due to malaria? (Y/N)	Number of days in hospital (if available)	Event severity (considered severe if requiring hospitalisation)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

(c) Cotrimoxazole Preventive Treatment (CPT) related adverse event

	Patient number	Event date	Site	CPT-related adverse event type	Treatment for CPT-related adverse event (including dose and frequency)	Further diagnostic tests carried out (other than routine full blood counts)	Total duration of CPT-related adverse event (days) including any hospitalisations	Number of consultations due to CPT-related adverse event?	Hospitalisation due to CPT-related adverse event? (yes/no)	Number of days in hospital (if available)	Severity (1-4)
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Appendix 4.2: Further information on cost and health outcome data assumptions

CTX-preventable events (bacterial infections)

Costs

Number of cases were obtained from trial data set. Resources use data (diagnostics and treatment, including medication and surgical procedures) were obtained from patient files. Prices of medications largely obtained from JMS Price Catalogue. Price data for some diagnostics and surgical procedures obtained from Nsambya Hospital 2016 Price Catalogue (General).

Costs do not include diagnostics and treatments that were used to treat other concurrent events, or events that were initially misdiagnosed or explored in parallel to the CTX-preventable event (i.e., malaria). These costs were very small, and mostly related to malaria, which is already being accounted for.

Health outcomes

DALY weights were calculated by taking into account a base DALY of infectious disease: acute episode, mild, moderate, or severe from Salomon et al. 2015 and, when appropriate (a) secondary symptom DALY weight(s) if other symptom(s) of the condition were salient (in addition to lay description already included in base DALY weight) as per expert workshop and if available in Salomon et al. 2015. Some illnesses (e.g., epydidymorchitis) already had a DALY weight as per Salomon et al 2015. In such cases, the Salomon et al. 2015 DALY weight was used.

Duration of illness was determined from patient file review. If unavailable assumed by intensity: mild 7 days, moderate 14 days and severe 21 days. Event severity (mild, moderate, severe) determined from clinician review of patient files as per Salomon et al. base infectious disease DALY lay description.

Final DALY weight was calculated as follows: 1-((1-base DALY weight) * (1-secondary symptom DALY weight)). DALY calculated by multiplying DALY weight by duration of illness in years.

When relevant, and in accordance with expert workshop, an additionally DALY weight was applied to account for short-term physical consequences following illness (Infectious disease: post-acute consequence DALY weight from Salomon et al. 2015). Duration of these consequences were determined by the expert workshop, by illness and severity (no longer than 30 days at most). No other longer-term sequelae were assumed.

CTX-related adverse events (haematological)

Costs

Number of cases and severity of neutropenia, thrombocytopenia and anaemia per person were obtained from trial dataset. Resources used: diagnostic and treatments used estimated at expert workshop, according to illness and severity. Treatment and diagnostics used could not be obtained from specific patient files due to volume: nearly 11,000 cases (of all severities, 1-4) across all three illnesses.

Prices of medications, diagnostics and surgical procedures: same as for CTX-preventable events. Costs of diagnostics included only for those cases for which an adverse event was identified (blood tests done routinely throughout the trial were not included).

Health Outcomes

DALY weights: Used existing weight from Salomon et al. (2015) for anaemia. Weights for neutropenia and thrombocytopenia agreed at the expert workshop using Salomon et al.'s (2015) weights for generic uncomplicated disease and anxiety about diagnosis. Duration of illness was assumed to be 14 days (mild), 21 days (moderate), and 30 days (severe).

DALY calculated by multiplying DALY weight by duration of illness in years. We assumed no other longer-term sequelae.

Malaria

Costs

Number of cases obtained from trial data set. Only cases of symptomatic malaria (fever) included in the analysis. Asymptomatic malaria cases (detected through regular screenings during the trial) were not included.

Resources used: treatment categories obtained from trial data set. Used literature to match treatment categories with specific medications. Number of tests obtained from the trial data set. Prices of medications, diagnostics and surgical procedures: same as for CTX-preventable events.

Health Outcomes

DALY weights calculated by taking into account a base DALY of infectious disease: acute episode, mild, or severe from Salomon et al. 2015. Duration of illness was assumed to be 10 days for mild cases and 30 days for severe cases. Even severity was determined by whether patient was hospitalised (severe) or not (mild). DALYs calculated by multiplying DALY weight by duration of illness in years.

When relevant, and in accordance with expert workshop, an additionally DALY weight was applied to account for short-term physical consequences following illness (Infectious disease: post-acute consequence DALY weight from Salomon et al. 2015). Duration of these consequences determined by the expert workshop, by severity. We assumed no longer-term sequelae.

Deaths

Only deaths deemed CTX-preventable were included (6 in total). Disability adjusted life years lost were calculated using expectation of life at age of death (from WHO's Global Health Observatory Data Repository: age bracket, gender and country-specific). Age at time of death calculated by determining days between enrolment and death and adding to age at enrolment date.

Disability weights applied to life years lost: HIV/AIDS: receiving antiretroviral treatment (0.078) from Salomon et al 2015.

Health Systems Costs

Cost per consultation was calculated by a fixed cost of $7.01 per visit plus $0.05 for every 5-minute interval in a HC IV out-patient facility, attended by a registered nurse. Cost per day of hospitalisation was assumed to be $16.13 per overnight stay in a HC IV type facility in-patient.

Number of consultations: for CTX-preventable events, obtained from patient records; for CTX-related adverse events, assuming 1 consultation per event; for malaria, assuming 1 consultation per malaria case.

Length of consultations (mins) were based on disease type and severity as per expert workshop for all CTX-preventable events, CTX-related adverse events and malaria cases.

Number of days of hospitalisation: for CTX-preventable events, obtained from patient records; for CTX-related adverse events, obtained from expert workshop estimates according to illness type and severity; for malaria, from trial data set.

Delivery of CTX

Cost of treatment was assumed as 1 tablet of Cotrimoxazole 960MG per patient per day (price of 74 UGX per tablet). Duration of treatment perm participant was obtained from trial records. No health systems cost attached as delivery would be done concurrently with ART. Cost of the placebo tablet was not included.

Appendix 4.3: Parameter inputs for costs and health outcomes

Mean values used for base case estimate and minimum and maximum values for probabilistic sensitivity analysis. Gamma distributions were used for costs and beta distributions were used for health outcomes.

	Mean value	Minimum value	Maximum value
Costs (2016 UGX)			
Delivery of CTX			
COTRIMOXAZOLE 960MG TAB	73.98	66.58	81.38
CTX-preventable and CTX-related events			
Treatment			
ALBENDAZOLE 400MG TAB	335.00	301.50	368.50
AMOXYCILLIN 250MG CAPS	64.45	58.01	70.90
AMPICILLIN/CLOXACILLIN 500MG CAPS	106.74	96.07	117.41
ARTEMETHER/LUMEFANTRINE 20/120MG TAB	129.88	116.89	142.86
ARTESUNATE INJECTION 60MG VIAL	7079.00	6371.10	7786.90
AZITHROMYCIN 500MG TAB	722.00	649.80	794.20
CEFIXIME TABLETS 200MG (TAXIM-O)	1873.90	1686.51	2061.29
CEFTRIAXONE 1G VIAL	1130.00	1017.00	1243.00
CHLORHEXIDINE/CETRIMIDE 1.5/15% 1LTR	17247.00	15522.30	18971.70
CIPROFLOXACINE 500MG TAB	95.85	86.27	105.44
AMOXYCILLIN/CLAVULANATE TABS 625MG	818.65	736.79	900.52
DICLOFENAC 50MG TAB	14.92	13.43	16.41
DICLOFENAC 25MG/ML 3 ML AMP	172.36	155.12	189.60
ERYTHROMYCIN 250MG TAB	102.82	92.54	113.10
FERROUS SULPHATE 200MG TAB	23.91	21.52	26.30
FOLIC ACID 5MG TAB	29.07	26.16	31.98
GENTAMICIN 40MG/ML 2ML AMP	428.21	385.39	471.03
IBUPROFEN 200MG TAB 100S	21.05	18.95	23.16
QUININE DI-HCL 600MG/2ML AMP	693.17	623.85	762.49
Intravenous Cefuroxime 1 gm od	14200.00	12780.00	15620.00
METRONIDAZOLE 5MG/ML 100ML IV	949.00	854.10	1043.90
LEVOFLOXACIN 500MG TABLETS	1159.30	1043.37	1275.23
LEVOFLOXACIN INJECTION (500 mg /100 ml)	3480.00	3132.00	3828.00
METRONIDAZOLE 200MG TAB	17.98	16.18	19.78
DROTAVERINE HCL 40MG	257.04	231.34	282.74
ORAL REHYDRATION SALT (ORS 0.5L)	120.00	108.00	132.00
PARACETAMOL 500MG TAB	17.49	15.74	19.24
SECNIDAZOLE 1GM TAB	980.00	882.00	1078.00
TRAMADOL 50 MG CAPS	165.33	148.80	181.86
TRAMADOL 100MG/2ML AMP	929.80	836.82	1022.78
VITAMIN A 200.000 IU 30 CAPS	444.97	400.47	489.46
ZINC SULPHATE 20MG TAB	36.30	32.67	39.93
ACYCLOVIR DERMATOLOGICAL CREAM 10G	0.00	0.00	0.00
AMINOPHYLLINE 100MG TAB	0.03	0.02	0.03

	Mean value	Minimum value	Maximum value
AMOXYCILLIN 250MG CAPS	0.02	0.01	0.02
AMPICILLIN CAPSULE BP 250MG	0.02	0.01	0.02
ASPIRIN 75MG ENTERIC COATED TABLETS	0.01	0.01	0.02
ATENOLOL 50MG TAB	0.02	0.02	0.02
AZITHROMYCIN 500MG TAB	0.00	0.00	0.00
BENDROFLUAZIDE 5MG TAB	0.02	0.02	0.02
CEFTRIAXONE 1G VIAL	0.00	0.00	0.00
CEFUROXIME TABS 500MG	0.00	0.00	0.00
CEPHALEXIN 250MG CAPS	0.01	0.01	0.01
CLOTRIMAZOLE 1% CREAM 20G	0.00	0.00	0.00
CLOXACILLIN 250MG CAPS	0.01	0.01	0.01
AMOXYCILLIN/CLAVULANATE 375MG TAB	0.00	0.00	0.00
COUGH LINCTUS 200ML	0.00	0.00	0.00
DEXAMETHASONE 0.5MG TAB	0.04	0.04	0.04
DICLOFENAC 50MG TAB	0.07	0.06	0.07
DOXYCYCLINE 100MG CAP	0.02	0.02	0.02
ERYTHROMYCIN 250MG TAB	0.01	0.01	0.01
HYDROCORTISONE 100MG VIAL	0.00	0.00	0.00
AMPICILLIN 500MG VIAL	0.00	0.00	0.00
MULTIVITAMIN TAB	0.05	0.05	0.06
OMEPRAZOLE 20MG CAPS	0.02	0.02	0.03
POVIDONE IODINE 10% SOLUTION 100ML	0.00	0.00	0.00
PREDNISOLONE 5MG TAB	0.02	0.02	0.02
SALBUTAMOL 4MG TAB	0.03	0.03	0.04
AMINOPHYLLINE 25MG/ML, 10ML AMP	0.00	0.00	0.00
CLOXACILLIN 500MG VIAL	0.00	0.00	0.00
CIPROFLOXACIN 200MG/100ML IV	0.00	0.00	0.00
BENDROFLUAZIDE 5MG TAB	55.59	50.03	61.15
AMOXYCILLIN/CLAVULANATE TABS 625MG	818.65	736.79	900.52
BRO-ZEDEX SYRUP 100ML [suspensions are given as the total ml in the bottle]	3960.00	3564.00	4356.00
Hyosine 10mg [10mg x 2]	368.74	331.87	405.61
CETIRIZINE 10MG TAB	16.23	14.61	17.85
AMPICILLIN CLOXACILLIN INJECTION	1293.00	1163.70	1422.30
MAGNESIUM TRISILICATE SUSPENSION 100ML [suspensions are given as the total ml in the bottle]	1947.00	1752.30	2141.70
ASCORBIC ACID 100MG TAB	26.40	23.76	29.04
BENZYL PENICILLIN 1 MIU VIAL	272.34	245.11	299.57
FLUCONAZOLE 200MG	489.50	440.55	538.45
PENICILLIN	73.53	66.18	80.88
Praziquantel 600mg	300.00	270.00	330.00
SODIUM CHLORIDE 0.9% IV 500ML [usually about 200ml are used for daily dressing]	1260.00	1134.00	1386.00
POVIDONE IODINE 10% SOLUTION 100ML	2967.00	2670.30	3263.70

	Mean value	Minimum value	Maximum value
SODIUM CHLORIDE 0.9% IV 500ML [usually about 200ml are used for daily dressing]	1260.00	1134.00	1386.00
SINUTABS (FLUFFED TABLETS)	64.76	58.28	71.24
Diagnostics			
Blood Culture	89000.00	80100.00	97900.00
Blood Grouping	8000.00	7200.00	8800.00
Cross Match (Blood)	17000.00	15300.00	18700.00
Malaria Test	6000.00	5400.00	6600.00
Blood Glucose Random (test done in Lab)	8000.00	7200.00	8800.00
Bone marrow [preparation cost only] and Bone marrow - Ngapi	189000.00	170100.00	207900.00
Full Blood Count - FBC	14000.00	12600.00	15400.00
CD4 / CD8 CD45	43000.00	38700.00	47300.00
X - ray - Chest AP	35000.00	31500.00	38500.00
Clotting time	8000.00	7200.00	8800.00
Aspirate [including culture/sensitivity]	57000.00	51300.00	62700.00
Urine Culture & Sensitivity	54000.00	48600.00	59400.00
Echo Doppler/Cardiography	184000.00	165600.00	202400.00
Full Blood Count - FBC	14000.00	12600.00	15400.00
High Vaginal Swab	54000.00	48600.00	59400.00
Liver Function Test (L.F.T)	68000.00	61200.00	74800.00
Renal Function Test (RFT)	54000.00	48600.00	59400.00
Sputum Analysis (for TB - 3 tests)	15000.00	13500.00	16500.00
Stool Examination	12000.00	10800.00	13200.00
Throat Swab	54000.00	48600.00	59400.00
Ultrasound guided - FNAC	132000.00	118800.00	145200.00
Ultrasound guided - FNAC	132000.00	118800.00	145200.00
Urine Analysis 10 Parameters	10000.00	9000.00	11000.00
Urine Culture & Sensitivity	54000.00	48600.00	59400.00
X-ray - skull	46000.00	41400.00	50600.00
X-ray - Hand	36000.00	32400.00	39600.00
Pus swabs	54000.00	48600.00	59400.00
X-ray - Hip	46000.00	41400.00	50600.00
Ultrasound guided - FNAC	132000.00	118800.00	145200.00
Electrolytes [Na+ K+ CL]	24000.00	21600.00	26400.00
ZN Staining	41000.00	36900.00	45100.00
Ultrasound guided - FNAC	132000.00	118800.00	145200.00
Ultrasound guided - FNAC	132000.00	118800.00	145200.00
MOD/ZN	20000.00	18000.00	22000.00
Procedures			
Surgery: Laparatomy under general anaesthesia	559000.00	503100.00	614900.00
Surgical Drainage - 1 day in Hospital (Day Care Case)	189000.00	170100.00	207900.00
Transfusion FFP or whole Blood - 5 units	261000.00	234900.00	287100.00
Under waterseal drain	273000.00	245700.00	300300.00

	Mean value	Minimum value	Maximum value
Health Systems Costs			
Out-patient (fixed) (UGX)	13310.22	11979.20	14641.24
Out-patient (variable): 5 mins (UGX)	160.42	144.38	176.46
In-patient (days) (UGX)	145584.67	131026.20	160143.14
Malaria Treatment			
Fansidar	584.88	526.39	643.37
Arthemeter	3117.00	2805.30	3428.70
Amodiaquine	1180.00	1062.00	1298.00
Tab Quinine	5689.95	5120.96	6258.95
IV Quinine	2079.51	1871.56	2287.46
Doxycycline	701.68	631.51	771.85
Effects			
DALYS weights Mild			
1. Recurrent Bacterial URTI	0.01	0.00	0.01
2. Sinusitis	0.01	0.00	0.01
3. Cellulitis	0.01	0.00	0.01
4. Acute Appendicitis	0.02	0.01	0.03
5. Otitis Media	0.01	0.00	0.01
6. Atypical Pneumonia	0.01	0.00	0.01
7. Bartholin's Abscess	0.00	0.00	0.00
8. Bacterial Bronchopneumonia	0.01	0.00	0.01
9. Epididymorchitis	0.01	0.00	0.01
10. Infected Uterine Fibroids	0.02	0.01	0.03
11. Infective Endocarditis	0.00	0.00	0.00
12. Lobar Pneumonia	0.01	0.00	0.01
13. Septic Skin Lesions	0.00	0.00	0.00
14. Skin Abscess	0.00	0.00	0.00
15. Pelvic Abscess	0.00	0.00	0.00
16. Pelvic Inflammatory Disease	0.00	0.00	0.00
17. Perirectal Abscess	0.00	0.00	0.00
18. Pharyngitis	0.01	0.00	0.01
19. Puerperal Sepsis	0.00	0.00	0.00
20. Pyelonephritis	0.00	0.00	0.00
21. Pyomyositis	0.00	0.00	0.00
22. Septic Arthritis	0.00	0.00	0.00
23. Septicaemia	0.00	0.00	0.00
24. Submandibular Abscess	0.00	0.00	0.00
25. Urinary Tract Infection	0.01	0.00	0.01
26. Tracheobronchitis	0.00	0.00	0.00
27. Chronic Unexplained Diarrhoea	0.08	0.05	0.11
28. Malaria	0.01	0.00	0.01
29. Anaemia	0.00	0.00	0.01
30. Neutropenia	0.01	0.01	0.02
31. Thrombocytopenia	0.01	0.01	0.02

	Mean value	Minimum value	Maximum value
DALY weights Moderate			
1. Recurrent Bacterial URTI	0.05	0.03	0.07
2. Sinusitis	0.05	0.03	0.07
3. Cellulitis	0.06	0.04	0.09
4. Acute Appendicitis	0.26	0.18	0.35
5. Otitis Media	0.05	0.03	0.07
6. Atypical Pneumonia	0.08	0.05	0.12
7. Bartholin's Abscess	0.06	0.04	0.27
8. Bacterial Bronchopneumonia	0.08	0.05	0.12
9. Epididymorchitis	0.05	0.03	0.07
10. Infected Uterine Fibroids	0.16	0.11	0.22
11. Infective Endocarditis	0.10	0.06	0.15
12. Lobar Pneumonia	0.08	0.05	0.12
13. Septic Skin Lesions	0.06	0.04	0.09
14. Skin Abscess	0.11	0.07	0.16
15. Pelvic Abscess	0.11	0.07	0.16
16. Pelvic Inflammatory Disease	0.16	0.11	0.22
17. Perirectal Abscess	0.11	0.07	0.16
18. Pharyngitis	0.05	0.03	0.07
19. Puerperal Sepsis	0.05	0.03	0.07
20. Pyelonephritis	0.00	0.00	0.00
21. Pyomyositis	0.06	0.04	0.09
22. Septic Arthritis	0.05	0.03	0.07
23. Septicaemia	0.00	0.00	0.00
24. Submandibular Abscess	0.11	0.07	0.16
25. Urinary Tract Infection	0.05	0.03	0.07
26. Tracheobronchitis	0.05	0.03	0.07
27. Chronic Unexplained Diarrhoea	0.23	0.15	0.32
28. Malaria	0.05	0.03	0.07
29. Anaemia	0.05	0.03	0.08
30. Neutropenia	0.00	0.00	0.00
31. Thrombocytopenia	0.00	0.00	0.00
DALY weights Severe			
1. Recurrent Bacterial URTI	0.13	0.09	0.19
2. Sinusitis	0.13	0.09	0.19
3. Cellulitis	0.13	0.09	0.19
4. Acute Appendicitis	0.60	0.37	0.69
5. Otitis Media	0.14	0.09	0.21
6. Atypical Pneumonia	0.13	0.09	0.19
7. Bartholin's Abscess	0.00	0.00	0.00
8. Bacterial Bronchopneumonia	0.13	0.09	0.19
9. Epididymorchitis	0.13	0.09	0.19
10. Infected Uterine Fibroids	0.41	0.29	0.55
11. Infective Endocarditis	0.00	0.00	0.00

	Mean value	Minimum value	Maximum value
12. Lobar Pneumonia	0.13	0.09	0.19
13. Septic Skin Lesions	0.00	0.00	0.00
14. Skin Abscess	0.00	0.00	0.00
15. Pelvic Abscess	0.00	0.00	0.00
16. Pelvic Inflammatory Disease	0.00	0.00	0.00
17. Perirectal Abscess	0.00	0.00	0.00
18. Pharyngitis	0.13	0.09	0.19
19. Puerperal Sepsis	0.00	0.00	0.00
20. Pyelonephritis	0.13	0.09	0.19
21. Pyomyositis	0.00	0.00	0.00
22. Septic Arthritis	0.00	0.00	0.00
23. Septicaemia	0.13	0.09	0.19
24. Submandibular Abscess	0.00	0.00	0.00
25. Urinary Tract Infection	0.13	0.09	0.19
26. Tracheobronchitis	0.00	0.00	0.00
27. Chronic Unexplained Diarrhoea	0.13	0.09	0.19
28. Malaria	0.13	0.09	0.19
29. Anaemia	0.15	0.10	0.21
30. Neutropenia	0.01	0.01	0.02
31. Thrombocytopenia	0.01	0.01	0.02
Case Fatality rate			
CTX preventable events*	0.11	0.10	0.13
Malaria**	0.10	0.05	0.25

*Estimates for case fatality rates for CTX preventable events obtained from: Tornheim et al. The epidemiology of hospitalized pneumonia in rural Kenya: the potential of surveillance data in setting public health priorities. Int J Infect Dis. 2007 Nov;11(6):536-43.

**Estimates for case fatality rates for malaria obtained from: Laufer MK, Plowe CV. The Interaction between HIV and malaria in Africa. Curr Infect Dis Rep. 2007 Jan;9(1):47-54. doi: 10.1007/s11908-007-0022-3. PMID: 17254504; and Dondorp AM et al; AQUAMAT group. Artesunate versus quinine in the treatment of severe falciparum malaria in African children (AQUAMAT): an open-label, randomised trial. Lancet. 2010 Nov 13;376(9753):1647-57. doi: 10.1016/S0140-6736(10)61924-1.

Appendix 4.4: Ethical approval letters from Uganda Virus Research Institute and London School of Hygiene & Tropical Medicine

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT
United Kingdom
Switchboard: +44 (0)20 7636 8636

www.lshtm.ac.uk

Observational / Interventions Research Ethics Committee

Mr Sergio Torres-Rueda
Research Fellow
Department of Global Health and Development (GHD)
Public Health and Policy (PHP)
LSHTM

22 March 2016

Dear Sergio

Study Title: Cost-effectiveness of discontinuing cotrimoxazole preventive therapy in adults

LSHTM Ethics Ref: 10575

Thank you for responding to the Observational Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Investigator CV	CV Anna Vassal	17/01/2016	1
Investigator CV	SERGIO TORRES RUEDA CV	17/01/2016	1
Protocol / Proposal	Cotrimoxazole Protocol 14-01-16	17/01/2016	1
Information Sheet	Information sheet	17/01/2016	1
Covering Letter	Response letter to Ethics Committee 10 03 16	10/03/2016	1
Protocol / Proposal	Cotrimoxazole Protocol 10 03 16	10/03/2016	2
Information Sheet	Information sheet 10 03 16	10/03/2016	2
Information Sheet	Consent Form	10/03/2016	1
Local Approval	Cost Effectiveness study of COSTOP UVRI REC Approval_1	10/03/2016	1

After ethical review

The Chief Investigator (CI) or delegate is responsible for informing the ethics committee of any subsequent changes to the application. These must be submitted to the Committee for review using an Amendment form. Amendments must not be initiated before receipt of written favourable opinion from the committee.

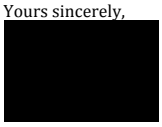
The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reactions (SUSARs) which occur during the project by submitting a Serious Adverse Event form.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at: http://leo.lshtm.ac.uk

Additional information is available at: www.lshtm.ac.uk/ethics

Yours sincerely,



[redacted]
Professor John DH Porter
Chair

ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

Improving health worldwide

UNHRO
Uganda National Health Research Organisation

Uganda Virus Research Institute

Plot 51-59, Nakiwogo Road, Entebbe
P.O. Box 49, Entebbe-Uganda
Tel: +256 414 320 385 / 6
Fax: +256 414 320 483
Email: directoruvri@uvri.go.ug

REPUBLIC OF UGANDA

Our Ref: GC/127/16/03/550
Your Ref:

03rd March 2016

Dr. Paula Munderi,

RE: UVRI REC review of protocol titled **"Cost-effectiveness of discontinuing cotrimoxazole preventive therapy in adults"**

Thank you for submitting your protocol dated 12th February 2016 to the UVRI Research Ethics Committee.

This is to inform you that your protocol was reviewed during the REC meeting of 25th February 2016 and met the requirements of the UVRI REC.

UVRI REC annual approval has been given for you to conduct your research up to 03rd March 2017. Annual progress report and request for extension should be submitted to UVRI REC prior to the expiry date, to allow timely review.

The reviewed and approved documents included;

1. UVRI REC Application form
2. Study Protocol.
3. Information sheet
4. Consent Form
5. Applicant's CVs

You can now continue with your study after registration with the Uganda National Council for Science and Technology (UNCST).

Note: UVRI REC requires you to submit a copy of the UNCST approval letter for the above study before commencement.

Yours sincerely,

[redacted]

Mr. Tom Lutalo
Chair, UVRI REC
C.C Secretary, UVRI REC

Chapter 5

Appendix 5.1: Preliminary draft of 'Assessing global evidence on cost-effectiveness to inform Pakistan's Health Benefit Package'

Maryam Huda[1],

Nichola Kitson[2],

Nuru Saadi[2],

Saira Kanwal[3],

Urooj Gul[3],

DCP3 Pakistan Country Translation Group

Sameen Siddiqi[1],

Anna Vassall[2],

1 Community Health Sciences of Aga Khan University (AKU), Karachi, Pakistan.

2 London School of Hygiene and Tropical Medicine, London, UK.

3 Health Planning, System Strengthening & Information Analysis Unit (HPSIU), Ministry of National Health Services Regulations & Coordination, Islamabad, Pakistan

Abstract

Background: Countries designing a health benefit package (HBP) to support progress towards universal health coverage (UHC) require high quality evidence of the cost-effectiveness of interventions. This paper reports on Pakistan's approach to assessing the applicability of global cost-effectiveness evidence to country context as part of a health benefit package design process.

Methods: A seven-step process was developed and implemented with Disease Control Priority 3 (DCP3) project partners to assess the applicability of global incremental cost-effectiveness ratios (ICER) to Pakistan. In the first step, the scope of the interventions to be assessed was defined, and an independent, interdisciplinary team was formed. In the second step, the team familiarized itself with intervention descriptions. In the third step, the team identified studies from the Tufts Medical School Global Health Cost-Effectiveness Analysis (GHCEA) registry. In the fourth step, the team applied specific knock-out criteria, to match identified studies to local intervention descriptions. In the fifth step, matches were cross-checked across reviewers and further selection was made where there were multiple ICER matches. In the sixth step, a quality scoring system was applied to ICER values. In the seventh step, a database was created for all the ICER results with a justification for each decision that was made available to decision makers as part of their evidence-based deliberation on the HBP.

Results: Our assessment found that less than 50% of the interventions in DCP3 could be supported with evidence of cost-effectiveness applicable to the country context. Out of 81 ICERs identified as applicable to Pakistan from the Tufts GH-CEA registry, only 20 ICERs were exact matches of the DCP3 Pakistan intervention descriptions and 61 were partial matches.

Conclusions: DCP3 defines a set of 'generally cost-effective' interventions for countries with different income levels. When assessed from a lower middle income country perspective, we found that the global body of evidence on DCP3 intervention could only be partially applied, when considering intervention match. Our process provides transparency around the challenges associated with transferability of global evidence; clearly identifying ICERs that are not applicable to country context and grading evidence quality, so that governments can make informed decisions.

MAIN TEXT

Introduction

Universal Health Coverage (UHC) is based on the principle that all individuals and communities have access to essential, quality healthcare services without suffering financial difficulty (Evans, Hsu, & Boerma, 2013). Defining the health benefit package (HBP) is one of the first steps towards achieving UHC. An HBP is a set of health services that can be feasibly financed and delivered to all citizens according to a country's available resources (Woods, Revill, Sculpher, & Claxton, 2016). Defining an HBP involves the selection and definition of decision criteria and assessing the performance of interventions against those criteria (Baltussen et al., 2016). A key criterion used to prioritize health interventions for inclusion in the HBP and ensure efficient use of existing resources is cost-effectiveness.

The Disease Control Priorities 3 (DCP3) project provides a periodic review of the most up-to-date global evidence on cost-effectiveness of interventions to address the burden of disease in low-resource settings. DCP3 provides guidance on priority health interventions for UHC in the form of model UHC packages. The packages include an Essential UHC package (EUHC), comprising 218 interventions and the more limited High Priority Package (HPP), comprising a subset of 108 interventions, which could be adapted to reflect country-specific needs, health system capacities, financing structures, available resources, and other local circumstances. These interventions are recommended as a priority based on an expert assessment of the evidence on cost-effectiveness globally. The full EUHC package, at 80% population coverage, is estimated to have a cost of 2016 US$79 per capita in low-income countries (LICs) and US$130 per capita in lower-middle income countries (Watkins et al., 2020), which exceeds current health expenditure in many settings. Therefore, further prioritization of the DCP3 model UHC package is required at the country level, tailored to local needs and by considering relevant evidence across several criteria, commonly including cost-effectiveness. Pakistan is one of the first countries to use a DCP3 model UHC package as the starting point for the design of an HBP and adapting it further using an evidence-informed deliberative process (EDP).

Cost-effectiveness is a concept that is inherently context specific, and the cost-effectiveness of interventions will vary according to demographic, epidemiological and health system characteristics. If local cost-effectiveness evidence is unavailable, there are several approaches available for adapting or transferring estimates of cost-effectiveness across settings. One approach is to model cost-effectiveness ratios using local data. However, this can be time consuming and demands extensive capacity if many interventions need to be considered. An alternative is to apply frameworks typically used in the context of Health Technology Assessment (HTA) to transfer cost-effectiveness results for specific new technologies across settings (Hutchings et al., 2009), one form of which is to extrapolate cost-effectiveness ratios from other settings, adjusting for country income groups (as was done by DCP3). HTA frameworks, that adjust for a range of factors determining cost-effectiveness are often focused on single incremental interventions and require substantial data input, both from the context of the original estimate and the jurisdiction to which it is being applied. HBP design processes typically have timeframes of a year or less and can cover hundreds of interventions: it is thus unclear how feasible current transferability guidance may be for HBP design.

This paper sets out the approach used by the Ministry of National Health Services, Regulation and Co-ordination (MoNHSR&C) of Pakistan to move beyond simple income based extrapolation, and additionally assess the applicability of the global evidence base on cost-effectiveness to the country context, using a simplified transferability framework. The paper reflects on the appropriateness of the method used, and more broadly on the appropriateness of the existing global body of literature on cost-effectiveness for the purposes of HBP design in LMICs.

Methods

The overall process of priority setting for the HBP in Pakistan was rooted in the approach outlined in (Baltussen et al., 2016), employing evidence-informed deliberation, whereby evidence is summarized and appraised in a systematic and transparent way by relevant stakeholders. Given the timeframe of the HBP design process (six months to one year), and after review of the various models available, the MoNHSR&C decided it was not possible to model cost-effectiveness for multiple interventions, using local data. It was therefore decided to use global estimates of cost-effectiveness summarized by DCP3 and transfer these to the country context by developing a novel approach that assesses the applicability of incremental cost-effectiveness ratio's (ICERs) to Pakistan's context.

ICER is the most frequently used measure of cost-effectiveness calculated by dividing the difference in total costs between an intervention and comparator (incremental costs) by the difference in the chosen measure of the health outcome or effect (incremental effect) to provide an incremental ratio of 'cost per unit of health effect (Consortium, 2016). ICERs can be a limited measure of cost-effectiveness in respect of HBP design, where average cost-effectiveness ratios (ACERs) are sometimes used to examine the most efficient package assuming a null comparator. However, ACERs do not take into account both the shared costs and impact of different combinations of interventions, and hence in principle ICERs are more appropriate if looking at an expansion pathway to UHC. There is also very limited empirical evidence on ACERS, so in practice, and in the case of DCP3, ICERS are used as the measure of cost-effectiveness, despite the fact that they are highly unlikely to be estimated against the past and proposed combination of interventions being considered in HBP processes.

Our approach presumes that ICERs from other settings may be uncertain and biased, when applied to Pakistan; and that the overall process should ensure as much transparency about global evidence quality as was feasible within our timeframe. To this end, we developed an assessment process that did not transfer ICER values for Pakistan, but instead selected the most appropriate ICER and characterized the quality of the ICER in terms of relevance to the Pakistan's context, as a novel means to facilitate the application of ICERs to Pakistan's context, in an easily interpretable manner for decisions makers unfamiliar with economic evaluation. Our aim was to facilitate critical stakeholder review of ICER estimates to arrive at consensus regarding interventions to include in the HBP, using ICERS alongside expert judgement and appraisal. In this way our approach is in line with the approach of DCP3 globally, that combines expert judgement and literature on ICERs, accepting that the underlying literature base is incomplete and biased.

The scope of our analysis took the DCP3 model EUHC package as a point of departure with 218 interventions divided into 4 clusters (Reproductive, Maternal, Neonatal, Child and Adolescent Health and Nutrition (RMNCAH-N), Infectious diseases, Non-Communicable Disease (NCD) and general health services) across 5 levels (Community, primary health care (PHC), first level hospital, referral hospital, and population level). These were further narrowed down by the MoNHSR&C and an extensive consultation process to 170 interventions (including some that were splits of DCP3 interventions were considered for assessment and appraisal for inclusion in the Pakistan HBP (see [Baltussen et al. 2021] for further details).

To determine our general approach to assessing the applicability of ICERs to Pakistan, we reviewed tools and checklists from the HTA literature to try to aid the process and identify factors that would impact evidence quality (Goeree et al.). Most approaches involve an initial assessment to examine whether the study/ evidence under consideration is a suitable candidate for transferability to a new setting. This initial assessment is often referred to as the 'knock-out' criteria, or the 'minimal methodology standard' and usually involves considering the: quality of the study, transparency of methods, level of reporting of methods and results, and applicability of the treatment comparators to

the target country. A further assessment is then carried out based on other context specific factors using checklists, flowcharts and toolkits of criteria covering domains deemed to be important influences on transferability, for example the transferability of the health outcome data, the perspective, the study design etc. Some approaches generated a quantitative score or index to measure transferability. The assessment criteria chosen by different authors varied widely in both content and extensiveness, (Knies, Ament, Evers, & Severens, 2009) for example Welte's consist of three assessment criteria, in comparison to Boulanger's transferability information checklist which is a 42-question tool (Glassman, Giedion, & Smith, 2017).

After piloting several approaches to test the feasibility within our time and resource constraints it was decided that it was not feasible to adjust ICER values but instead to select the most appropriate ICER and characterize the quality of the ICER in terms of relevance to the Pakistan's context. We developed and employed a 7-step process (Figure 1). The first step in our process was scoping the interventions to be assessed and forming an independent, interdisciplinary team. The review team consisted of 5 core members, and combined experience in health economics, research, and clinical practice. It consisted of 2 international DCP3 staff (health economist, systematic review expert), 1 local academic (clinical expert and health economist) and 2 MoNHSR&C staff (clinical expert, statistician). In addition, the results were reviewed both by an additional senior international health economist, and the full DCP secretariat at the MoNHSR&C.

The second step was for the team members to become familiar with the interventions being considered for the HBP. The MoNHSR&C prepared detailed intervention description sheets which described how the intervention will be implemented; at what platform, the population in need, the procedures, technologies, and medicines involved (Alwan et al. 2022). These were reviewed by the core team members.

Step three identifies studies to review as potential matches to the Pakistan-specific DCP3 interventions. Out of the total 170 interventions included in the assessment, we searched for ICERS for 166 interventions: 41 interventions at community, 56 at PHC level, 49 interventions at the FLH and 20 interventions at RH level. While not considered for inclusion in the HBP at the district level, we also searched ICERs for 13 population level interventions. No ICERs could be searched for 4 interventions because they were too broad in their definition (FLH57 - Prevention and relief of refractory suffering and acute pain related to surgery, serious injury or other serious, complex or life-limiting health problems, FLH58 - First level hospital pathology services, HC67 - Expanded palliative care and pain control measures, including prevention and relief of all physical and psychological symptoms of suffering and HC68 - Health center pathology services). A full list of interventions analyzed is contained in the supplementary material in Table S1.

We piloted several approaches to identify ICERS from the literature. The initial approach tried to use the systematic reviews prepared by DCP3 as the basis to identify the best country specific ICER estimate, and to update these reviews. However, the DCP3 database did not provide sufficient detail, nor were each of the searches (and study extraction methods) consistent across volumes. It was therefore not possible to re-do the systematic reviews of all DCP3 evidence within our time frame. We therefore decided to use Tuft Medical School GH-CEA registry (15) as the registry extracts all elements needed both in terms of ICER values but also standard quality assessment tools, such as scoring against the CHEERS checklist.

The GH-CEA registry extracts several outcomes from the global literature, including a "incremental cost-per-disability life year (DALY) averted" metric, the same metric as used in DCP3, which enables comparability, but may bias searches towards newer technologies or studies on treatment, as DALYs have been increasingly used over time. We have included the details of our search terms and process in

the supplementary material. Once we had arrived at a set of studies to be evaluated, we downloaded the database into Excel. It was organized and distributed amongst team members for review. The downloaded file included the publication year, target population, study country, intervention description, comparator description and incremental cost per DALY averted in current United States Dollar (USD). A full list of the data extracted can be found in the supplementary material, Table S1.

In step four, each team member reviewed the studies for inclusion by applying specific knock-out criteria. We used Welte et al's general knock-out criteria, which is comprised of 3 factors: 1) the relevant technology (intervention) is not comparable to the one that shall be used in the decision country; 2) the comparator is not comparable to the one that is relevant to the decision country; and 3) the study does not possess an acceptable quality, according to a standard reporting standard (CHEERs checklist) (Husereau et al., 2013). To assess the intervention for matching, the reviewers first reviewed the intervention description, extracted from the GH-CEA for each study to see how well they matched those provided by the MoNHSR&C. Reviewers were asked to score whether there was an exact match, a partial or no match. An exact match refers to an intervention description from the GH-CEA results which matches the DCP3- Pakistan intervention description in terms of method, delivery, and technology used. A partial match refers to an intervention description from the GH-CEA results which only matches some of those elements. This process was completed by each reviewer blinded to other reviewers, and cross-checked by a second reviewer, followed by discussion. Those with exact or partial matches were paired with the relevant DCP3 intervention.

Step five selected the most relevant ICER in case multiple studies survived the knock-out step. The pros and cons of each study in terms of matching to the Pakistani setting were discussed until one ICER value agreed to be the most relevant. Factors that favored selection of the study included the most recent publication date, best intervention match, appropriate comparator, context specific factors such as service delivery level, or specific drug or vaccine used. Finally, a one-line justification was written to explain why a study was chosen.

Step six scored the quality of the extracted ICERs by adding a simple 3* scoring system focusing on providing an indication of how applicable the ICER was to the Pakistani context. For 3 stars, the ICER result came from Pakistan, and was either a partial or exact match. To receive 2 stars, the ICER values came from a study from another LMIC setting and was either a partial or exact match. One star was given to interventions where a partial or exact match was not found.

In step seven, we summarized the justification for why each ICER value was chosen for each intervention. This was made available to the stakeholders, in long form and in simple evidence sheets, alongside evidence of costs and burden of disease (Baltussen et al. 2022). During the evidence deliberation sessions, the core team was available to answer any questions and ready to provide access to full study texts if requested.

Where we did not find any value, we used the default values from DCP3, with the lowest quality score. Finally, these values were entered into the Health Interventions Prioritization Tool (HIPtool), developed by University College London (UCL) and The World Bank (see further details in the supplementary appendix). This tool adjusts ICERs by the attributable disease burden, where the impact generated cannot exceed total annual disease burden for the discase. Where this was done, we also gave the lowest quality to final ICER value presented to decision makers.

Results

Figure 1 presents the number of studies considered in each of the 7 steps. The Tufts GH-CEA registry includes a total of 5597 studies from 1995-2019. After applying the general knock out criteria, we

identified 500 studies for PHC (phase 1 of the HBP) applying both the 1st and 2nd knock-out criteria. During phase 2, for first level and referral level hospitals we identified 2198 and 1508 studies, after the 1st and 2nd general knock out criteria respectively. Finally, in phase 3 for population level interventions, we found 2198 and 2119 studies after applying the 1st and 2nd general knock out criteria.

Applying the specific knock-out criteria as part of step 4 in our process, we could only identify ICERS for 78 interventions that had a relevant technology, and quality. Of these only 13 had a relevant comparator (see Table S3). Applying the quality scoring, almost 48% of these had a rating of 2 or 3 stars. The values of ICERs selected in step 5 can be found in Table S1.

The proportion of interventions for which matches were found varied by platform (see Table 1). At the community level 18 interventions out of 41 were found from the Tufts GH-CEA registry. For the PHC level interventions, 25 out of the 56 ICERs were found from the Tufts GH-CEA registry. Out of these 43 GH-CEA studies, only 7 were exact matches of the DCP3 intervention and the study intervention while 36 were partial matches. 13 studies were from Pakistan, 25 studies were from South Asia and 5 from other LMIC.

For the first level hospital interventions 25 of the 49 ICERs were found from Tufts GH-CEA registry. Out of the 25 results, 8 were exact matches of the DCP3 interventions and the study intervention while 17 were partial matches. 1 study was from South Asia and 24 were from other LMICs. Of the referral hospital interventions 10 ICERs were from the Tufts GH-CEA registry, 5 were an exact match, whilst 5 were a partial match. All 10 were from LMICs. Lastly after a systematic search for ICERs for the 13 population level interventions, 7 were identified through the Tufts GH-CEA registry. Out of these 7, 2 were from Pakistan, 2 from South Asia and the remaining 3 from other LMICs. All 7 were partial matches.

Quality scoring for each of the studies by platform and cluster is shown in Figure 3a and 3b, and more detail provided in Table 1. Out of the total 166 interventions reviewed, 87 studies received one star, 66 studies received two stars and 13 studies received three stars. The remaining ICERs (default DCP3 values) were all scored one star.

Discussion

We have presented here a pragmatic, but systematic approach to assess the applicability of the global cost-effectiveness evidence for use in health benefit package design processes. We found that, even when partial geographical and intervention matched ICERs were used, there was a dearth of context relevant evidence on the cost-effectiveness of DCP3 interventions, with under 50% of the interventions receiving an ICER value, that we could source from the incremental cost per DALY literature evidence base.

The lack of sufficient economic evaluation evidence to inform priority setting in LMICs has been long noted (Lewin et al., 2008). In simple terms there are three approaches used to address this data gap a) modelling context specific estimates using local cost, effectiveness and epidemiological data, b) extrapolation of the current evidence base across settings and c) reviewing the literature, without adjustment, using expert judgement. At the global level DCP3 attempted to facilitate those wishing to use the third approach locally, by conducting a global exercise to identify interventions where there is strong evidence of cost-effectiveness, to provide a longlist of interventions for LMICs to include in benefit packages and to provide a broad estimation of cost-effectiveness by country income group. We found that a similar combination and expert review is likely to be required at the country level.

Limiting our evidence review to those studies found on the GH-CEA database, restricted us to incremental cost per DALY averted studies. This limitation in part, explains the gap in the evidence base between the scope of DCP3 global review of cost-effectiveness and our localized evidence of cost-effectiveness. DCP3 also has gaps, circumscribed by the overall economic literature, and does not include foundation non-disease specific interventions, such as routine symptom screening services. The exclusion of non-DALY studies biases towards more recent interventions. However, while evidence of cost-effectiveness which does not estimate cost per DALY averted may be appropriate when comparing interventions with the same outcomes, it is not appropriate for health benefit packages exercises, where a generic health outcome metric is required. Further work estimating the cost per DALY averted for economic evaluations that currently use other disease specific metrics is urgently required before any future DCP-type global exercises.

We also found substantial differences in the numbers of studies available across interventions, which suggests that funding for economic evaluations in LMIC contexts may not be balanced from a health sector wide perspective. The interventions with the most substantial evidence base were typically those with potentially high commodity costs, such as Rotavirus vaccination. This publication bias is not surprising, as new (and high cost) interventions may be more likely to be subjected to health technology assessment (HTA). Going forward, relying on a body of literature primarily geared to supporting incremental analyses may not best redress this evidence gap; and more investment is needed in economic evaluations targeting some of the gaps we found, once prior to DALY studies have been considered.

In addition to empirical limitations there are also theoretical concerns when transferring ICERs to support health benefit package prioritization. The main challenge is that ICERs are estimated as incremental to 'a comparator' that may not be appropriate for the context. We prioritized ICERs compared to a 'do-nothing' comparator, but we only found 13 studies that included this comparator; other ICERs intrinsically reflect the underlying status quo of health service delivery in the study country. An alternative approach is to generate an evidence base on average cost-effectiveness ratios (ACERs) compared to a null (no health service delivery), replicating building a health system up from nothing. However, ACERs cannot be validated empirically. It is unlikely that current health service delivery will be dismantled and rebuilt, and thus to some extent even the most radical reallocation of resources will also be in practice incremental, with ACERs being more a theoretical construct to help countries determine how far off the current system has shifted from optimal resource allocation.

The above biases and limitations may be avoided if efforts are made to locally model ICERs. Infectious disease programs commonly conduct such exercises to inform resource allocation, and WHO CHOICE provides a framework for bringing some of those models with other analyses together to look at multiple interventions. WHO CHOICE was recently applied to benefit package definition in Ethiopia (Obse, Ryan, Heidenreich, Normand, & Hailemariam, 2016). In this case it was able to cover around half the interventions. Ochalek and colleagues also combined both modelling and existing data when supporting the National Essential Health Package (EHP) of Malawi (Love-Koh et al., 2019). In our first feasibility assessment, modelling ICERs using WHO CHOICE was considered in Pakistan too, however, while WHO-CHOICE can produce results in short time frames, understanding the assumptions, epidemiologic models and costs driving those results sufficiently to judge their quality, was not considered possible by the stakeholders within the time frame. While the published evidence base is subject to the same complexity, the combination of peer review, quality assessment and finally stakeholder review (as part of the evidence-based deliberation) was chosen by the MoNHSR&C for greater assurance of quality, transparency and stakeholder engagement, as important outcomes of HBP prioritization processes, even if the empirical evidence may be of lower quality.

Our experience of applying DCP3 evidence in Pakistan highlights the challenges LMICs face when trying to use limited global evidence for UHC benefit package definition. While DCP3 reflects the consensus around a very broad package of essential services that can be adapted according to local needs and affordances, there remains a stark trade-off between satisfying the political and accountability imperatives to produce benefit packages rapidly and evidence quality. Health benefit package design processes should thus not be seen as one-off exercises but allow for continual evidence review to refine packages over time, particularly in high cost, marginal interventions where quality evidence is not available in the short term.

Future global efforts can support this effort by focusing on evidence review processes that incorporate both a general and transferability assessment of evidence from different regional perspectives, rather than simply adjusting ICERs by country income level. Where ICERs are used from other settings, this should be done with full transparency of the uncertainty and biases in such approaches. Such regional analyses and reviews, that include some degrees of contextual assessment, would assist countries, funders and the research community focus effort towards the most important evidence gaps.

At the country level HBP design processes need to be conducted using carefully designed evidence review processes, that allow time for stakeholders to systematically and explicitly understand and appraise the applicability of evidence to their context. Benefit package definition should be followed up with a process to monitor and evaluate the package as it is implemented, ideally producing local evidence on costs and cost-effectiveness, that can add to the global evidence base. Finally, further involvement and interaction between those assessing ICERs at the country level and those engaged in global reviews/ modelling efforts is critical to develop a community of practice in this complex but important area of UHC policy.

References (Appendix 5.1)

Baltussen, R., Jansen, M. P., Mikkelsen, E., Tromp, N., Hontelez, J., Bijlmakers, L., & Van Der Wilt, G. J. (2016). Priority setting for universal health coverage: we need evidence-informed deliberative processes, not just more evidence on cost-effectiveness. *International journal of health policy and management, 5*(11), 615.

Consortium, Y. H. E. (2016). Incremental Cost-Effectiveness Ratio (ICER). Retrieved from https://yhec.co.uk/glossary/incremental-cost-effectiveness-ratio-icer/. Retrieved 24th November 2020 https://yhec.co.uk/glossary/incremental-cost-effectiveness-ratio-icer/

Evans, D. B., Hsu, J., & Boerma, T. (2013). Universal health coverage and universal access. In (Vol. 91, pp. 546-546A): SciELO Public Health.

Glassman, A., Giedion, U., & Smith, P. C. (2017). *What's in, what's out: designing benefits for universal health coverage*: Brookings Institution Press.

Goeree, R., He, J., O'Reilly, D., Tarride, J., Xie, F., Lim, M., & Burke, N. Transferability of health technology assessments and economic evaluations: a systematic review of approaches for assessment and application. Clinicoecon Outcomes Res. 2011; 3: 89-104. In.

Husereau, D., Drummond, M., Petrou, S., Carswell, C., Moher, D., Greenberg, D., . . . Loder, E. (2013). Consolidated health economic evaluation reporting standards (CHEERS)—explanation and elaboration: a report of the ISPOR health economic evaluation publication guidelines good reporting practices task force. *Value in Health, 16*(2), 231-250.

Hutchings, A., Durand, M. A., Grieve, R., Harrison, D., Rowan, K., Green, J., . . . Black, N. (2009). Evaluation of modernisation of adult critical care services in England: time series and cost effectiveness analysis. *Bmj, 339*.

Knies, S., Ament, A. J., Evers, S. M., & Severens, J. L. (2009). The transferability of economic evaluations: testing the model of Welte. *Value in Health, 12*(5), 730-738.

Lewin, S., Lavis, J. N., Oxman, A. D., Bastías, G., Chopra, M., Ciapponi, A., . . . Rada, G. (2008). Supporting the delivery of cost-effective interventions in primary health-care systems in low-income and middle-income countries: an overview of systematic reviews. *The Lancet, 372*(9642), 928-939.

Love-Koh, J., Walker, S. M., Kataika, E., Sibandze, S., Arnold, M., Ochalek, J. M., . . . Sculpher, M. J. (2019). Economic analysis for health benefits package design.

Obse, A., Ryan, M., Heidenreich, S., Normand, C., & Hailemariam, D. (2016). Eliciting preferences for social health insurance in Ethiopia: a discrete choice experiment. *Health policy and Planning, 31*(10), 1423-1432.

Watkins, D. A., Qi, J., Kawakatsu, Y., Pickersgill, S. J., Horton, S. E., & Jamison, D. T. (2020). Resource requirements for essential universal health coverage: a modelling study based on findings from Disease Control Priorities. *The Lancet Global Health, 8*(6), e829-e839.

Woods, B., Revill, P., Sculpher, M., & Claxton, K. (2016). Country-level cost-effectiveness thresholds: initial estimates and the need for further research. *Value in Health, 19*(8), 929-935.

TABLES AND FIGURES

Figure 1: 7-step process 'Assessing ICERs for HBP design' in Pakistan

Figure 2: Search Process using Tufts GH-CEA registry

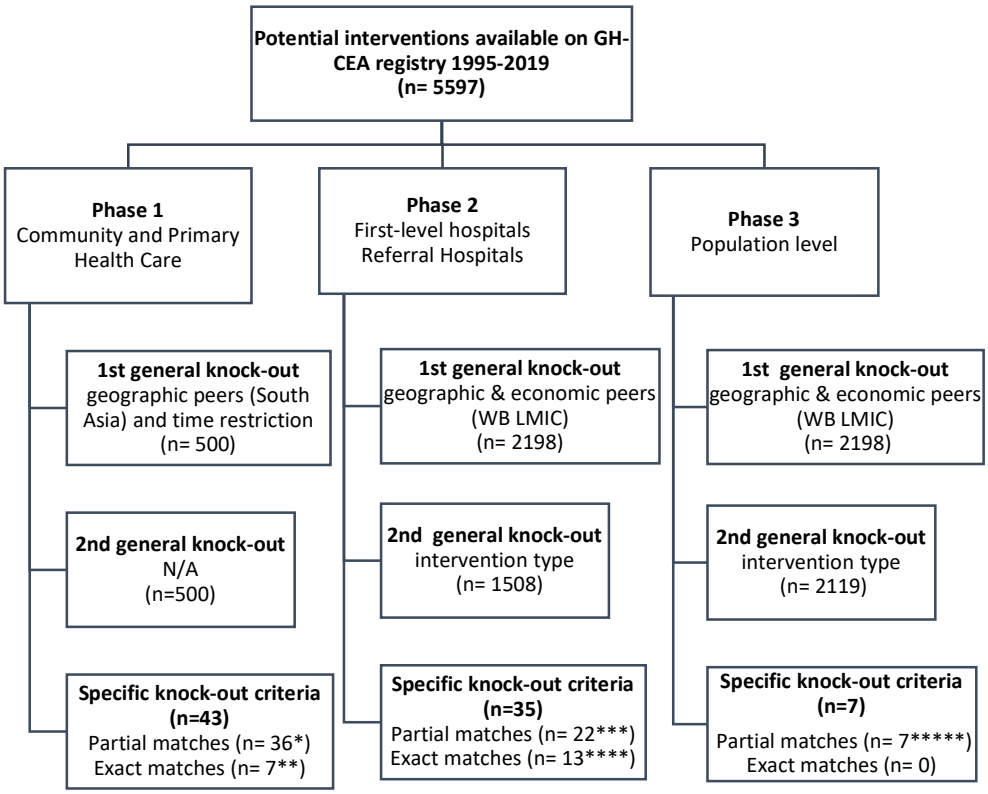


Table 1a – Interventions per cluster, search results and quality scoring

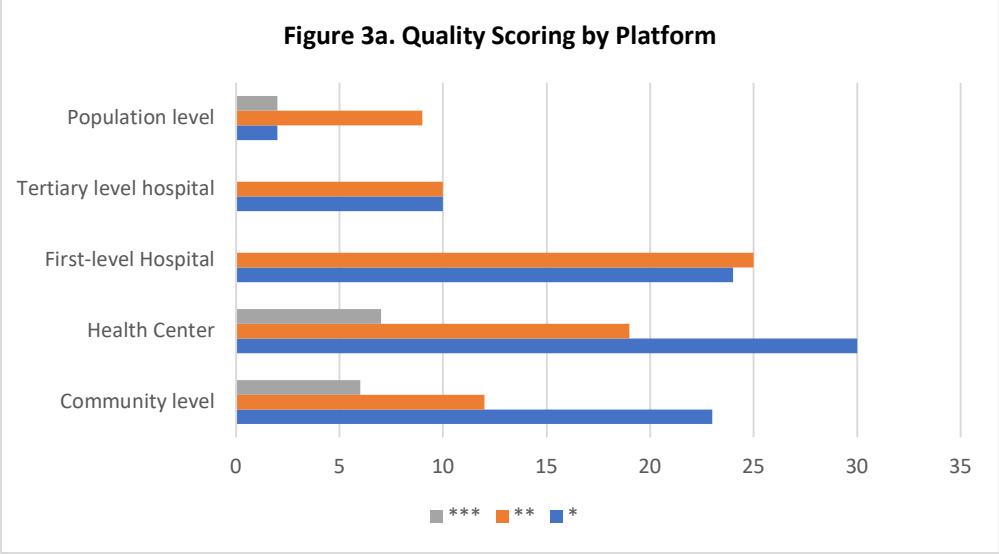
Platform/ level	No. of interventions	Tufts GH CEA registry (78)			Final Quality Scoring for all ICERs (166)[1]		
		Meeting knockout criteria 1 and 2	Exact/ Partial match	Pakistan/ South Asia/ LMIC match	*	**	***
Community	**41**	18	Exact = 5 Partial = 13	Pakistan = 6 South Asia = 10 LMIC = 2	23	12	6
Primary Health Care	**56**	25	Exact = 2 Partial = 23	Pakistan = 7 South Asia = 15 LMIC = 3	31	18	7
First Level Hospital	**49**	25	Exact = 8 Partial = 17	Pakistan = 0 South Asia = 1 LMIC = 24	24	25	-
Referral Hospital	**20**	10	Exact = 5 Partial = 5	Pakistan = 0 South Asia = 0 LMIC = 10	10	10	-
Total	**166**	**78**	**Exact = 20 Partial = 58**	**Pakistan = 13 South Asia = 26 LMIC = 39**	**88**	**66**	**12**

(1) This includes a * scoring where no ICER available from the search, and default DCP

Table 1b –Quality scoring of ICERs for Population level interventions

Platform/ level	No. of interventions	Tufts GH CEA registry			Final Quality Scoring for all ICERs		
		Meeting knockout criteria 1 and 2	Exact/ Partial match	Pakistan/ South Asia/ LMIC match	*	**	***
Population level	**13**	7	Exact = 0 Partial = 7	Pakistan = 2 South Asia = 2 LMIC = 3	2	9	2

Figure 3 – Quality Scoring by cluster and platform



5.2: Population-level interventions: methods and results

Population-based interventions were categorised into three groups: mass media interventions, interventions related to the development of national-level protocols, and high-level training and other exercises. These interventions have high fixed costs at the national level and take place above the service delivery level. A top-down costing approach was used.

To calculate costs, the HPSIU reviewed budget estimates of similar activities previously undertaken at the national level. We did not break down resource use by input as most expenditure was classified as contracted services (e.g., development of a television advertisement) and therefore difficult to disaggregate. Unit costs were estimated by dividing total national-level costs by an estimated population in need.

See Table A1.

Table A1: Population-based interventions: total costs, population in need and unit costs

DCP code	Intervention	Package	Total cost (2019 US$)	Population in need (description)	Population in need	Unit Cost (2019 US$)
P1	Mass media messages concerning sexual and reproductive health and mental health for adolescents	Adolescent health	$2,952,645.75	Population above the age of 10 years	160,556,777	$0.02
P2	Mass media messages concerning healthy eating or physical activity	Adolescent health	$2,952,645.75	Population above the age of 10 years	160,556,777	$0.02
P3	Mass media messages concerning use of tobacco and alcohol	Adolescent health	$2,952,645.75	Population above the age of 10 years	160,556,777	$0.02
P4	Mass media encouraging use of condoms, voluntary medical male circumcision and STI testing	HIV	$2,952,645.75	Population above the age of 10 years	160,556,777	$0.02
P6	Sustained integrated vector management for effective control of Chagas disease, visceral Leishmaniasis, dengue, chikungunya, CCHF and other nationally important causes of non-malarial fever vector borne NTDs	Adult febrile illness	$2,986,536.07	Population above the age of 10 years	160,556,777	$0.02
P7	Conduct a comprehensive assessment of International Health Regulations (IHR) competencies using the Joint External Evaluation (JEE) tool	Pandemics	$57,121.28	Population above the age of 10 years	160,556,777	<$0.01
P8	Conduct simulation exercises and health worker training for outbreak events including outbreak investigation, contact tracing and emergency response	Pandemics	$154,838.71	Population above the age of 10 years	160,556,777	<$0.01
P9	Decentralize stocks of antiviral medications in order to reach at risk groups and disadvantaged populations	Pandemics	$175,750.95	Population at risk of HIV	1,254,507	$0.14
P10	Develop and implement a plan to ensure surge capacity in hospital beds, stockpiles of disinfectants, equipment for supportive care and personal protective equipment	Pandemics	$78,290,663.04	Population above the age of 10 years	160,556,777	$0.49
P11	Develop plans and legal authority for curtaining interactions between infected persons and un-infected population and implement and evaluate infection control measures in health facilities	Pandemics	$1,722,520.50	Population above the age of 10 years	160,556,777	$0.01

DCP code	Intervention	Package	Total cost (2019 US$)	Population in need (description)	Population in need	Unit Cost (2019 US$)
P13	Mass media messages concerning awareness on handwashing and health effects of household air pollution	Environmental	$2,952,645.75	Population above the age of 10 years	160,556,777	$0.02
C25	Education campaign for the prevention of gender-based violence	Reproductive health	$2,952,645.75	Population above the age of 10 years	160,556,777	$0.02

Appendix 5.3: List of DCP3 interventions considered in the priority-setting process but not costed

FLH58 Specialty pathology services

RH19 Identify and refer patients with high risk

RH20 Prevention and relief of refractory suffering

Appendix 5.4: Further details on resource use estimation

Staff requirements were described in terms of staff type and duration of direct contact with the patient. For activities carried out at the community level, a standard seven minutes per patient were added to account for average health worker transportation time between households, as per HPSIU estimates. Drug regimens were described by including the medication type, dose, frequency of use and duration of treatment. For some interventions, multiple drug regimens were described depending on the target population. In these cases, we used a weighted average (based on the percentage of patients using each regimen) to calculate costs. The types and total number of diagnostic procedures were specified, as were other supplies used. Equipment resource use was quantified by the number of minutes used per intervention. Equipment costs were treated as capital costs and were annuitized using a 3% discount rate. An average useful life for each piece of equipment was estimated with the input of HPSIU. Building costs (space, utilities and furniture) were quantified by estimating the rental costs of the room per minute and multiplying by the number of minutes of staff time required for each intervention.

Resource use for inpatient bed-days and surgeries were calculated using peer-reviewed literature as a protocol-based cost would not have been appropriate given the large quantities of supplies and equipment generally used. A literature search was carried out and Khan et al.'s (2017) activity-based hospital costing study was deemed most appropriate as the methodology was clearly outlined and in line with our approach [1]. The paper reports the results of a knee replacement surgery in a Karachi hospital broken down by phase of care. Raw data was shared by the authors and was further disaggregated. We reviewed cost inputs, including ancillary staff, for both the inpatient ward day and the surgery, removing inputs that were knee surgery-specific in order to arrive at a generic list of resources applicable to inpatient bed-days and surgeries across disease areas. These standard quantities of resources used for both bed-days and surgeries were used for all DCP3 interventions. Daily services such as laundry and food catering [2, 3], were added. Additional equipment or supplies required beyond what was contained in the standard package were also added to the intervention-specific service descriptions.

Due to feasibility issues, MNHSR&C changed the delivery platform specified in 23 DCP3 interventions to better suit the national context; interventions were costed assuming resource use in the platform in which they would be delivered in Pakistan. See Table A2.

Table A2: Interventions costed assuming implementation in platforms different from those in DCP3

DCP platform	Pakistan platform	Intervention Code DCP	Intervention Name
PHC	Community	HC4a	Condoms and hormonal contraceptives
PHC	Community	HC5a	Counselling on kangaroo care for new-borns
PHC	Community	HC9a	Screening of hypertensive disorders in pregnancy
PHC	Community	HC28	Screening for HIV in all individuals with a diagnosis of active TB; if HIV infection is present, start (or refer for) ARV treatment and HIV care
PHC	Community	HC66	Psychosocial support and counselling services for individuals with serious, complex, or life-limiting health problems and their caregivers
Population	Community	P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkage to care (“active case finding”)
Community	PHC	C3c	Management of labour and delivery in low-risk women by skilled attendant
Community	PHC	C3d	Basic neonatal resuscitation following delivery
Community	PHC	C33	For malaria due to P. vivax, test for G6PD deficiency; if normal, add chloroquine or chloroquine plus 14-day course of primaquine
Community	PHC	C5	Tetanus toxoid immunization among schoolchildren and among women attending antenatal care
Community	PHC	C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households
Community	PHC	C53b	ECD rehabilitation interventions
Community	FLH	C50	Parent training of high-risk families, including nurse home visitation for child maltreatment
PHC	FLH	HC6	Management of neonatal sepsis, pneumonia, and meningitis using injectable and oral antibiotics
PHC	FLH	HC10	Screening and management of diabetes in pregnancy (gestational diabetes or pre-existing type II diabetes)
PHC	FLH	HC13	Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load

DCP platform	Pakistan platform	Intervention Code DCP	Intervention Name
PHC	FLH	HC19	For individuals testing positive for hepatitis B and C, assessment of treatment eligibility by trained providers followed by initiation and monitoring of ART when indicated
PHC	FLH	HC24	Hepatitis B vaccination for high-risk populations, including healthcare workers, IDU, MSM, household contacts and partners with multiple sex partners
PHC	FLH	HC57b	Dental Extraction
PHC	FLH	HC67	Expanded palliative care and pain control measures, including prevention and relief of all physical and psychological symptoms of suffering
Referral hospital	FLH	RH1	Full supportive care for preterm new-borns
Referral hospital	FLH	RH14	Cataract Extraction and Insertion of Intraocular Lens
First-level hospital	RH	FLH33	Craniotomy for Trauma

Appendix 5.5: Further details on price sources used

Federal-level healthcare worker pay scales were used to determine average staff time pricing per health worker cadre [4]. This source was selected as it was both recent and from the public sector. When activities could be carried out by multiple members of staff (e.g., nurse or lady health worker), we used salaries for each type of worker, costing each staff configuration as a separate intervention, and presented an average unit cost weighting options equally.

There were a number of sources available for the price of medications. No source contained all medications used. The primary source of price data used was the Sindh Health Department Procurement Price list of 2018-19 [5]. This was found to be the most appropriate price source since it was both recent and listed public sector prices. If a price was unavailable in the Sindh procurement list, the Federal Wholesale Price List for Generic Medicines was used as a second option [6]. The third option was the list of procurement purchasing prices from a public-private partnership under the Medical Emergency Resilience Fund 2019-2020 [7]. Private sector wholesale market prices were used as a fourth and final option [8].

A price source hierarchy was also established for supplies and equipment. The first choice of source was procurement prices from the Medical Emergency Resilience Fund 2019-2020 [7]. When price data were unavailable, we used private sector market prices [8]. Equipment costs were treated as capital costs and were annuitized using a 3% discount rate. An average useful life for each piece of equipment was estimated with the input of HPSIU.

Physical space prices were calculated by using price data from budget documents from the Federal government [9]. We obtained the estimated price of utilities per consultation from a costing study carried out in Khyber Pakhtunkhwa Province [10]. A generic cost of furniture was added and assumed at 10% of the cost of space.

We were unable to construct diagnostic and radiology costs through an ingredients-based approach ourselves due to time constraints and the complexity of supplies and equipment used. We resorted to available literature and market prices. We assessed strengths and weaknesses of different price and cost sources. We used the 'Costing and Pricing of Services in Private Hospitals of Lahore: Summary Report' as our primary source as it also used an ingredients-based approach which is consistent with our methodology [11]. If costs were unavailable, we used user fees from the Pakistan Institute of Medical Sciences [12] as a secondary option. We further used prices charged by private laboratories; Chugtai Labs user fees [13] were the third option and fees charged by the Aga Khan University Hospital (AKU) in Karachi [14] were the fourth and final option.

Prices for the generic surgery and ward day unit cost were obtained from the same sources as the resource use data [1, 2].

Appendix 5.6: Alternative sources of unit costs and main prices from the peer-reviewed literature

Intervention	Type of cost	Cost (USD)	Reason for using cost from literature	Source
HC25. Provision of voluntary medical male circumcision in settings with high prevalence of HIV	Cost of a VMMC surgical set	$23.00	Many implements involved and easier to use literature. Many costings have been done in this area already.	Larson et al. (2015) (15)
HC13. Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load	Cost of viral load test	$20.50	Costs only found in AKU (prices). Prices considered to be many times higher than international estimates	Freedberg et al (2018) (16)
HC13. Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load	Cost of CD4 test	$3.40	Costs only found in AKU (prices). Prices considered to be many times higher than international estimates	Freedberg et al (2018) (16)
HC13. Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load	Cost of first-line treatment for adults (yearly)	$96.00	Prices across all price lists led to total costs that were 10-12 times higher than the average costs for LMICs. We assume these lists did not take into account tiered pricing used by governments.	Freedberg et al (2018) (16)
HC13. Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load	Cost of second-line treatment for adults (yearly)	$260.00	Prices across all price lists led to total costs that were 10-12 times higher than the average costs for LMICs. We assume these lists did not take into account tiered pricing used by governments.	Freedberg et al (2018) (16)
HC13. Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load	Cost of first-line treatment for children (yearly)	$96.00	Prices across all price lists led to total costs that were 10-12 times higher than the average costs for LMICs. We assume these lists did not take into account tiered pricing used by governments. Note that we have not differentiated prices between adult and children's dosages.	Freedberg et al (2018) (16)
HC13. Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load	Cost of second-line treatment for children (yearly)	$260.00	Prices across all price lists led to total costs that were 10-12 times higher than the average costs for LMICs. We assume these lists did not take into account tiered pricing used by governments. Note that we have not differentiated prices between adult and children's dosages.	Freedberg et al (2018) (16)
FLH17. Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO	Cost of a GeneXpert test	$24.42	Costs only found in AKU (prices). Prices considered to be many times higher than international estimates	Vassall et al. (2017) (17)

Intervention	Type of cost	Cost (USD)	Reason for using cost from literature	Source
guidelines (either short- or long-term regimen)				
RH13. Repair of clubfoot	Cost of a unilateral club foot brace	$90.00	We could not find a local cost. This cost represents the main part of the intervention.	Grimes et al. (2016) (18)

Appendix 5.7: Research ethics approvals and letters from the Aga Khan University and the London School of Hygiene & Tropical Medicine Appendix

آغا خان یونیورسٹی

THE AGA KHAN UNIVERSITY

25-Sep-2019

Sameen Siddiqi
Department of Community Health Sciences
Aga Khan University
Karachi

Dear Sameen Siddiqi,

2019-1992-5190. Sameen Siddiqi: Disease Control Priorities 3 Localisation project

Thank you for your application for exemption from ethical approval regarding the above mentioned study.

Your study was reviewed and approved as exemption. Please ensure that the study is performed as per protocol following all AKU standards.

You may proceed with the study.

Thank you.

Sincerely,

[redacted]

Dr. Hammad Ather

Chairperson
Ethics Review Committee

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT
United Kingdom
Switchboard: +44 (0)20 7636 8636

www.lshtm.ac.uk

Observational / Interventions Research Ethics Committee

Professor Anna Vassall
LSHTM

13 March 2020

Dear Anna

Study Title: Disease Control Priorities (DCP3) UHC

LSHTM Ethics Ref: 21247

Thank you for responding to the Observational Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Investigator CV	SERGIO TORRES RUEDA CV 23 05 19 DCP	31/01/2020	1
Protocol / Proposal	Mapping Template Hospital STR 23 12 19	31/01/2020	1
Information Sheet	INFORMATION SHEET AND CONSENT FORM - Focus Groups	31/01/2020	1
Information Sheet	INFORMATION SHEET AND CONSENT FORM - IDIs	31/01/2020	1
Information Sheet	INFORMATION SHEET AND CONSENT FORM - Participant Observation	31/01/2020	1
Information Sheet	INFORMATION SHEET - Survey	31/01/2020	1
Investigator CV	CV Leon B _updated Jan 2020 bis	31/01/2020	1
Investigator CV	CV MJansen	31/01/2020	1
Investigator CV	CV Rob Baltussen 2018	31/01/2020	1
Investigator CV	MH CV 2020	31/01/2020	1
Investigator CV	MRC CV Vassall 2019	31/01/2020	1
Investigator CV	CV Dr Ala Alwan	31/01/2020	1
Other	RETC_Certificate	31/01/2020	1
Protocol / Proposal	Disease Control Priorities 3 Protocol 31-01-2020_Final	31/01/2020	1
Protocol / Proposal	Disease Control Priorities 3 Protocol Revision 09 03 2020	09/03/2020	2
Information Sheet	INFORMATION SHEET -Survey 09 03 2020	09/03/2020	2
Covering Letter	Ethics responses 09 03 20	09/03/2020	1

After ethical review

The Chief Investigator (CI) or delegate is responsible for informing the ethics committee of any subsequent changes to the application. These must be submitted to the Committee for review using an Amendment form. Amendments must not be initiated before receipt of written favourable opinion from the committee.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reactions (SUSARs) which occur during the project by submitting a Serious Adverse Event form.

An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at: http://leo.lshtm.ac.uk

Additional information is available at: www.lshtm.ac.uk/ethics

Yours sincerely,

[redacted]

Professor Jimmy Whitworth
Chair

ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

Improving health worldwide

References (Appendices 5.2 – 5.7)

1. Khan RM, Albutt K, Qureshi MA, Ansari Z, Drevin G, Mukhopadhyay S, et al. Time-driven activity-based costing of total knee replacements in Karachi, Pakistan. BMJ Open. 2019;9(5):e025258.

2. Sagheer U., Kielmann A., Mumtaz Z, S. S. Cost of establishing and maintaining a bed in a tertiary care hospital in Pakistan. 2000.

3. Ministry of Industries and Production. Pre-feasibility Study: Laundry and dry cleaning. .

4. Ministry of National Health Services RaC. Federal Pay Scales for Health Workers Islamabad Capital Territory. 2019.

5. Government of Sindh HD. Procurement of Drugs, Medicines, Surgical and Disposable Items, Xray files, Chemicals & Allied Items Under Rate Contract Basis During the Year. 2019.

6. Ministry of National Health Services Regulation and Coordination. Wholesale market prices for generic medicines. 2019.

7. Medical Emergency Resilience Fund. Procurement Prices. 2019.

8. Online Drug Information System. Pharma professional services Pakistan 2019 [Available from: http://www.druginfosys.com/.

9. Ministry of National Health Services Regulation and Coordination. Islamabad Capital Territory Health Infrastructure 2020-2021 PC-1. 2020.

10. Ministry of National Health Services Regulation & Coordination. Khyber Pakhtunkhwa Province Hospital Costing.

11. Punjab Healthcare Commission. Costing and pricing of services in private hospitals of Lahore. 2018.

12. Pakistan Institute of Medical Sciences. Pathology Department Price List (payment). 2019.

13. Chugtai Labs. Diagnostic user fees. 2019.

14. Aga Khan University Hospital. Diagnostic User Fees. 2019.

15. Larson B, Tindikahwa A, Mwidu G, Kibuuka H, Magala F. How much does it cost to improve access to voluntary medical male circumcision among high-risk, low-income communities in Uganda? PLoS One. 2015;10(3):e0119484.

16. Freedberg KA, Kumarasamy N, Borre ED, Ross EL, Mayer KH, Losina E, et al. Clinical Benefits and Cost-Effectiveness of Laboratory Monitoring Strategies to Guide Antiretroviral Treatment Switching in India. AIDS Res Hum Retroviruses. 2018;34(6):486-97.

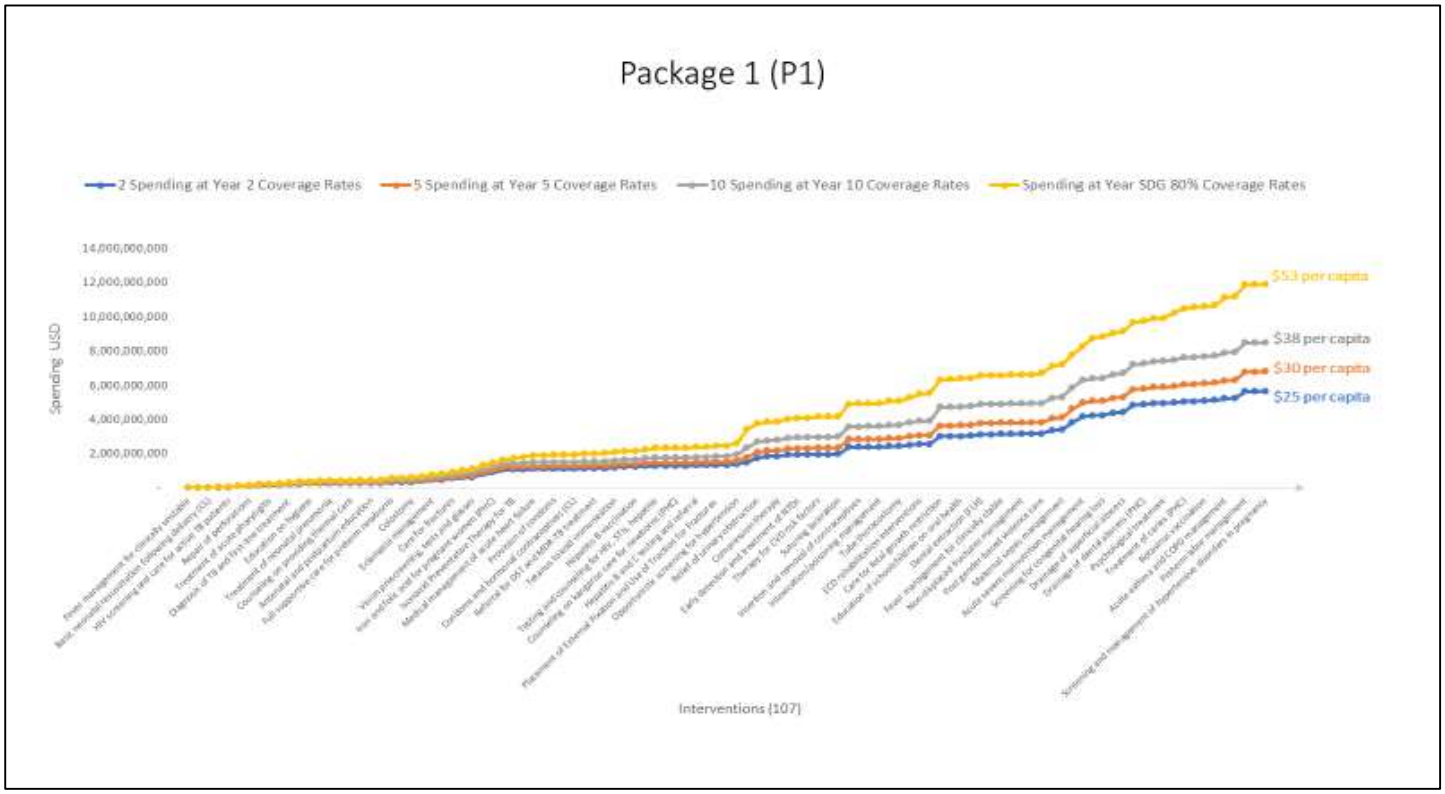
17. Vassall A, Siapka M, Foster N, Cunnama L, Ramma L, Fielding K, et al. Cost-effectiveness of Xpert MTB/RIF for tuberculosis diagnosis in South Africa: a real-world cost analysis and economic evaluation. Lancet Glob Health. 2017;5(7):e710-e9.

18. Grimes CE, Holmer H, Maraka J, Ayana B, Hansen L, Lavy CBD. Cost-effectiveness of club-foot treatment in low-income and middle-income countries by the Ponseti method. BMJ Glob Health. 2016;1(1):e000023.

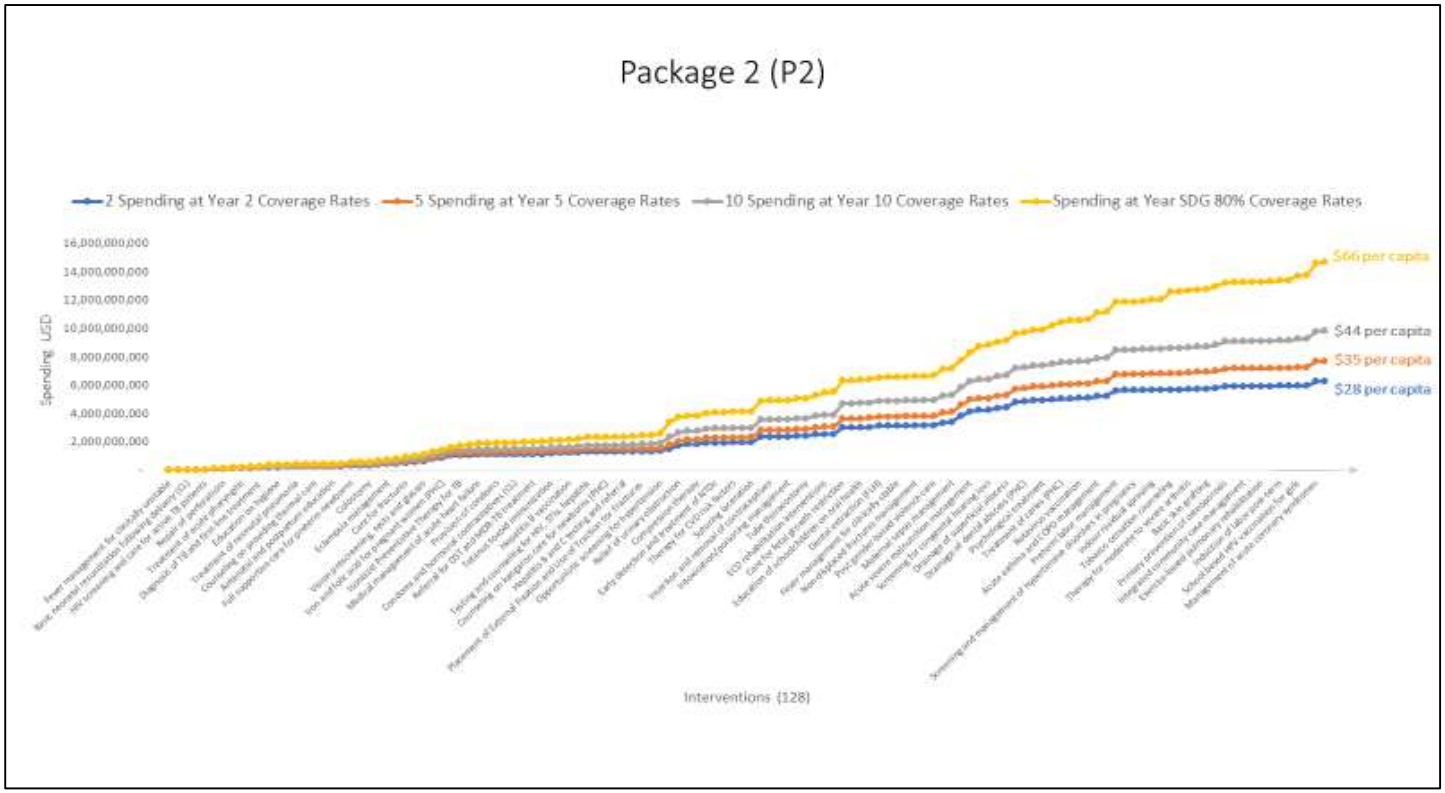
Chapter 6

Appendix 6.1: Packages presented at the Second National Advisory Council (NAC 2)

(a) Package 1 (P1): High-priority interventions: Graph shows the cumulative optimised spending for high-priority interventions according to the pre-specified coverage rates determined by the DCP3 secretariat. The graph illustrates four different 'snapshots': at Year 2 (with Year 2 coverage rates), at Year 5 (with Year 5 coverage rates), and Year 10 (with Year 10 coverage rates) and with the SDG 80% specified coverage rates. The per capita totals are shown on the right-hand side.

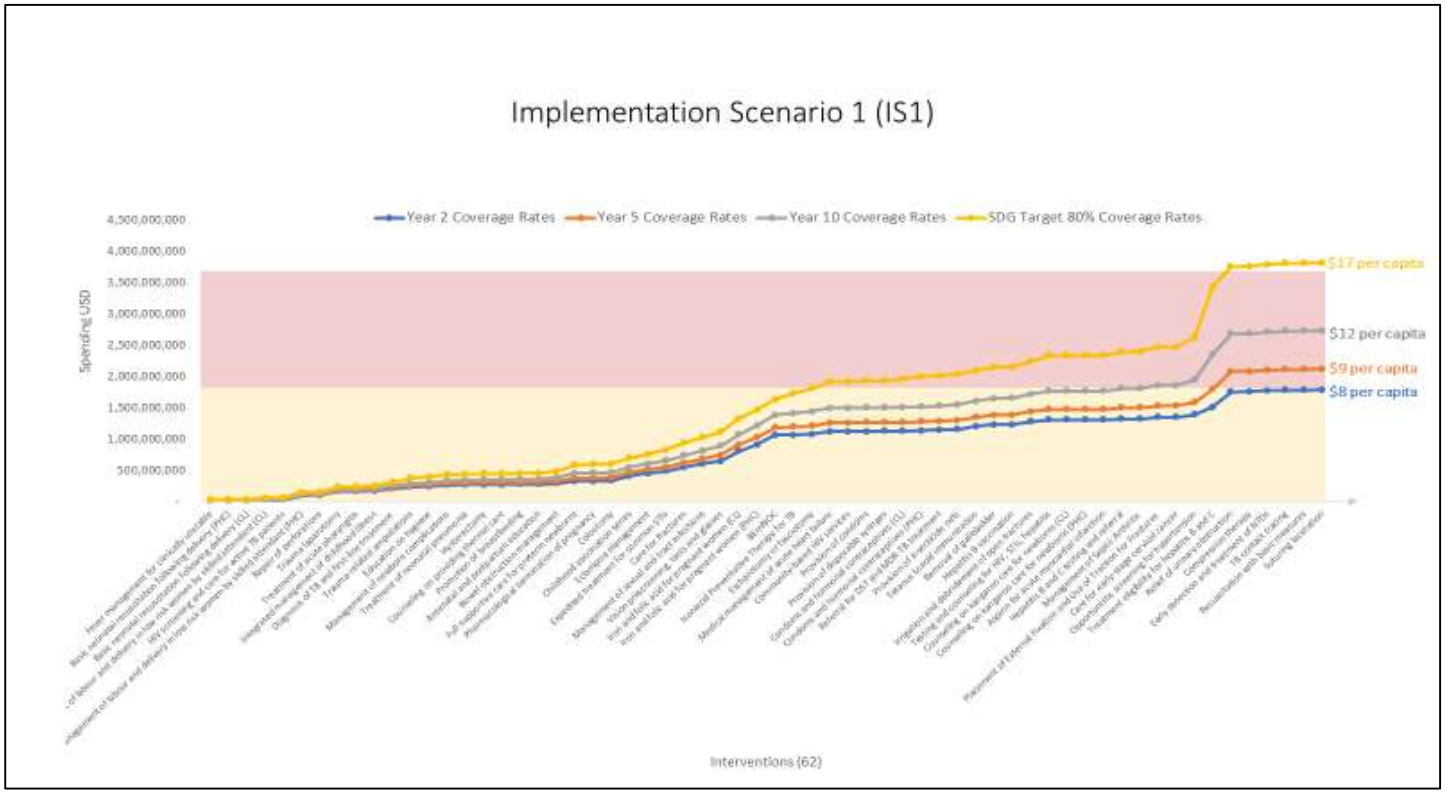


(b) Package 2 (P2): High-priority interventions: Graph shows the cumulative optimised spending for high-and medium priority interventions according to the pre-specified coverage rates determined by the DCP3 secretariat. The graph illustrates four different 'snapshots': at Year 2 (with Year 2 coverage rates), at Year 5 (with Year 5 coverage rates), and Year 10 (with Year 10 coverage rates) and with the SDG 80% specified coverage rates. The per capita totals are shown on the right-hand side.

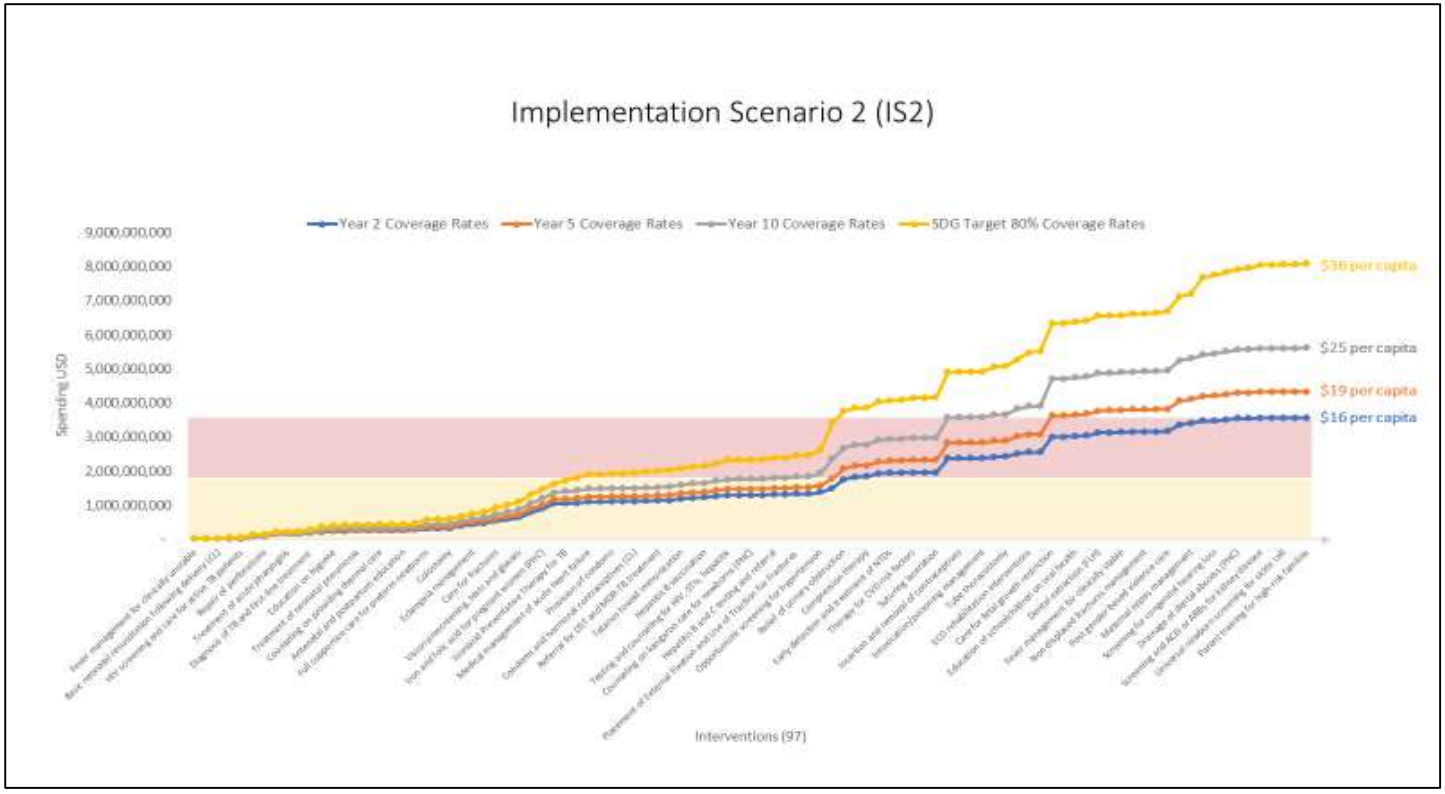


Appendix 6.2: Implementation scenarios presented at the Second National Advisory Council (NAC 2)

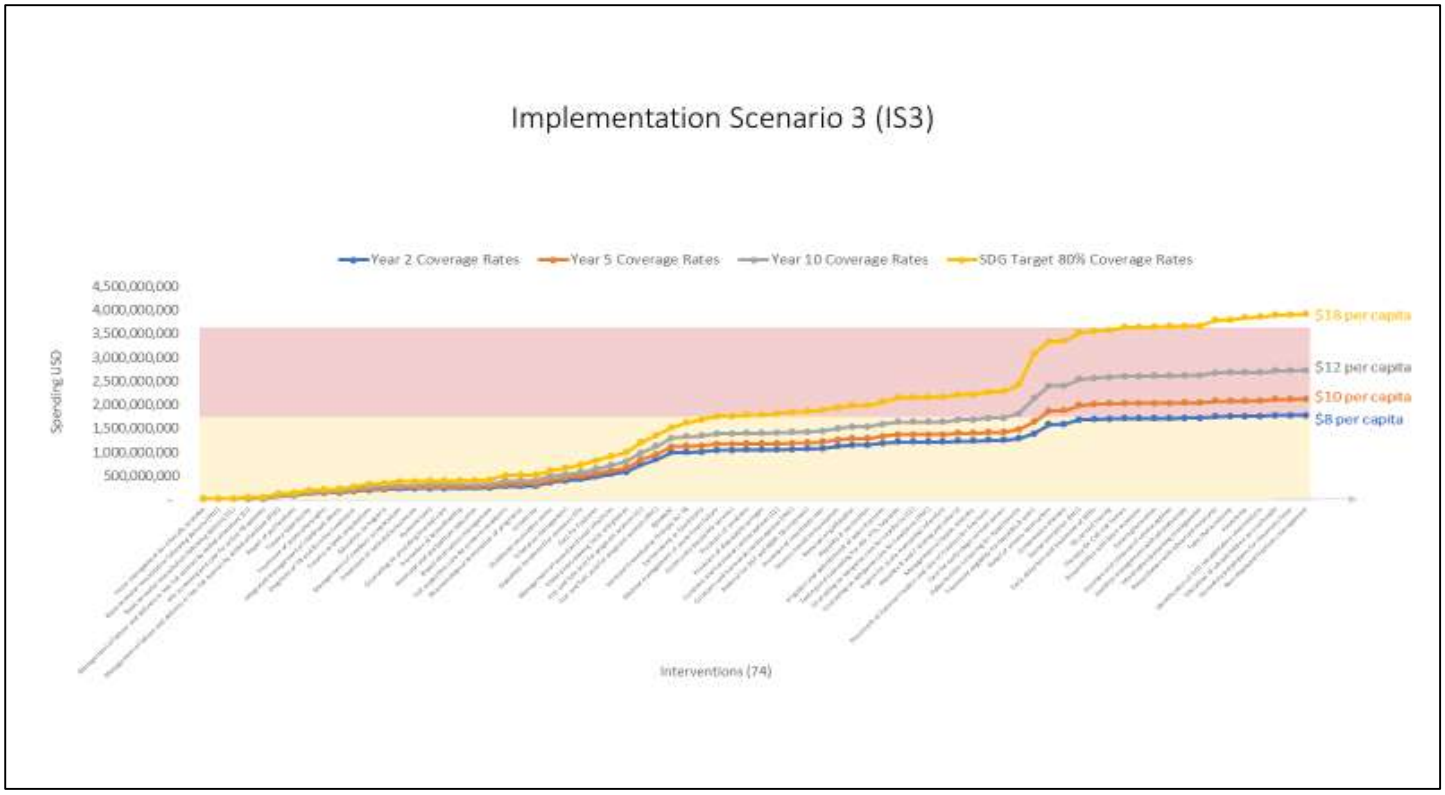
(a) Implementation Scenario 1: This graph illustrates all high priority interventions that fit within a fiscal space of $8 per capita at Year 2. Under a fiscal space limit of $8 per capita at year 2, 62 interventions are provided with 43,760,300 disability-adjusted life years (DALYs) averted. Financing these 62 interventions, with increasing coverage for Year 5, Year 10 and for the SDG 80% target coverage rates, results in increased spending and higher per capita spending. The yellow shaded box is indicative of interventions fitting within $8 per capita and the red shaded box is indicative of interventions fitting within $16 per capita.



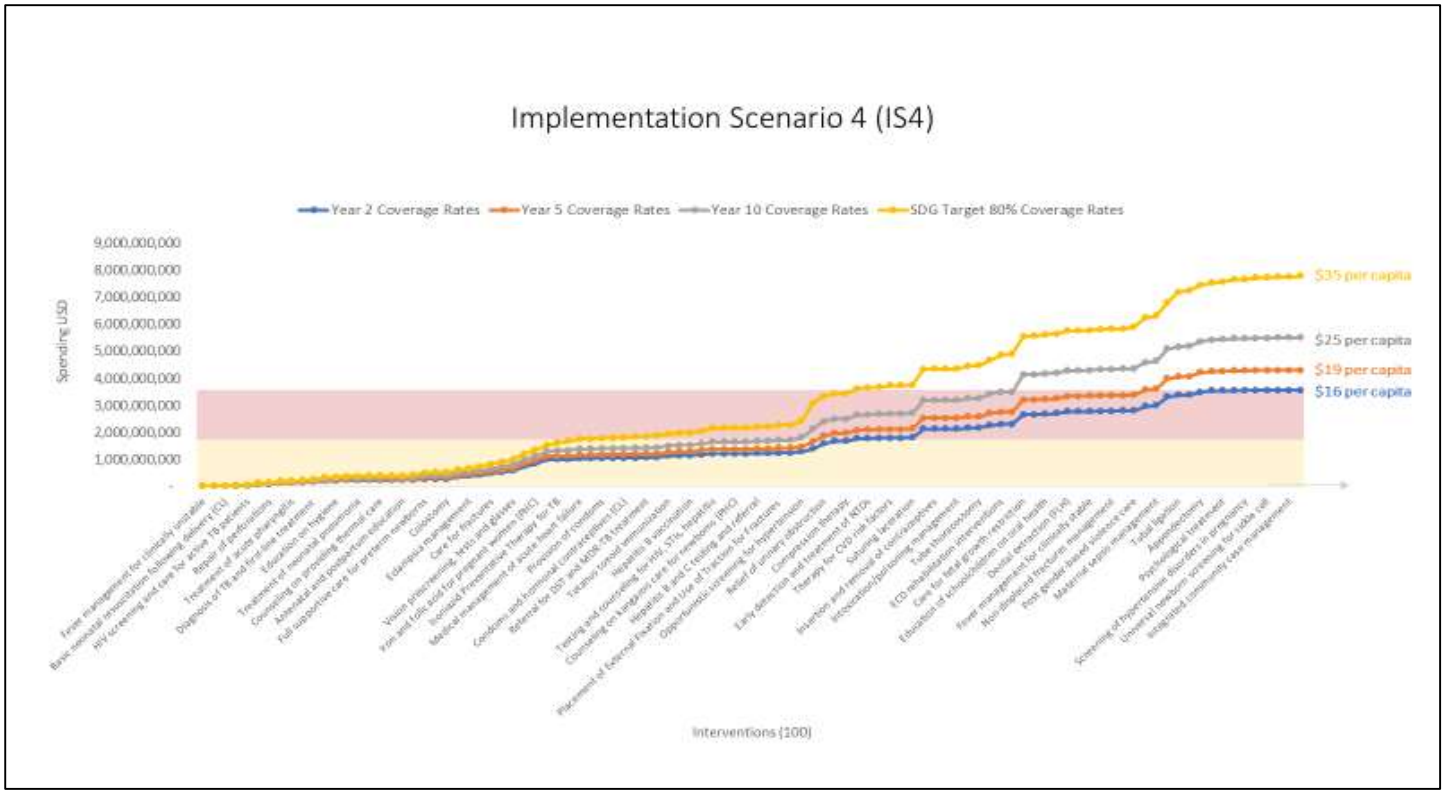
(b) Implementation Scenario 2: This graph illustrates all high priority interventions that fit within a fiscal space of $16 per capita at Year 2. Under a fiscal space limit of $8 per capita at Year 2, 97 interventions are provided with 45,352,618 disability-adjusted life years (DALYs) averted. Financing these 97 interventions, with increasing coverage for Year 5, Year 10 and for the SDG 80% target coverage rates, results in increased spending, and higher per capita spending. The yellow shaded box is indicative of interventions fitting within $8 per capita and the red shaded box is indicative of interventions fitting within $16 per capita.



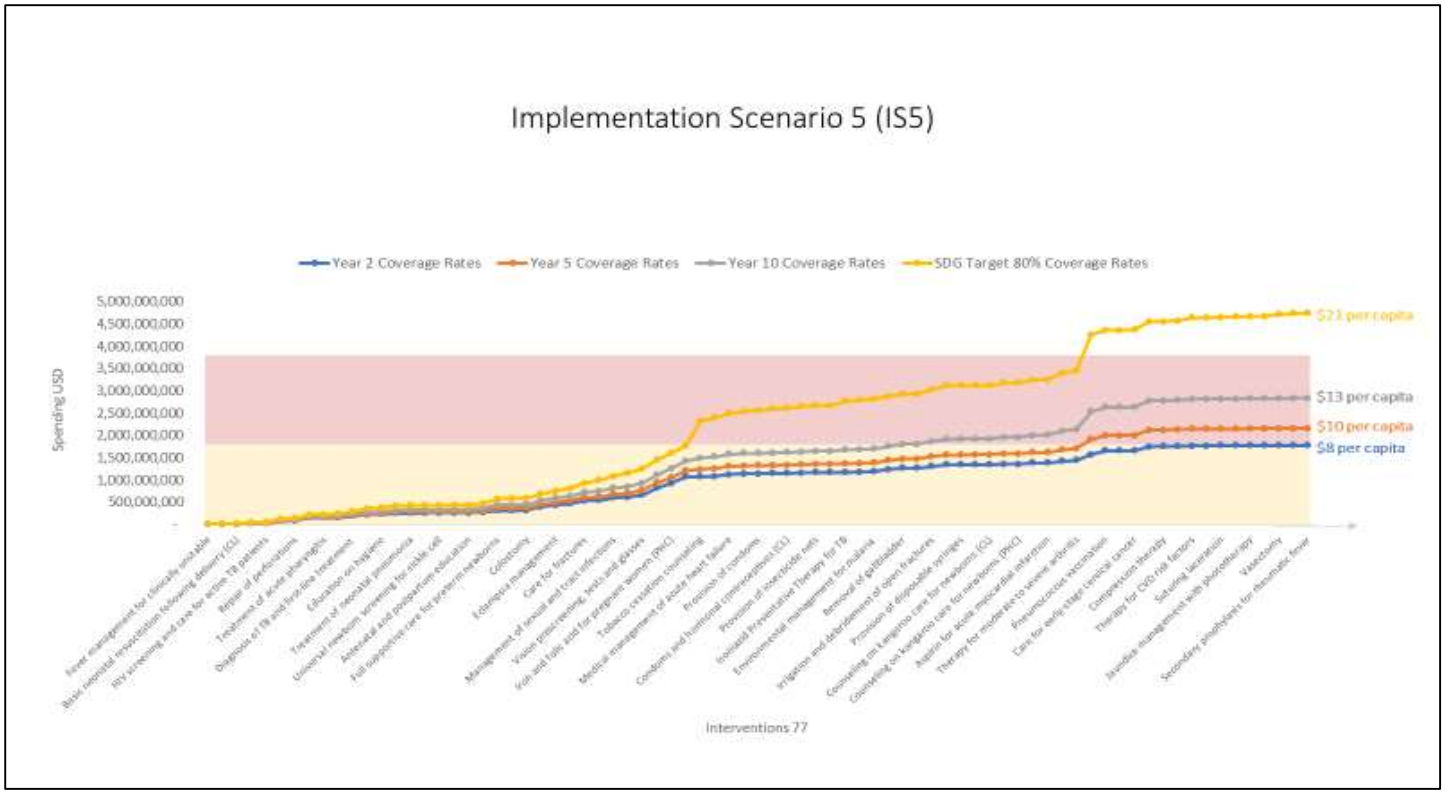
(c) Implementation Scenario 3: This graph illustrates all high priority interventions that fit within a fiscal space of $8 per capita at Year 2. All first-level hospital interventions spending is at capped at 80% (20% will be co-payments). Under a fiscal space limit of $8 per capita at Year 2, 74 interventions are provided with 43,927,295 disability-adjusted life years (DALYs) averted. Financing these 74 interventions, with increasing coverage for Year 5, Year 10 and for the SDG 80% target coverage rates, results in increased spending, and higher per capita spending. The yellow shaded box is indicative of interventions fitting within $8 per capita and the red shaded box is indicative of interventions fitting within $16 per capita.



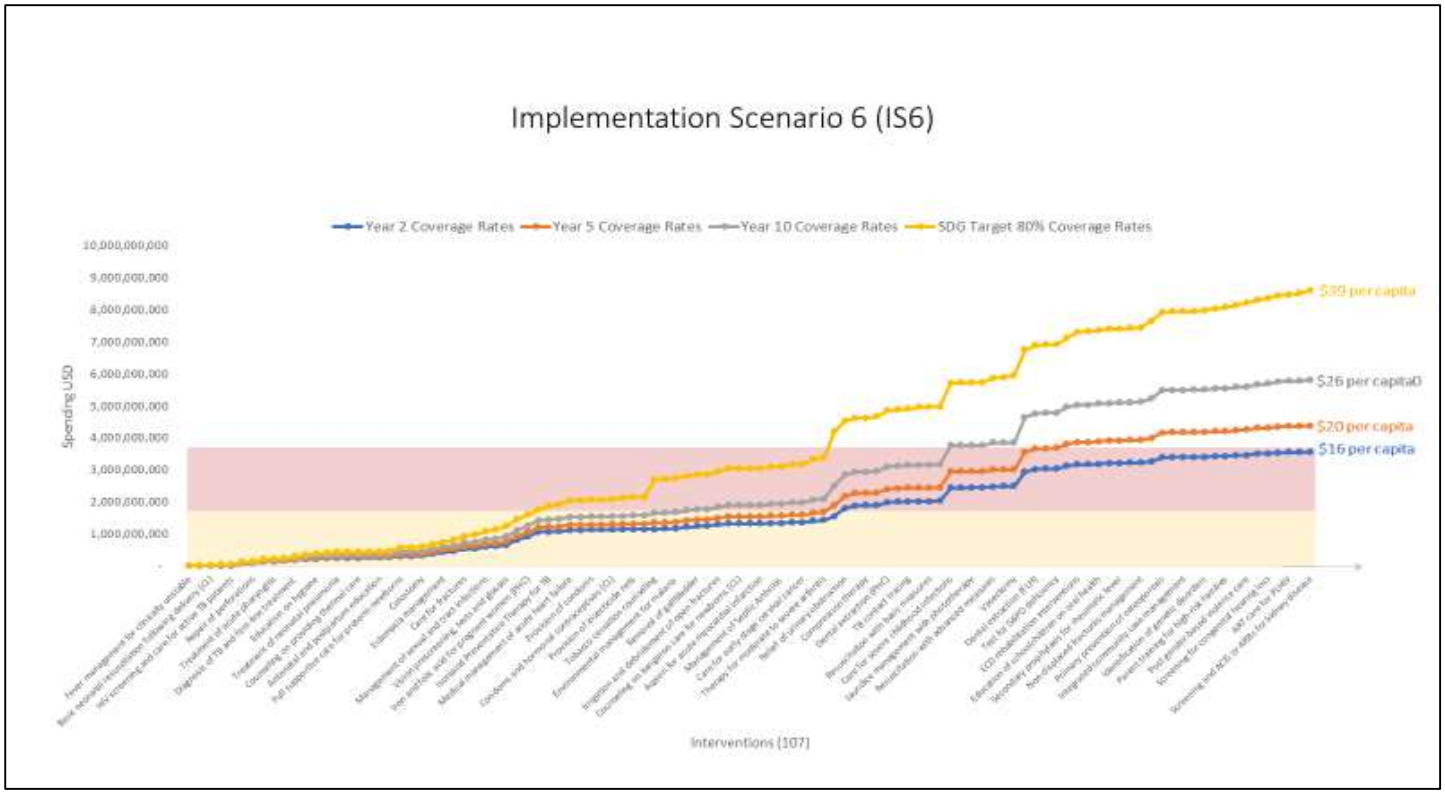
(d) Implementation Scenario 4: This graph illustrates all high priority interventions that fit within a fiscal space of $16 per capita at Year 2. All first-level hospital interventions spending is at 80% (20% will be co-payments). Under a fiscal space limit of $8 per capita at Year 2, 100 interventions are provided with 45,685,351 disability-adjusted life years (DALYs) averted. Financing these 74 interventions, with increasing coverage for Year 5, Year 10 and for the SDG 80% target coverage rates, results in increased spending, and higher per capita spending. The yellow shaded box is indicative of interventions fitting within $8 per capita and the red shaded box is indicative of interventions fitting within $16 per capita.



(e) Implementation Scenario 5: This graph illustrates high and medium priority interventions that fit with a fiscal space limit of $8 per capita at Year 2. The interventions are ranked based on cost-effectiveness and not by levels of priority. Under a fiscal space of $8 per capita at Year 2, 77 interventions are provided with 43,825,311 disability-adjusted life years (DALYs) averted. Financing these 77 interventions, with increasing coverage for Year 5, Year 10 and for the SDG 80% target coverage rates, results in increased spending, and higher per capita spending. The yellow shaded box is indicative of interventions fitting within $8 per capita and the red shaded box is indicative of interventions fitting within $16 per capita.



(f) Implementation Scenario 6: This graph illustrates all high and medium priority interventions that fit within a fiscal space of $16 per capita at Year 2. The interventions are ranked based on cost-effectiveness and not by levels of priority. Under a fiscal space of $16 per capita at Year 2, 107 interventions are provided with 84,711,659 disability-adjusted life years (DALYs) averted. Financing these 107 interventions, with increasing coverage for Year 5, Year 10 and for the SDG 80% target coverage rates, results in increased spending, and higher per capita spending. The yellow shaded box is indicative of interventions fitting within $8 per capita and the red shaded box is indicative of interventions fitting within $16 per capita.



Appendix 6.3: Definition of categorisation of interventions

Criteria	Methods for categorisation
(1) Cost-effectiveness	Interventions were categorised as having high, medium or low cost-effectiveness (or having no available data) based on their classification in the evidence sheets. ICERs were ranked in numerical order and divided evenly into three groups before each technical working group (TWG). Interventions in the group with lowest ICERs were classified as having high-cost effectiveness, and those in the group with the highest ICERs were classified as having low cost-effectiveness.
(2) Budget impact	Interventions were categorised as having high, medium or low budget impact (or no available data) based on their classification in the evidence sheets: low budget impact= total cost is <0.5% of total budget, medium budget impact is 0.5%-1% of total budget, high budget impact is >1% of total budget.
(3) Burden of preventable disease	Interventions were categorised as preventing a high, medium or low burden of disease (or no data available) based on their classification in the evidence sheets. DALYs averted per intervention were obtained from the HIP Tool and the Institute of Health Metrics and Evaluation (IHME). Total DALYs averted were ranked in numerical order and divided evenly into three groups before each TWG. The interventions in the group with the lowest number of total DALYs averted were classified as preventing low burden of disease and those in the group with the highest number of total DALYs averted were classified as preventing a high burden of disease.
(4) ICER quality	ICERs were categorised as having low, medium or high applicability to the Pakistani setting. See Huda et al. (2022) for further details [1].
(5) Current coverage	Current coverage data were procured by the Health Planning, System Strengthening & Information Analysis Unit (HPSIU) at the Ministry of National Health Services, Regulations & Coordination (MNHSR&C) of Pakistan. Specific coverage rates are presented in Appendix 6. Categories were constructed: no current coverage= 0%, low current coverage 1%-20%, medium current coverage= 21%-40%, high current coverage= 41%-100%.
(5) Delivery platform	Delivery platforms were categorised as per DCP3 Essential Universal Health Coverage (EUHC) package interventions [2]: community-based, primary health care, first-level hospitals and referral hospitals.
(6) Intervention cluster	Intervention clusters were categorised as per DCP3 EUHC package interventions: Reproductive, maternal, neonatal and child health (RMNCH), infectious diseases, non-communicable diseases and Injury prevention and care (NCD & IPC), and health services [2].
(7) Intervention purpose	Interventions were divided by their primary purpose using World Health Organization (WHO) Universal Health Coverage (UHC) categories: promotive, preventative, curative, rehabilitative and palliative [3].
(8) Vulnerable population	Interventions addressing the needs of vulnerable populations where those involving reproductive, maternal, neonatal and child health (as per NAC guidance).
(9) Rule of rescue	Interventions categorised as not involving or involving the rule of rescue, which was defined as the imperative to rescue identifiable individuals facing avoidable death [4].

Appendix 6.4 Values used for each intervention for each decision criteria (evidence and evidence quality)

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
C1	Antenatal and postpartum education on birth spacing	High	Low	Medium	Medium	High
C10	Education on handwashing, personal hygiene and safe disposal of children's stool	High	Low	High	Medium	High
C11	Pneumococcus vaccination	Medium	Medium	High	High	High
C12	Rotavirus vaccination	Medium	Low	High	High	High
C14	Vitamin A and zinc for children	Medium	High	High	Low	High
C16	Childhood vaccination series (diphtheria, pertussis, tetanus, polio, BCG, measles, hepatitis B, HiB, rubella)	High	Medium	High	Medium	High
C17	Indoor residual spraying	Medium	Medium	High	Medium	Low
C18	Education of schoolchildren on oral health	Medium	High	Medium	Low	Low
C19	Vision pre-screening by teachers; vision tests and provision of ready-made glasses on-site by eye specialists	Medium	High	High	Low	Low
C2	Counselling of mothers on providing thermal care for pre- term new-borns (delayed bath and skin to skin contact)	High	Low	Medium	Medium	Low
C20	School based HPV vaccination for girls	Low	Low	Low	High	No
C21	Mass drug administration (NTDs)	Low	High	Medium	Low	No
C23	Adolescent-friendly services for STIs	Medium	Low	Medium	Low	Low
C24	Life skills training in schools	Low	High	High	Low	Low
C27a	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households	High	High	High	Medium	High
C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecurity households	High	High	High	Medium	High
C28	Community-based HIV testing and counselling (for example, mobile units and venue-based testing), with appropriate referral or linkage to care and	High	Low	Low	Medium	Low
C30a	Provision of condoms to key populations, including sex workers, men who have sex with men, people who inject drugs, transgender populations, and prisoners	High	Low	Medium	Medium	Low
C30b	Provision of Disposable syringes who inject drugs (IDU)	High	Low	Medium	Medium	Low
C32	Routine contact tracing to identify individuals exposed to TB and link them to care	Low	Low	Low	Low	High
C33	Test for G6PD deficiency	Low	Low	Low	Low	Medium

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
C3a	Management of labour and delivery in low-risk women by skilled attendant (CL)	High	Low	High	Low	Low
C3b	Basic neonatal resuscitation following delivery (CL)	High	Low	High	Low	Low
C3c	Management of labour and delivery in low-risk women by skilled attendant (PHC)	High	Low	High	Low	High
C3d	Basic neonatal resuscitation following delivery (PHC)	High	Low	High	Low	High
C34	Environmental management for malaria	High	Medium	High	Low	Low
C4	Promotion of breastfeeding and complementary feeding by community health workers	High	Low	High	Medium	High
C41	Mass drug administration (malaria)	High	High	High	Low	No
C43	Early detection and treatment of leishmaniasis, dengue, chikungunya, rabies, trachoma and helminthiasis.	Medium	Low	Medium	Low	Medium
C45	Identify and refer patients with high risk	None	None	None	None	High
C46	In the context of an emerging infectious outbreak, provide advice and guidance on how to recognize early symptoms and signs and when to seek medical attention	Medium	Low	Medium	Low	High
C47	Exercise-based pulmonary rehabilitation	Medium	Low	Low	Low	No
C48	Self-managed treatment of migraine	Low	Low	Medium	Low	No
C5	Tetanus toxoid immunization among schoolchildren and women attending antenatal care	High	Low	Medium	Medium	High
C50	Parent training of high-risk families, including nurse home visitation for child maltreatment	Medium	High	High	Low	Low
C51	WASH behaviour change interventions, such as community led total sanitation	Low	Medium	Medium	Low	High
C53a	Identification/screening of the early childhood development issues motor, sensory and language stimulation	Medium	High	High	Low	Low
C53b	ECD rehabilitation interventions	Medium	High	High	Low	Low
C56	Interventions for wheelchair users	None	None	None	None	No
C8	Acute severe malnutrition management	Low	High	High	Low	High
C9	Integrated community case management	Medium	Low	Low	Low	Low
FLH1	Care for foetal growth restriction	Medium	High	High	Low	Medium
FLH10	Surgical termination of pregnancy by maternal vacuum aspiration and dilatation & curettage	Low	Low	Low	Low	Low
FLH11	Care for severe childhood infections	Medium	High	High	Low	Medium

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
FLH12	Severe acute malnutrition management	Medium	Low	Low	Medium	Medium
FLH13	Early detection and treatment of early-stage cervical cancer	Medium	Low	Low	Medium	Low
FLH14	Insertion and removal of contraceptives	Medium	Low	Medium	Low	Low
FLH15	Tubal ligation	Low	High	High	Low	Low
FLH16	Vasectomy	Medium	Low	Medium	Low	Low
FLH17	Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO guidelines (either short- or long-term regimen)	High	Low	High	Low	High
FLH18	Evaluation and management of fever in clinically unstable individuals using WHO IMAI guidelines, including empiric parenteral antimicrobials and antimalarial and resuscitative measures for septic shock	High	Low	High	Medium	Medium
FLH2	Induction of labour post-term	Medium	Low	Medium	Low	Medium
FLH20	Management of acute coronary syndromes	Low	High	Medium	Low	Medium
FLH22	Management of acute exacerbations of asthma and COPD using systemic steroids, inhaled beta-agonists and if indicated oral antibiotics and oxygen therapy	Low	High	Medium	Medium	Low
FLH23	Medical management of acute heart failure	Medium	Low	High	Medium	Medium
FLH24	Bowel obstruction management	High	Low	Medium	Low	Medium
FLH25	Calcium and vitamin D supplementation for secondary prevention of osteoporosisE264	Low	High	High	Low	Low
FLH26	Combination therapy, including low-dose corticosteroids and generic disease-modifying antirheumatic drugs (including methotrexate), for individuals with moderate to severe rheumatoid arthritis	High	Low	Medium	Low	Medium
FLH27	In settings where sickle cell disease is a public health concern, universal new-born screening followed by standard prophylaxis against bacterial infections and malaria	Medium	Low	Low	Medium	Low
FLH28	In setting where specific single-gene disorders are a public health concern (for example thalassemia), retrospective identification of carriers plus prospective (premarital) screening and counselling to reduce rates of conceptionE311	Medium	Low	Low	Low	Low
FLH3	Jaundice management with phototherapy	Medium	Low	Low	Low	Medium
FLH30	Intoxication/poisoning management	Medium	Low	Low	Low	Low
FLH31	Appendectomy	Low	Medium	Medium	Medium	High
FLH32	Assisted vaginal delivery using vacuum extraction or forceps	Medium	Low	Medium	Medium	Low
FLH33	Craniotomy for trauma	Medium	Low	Low	Medium	Low

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
FLH34	Colostomy for acute bowel obstruction/volvulus and injuries.	High	Low	Medium	Low	Medium
FLH35	Escharotomy or fasciotomy	Medium	Low	High	Medium	Low
FLH36	Management of non-displaced fractures	High	Low	High	Medium	Medium
FLH37	Hernia Repair	Medium	Low	Medium	Medium	Medium
FLH38	Hysterectomy for uterine rupture or intractable postpartum haemorrhage	High	Low	Medium	Medium	High
FLH39	Irrigation and debridement of open fractures	Medium	Low	Medium	Low	Medium
FLH4	Eclampsia management with magnesium sulphate, including initial stabilization at health centres	Medium	Low	High	Medium	High
FLH40	Management of osteomyelitis, including surgical debridement	Medium	Medium	High	Low	Medium
FLH41a	Management of Septic Arthritis	Medium	Low	Low	Medium	Low
FLH41b	Placement of External Fixation and Use of Traction for Fractures	Medium	Low	Low	Medium	Low
FLH42	Relief of urinary obstruction by catheterization for fractures	High	Low	High	Low	High
FLH43	Removal of gallbladder, including emergency surgery	Medium	Low	Medium	Low	Medium
FLH44	Repair of perforations (for example perforated peptic ulcer, typhoid ileal perforation)	High	Low	High	Low	High
FLH45	Resuscitation with advanced measures	Medium	Low	Medium	Low	Low
FLH46	Basic Skin grafting	Medium	Low	Low	Medium	Low
FLH48a	Trauma laparotomy	High	Low	High	Medium	High
FLH49	Trauma-related amputations	High	Low	High	Low	Medium
FLH5	Maternal sepsis management	Medium	Low	Medium	Medium	Medium
FLH50	Tube thoracostomy	Medium	Low	Low	Low	Medium
FLH52	Compression therapy for amputations, burns, and vascular or lymphatic disorders	Medium	Low	Low	Medium	Medium
FLH53	Evaluation and acute management of swallowing dysfunctionE307	Medium	Low	Low	Low	Medium
FLH57	Prevention and relief of refractory suffering and acute pain related to surgery, serious injury or other serious, complex or life-limiting health problems	None	None	None	None	Low

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
FLH58	First level hospital pathology services	None	None	None	None	Medium
FLH6	Management of new-born complications infections, meningitis, septicaemia, pneumonia and other very serious infections requiring continuous supportive care (such as IV fluids and oxygen)	High	Low	High	Medium	Medium
FLH7	Preterm labour management	Low	Medium	Low	Medium	Medium
FLH8	Management of labour and delivery in high-risk women, including operative delivery (CEmONC)	Low	High	High	Low	Medium
FLH9	Surgery for ectopic pregnancy	High	Low	Medium	Medium	Medium
HC1	Early detection and treatment of neonatal pneumonia with oral antibiotics	High	Low	High	Medium	High
HC10	Screening and management of diabetes (gestational diabetes or pre-existing type II diabetes)	Low	Low	Low	Medium	Low
HC11	Management of labour and delivery in low-risk women (BEmONC), including initial treatment of obstetric or delivery complications prior to transfer (Also included in Surgery package of services)	High	High	High	Low	High
HC12	Detection and treatment of childhood infections with danger signs (IMCI)	High	High	High	Low	Low
HC13	Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load for	Low	Low	Low	Medium	Low
HC14	Psychological treatment	Low	High	Medium	Medium	Low
HC16	Post gender-based violence care	Low	Medium	Medium	Low	Low
HC17	Syndromic management of common sexual and reproductive tract infections (for example urethral discharge, genital ulcer and others)	Medium	High	High	Low	High
HC19	For individuals testing positive for hepatitis B and C, assessment of treatment eligibility by trained providers followed by initiation and monitoring of ART when indicated	Low	High	High	Medium	Low
HC2	Miscarriage and abortions management	Low	Low	Medium	Low	Medium
HC20	Hepatitis B and C testing of High-risk individuals identified in the national testing policy with appropriate referral of positive individuals to trained providers	Medium	Medium	Medium	Low	Low
HC21	Partner notification and expedited treatment for common STIs including HIV	High	Medium	High	Medium	Medium
HC23	Provider-initiated testing and counselling for HIV, STIs and hepatitis for all in contact with the health system in high- prevalence setting, including prenatal care with appropriate referral/ linkages to care including immediate ART initiation for those testing positive for HIV	Medium	High	High	Medium	Medium
HC24	Hepatitis B vaccination for high-risk populations, including healthcare workers, IDU, MSM, household contacts and partners with multiple sex partners	Medium	Low	Low	Medium	Low
HC25	Medical male circumcision	Medium	Medium	Medium	Low	Low

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
HC26	For PLHIV and children under five who are close contacts or household members of individuals with active TB, perform symptom screening and chest radiograph; if there is no active TB, provide isoniazid preventive therapy according to current WHO guidelines	High	Medium	High	Medium	Low
HC27	Diagnosis of TB and first-line treatment	High	Low	High	Low	High
HC28	Screening for HIV in all individuals with a diagnosis of active TB; if HIV infection is present, start (or refer for) ARV treatment and HIV care	High	Low	Medium	Low	Low
HC29	Latent-TB screening and IPT for PLHIV	High	Low	Medium	Low	Low
HC3	Management of premature rupture of membranes, including administration of antibiotics	Low	Low	Low	Low	Low
HC30	Fever management for clinically stable	Medium	Low	Low	Low	High
HC32	Provision of insecticide nets to U5 children and pregnant women attending health centres	High	Low	Medium	Medium	Medium
HC33	Identify and refer for progressive illness **	None	None	None	None	Medium
HC36	Long-term combination therapy for persons with multiple CVD risk factors, including screening for CVD in community setting using non-lab-based tools to assess overall CVD risk	Low	Medium	Medium	Low	Low
HC37	Low-dose inhaled corticosteroids and bronchodilators for asthma and for selected patients with COPD	Low	Low	Low	Medium	Low
HC38	Provision of aspirin for all cases of suspected acute myocardial infarction	Medium	Low	Low	High	Low
HC39a	Screening and ACEi or ARBs for kidney disease	Low	Low	Low	Low	Low
HC41	Secondary prophylaxis for rheumatic fever	Low	Low	Low	Low	Low
HC42	Treatment of acute pharyngitis for rheumatic fever	High	Low	Medium	Low	High
HC45	Opportunistic screening for hypertension	Medium	High	High	Medium	Low
HC46	Tobacco cessation counselling	High	High	High	Medium	No
HC48	Support for caregivers of dementia patients	Medium	Low	Low	Medium	No
HC49	Bipolar disorder management	Low	Medium	Low	Low	No
HC4a	Provision of condoms and hormonal contraceptives, including emergency contraceptives	High	Low	High	Medium	Low
HC4b	Provision of condoms and hormonal contraceptives, including insertion and removal of contraceptives (PHC)	High	Low	High	Medium	Low
HC50	Management of depression and anxiety disorders with psychological and generic antidepressants therapy	Low	High	Medium	Low	Low

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
HC53	Screening and brief alcohol intervention	Low	Low	Low	Low	No
HC55	Primary prevention of osteoporosis	Low	Low	Medium	Low	Medium
HC56	Screening for congenital hearing loss	Low	Medium	Medium	Medium	Low
HC57a	Dental extraction (PHC)	Medium	High	High	Low	Medium
HC57b	Dental extraction (FLH)	Low	High	High	Low	Medium
HC58a	Drainage of dental abscess (PHC)	Low	High	Medium	Low	Low
HC59	Drainage of superficial abscess	Low	Medium	Medium	Low	Medium
HC5a	Counselling on kangaroo care for new-borns (CL)	Medium	Low	Low	Low	Low
HC5b	Counselling on kangaroo care for new-borns (PHC)	Medium	Low	Low	Low	Low
HC6	Management of neonatal sepsis, pneumonia and meningitis using injectable and oral antibiotics	High	Low	Low	Medium	Low
HC60	Non-displaced fractures management	Low	Low	Low	Low	Low
HC61	Resuscitation with basic life support measures	None	None	None	None	Low
HC62	Suturing laceration	Low	Low	Low	Low	Medium
HC63a	Treatment of caries (PHC)	Low	High	Medium	Low	Low
HC64	Basic management of MNIs and disorders	Low	Low	Low	Low	Low
HC66	Psychosocial support and counselling	Low	Low	Low	Low	Low
HC67	Expanded palliative care and pain control measures, including prevention and relief of all physical and psychological symptoms of suffering	None	None	None	None	Low
HC68	Health centre pathology services **	None	None	None	None	Low
HC7	Pharmacological termination of pregnancy	High	Low	High	Low	Low
HC9a	Screening of hypertensive disorders in pregnancy	Low	Low	Low	Low	High
HC9b	Screening and management of hypertensive disorders in pregnancy	Low	Low	Low	Low	High
P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkages to care (active case finding)	Low	Medium	Medium	Medium	High

DCP3 Code	Intervention name	Cost-effectiveness	Budget impact	Burden of disease	ICER quality	Current coverage
RH1	Full supportive care for preterm new-borns	High	Low	High	Medium	Medium
RH2	Specialized TB services, including management of MDR- and XDR-TB treatment failure and surgery for TB	Medium	Low	Medium	Low	Medium
RH3	Management of refractory febrile illness including etiologic diagnosis at reference microbial laboratory	Medium	Low	Low	Low	Medium
RH4	Management of acute ventilator failure due to acute exacerbations of asthma and COPD	Low	Low	Low	Medium	Low
RH5	Retinopathy screening via telemedicine, followed by treatment using laser photocoagulation	Medium	Low	Low	Medium	Low
RH6	Use of percutaneous coronary intervention for acute myocardial infarction where resources permit	Low	Medium	High	Low	Low
RH7	Treatment of early-stage breast cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	Low	Low	Low	Medium	Medium
RH8	Treatment of early-stage colorectal cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	Low	Low	Low	Medium	Low
RH9	Treatment of early-stage childhood cancers (such as Burkitt and Hodgkin lymphoma, acute lymphoblastic leukaemia, retinoblastoma and Wilms tumour) with curative intent in paediatric cancer units or hospitals	Low	Low	Medium	Medium	Low
RH10	Elective surgical repair of common orthopaedic injuries (for example meniscal and ligamentous tears) in individuals with severe functional limitation	High	Medium	High	Medium	Low
RH11	Urgent, definitive surgical management of orthopaedic injuries (for example open reduction and internal fixation)	Medium	Low	High	Medium	Low
RH12	Repair of cleft lip and cleft palate	Low	Low	Low	Low	Medium
RH13	Repair of club foot	High	Low	Medium	Low	Low
RH14	Cataract extraction	Low	Medium	High	Medium	High
RH15	Repair of anorectal malformations and Hirschsprung's disease	Medium	Low	Low	Low	Low
RH16	Repair of obstetric fistula	Medium	Low	Medium	Low	Low
RH17	Ventriculoperitoneal Shunt	Medium	Low	Low	Low	Low
RH18	Surgery for Trachomatous Trichiasis	Medium	Low	Medium	Medium	Medium
RH19	Referral level hospital pathology services	None	None	None	None	Medium
RH20	Speciality pathology services	None	None	None	None	Medium

Appendix 6.5 Values used for each intervention for each intervention characteristics

Abbreviations: CL= Community level, PHC= Primary health care level, FLH= First-level hospital, RH=Referral hospital, RMNCH= Reproductive, maternal, neonatal and child health, NCD & IPC = non-communicable diseases and injury prevention and care.

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
C1	Antenatal and postpartum education on birth spacing	CL	RMNCH	Yes	No	Preventive
C10	Education on handwashing, personal hygiene and safe disposal of children's stool	CL	RMNCH	Yes	No	Preventive
C11	Pneumococcus vaccination	CL	RMNCH	Yes	No	Preventive
C12	Rotavirus vaccination	CL	RMNCH	Yes	No	Preventive
C14	Vitamin A and zinc for children	CL	RMNCH	Yes	No	Preventive
C16	Childhood vaccination series (diphtheria, pertussis, tetanus, polio, BCG, measles, hepatitis B, HiB, rubella)	CL	RMNCH, Infectious Disease, NCD & IPC	Yes	No	Preventive
C17	Indoor residual spraying	CL	RMNCH, Infectious Disease	Yes	No	Preventive
C18	Education of schoolchildren on oral health	CL	RMNCH	Yes	No	Preventive
C19	Vision pre-screening by teachers; vision tests and provision of ready-made glasses on-site by eye specialists	CL	RMNCH	Yes	No	Preventive
C2	Counselling of mothers on providing thermal care for pre- term new-borns (delayed bath and skin to skin contact)	CL	RMNCH	Yes	No	Preventive
C20	School based HPV vaccination for girls	CL	RMNCH, Infectious Disease	Yes	No	Preventive
C21	Mass drug administration (NTDs)	CL	RMNCH, Infectious Disease	Yes	No	Preventive
C23	Adolescent-friendly services for STIs	CL	RMNCH, Infectious Disease	Yes	No	Preventive

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
C24	Life skills training in schools	CL	RMNCH, NCD & IPC	Yes	No	Preventive
C27a	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households	CL	RMNCH, NCD & IPC	Yes	No	Promotive
C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecurity households	PHC	RMNCH, NCD & IPC	Yes	No	Promotive
C28	Community-based HIV testing and counselling (for example, mobile units and venue-based testing), with appropriate referral or linkage to care and	CL	Infectious Disease	No	No	Curative
C30a	Provision of condoms to key populations, including sex workers, men who have sex with men, people who inject drugs, transgender populations, and prisoners	CL	Infectious Disease	No	No	Promotive
C30b	Provision of Disposable syringes who inject drugs (IDU)	CL	Infectious Disease	No	No	Promotive
C32	Routine contact tracing to identify individuals exposed to TB and link them to care	CL	Infectious Disease	No	No	Curative
C33	Test for G6PD deficiency	PHC	Infectious Disease	No	No	Curative
C3a	Management of labour and delivery in low-risk women by skilled attendant (CL)	CL	RMNCH	Yes	Yes	Curative
C3b	Basic neonatal resuscitation following delivery (CL)	CL	RMNCH	Yes	Yes	Curative
C3c	Management of labour and delivery in low-risk women by skilled attendant (PHC)	PHC	RMNCH	Yes	Yes	Curative
C3d	Basic neonatal resuscitation following delivery (PHC)	PHC	RMNCH	Yes	Yes	Curative
C34	Environmental management for malaria	CL	Infectious Disease	No	No	Preventive
C4	Promotion of breastfeeding and complementary feeding by community health workers	CL	RMNCH	Yes	No	Promotive
C41	Mass drug administration (malaria)	CL	Infectious Disease	No	No	Preventive
C43	Early detection and treatment of leishmaniasis, dengue, chikungunya, rabies, trachoma and helminthiasis.	PHC	Infectious Disease	No	No	Curative
C45	Identify and refer patients with high risk	CL	Infectious Disease	No	No	Curative

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
C46	In the context of an emerging infectious outbreak, provide advice and guidance on how to recognize early symptoms and signs and when to seek medical attention	CL	Infectious Disease	No	No	Promotive
C47	Exercise-based pulmonary rehabilitation	CL	NCD & IPC	No	No	Rehabilitative
C48	Self-managed treatment of migraine	CL	NCD & IPC	No	No	Curative
C5	Tetanus toxoid immunization among schoolchildren and women attending antenatal care	PHC	RMNCH	Yes	No	Preventive
C50	Parent training of high-risk families, including nurse home visitation for child maltreatment	FLH	NCD & IPC	No	No	Promotive
C51	WASH behaviour change interventions, such as community led total sanitation	CL	NCD & IPC	No	No	Preventive
C53a	Identification/screening of the early childhood development issues motor, sensory and language stimulation	CL	Health Services	No	No	Rehabilitative
C53b	ECD rehabilitation interventions	PHC	Health Services	No	No	Rehabilitative
C56	Interventions for wheelchair users	CL	Health Services	No	No	Preventive
C8	Acute severe malnutrition management	CL	RMNCH	Yes	No	Preventive
C9	Integrated community case management	CL	RMNCH	Yes	No	Preventive
FLH1	Care for foetal growth restriction	FLH	RMNCH	Yes	No	Curative
FLH10	Surgical termination of pregnancy by maternal vacuum aspiration and dilatation & curettage	FLH	RMNCH, Health Services	Yes	No	Curative
FLH11	Care for severe childhood infections	FLH	RMNCH	Yes	Yes	Curative
FLH12	Severe acute malnutrition management	FLH	RMNCH	Yes	Yes	Curative
FLH13	Early detection and treatment of early-stage cervical cancer	FLH	RMNCH, Infectious Disease, NCD & IPC	Yes	No	Curative
FLH14	Insertion and removal of contraceptives	FLH	RMNCH, Health Services	Yes	No	Preventive

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
FLH15	Tubal ligation	FLH	RMNCH, Health Services	Yes	No	Preventive
FLH16	Vasectomy	FLH	RMNCH, Health Services	Yes	No	Preventive
FLH17	Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO guidelines (either short- or long-term regimen)	FLH	Infectious Disease	No	No	Curative
FLH18	Evaluation and management of fever in clinically unstable individuals using WHO IMAI guidelines, including empiric parenteral antimicrobials and antimalarial and resuscitative measures for septic shock	FLH	Infectious Disease	No	No	Curative
FLH2	Induction of labour post-term	FLH	RMNCH	Yes	Yes	Curative
FLH20	Management of acute coronary syndromes	FLH	NCD & IPC	No	No	Curative
FLH22	Management of acute exacerbations of asthma and COPD using systemic steroids, inhaled beta-agonists and if indicated oral antibiotics and oxygen therapy	FLH	NCD & IPC	No	Yes	Curative
FLH23	Medical management of acute heart failure	FLH	NCD & IPC	No	Yes	Curative
FLH24	Bowel obstruction management	FLH	NCD & IPC, Health Services	No	Yes	Curative
FLH25	Calcium and vitamin D supplementation for secondary prevention of osteoporosisE264	FLH	NCD & IPC	No	No	Preventive
FLH26	Combination therapy, including low-dose corticosteroids and generic disease-modifying antirheumatic drugs (including methotrexate), for individuals with moderate to severe rheumatoid arthritis	FLH	NCD & IPC	No	No	Curative
FLH27	In settings where sickle cell disease is a public health concern, universal new-born screening followed by standard prophylaxis against bacterial infections and malaria	FLH	NCD & IPC	No	No	Preventive
FLH28	In setting where specific single-gene disorders are a public health concern (for example thalassemia), retrospective identification of carriers plus prospective (premarital) screening and counselling to reduce rates of conceptionE311	FLH	NCD & IPC	No	No	Curative

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
FLH3	Jaundice management with phototherapy	FLH	RMNCH	Yes	No	Curative
FLH30	Intoxication/poisoning management	FLH	NCD & IPC	No	Yes	Curative
FLH31	Appendectomy	FLH	Health Services	No	Yes	Curative
FLH32	Assisted vaginal delivery using vacuum extraction or forceps	FLH	Health Services	No	Yes	Curative
FLH33	Craniotomy for trauma	RH	Health Services	No	Yes	Curative
FLH34	Colostomy for acute bowel obstruction/volvulus and injuries.	FLH	Health Services	No	Yes	Curative
FLH35	Escharotomy or fasciotomy	FLH	Health Services	No	Yes	Curative
FLH36	Management of non-displaced fractures	FLH	Health Services	No	Yes	Curative
FLH37	Hernia Repair	FLH	Health Services	No	Yes	Curative
FLH38	Hysterectomy for uterine rupture or intractable postpartum haemorrhage	FLH	Health Services	No	Yes	Curative
FLH39	Irrigation and debridement of open fractures	FLH	Health Services	No	Yes	Curative
FLH4	Eclampsia management with magnesium sulphate, including initial stabilization at health centres	FLH	RMNCH	Yes	Yes	Curative
FLH40	Management of osteomyelitis, including surgical debridement	FLH	Health Services	No	Yes	Curative
FLH41a	Management of Septic Arthritis	FLH	Health Services	No	Yes	Curative
FLH41b	Placement of External Fixation and Use of Traction for Fractures	FLH	Health Services	No	Yes	Curative
FLH42	Relief of urinary obstruction by catheterization for fractures	FLH	Health Services	No	Yes	Curative
FLH43	Removal of gallbladder, including emergency surgery	FLH	Health Services	No	Yes	Curative
FLH44	Repair of perforations (for example perforated peptic ulcer, typhoid ileal perforation)	FLH	Health Services	No	Yes	Curative
FLH45	Resuscitation with advanced measures	FLH	Health Services	No	Yes	Curative

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
FLH46	Basic Skin grafting	FLH	Health Services	No	No	Curative
FLH48a	Trauma laparotomy	FLH	Health Services	No	Yes	Curative
FLH49	Trauma-related amputations	FLH	Health Services	No	Yes	Curative
FLH5	Maternal sepsis management	FLH	RMNCH	Yes	Yes	Curative
FLH50	Tube thoracostomy	FLH	Health Services	No	Yes	Curative
FLH52	Compression therapy for amputations, burns, and vascular or lymphatic disorders	FLH	Health Services	No	No	Curative
FLH53	Evaluation and acute management of swallowing dysfunctionE307	FLH	Health Services	No	No	Curative
FLH57	Prevention and relief of refractory suffering and acute pain related to surgery, serious injury or other serious, complex or life-limiting health problems	FLH	Health Services	No	No	Palliative
FLH58	First level hospital pathology services	FLH	Health Services	No	No	Curative
FLH6	Management of new-born complications infections, meningitis, septicaemia, pneumonia and other very serious infections requiring continuous supportive care (such as IV fluids and oxygen)	FLH	RMNCH	Yes	Yes	Curative
FLH7	Preterm labour management	FLH	RMNCH	Yes	No	Curative
FLH8	Management of labour and delivery in high-risk women, including operative delivery (CEmONC)	FLH	RMNCH, Health Services	Yes	Yes	Curative
FLH9	Surgery for ectopic pregnancy	FLH	RMNCH, Health Services	Yes	Yes	Curative
HC1	Early detection and treatment of neonatal pneumonia with oral antibiotics	PHC	RMNCH	Yes	No	Curative
HC10	Screening and management of diabetes (gestational diabetes or pre-existing type II diabetes)	FLH	RMNCH, NCD & IPC	Yes	No	Curative
HC11	Management of labour and delivery in low-risk women (BEmONC), including initial treatment of obstetric or delivery complications prior to transfer (Also included in Surgery package of services)	PHC	RMNCH, Health Services	Yes	Yes	Curative

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
HC12	Detection and treatment of childhood infections with danger signs (IMCI)	PHC	RMNCH	Yes	Yes	Curative
HC13	Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load for	FLH	RMNCH, Infectious Disease	Yes	No	Curative
HC14	Psychological treatment	PHC	RMNCH, NCD & IPC	Yes	No	Curative
HC16	Post gender-based violence care	PHC	RMNCH, Infectious Disease	Yes	No	Rehabilitative
HC17	Syndromic management of common sexual and reproductive tract infections (for example urethral discharge, genital ulcer and others)	PHC	RMNCH, Infectious Disease	Yes	No	Curative
HC19	For individuals testing positive for hepatitis B and C, assessment of treatment eligibility by trained providers followed by initiation and monitoring of ART when indicated	FLH	Infectious Disease	No	No	Curative
HC2	Miscarriage and abortions management	PHC	RMNCH	Yes	Yes	Curative
HC20	Hepatitis B and C testing of High-risk individuals identified in the national testing policy with appropriate referral of positive individuals to trained providers	PHC	Infectious Disease	No	No	Curative
HC21	Partner notification and expedited treatment for common STIs including HIV	PHC	Infectious Disease	No	No	Curative
HC23	Provider-initiated testing and counselling for HIV, STIs and hepatitis for all in contact with the health system in high- prevalence setting, including prenatal care with appropriate referral/ linkages to care including immediate ART initiation for those testing positive for HIV	PHC	Infectious Disease	No	No	Curative
HC24	Hepatitis B vaccination for high-risk populations, including healthcare workers, IDU, MSM, household contacts and partners with multiple sex partners	FLH	Infectious Disease, NCD & IPC	No	No	Preventive
HC25	Medical male circumcision	PHC	Infectious Disease, Health Services	No	No	Preventive
HC26	For PLHIV and children under five who are close contacts or household members of individuals with active TB, perform symptom screening and chest radiograph; if there is no active TB, provide isoniazid preventive therapy according to current WHO guidelines	PHC	Infectious Disease	No	No	Curative

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
HC27	Diagnosis of TB and first-line treatment	PHC	Infectious Disease	No	No	Curative
HC28	Screening for HIV in all individuals with a diagnosis of active TB; if HIV infection is present, start (or refer for) ARV treatment and HIV care	CL	Infectious Disease	No	No	Curative
HC29	Latent-TB screening and IPT for PLHIV	PHC	Infectious Disease	No	No	Curative
HC3	Management of premature rupture of membranes, including administration of antibiotics	FLH	RMNCH	Yes	No	Curative
HC30	Fever management for clinically stable	PHC	Infectious Disease	No	No	Curative
HC32	Provision of insecticide nets to U5 children and pregnant women attending health centres	PHC	Infectious Disease	No	No	Preventive
HC33	Identify and refer for progressive illness **	FLH	Infectious Disease	No	No	Curative
HC36	Long-term combination therapy for persons with multiple CVD risk factors, including screening for CVD in community setting using non-lab-based tools to assess overall CVD risk	PHC	NCD & IPC	No	No	Curative
HC37	Low-dose inhaled corticosteroids and bronchodilators for asthma and for selected patients with COPD	PHC	NCD & IPC	No	No	Curative
HC38	Provision of aspirin for all cases of suspected acute myocardial infarction	PHC	NCD & IPC	No	Yes	Curative
HC39a	Screening and ACEi or ARBs for kidney disease	PHC	NCD & IPC	No	No	Curative
HC41	Secondary prophylaxis for rheumatic fever	PHC	NCD & IPC	No	No	Preventive
HC42	Treatment of acute pharyngitis for rheumatic fever	PHC	NCD & IPC	No	Yes	Curative
HC45	Opportunistic screening for hypertension	PHC	NCD & IPC	No	No	Curative
HC46	Tobacco cessation counselling	PHC	NCD & IPC	No	No	Promotive
HC48	Support for caregivers of dementia patients	PHC	NCD & IPC	No	No	Promotive
HC49	Bipolar disorder management	PHC	NCD & IPC	No	No	Curative
HC4a	Provision of condoms and hormonal contraceptives, including emergency contraceptives	CL	RMNCH	Yes	No	Promotive

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
HC4b	Provision of condoms and hormonal contraceptives, including insertion and removal of contraceptives (PHC)	PHC	RMNCH	Yes	No	Promotive
HC50	Management of depression and anxiety disorders with psychological and generic antidepressants therapy	PHC	NCD & IPC	No	No	Curative
HC53	Screening and brief alcohol intervention	PHC	NCD & IPC	No	No	Preventive
HC55	Primary prevention of osteoporosis	PHC	NCD & IPC	No	No	Preventive
HC56	Screening for congenital hearing loss	PHC	NCD & IPC	No	No	Curative
HC57a	Dental extraction (PHC)	PHC	Health Services	No	No	Curative
HC57b	Dental extraction (FLH)	FLH	Health Services	No	No	Curative
HC58a	Drainage of dental abscess (PHC)	PHC	Health Services	No	No	Curative
HC59	Drainage of superficial abscess	PHC	Health Services	No	No	Curative
HC5a	Counselling on kangaroo care for new-borns (CL)	CL	RMNCH	Yes	No	Preventive
HC5b	Counselling on kangaroo care for new-borns (PHC)	PHC	RMNCH	Yes	No	Preventive
HC6	Management of neonatal sepsis, pneumonia and meningitis using injectable and oral antibiotics	FLH	RMNCH	Yes	No	Curative
HC60	Non-displaced fractures management	PHC	Health Services	No	No	Curative
HC61	Resuscitation with basic life support measures	PHC	Health Services	No	No	Curative
HC62	Suturing laceration	PHC	Health Services	No	No	Curative
HC63a	Treatment of caries (PHC)	PHC	Health Services	No	No	Curative
HC64	Basic management of MNIs and disorders	PHC	Health Services	No	No	Curative
HC66	Psychosocial support and counselling	CL	NCD & IPC	No	No	Palliative

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
HC67	Expanded palliative care and pain control measures, including prevention and relief of all physical and psychological symptoms of suffering	FLH	Health Services	No	No	Palliative
HC68	Health centre pathology services **	PHC	Health Services	No	No	Curative
HC7	Pharmacological termination of pregnancy	PHC	RMNCH	Yes	No	Curative
HC9a	Screening of hypertensive disorders in pregnancy	CL	RMNCH, NCD & IPC	Yes	No	Curative
HC9b	Screening and management of hypertensive disorders in pregnancy	PHC	RMNCH, NCD & IPC	Yes	No	Curative
P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkages to care (active case finding)	CL	Infectious Disease	No	No	Curative
RH1	Full supportive care for preterm new-borns	FLH	RMNCH	Yes	Yes	Curative
RH2	Specialized TB services, including management of MDR- and XDR-TB treatment failure and surgery for TB	RH	Infectious Disease	No	No	Curative
RH3	Management of refractory febrile illness including etiologic diagnosis at reference microbial laboratory	RH	Infectious Disease	No	No	Curative
RH4	Management of acute ventilator failure due to acute exacerbations of asthma and COPD	RH	NCD & IPC	No	Yes	Curative
RH5	Retinopathy screening via telemedicine, followed by treatment using laser photocoagulation	RH	NCD & IPC	No	No	Curative
RH6	Use of percutaneous coronary intervention for acute myocardial infarction where resources permit	RH	NCD & IPC	No	No	Curative
RH7	Treatment of early-stage breast cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	RH	NCD & IPC	No	No	Curative
RH8	Treatment of early-stage colorectal cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	RH	NCD & IPC	No	No	Curative

DCP3 Code	Intervention name	Platform	Cluster	Vulnerable Population	Rule of rescue	Intervention Purpose
RH9	Treatment of early-stage childhood cancers (such as Burkitt and Hodgkin lymphoma, acute lymphoblastic leukaemia, retinoblastoma and Wilms tumour) with curative intent in paediatric cancer units or hospitals	RH	NCD & IPC	No	No	Curative
RH10	Elective surgical repair of common orthopaedic injuries (for example meniscal and ligamentous tears) in individuals with severe functional limitation	RH	NCD & IPC	No	No	Curative
RH11	Urgent, definitive surgical management of orthopaedic injuries (for example open reduction and internal fixation)	RH	NCD & IPC	No	Yes	Curative
RH12	Repair of cleft lip and cleft palate	RH	NCD & IPC, Health Services	No	No	Curative
RH13	Repair of club foot	RH	NCD & IPC, Health Services	No	No	Curative
RH14	Cataract extraction	FLH	Health Services	No	No	Curative
RH15	Repair of anorectal malformations and Hirschsprung's disease	RH	Health Services	No	No	Curative
RH16	Repair of obstetric fistula	RH	Health Services	No	Yes	Curative
RH17	Ventriculoperitoneal Shunt	RH	Health Services	No	Yes	Curative
RH18	Surgery for Trachomatous Trichiasis	RH	Health Services	No	No	Curative
RH19	Referral level hospital pathology services	RH	Health Services	No	No	Curative
RH20	Speciality pathology services	RH	Health Services	No	No	Curative

Appendix 6.6: Estimated current coverage by intervention (2019)

DCP3 Code	Intervention name	Estimated current coverage (2019)
C1	Antenatal and postpartum education on birth spacing	41%
C10	Education on handwashing, personal hygiene and safe disposal of children's stool	41%
C11	Pneumococcus vaccination	75%
C12	Rotavirus vaccination	70%
C14	Vitamin A and zinc for children	56%
C16	Childhood vaccination series (diphtheria, pertussis, tetanus, polio, BCG, measles, hepatitis B, HiB, rubella)	66%
C17	Indoor residual spraying	10%
C18	Education of schoolchildren on oral health	20%
C19	Vision pre-screening by teachers; vision tests and provision of ready-made glasses on-site by eye specialists	20%
C2	Counselling of mothers on providing thermal care for pre- term new-borns (delayed bath and skin to skin contact)	5%
C20	School based HPV vaccination for girls	0%
C21	Mass drug administration (NTDs)	0%
C23	Adolescent-friendly services for STIs	5%
C24	Life skills training in schools	5%
C27a	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households	59%
C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecurity households	59%
C28	Community-based HIV testing and counselling (for example, mobile units and venue-based testing), with appropriate referral or linkage to care and	8%
C30a	Provision of condoms to key populations, including sex workers, men who have sex with men, people who inject drugs, transgender populations, and prisoners	20%
C30b	Provision of Disposable syringes who inject drugs (IDU)	20%
C32	Routine contact tracing to identify individuals exposed to TB and link them to care	41%
C33	Test for G6PD deficiency	40%
C3a	Management of labour and delivery in low-risk women by skilled attendant (CL)	20%
C3b	Basic neonatal resuscitation following delivery (CL)	20%

DCP3 Code	Intervention name	Estimated current coverage (2019)
C3c	Management of labour and delivery in low-risk women by skilled attendant (PHC)	69%
C3d	Basic neonatal resuscitation following delivery (PHC)	69%
C34	Environmental management for malaria	15%
C4	Promotion of breastfeeding and complementary feeding by community health workers	41%
C41	Mass drug administration (malaria)	0%
C43	Early detection and treatment of leishmaniasis, dengue, chikungunya, rabies, trachoma and helminthiasis.	40%
C45	Identify and refer patients with high risk	50%
C46	In the context of an emerging infectious outbreak, provide advice and guidance on how to recognize early symptoms and signs and when to seek medical attention	50%
C47	Exercise-based pulmonary rehabilitation	0%
C48	Self-managed treatment of migraine	0%
C5	Tetanus toxoid immunization among schoolchildren and women attending antenatal care	60%
C50	Parent training of high-risk families, including nurse home visitation for child maltreatment	1%
C51	WASH behaviour change interventions, such as community led total sanitation	41%
C53a	Identification/screening of the early childhood development issues motor, sensory and language stimulation	2%
C53b	ECD rehabilitation interventions	10%
C56	Interventions for wheelchair users	0%
C8	Acute severe malnutrition management	50%
C9	Integrated community case management	5%
FLH1	Care for foetal growth restriction	40%
FLH10	Surgical termination of pregnancy by maternal vacuum aspiration and dilatation & curettage	20%
FLH11	Care for severe childhood infections	40%
FLH12	Severe acute malnutrition management	35%
FLH13	Early detection and treatment of early-stage cervical cancer	2%
FLH14	Insertion and removal of contraceptives	3%
FLH15	Tubal ligation	9%
FLH16	Vasectomy	1%

DCP3 Code	Intervention name	Estimated current coverage (2019)
FLH17	Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO guidelines (either short- or long-term regimen)	60%
FLH18	Evaluation and management of fever in clinically unstable individuals using WHO IMAI guidelines, including empiric parenteral antimicrobials and antimalarial and resuscitative measures for septic shock	40%
FLH2	Induction of labour post-term	30%
FLH20	Management of acute coronary syndromes	30%
FLH22	Management of acute exacerbations of asthma and COPD using systemic steroids, inhaled beta-agonists and if indicated oral antibiotics and oxygen therapy	20%
FLH23	Medical management of acute heart failure	30%
FLH24	Bowel obstruction management	40%
FLH25	Calcium and vitamin D supplementation for secondary prevention of osteoporosisE264	20%
FLH26	Combination therapy, including low-dose corticosteroids and generic disease-modifying antirheumatic drugs (including methotrexate), for individuals with moderate to severe rheumatoid arthritis	40%
FLH27	In settings where sickle cell disease is a public health concern, universal new-born screening followed by standard prophylaxis against bacterial infections and malaria	10%
FLH28	In setting where specific single-gene disorders are a public health concern (for example thalassemia), retrospective identification of carriers plus prospective (premarital) screening and counselling to reduce rates of conceptionE311	10%
FLH3	Jaundice management with phototherapy	40%
FLH30	Intoxication/poisoning management	20%
FLH31	Appendectomy	50%
FLH32	Assisted vaginal delivery using vacuum extraction or forceps	20%
FLH33	Craniotomy for trauma	10%
FLH34	Colostomy for acute bowel obstruction/volvulus and injuries.	30%
FLH35	Escharotomy or fasciotomy	10%
FLH36	Management of non-displaced fractures	40%
FLH37	Hernia Repair	40%
FLH38	Hysterectomy for uterine rupture or intractable postpartum haemorrhage	60%
FLH39	Irrigation and debridement of open fractures	40%

DCP3 Code	Intervention name	Estimated current coverage (2019)
FLH4	Eclampsia management with magnesium sulphate, including initial stabilization at health centres	50%
FLH40	Management of osteomyelitis, including surgical debridement	30%
FLH41a	Management of Septic Arthritis	20%
FLH41b	Placement of External Fixation and Use of Traction for Fractures	20%
FLH42	Relief of urinary obstruction by catheterization for fractures	50%
FLH43	Removal of gallbladder, including emergency surgery	40%
FLH44	Repair of perforations (for example perforated peptic ulcer, typhoid ileal perforation)	60%
FLH45	Resuscitation with advanced measures	20%
FLH46	Basic Skin grafting	20%
FLH48a	Trauma laparotomy	60%
FLH49	Trauma-related amputations	25%
FLH5	Maternal sepsis management	40%
FLH50	Tube thoracostomy	25%
FLH52	Compression therapy for amputations, burns, and vascular or lymphatic disorders	40%
FLH53	Evaluation and acute management of swallowing dysfunctionE307	40%
FLH57	Prevention and relief of refractory suffering and acute pain related to surgery, serious injury or other serious, complex or life-limiting health problems	20%
FLH58	First level hospital pathology services	40%
FLH6	Management of new-born complications infections, meningitis, septicaemia, pneumonia and other very serious infections requiring continuous supportive care (such as IV fluids and oxygen)	40%
FLH7	Preterm labour management	40%
FLH8	Management of labour and delivery in high-risk women, including operative delivery (CEmONC)	40%
FLH9	Surgery for ectopic pregnancy	40%
HC1	Early detection and treatment of neonatal pneumonia with oral antibiotics	50%
HC10	Screening and management of diabetes (gestational diabetes or pre-existing type II diabetes)	5%

DCP3 Code	Intervention name	Estimated current coverage (2019)
HC11	Management of labour and delivery in low-risk women (BEmONC), including initial treatment of obstetric or delivery complications prior to transfer (Also included in Surgery package of services)	66%
HC12	Detection and treatment of childhood infections with danger signs (IMCI)	20%
HC13	Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load for	13%
HC14	Psychological treatment	5%
HC16	Post gender-based violence care	5%
HC17	Syndromic management of common sexual and reproductive tract infections (for example urethral discharge, genital ulcer and others)	50%
HC19	For individuals testing positive for hepatitis B and C, assessment of treatment eligibility by trained providers followed by initiation and monitoring of ART when indicated	10%
HC2	Miscarriage and abortions management	30%
HC20	Hepatitis B and C testing of high-risk individuals identified in the national testing policy with appropriate referral of positive individuals to trained providers	20%
HC21	Partner notification and expedited treatment for common STIs including HIV	40%
HC23	Provider-initiated testing and counselling for HIV, STIs and hepatitis for all in contact with the health system in high-prevalence setting, including prenatal care with appropriate referral/ linkages to care including immediate ART initiation for those testing positive for HIV	25%
HC24	Hepatitis B vaccination for high-risk populations, including healthcare workers, IDU, MSM, household contacts and partners with multiple sex partners	10%
HC25	Medical male circumcision	20%
HC26	For PLHIV and children under five who are close contacts or household members of individuals with active TB, perform symptom screening and chest radiograph; if there is no active TB, provide isoniazid preventive therapy according to current WHO guidelines	1%
HC27	Diagnosis of TB and first-line treatment	69%
HC28	Screening for HIV in all individuals with a diagnosis of active TB; if HIV infection is present, start (or refer for) ARV treatment and HIV care	12%
HC29	Latent-TB screening and IPT for PLHIV	20%
HC3	Management of premature rupture of membranes, including administration of antibiotics	20%
HC30	Fever management for clinically stable	50%

DCP3 Code	Intervention name	Estimated current coverage (2019)
HC32	Provision of insecticide nets to U5 children and pregnant women attending health centres	30%
HC33	Identify and refer for progressive illness **	30%
HC36	Long-term combination therapy for persons with multiple CVD risk factors, including screening for CVD in community setting using non-lab-based tools to assess overall CVD risk	5%
HC37	Low-dose inhaled corticosteroids and bronchodilators for asthma and for selected patients with COPD	20%
HC38	Provision of aspirin for all cases of suspected acute myocardial infarction	20%
HC39a	Screening and ACEi or ARBs for kidney disease	10%
HC41	Secondary prophylaxis for rheumatic fever	20%
HC42	Treatment of acute pharyngitis for rheumatic fever	50%
HC45	Opportunistic screening for hypertension	20%
HC46	Tobacco cessation counselling	0%
HC48	Support for caregivers of dementia patients	0%
HC49	Bipolar disorder management	0%
HC4a	Provision of condoms and hormonal contraceptives, including emergency contraceptives	14%
HC4b	Provision of condoms and hormonal contraceptives, including insertion and removal of contraceptives (PHC)	14%
HC50	Management of depression and anxiety disorders with psychological and generic antidepressants therapy	10%
HC53	Screening and brief alcohol intervention	0%
HC55	Primary prevention of osteoporosis	30%
HC56	Screening for congenital hearing loss	1%
HC57a	Dental extraction (PHC)	30%
HC57b	Dental extraction (FLH)	35%
HC58a	Drainage of dental abscess (PHC)	20%
HC59	Drainage of superficial abscess	30%
HC5a	Counselling on kangaroo care for new-borns (CL)	2%
HC5b	Counselling on kangaroo care for new-borns (PHC)	2%
HC6	Management of neonatal sepsis, pneumonia and meningitis using injectable and oral antibiotics	20%
HC60	Non-displaced fractures management	20%

DCP3 Code	Intervention name	Estimated current coverage (2019)
HC61	Resuscitation with basic life support measures	20%
HC62	Suturing laceration	30%
HC63a	Treatment of caries (PHC)	10%
HC64	Basic management of MNIs and disorders	20%
HC66	Psychosocial support and counselling	1%
HC67	Expanded palliative care and pain control measures, including prevention and relief of all physical and psychological symptoms of suffering	5%
HC68	Health centre pathology services **	5%
HC7	Pharmacological termination of pregnancy	20%
HC9a	Screening of hypertensive disorders in pregnancy	50%
HC9b	Screening and management of hypertensive disorders in pregnancy	50%
P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkages to care (active case finding)	41%
RH1	Full supportive care for preterm new-borns	25%
RH2	Specialized TB services, including management of MDR- and XDR-TB treatment failure and surgery for TB	40%
RH3	Management of refractory febrile illness including etiologic diagnosis at reference microbial laboratory	40%
RH4	Management of acute ventilator failure due to acute exacerbations of asthma and COPD	10%
RH5	Retinopathy screening via telemedicine, followed by treatment using laser photocoagulation	20%
RH6	Use of percutaneous coronary intervention for acute myocardial infarction where resources permit	20%
RH7	Treatment of early-stage breast cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	25%
RH8	Treatment of early-stage colorectal cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	15%
RH9	Treatment of early-stage childhood cancers (such as Burkitt and Hodgkin lymphoma, acute lymphoblastic leukaemia, retinoblastoma and Wilms tumour) with curative intent in paediatric cancer units or hospitals	10%
RH10	Elective surgical repair of common orthopaedic injuries (for example meniscal and ligamentous tears) in individuals with severe functional limitation	20%
RH11	Urgent, definitive surgical management of orthopaedic injuries (for example open reduction and internal fixation)	10%
RH12	Repair of cleft lip and cleft palate	40%

DCP3 Code	Intervention name	Estimated current coverage (2019)
RH13	Repair of club foot	10%
RH14	Cataract extraction	63%
RH15	Repair of anorectal malformations and Hirschsprung's disease	20%
RH16	Repair of obstetric fistula	5%
RH17	Ventriculoperitoneal Shunt	10%
RH18	Surgery for Trachomatous Trichiasis	40%
RH19	Referral level hospital pathology services	40%
RH20	Speciality pathology services	40%

Appendix 6.7: Status of intervention per stage in the deliberation process

In DCP3 shortlist 1 means intervention shortlisted. In TWGs 1 means the intervention was prioritised according to priority level stated in parenthesis. In national advisory council (NAC) and international advisory committee (IAG) 1 means the intervention was included in the package, differentiating between the full essential package of health services (EPHS) and the immediate implementation package (IIP). Note that the inclusion of interventions in the final steering-committee-sanctioned package can be found in Alwan et al. (2022) [5].

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
C1	Antenatal and postpartum education on birth spacing	1	1	0	1	0	0	1	1	1	1
C10	Education on handwashing, personal hygiene and safe disposal of children's stool	1	1	0	1	0	0	1	1	1	1
C11	Pneumococcus vaccination	1	1	0	1	0	0	1	1	1	1
C12	Rotavirus vaccination	1	1	0	1	0	0	1	1	1	1
C14	Vitamin A and zinc for children	1	1	0	1	0	0	1	0	1	0
C16	Childhood vaccination series (diphtheria, pertussis, tetanus, polio, BCG, measles, hepatitis B, HiB, rubella)	1	0	1	1	0	0	1	1	1	1
C17	Indoor residual spraying	1	0	1	0	0	0	0	0	0	0
C18	Education of schoolchildren on oral health	1	1	0	1	0	0	1	0	1	1
C19	Vision pre-screening by teachers; vision tests and provision of ready-made glasses on-site by eye specialists	1	1	0	1	0	0	1	1	1	1
C2	Counselling of mothers on providing thermal care for pre-term new-borns (delayed bath and skin to skin contact)	1	1	0	1	0	0	1	1	1	1
C20	School based HPV vaccination for girls	1	1	0	0	0	0	0	0	0	0
C21	Mass drug administration (NTDs)	1	0	0	0	0	0	0	0	0	0
C23	Adolescent-friendly services for STIs	1	1	0	0	0	0	0	0	0	0
C24	Life skills training in schools	1	1	0	0	0	0	0	0	0	0
C27a	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households	1	1	0	1	0	0	1	1	1	1
C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecurity households	1	1	0	1	0	0	1	1	1	1

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
C28	Community-based HIV testing and counselling (for example, mobile units and venue-based testing), with appropriate referral or linkage to care and	1	1	0	1	0	0	1	1	1	1
C30a	Provision of condoms to key populations, including sex workers, men who have sex with men, people who inject drugs, transgender populations, and prisoners	1	1	0	1	0	0	1	1	1	1
C30b	Provision of Disposable syringes who inject drugs (IDU)	1	1	0	1	0	0	1	1	1	1
C32	Routine contact tracing to identify individuals exposed to TB and link them to care	1	1	0	1	0	0	1	1	1	1
C33	Test for G6PD deficiency	1	0	0	1	0	0	1	0	1	0
C3a	Management of labour and delivery in low-risk women by skilled attendant (CL)	1	1	0	1	0	0	1	1	1	1
C3b	Basic neonatal resuscitation following delivery (CL)	1	1	0	1	0	0	1	1	1	1
C3c	Management of labour and delivery in low-risk women by skilled attendant (PHC)	1	1	0	1	0	0	1	1	1	1
C3d	Basic neonatal resuscitation following delivery (PHC)	1	1	0	1	0	0	1	1	1	1
C34	Environmental management for malaria	1	1	0	0	0	0	0	0	0	0
C4	Promotion of breastfeeding and complementary feeding by community health workers	1	1	0	1	0	0	1	1	1	1
C41	Mass drug administration (malaria)	1	0	1	0	0	0	0	0	0	0
C43	Early detection and treatment of leishmaniasis, dengue, chikungunya, rabies, trachoma and helminthiasis.	1	0	1	1	0	0	1	1	1	1
C45	Identify and refer patients with high risk	1	1	0	1	0	0	1	0	1	0
C46	In the context of an emerging infectious outbreak, provide advice and guidance on how to recognize early symptoms and signs and when to seek medical attention	1	1	0	1	0	0	1	0	1	0
C47	Exercise-based pulmonary rehabilitation	1	0	1	0	0	0	0	0	0	0
C48	Self-managed treatment of migraine	1	0	0	0	0	0	0	0	0	0
C5	Tetanus toxoid immunization among schoolchildren and women attending antenatal care	1	1	0	1	0	0	1	1	1	1
C50	Parent training of high-risk families, including nurse home visitation for child maltreatment	1	1	0	0	0	1	0	0	0	0

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
C51	WASH behaviour change interventions, such as community led total sanitation	1	1	0	1	0	0	1	1	1	1
C53a	Identification/screening of the early childhood development issues motor, sensory and language stimulation	1	1	0	1	0	0	1	0	1	0
C53b	ECD rehabilitation interventions	1	1	0	0	0	0	1	0	1	0
C56	Interventions for wheelchair users	1	0	0	0	0	0	0	0	0	0
C8	Acute severe malnutrition management	1	1	0	1	0	0	1	0	1	0
C9	Integrated community case management	1	0	1	0	0	0	0	0	0	0
FLH1	Care for foetal growth restriction	1	0	0	0	1	0	1	0	1	0
FLH10	Surgical termination of pregnancy by maternal vacuum aspiration and dilatation & curettage	1	0	1	0	0	0	1	1	1	1
FLH11	Care for severe childhood infections	1	0	0	0	1	0	1	0	1	0
FLH12	Severe acute malnutrition management	1	0	0	0	1	0	1	0	1	0
FLH13	Early detection and treatment of early-stage cervical cancer	1	0	0	0	1	0	1	1	1	1
FLH14	Insertion and removal of contraceptives	1	0	0	0	1	0	1	0	1	0
FLH15	Tubal ligation	1	0	0	0	1	0	1	0	1	0
FLH16	Vasectomy	1	0	0	0	1	0	1	0	1	0
FLH17	Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO guidelines (either short- or long-term regimen)	1	0	0	0	1	0	1	1	1	1
FLH18	Evaluation and management of fever in clinically unstable individuals using WHO IMAI guidelines, including empiric parenteral antimicrobials and antimalarial and resuscitative measures for septic shock	1	0	0	0	1	0	1	1	1	1
FLH2	Induction of labour post-term	1	0	0	0	0	1	0	0	0	0
FLH20	Management of acute coronary syndromes	1	0	0	0	0	1	1	0	1	1
FLH22	Management of acute exacerbations of asthma and COPD using systemic steroids, inhaled beta-agonists and if indicated oral antibiotics and oxygen therapy	1	0	0	0	1	0	1	1	1	1
FLH23	Medical management of acute heart failure	1	0	0	0	1	0	1	1	1	1

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
FLH24	Bowel obstruction management	1	0	0	0	1	0	1	1	1	1
FLH25	Calcium and vitamin D supplementation for secondary prevention of osteoporosisE264	1	0	0	0	1	0	0	0	0	0
FLH26	Combination therapy, including low-dose corticosteroids and generic disease-modifying antirheumatic drugs (including methotrexate), for individuals with moderate to severe rheumatoid arthritis	1	0	0	0	0	1	0	0	0	0
FLH27	In settings where sickle cell disease is a public health concern, universal new-born screening followed by standard prophylaxis against bacterial infections and malaria	1	0	0	0	0	1	0	0	0	0
FLH28	In setting where specific single-gene disorders are a public health concern (for example thalassemia), retrospective identification of carriers plus prospective (premarital) screening and counselling to reduce rates of conceptionE311	1	0	0	0	0	1	0	0	0	0
FLH3	Jaundice management with phototherapy	1	0	0	0	1	0	1	1	1	1
FLH30	Intoxication/poisoning management	1	0	0	0	1	0	1	0	1	0
FLH31	Appendectomy	1	0	0	0	1	0	1	0	1	0
FLH32	Assisted vaginal delivery using vacuum extraction or forceps	1	0	0	0	0	0	0	0	0	0
FLH33	Craniotomy for trauma	1	0	0	0	0	1	0	0	0	0
FLH34	Colostomy for acute bowel obstruction/volvulus and injuries.	1	0	0	0	1	0	1	1	1	1
FLH35	Escharotomy or fasciotomy	1	0	0	0	1	0	1	1	1	1
FLH36	Management of non-displaced fractures	1	0	0	0	1	0	1	1	1	1
FLH37	Hernia Repair	1	0	0	0	0	1	0	0	0	0
FLH38	Hysterectomy for uterine rupture or intractable postpartum haemorrhage	1	0	0	0	1	0	1	1	1	1
FLH39	Irrigation and debridement of open fractures	1	0	0	0	1	0	1	1	1	1
FLH4	Eclampsia management with magnesium sulphate, including initial stabilization at health centres	1	0	0	0	1	0	1	1	1	1
FLH40	Management of osteomyelitis, including surgical debridement	1	0	0	0	0	1	0	0	0	0
FLH41 a	Management of Septic Arthritis	1	0	0	0	1	0	1	1	1	1

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
FLH41b	Placement of External Fixation and Use of Traction for Fractures	1	0	0	0	1	0	1	1	1	1
FLH42	Relief of urinary obstruction by catheterization for fractures	1	0	0	0	1	0	1	1	1	1
FLH43	Removal of gallbladder, including emergency surgery	1	0	0	0	1	0	1	1	1	1
FLH44	Repair of perforations (for example perforated peptic ulcer, typhoid ileal perforation)	1	0	0	0	1	0	1	1	1	1
FLH45	Resuscitation with advanced measures	1	0	0	0	1	0	1	0	1	0
FLH46	Basic Skin grafting	1	0	0	0	0	1	0	0	0	0
FLH48a	Trauma laparotomy	1	0	0	0	1	0	1	1	1	1
FLH49	Trauma-related amputations	1	0	0	0	1	0	1	1	1	1
FLH5	Maternal sepsis management	1	0	0	0	1	0	1	0	1	1
FLH50	Tube thoracostomy	1	0	0	0	1	0	1	0	1	0
FLH52	Compression therapy for amputations, burns, and vascular or lymphatic disorders	1	0	0	0	1	0	1	1	1	1
FLH53	Evaluation and acute management of swallowing dysfunctionE307	1	0	0	0	0	1	0	0	0	0
FLH57	Prevention and relief of refractory suffering and acute pain related to surgery, serious injury or other serious, complex or life-limiting health problems	1	0	0	0	1	0	0	0	0	0
FLH58	First level hospital pathology services	1	0	0	0	1	0	0	0	0	0
FLH6	Management of new-born complications infections, meningitis, septicaemia, pneumonia and other very serious infections requiring continuous supportive care (such as IV fluids and oxygen)	1	0	0	0	1	0	1	1	1	1
FLH7	Preterm labour management	1	0	0	0	1	0	1	0	1	0
FLH8	Management of labour and delivery in high-risk women, including operative delivery (CEmONC)	1	0	0	0	0	0	1	0	1	1
FLH9	Surgery for ectopic pregnancy	1	0	0	0	0	0	0	0	0	0
HC1	Early detection and treatment of neonatal pneumonia with oral antibiotics	1	1	0	1	0	0	1	1	1	1

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
HC10	Screening and management of diabetes (gestational diabetes or pre-existing type II diabetes)	1	0	1	0	0	0	1	1	1	1
HC11	Management of labour and delivery in low-risk women (BEmONC), including initial treatment of obstetric or delivery complications prior to transfer (Also included in Surgery package of services)	1	1	0	1	0	0	1	1	1	1
HC12	Detection and treatment of childhood infections with danger signs (IMCI)	1	1	0	1	0	0	1	1	1	1
HC13	Among all individuals who are known to be HIV+, immediate ART initiation with regular monitoring of viral load for	1	1	0	0	0	1	0	0	0	0
HC14	Psychological treatment	1	1	0	1	0	0	1	0	1	1
HC16	Post gender-based violence care	1	1	0	1	0	0	1	0	1	0
HC17	Syndromic management of common sexual and reproductive tract infections (for example urethral discharge, genital ulcer and others)	1	1	0	1	0	0	1	1	1	1
HC19	For individuals testing positive for hepatitis B and C, assessment of treatment eligibility by trained providers followed by initiation and monitoring of ART when indicated	1	0	0	0	1	0	1	1	1	1
HC2	Miscarriage and abortions management	1	0	1	1	0	0	1	0	1	0
HC20	Hepatitis B and C testing of High-risk individuals identified in the national testing policy with appropriate referral of positive individuals to trained providers	1	1	0	1	0	0	1	1	1	1
HC21	Partner notification and expedited treatment for common STIs including HIV	1	1	0	1	0	0	1	1	1	1
HC23	Provider-initiated testing and counselling for HIV, STIs and hepatitis for all in contact with the health system in high-prevalence setting, including prenatal care with appropriate referral/ linkages to care including immediate ART initiation for those testing positive for HIV	1	1	0	1	0	0	1	1	1	1
HC24	Hepatitis B vaccination for high-risk populations, including healthcare workers, IDU, MSM, household contacts and partners with multiple sex partners	1	0	0	0	1	0	1	1	1	1
HC25	Medical male circumcision	1	1	0	1	0	0	1	0	1	0

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
HC26	For PLHIV and children under five who are close contacts or household members of individuals with active TB, perform symptom screening and chest radiograph; if there is no active TB, provide isoniazid preventive therapy according to current WHO guidelines	1	1	0	1	0	0	1	1	1	1
HC27	Diagnosis of TB and first-line treatment	1	1	0	1	0	0	1	1	1	1
HC28	Screening for HIV in all individuals with a diagnosis of active TB; if HIV infection is present, start (or refer for) ARV treatment and HIV care	1	1	0	1	0	0	1	1	1	1
HC29	Latent-TB screening and IPT for PLHIV	1	0	0	0	0	0	0	0	0	0
HC3	Management of premature rupture of membranes, including administration of antibiotics	1	0	1	0	0	0	1	1	1	1
HC30	Fever management for clinically stable	1	0	1	1	0	0	1	0	1	0
HC32	Provision of insecticide nets to U5 children and pregnant women attending health centres	1	0	1	1	0	0	1	1	1	1
HC33	Identify and refer for progressive illness **	1	1	0	1	0	0	1	0	1	0
HC36	Long-term combination therapy for persons with multiple CVD risk factors, including screening for CVD in community setting using non-lab-based tools to assess overall CVD risk	1	1	0	1	0	0	1	1	1	1
HC37	Low-dose inhaled corticosteroids and bronchodilators for asthma and for selected patients with COPD	1	1	0	1	0	0	1	1	1	1
HC38	Provision of aspirin for all cases of suspected acute myocardial infarction	1	1	0	1	0	0	1	1	1	1
HC39a	Screening and ACEi or ARBs for kidney disease	1	1	0	1	0	1	1	0	1	0
HC41	Secondary prophylaxis for rheumatic fever	1	0	1	1	0	0	1	0	1	0
HC42	Treatment of acute pharyngitis for rheumatic fever	1	1	0	1	0	0	1	1	1	1
HC45	Opportunistic screening for hypertension	1	1	0	1	0	0	1	0	1	0
HC46	Tobacco cessation counselling	1	1	0	0	0	0	0	0	0	0
HC48	Support for caregivers of dementia patients	1	0	1	0	0	0	0	0	0	0
HC49	Bipolar disorder management	1	0	0	0	0	0	0	0	0	0
HC4a	Provision of condoms and hormonal contraceptives, including emergency contraceptives	1	1	0	1	0	0	1	1	1	1

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
HC4b	Provision of condoms and hormonal contraceptives, including insertion and removal of contraceptives (PHC)	1	1	0	1	0	0	1	1	1	1
HC50	Management of depression and anxiety disorders with psychological and generic antidepressants therapy	1	1	0	1	0	0	1	1	1	1
HC53	Screening and brief alcohol intervention	1	1	0	0	0	0	0	0	0	0
HC55	Primary prevention of osteoporosis	1	1	0	0	0	0	0	0	0	0
HC56	Screening for congenital hearing loss	1	0	1	1	0	0	1	0	1	0
HC57a	Dental extraction (PHC)	1	1	0	1	0	0	1	0	1	0
HC57b	Dental extraction (FLH)	1	1	0	0	1	0	1	0	1	0
HC58a	Drainage of dental abscess (PHC)	1	1	0	1	0	0	1	0	1	0
HC59	Drainage of superficial abscess	1	1	0	1	0	0	1	0	1	0
HC5a	Counselling on kangaroo care for new-borns (CL)	1	1	0	1	0	0	1	1	1	1
HC5b	Counselling on kangaroo care for new-borns (PHC)	1	1	0	1	0	0	1	1	1	1
HC6	Management of neonatal sepsis, pneumonia and meningitis using injectable and oral antibiotics	1	1	0	0	0	0	1	1	1	1
HC60	Non-displaced fractures management	1	0	1	0	0	0	1	0	1	0
HC61	Resuscitation with basic life support measures	1	1	0	1	0	0	1	1	1	1
HC62	Suturing laceration	1	1	0	1	0	0	1	1	1	1
HC63a	Treatment of caries (PHC)	1	0	1	1	0	0	1	1	1	1
HC64	Basic management of MNIs and disorders	1	1	0	1	0	0	1	0	1	0
HC66	Psychosocial support and counselling	1	0	0	0	0	0	0	0	0	0
HC67	Expanded palliative care and pain control measures, including prevention and relief of all physical and psychological symptoms of suffering	1	0	0	0	1	0	0	0	0	0
HC68	Health centre pathology services **	1	1	0	1	0	0	1	0	1	0
HC7	Pharmacological termination of pregnancy	1	0	1	1	0	0	1	1	1	1
HC9a	Screening of hypertensive disorders in pregnancy	1	1	0	1	0	0	1	1	1	1
HC9b	Screening and management of hypertensive disorders in pregnancy	1	1	0	1	0	0	1	1	1	1

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkages to care (active case finding)	1	1	0	1	0	0	1	0	1	0
RH1	Full supportive care for preterm new-borns	1	0	0	0	1	0	1	1	1	1
RH2	Specialized TB services, including management of MDR- and XDR-TB treatment failure and surgery for TB	1	0	0	0	1	0	0	0	0	0
RH3	Management of refractory febrile illness including etiologic diagnosis at reference microbial laboratory	1	0	0	0	1	0	0	0	0	0
RH4	Management of acute ventilator failure due to acute exacerbations of asthma and COPD	1	0	0	0	1	0	0	0	0	0
RH5	Retinopathy screening via telemedicine, followed by treatment using laser photocoagulation	1	0	0	0	1	0	0	0	0	0
RH6	Use of percutaneous coronary intervention for acute myocardial infarction where resources permit	1	0	0	0	1	0	0	0	0	0
RH7	Treatment of early-stage breast cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	1	0	0	0	1	0	0	0	0	0
RH8	Treatment of early-stage colorectal cancer with appropriate multimodal approaches (including generic chemotherapy) with curative intent for cases detected by clinical examination	1	0	0	0	1	0	0	0	0	0
RH9	Treatment of early-stage childhood cancers (such as Burkitt and Hodgkin lymphoma, acute lymphoblastic leukaemia, retinoblastoma and Wilms tumour) with curative intent in paediatric cancer units or hospitals	1	0	0	0	0	1	0	0	0	0
RH10	Elective surgical repair of common orthopaedic injuries (for example meniscal and ligamentous tears) in individuals with severe functional limitation	1	0	0	0	0	1	0	0	0	0
RH11	Urgent, definitive surgical management of orthopaedic injuries (for example open reduction and internal fixation)	1	0	0	0	0	1	0	0	0	0
RH12	Repair of cleft lip and cleft palate	1	0	0	0	1	0	0	0	0	0
RH13	Repair of club foot	1	0	0	0	1	0	0	0	0	0
RH14	Cataract extraction	1	0	0	0	1	0	1	0	1	0
RH15	Repair of anorectal malformations and Hirschsprung's disease	1	0	0	0	1	0	0	0	0	0
RH16	Repair of obstetric fistula	1	0	0	0	1	0	0	0	0	0

DCP3 Code	Intervention name	DCP3 shortlist	TWG 1 (high priority)	TWG 1 (medium priority)	NAC 1	TWG 2 (high priority)	TWG 2 (medium priority)	NAC 2 full EPHS	NAC 2 IIP	IAG full EPHS	IAG IIP
RH17	Ventriculoperitoneal Shunt	1	0	0	0	1	0	0	0	0	0
RH18	Surgery for Trachomatous Trichiasis	1	0	0	0	1	0	0	0	0	0
RH19	Referral level hospital pathology services	1	0	0	0	1	0	0	0	0	0
RH20	Speciality pathology services	1	0	0	0	1	0	0	0	0	0

References

1. Huda, M., et al., *Assessing global evidence on cost-effectiveness to inform Pakistan's Essential Health Benefit Package* 2022.
2. Watkins, D.A., et al., *Universal Health Coverage and Essential Packages of Care*, in *Disease Control Priorities: Improving Health and Reducing Poverty*, rd, et al., Editors. 2017: Washington (DC).
3. Organization, W.H. *Universal health coverage (UHC)*. 2021 20 December 2021]; Available from: https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc).
4. McKie, J. and J. Richardson, *The rule of rescue.* Soc Sci Med, 2003. **56**(12): p. 2407-19.
5. Alwan, A. and e. al., *Addressing the UHC Challenge Using the Disease Control Priorities-3 Approach: Learning from the Pakistan Experience.* 2022.

Chapter 7

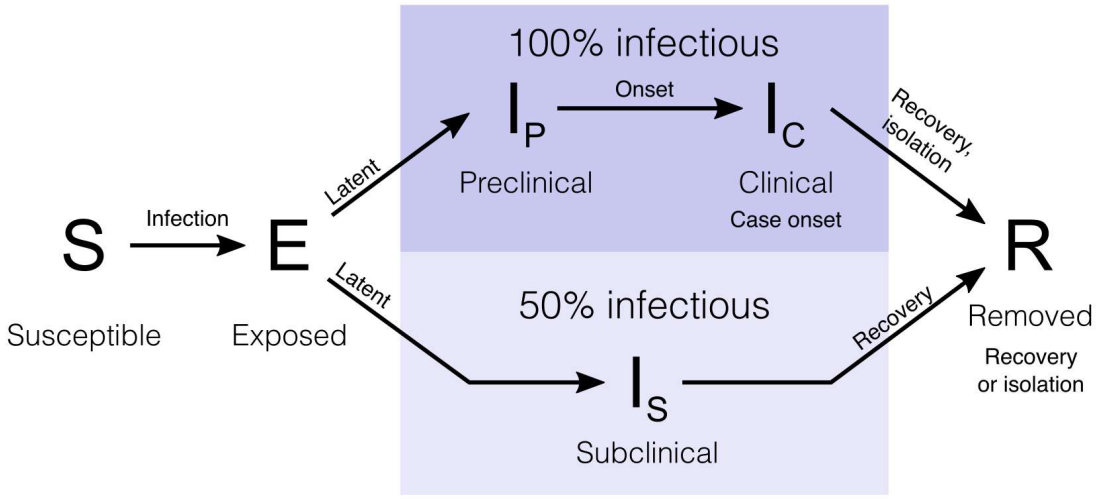
Appendix 7.1: Supplementary Methods Appendix

Appendix 7.1 Contents

1. Epidemiological model

1.1 Parameters used in epidemiological model

1.1.1 Flow diagram showing compartments and flows in the epidemiological model (Figure SM1)



1.1.2 Table SM1: General model parameters

Parameter	Description	Value	Reference
d_E	Latent period (E to I_P and E to I_S; days)	Gamma distribution (μ=4.0, k=4)	(1)
d_P	Duration of preclinical infectiousness (I_P to I_C; days)	Gamma distribution (μ=2.4, k=4)	(1)
d_C	Duration of clinical infectiousness (I_C to R; days)	Gamma distribution (μ=3.2, k=3.7)	(2)
d_S	Duration of subclinical infectiousness (I_S to R; days)	Gamma distribution (μ=7.0, k=4.0)	Assumed
	Incubation period (E to I_C; days)	$d_E + d_P$; mean 6.4 days	Derived
	Serial interval (days)	$d_E + (y_i(d_P + d_C) + (1 - y_i)d_S)/2$; mean approximately 7 days	Derived
u	Susceptibility to infection on contact	Calculated from R_0	Derived
y_i	Probability of clinical symptoms on infection for age group *i*	Estimated from case distributions across 6 countries	(3)
f	Relative infectiousness of subclinical cases	50%	Assumed
c_{ij}	Number of age-*j* individuals contacted by an age-*i* individual per day	Country-specific contact matrix	(4)
N_i	Number of age-*i* individuals	Demographic data	(5)
Δt	Time step for discrete-time simulation	0.25 days	
	Delay from onset to hospitalisation (days)	Gamma distribution (μ=7.0, k=5.0)	
	Duration of hospitalisation in non-ICU bed, severe case (days)	Gamma distribution (μ=14.6, k=5.0)	(6)
	Duration of hospitalisation in non-ICU bed, critical case (before ICU bed; days)	Gamma distribution (μ=6.0, k=5.0)	
	Duration of hospitalisation in ICU bed, critical case (after non-ICU bed; days)	Gamma distribution (μ=9.6, k=5.0)	(7-13)
	Delay from onset to death (days)	Gamma distribution (μ=22, k=10)	(14, 15)

1.1.3 Table SM2: Age-specific hospitalisation and fatality risk

Age group	Case-fatality risk	% of cases hospitalised	% of hospital patients needing ICU
0–9	0.00%	0.0%	30%
1–10	0.09%	0.8%	30%
20-29	0.10%	0.8%	30%
30-39	0.12%	1.0%	30%
40-49	0.23%	1.9%	30%
50-59	0.68%	5.4%	30%
60-69	1.87%	15.1%	30%
70-79	4.14%	33.3%	30%
80+	7.68%	61.8%	30%

Source: Davies et al (2020) (16)

1.2 Scenarios

The epidemiological model uses data from low- and middle-income countries. For each country, the model produces estimates on the number of cases, hospitalisations, number of days in hospital for severe cases (general ward) and critical cases (intensive care unit), and deaths for 57 distinct epidemiological scenarios (2).

For this study, four epidemiological scenarios were chosen out of the set of 57 possible scenarios. Scenario 1 represents an unmitigated epidemic. Scenarios 2-4 scenarios were chosen because they represent a variety of plausible policy options. Descriptions of the scenarios are presented below in Table SM3. Number of cases, days in hospital and deaths per country per scenario can be found in Table SM4.

1.2.1 Table SM3: Scenario descriptions

Scenario 1	Unmitigated epidemic: no mitigation policies are introduced, and there are no reductions in contacts across any population or setting.
Scenario 2	The whole population is covered in this intervention scenario. The intervention is triggered by daily incidence reaching 1 per 10,000. The intervention includes self-isolation of symptomatic persons for duration of symptoms, modelled as an additional reduction in contacts among symptomatic people of 75 %. The intervention includes distancing measures that reduce contacts at school by 20 %, at work by 20 %, in other settings by 20 %, and in the home setting by 0%. There is no difference in intervention by age.
Scenario 3	The whole population is covered in this intervention scenario. The intervention is triggered by daily incidence reaching 1 per 10,000. The intervention includes self-isolation of symptomatic persons for duration of symptoms, modelled as an additional reduction in contacts among symptomatic people of 75 %. The intervention includes distancing measures that reduce contacts at school by 80 %, at work by 80 %, in other settings by 80 % and in the home setting by 0 %. There is no difference in intervention by age.
Scenario 4	49.The intervention is temporary lockdown (30 days) which leads to 100 % of the population reducing their contacts through school, home, work and other settings by 100%, 0%, 37.5 % and 37.5 %, respectively, during Lockdown occurs for the first 30 days. After lockdown is lifted 100% of the population reduces their contacts through school, home, work and other settings by 20 %, 0%, 20% and 20%, respectively.

*For reference, these correspond to Scenarios 1, 4, 22 and 49 in the CovidM epidemiological model, respectively.

1.3 Table SM4: Expected number of cases, days of hospitalisations (ICU and non-ICU) and deaths per country per scenario per year

Country	Scenario	Total Number of Cases per Year	Total Number of ICU bed days per Year	Total Number of Non-ICU Bed Days per Year	Total Number of Deaths per Year
Afghanistan	1	12,218,384	1,644,757	3,068,969	102,557
Afghanistan	2	9,128,640	1,124,522	2,096,065	69,980
Afghanistan	3	5,057,917	659,168	1,228,500	40,911
Afghanistan	4	10,687,759	1,379,972	2,571,196	85,767
Angola	1	10,568,602	1,337,286	2,495,053	82,997
Angola	2	7,951,659	958,471	1,790,227	59,579
Angola	3	3,787,000	480,525	904,768	29,918
Angola	4	9,243,636	1,153,109	2,151,984	71,543
Argentina	1	16,773,845	7,129,192	13,331,843	443,779
Argentina	2	12,167,825	4,923,904	9,183,093	306,425
Argentina	3	7,206,744	3,179,287	5,930,435	197,212
Argentina	4	14,559,346	6,161,078	11,508,390	383,318
Burundi	1	3,825,576	487,746	912,821	30,294
Burundi	2	2,875,192	343,199	643,374	21,458
Burundi	3	1,563,194	192,617	359,761	11,941
Burundi	4	3,360,358	416,410	783,449	25,959
Benin	1	3,987,008	610,334	1,140,853	37,967
Benin	2	3,027,031	436,071	813,544	27,099
Benin	3	1,617,554	243,858	455,765	15,181
Benin	4	3,517,493	523,440	980,738	32,601
Burkina Faso	1	6,855,948	954,395	1,781,199	59,385
Burkina Faso	2	5,231,105	692,107	1,290,565	42,965
Burkina Faso	3	2,954,321	421,063	787,441	26,090
Burkina Faso	4	6,035,206	826,512	1,546,413	51,440
Bangladesh	1	57,227,127	14,236,788	26,575,364	885,269
Bangladesh	2	43,270,144	10,038,443	18,753,926	623,995
Bangladesh	3	23,696,469	5,910,527	11,038,187	366,351
Bangladesh	4	50,407,176	12,324,089	23,001,527	766,395
Bolivia	1	3,881,885	929,771	1,734,889	57,656
Bolivia	2	2,855,102	614,416	1,146,287	38,054
Bolivia	3	1,246,487	279,999	519,997	17,368
Bolivia	4	3,364,052	778,136	1,449,733	48,330
Brazil	1	76,815,441	27,418,043	51,183,619	1,705,997
Brazil	2	56,285,085	18,283,102	34,119,544	1,139,192
Brazil	3	30,752,013	10,628,491	19,851,593	658,619
Brazil	4	66,729,482	23,242,139	43,395,705	1,445,675
Botswana	1	765,573	159,461	296,629	9,918
Botswana	2	565,036	107,208	199,542	6,660
Botswana	3	305,082	61,841	114,201	3,789
Botswana	4	662,702	134,418	250,989	8,334
Central African Republic	1	1,542,576	227,256	422,653	14,108
Central African Republic	2	1,168,851	158,952	297,691	9,900
Central African Republic	3	696,607	102,635	192,340	6,435
Central African Republic	4	1,353,904	194,599	363,301	12,130
Cote d'Ivoire	1	8,535,012	1,316,578	2,457,106	82,053
Cote d'Ivoire	2	6,298,092	916,128	1,708,562	57,156

Country	Scenario	Total Number of Cases per Year	Total Number of ICU bed days per Year	Total Number of Non-ICU Bed Days per Year	Total Number of Deaths per Year
Cote d'Ivoire	3	2,781,975	429,891	803,017	26,661
Cote d'Ivoire	4	7,403,109	1,119,330	2,085,969	69,716
Cameroon	1	8,729,175	1,249,335	2,335,084	77,781
Cameroon	2	6,604,562	889,631	1,661,757	55,432
Cameroon	3	3,552,194	503,336	939,580	31,265
Cameroon	4	7,690,770	1,078,673	2,014,896	67,062
Congo, Dem. Rep.	1	28,914,535	4,131,603	7,713,654	257,149
Congo, Dem. Rep.	2	21,729,089	2,925,816	5,459,743	181,725
Congo, Dem. Rep.	3	10,339,605	1,480,493	2,755,736	91,223
Congo, Dem. Rep.	4	25,274,207	3,537,680	6,601,661	219,628
Congo, Rep.	1	1,819,210	284,222	531,531	17,714
Congo, Rep.	2	1,380,686	201,095	376,299	12,564
Congo, Rep.	3	828,849	128,924	241,162	8,085
Congo, Rep.	4	1,603,300	245,240	457,934	15,290
Colombia	1	18,341,207	6,156,014	11,493,004	382,745
Colombia	2	13,426,478	4,130,466	7,696,118	256,668
Colombia	3	7,192,838	2,342,407	4,372,127	144,933
Colombia	4	15,964,753	5,231,315	9,754,859	325,054
Comoros	1	290,557	47,011	87,853	2,912
Comoros	2	215,335	32,916	61,231	2,047
Comoros	3	114,052	18,551	34,354	1,129
Comoros	4	252,887	40,322	75,628	2,512
Cabo Verde	1	181,545	41,379	77,437	2,566
Cabo Verde	2	128,006	26,548	49,137	1,638
Cabo Verde	3	67,261	14,657	27,550	905
Cabo Verde	4	153,456	33,985	63,203	2,102
Costa Rica	1	1,822,573	652,845	1,218,194	40,619
Costa Rica	2	1,326,971	428,627	799,724	26,659
Costa Rica	3	745,696	252,693	470,210	15,641
Costa Rica	4	1,578,679	549,464	1,023,619	34,174
Dominican Republic	1	3,807,777	1,127,809	2,105,557	70,140
Dominican Republic	2	2,808,435	765,172	1,422,812	47,526
Dominican Republic	3	1,562,725	456,253	850,089	28,343
Dominican Republic	4	3,315,475	964,871	1,796,265	59,882
Algeria	1	14,034,753	3,466,815	6,462,518	215,453
Algeria	2	9,901,970	2,171,944	4,050,559	135,157
Algeria	3	5,054,134	1,144,758	2,139,221	70,840
Algeria	4	11,937,307	2,835,058	5,295,542	175,989
Ecuador	1	6,238,254	1,828,487	3,416,055	113,770
Ecuador	2	4,681,266	1,256,087	2,337,136	77,960
Ecuador	3	2,586,022	739,506	1,376,652	45,789
Ecuador	4	5,480,200	1,567,059	2,923,490	97,214
Egypt, Arab Rep.	1	32,689,306	7,149,998	13,352,308	444,818
Egypt, Arab Rep.	2	23,251,250	4,594,336	8,576,020	285,393
Egypt, Arab Rep.	3	11,840,379	2,461,239	4,607,143	152,674
Egypt, Arab Rep.	4	27,975,741	5,946,559	11,123,015	370,198
Ethiopia	1	37,424,355	6,123,830	11,438,760	380,821
Ethiopia	2	28,272,227	4,318,605	8,066,304	268,718

Country	Scenario	Total Number of Cases per Year	Total Number of ICU bed days per Year	Total Number of Non-ICU Bed Days per Year	Total Number of Deaths per Year
Ethiopia	3	14,996,880	2,457,012	4,593,452	152,671
Ethiopia	4	32,804,210	5,277,773	9,861,571	328,540
Gabon	1	752,440	127,913	239,231	7,960
Gabon	2	572,426	89,835	168,146	5,614
Gabon	3	347,308	58,095	109,709	3,636
Gabon	4	664,128	110,378	206,162	6,868
Ghana	1	10,378,959	1,826,469	3,406,632	113,608
Ghana	2	7,713,894	1,273,479	2,379,059	79,390
Ghana	3	3,423,372	602,270	1,120,060	37,244
Ghana	4	9,039,576	1,557,544	2,901,100	96,753
Guinea	1	4,258,486	700,273	1,311,264	43,627
Guinea	2	3,197,000	509,157	950,869	31,664
Guinea	3	1,702,115	304,198	565,934	18,716
Guinea	4	3,718,928	614,331	1,144,140	38,188
Gambia, The	1	787,667	120,450	224,342	7,491
Gambia, The	2	592,871	88,337	163,947	5,443
Gambia, The	3	324,942	53,737	101,076	3,350
Gambia, The	4	686,599	104,927	196,707	6,559
Guinea-Bissau	1	646,616	100,306	186,821	6,208
Guinea-Bissau	2	490,671	72,272	135,491	4,506
Guinea-Bissau	3	284,321	45,434	83,769	2,782
Guinea-Bissau	4	569,960	87,201	163,160	5,406
Equatorial Guinea	1	471,118	62,021	116,074	3,858
Equatorial Guinea	2	359,113	44,812	83,462	2,772
Equatorial Guinea	3	194,874	25,338	47,642	1,594
Equatorial Guinea	4	416,197	53,836	100,579	3,349
Guatemala	1	5,931,816	1,188,378	2,215,139	73,895
Guatemala	2	4,445,955	809,411	1,509,951	50,398
Guatemala	3	2,471,212	477,648	888,300	29,576
Guatemala	4	5,200,461	1,004,989	1,873,663	62,446
Honduras	1	3,368,666	711,832	1,328,439	44,068
Honduras	2	2,554,279	498,195	928,829	30,884
Honduras	3	1,508,915	311,766	579,276	19,368
Honduras	4	2,966,095	611,292	1,145,329	38,069
Haiti	1	3,844,733	864,008	1,611,689	53,684
Haiti	2	2,891,884	602,646	1,127,805	37,539
Haiti	3	1,628,745	363,202	678,225	22,680
Haiti	4	3,378,438	746,954	1,392,145	46,507
India	1	485,771,554	134,139,960	250,304,013	8,338,438
India	2	365,933,322	93,048,830	173,656,182	5,785,607
India	3	217,279,232	58,353,362	108,949,367	3,620,179
India	4	427,295,821	115,025,841	214,808,062	7,154,678
Iraq	1	13,378,016	2,160,706	4,036,577	134,704
Iraq	2	10,055,987	1,513,885	2,832,294	94,397
Iraq	3	5,444,676	850,809	1,586,861	52,768
Iraq	4	11,745,267	1,852,021	3,459,985	115,382

Country	Scenario	Total Number of Cases per Year	Total Number of ICU bed days per Year	Total Number of Non-ICU Bed Days per Year	Total Number of Deaths per Year
Jordan	1	3,230,121	545,182	1,014,537	33,793
Jordan	2	2,403,685	360,587	671,528	22,396
Jordan	3	1,441,002	226,241	421,434	14,020
Jordan	4	2,802,082	455,066	851,418	28,349
Kenya	1	17,932,718	3,334,486	6,220,435	207,231
Kenya	2	13,972,380	2,685,063	5,015,623	166,727
Kenya	3	8,920,887	1,777,161	3,304,638	110,214
Kenya	4	15,940,230	3,027,794	5,654,038	188,428
Cambodia	1	5,249,630	1,075,358	2,009,207	67,003
Cambodia	2	3,735,697	699,366	1,307,952	43,433
Cambodia	3	1,491,662	285,706	532,484	17,650
Cambodia	4	4,455,702	883,330	1,656,498	55,017
Lebanon	1	2,473,142	849,633	1,578,978	52,778
Lebanon	2	1,838,521	596,389	1,111,151	36,992
Lebanon	3	1,166,532	410,943	767,150	25,628
Lebanon	4	2,165,968	736,594	1,374,880	45,888
Liberia	1	1,679,614	288,953	537,755	17,919
Liberia	2	1,277,408	204,826	383,902	12,778
Liberia	3	740,784	127,259	237,192	7,905
Liberia	4	1,478,591	249,999	464,731	15,428
Libya	1	2,278,127	480,466	897,001	29,873
Libya	2	1,632,675	312,686	585,736	19,496
Libya	3	836,827	167,081	312,036	10,330
Libya	4	1,947,757	401,241	748,906	24,938
Sri Lanka	1	8,020,343	3,408,470	6,355,545	211,681
Sri Lanka	2	5,916,153	2,373,553	4,436,367	147,652
Sri Lanka	3	3,594,782	1,558,313	2,903,475	96,594
Sri Lanka	4	7,016,699	2,945,770	5,508,073	183,972
Lesotho	1	696,741	145,159	271,321	9,017
Lesotho	2	508,495	95,194	178,041	5,963
Lesotho	3	229,199	44,272	82,772	2,796
Lesotho	4	600,007	121,391	224,865	7,490
Morocco	1	13,242,617	4,386,424	8,186,000	272,409
Morocco	2	9,819,053	3,059,154	5,703,002	190,014
Morocco	3	5,899,932	1,973,056	3,680,792	122,031
Morocco	4	11,587,125	3,784,741	7,071,203	235,509
Madagascar	1	9,150,387	1,448,350	2,707,203	90,126
Madagascar	2	6,782,766	1,015,312	1,897,326	63,301
Madagascar	3	3,564,207	563,428	1,049,184	35,010
Madagascar	4	7,966,525	1,244,624	2,321,257	77,440
Mexico	1	46,024,529	13,801,740	25,788,653	858,167
Mexico	2	34,417,216	9,459,831	17,652,018	588,526
Mexico	3	21,097,466	6,179,136	11,554,983	384,123
Mexico	4	40,449,265	11,850,319	22,128,972	737,193
Mali	1	6,261,539	750,362	1,399,913	46,770
Mali	2	4,479,077	497,582	928,693	30,937

Country	Scenario	Total Number of Cases per Year	Total Number of ICU bed days per Year	Total Number of Non-ICU Bed Days per Year	Total Number of Deaths per Year
Mali	3	2,225,009	265,779	494,222	16,416
Mali	4	5,359,818	623,714	1,164,621	38,817
Mozambique	1	10,132,076	1,434,436	2,675,564	89,192
Mozambique	2	7,529,591	1,000,297	1,869,917	62,413
Mozambique	3	3,939,631	555,318	1,035,086	34,251
Mozambique	4	8,820,157	1,230,587	2,293,160	76,324
Mauritania	1	1,535,219	254,586	475,933	15,815
Mauritania	2	1,165,276	182,692	339,830	11,333
Mauritania	3	707,750	121,284	227,135	7,524
Mauritania	4	1,353,942	221,412	412,272	13,723
Mauritius	1	486,886	209,370	390,332	13,048
Mauritius	2	351,305	138,424	258,994	8,630
Mauritius	3	214,210	88,073	165,625	5,463
Mauritius	4	422,541	176,489	329,163	11,016
Malawi	1	6,206,021	853,281	1,590,559	52,896
Malawi	2	4,609,106	597,184	1,114,079	37,180
Malawi	3	2,414,872	329,973	616,215	20,406
Malawi	4	5,394,534	731,215	1,362,680	45,338
Namibia	1	805,969	113,125	211,467	7,032
Namibia	2	594,975	78,583	146,713	4,861
Namibia	3	271,680	36,561	68,779	2,297
Namibia	4	696,765	95,834	179,066	5,975
Niger	1	7,479,841	911,995	1,704,345	56,836
Niger	2	5,361,960	604,502	1,131,298	37,571
Niger	3	2,656,778	323,439	603,881	20,052
Niger	4	6,407,713	758,281	1,417,828	47,137
Nigeria	1	67,998,172	10,931,387	20,404,287	679,438
Nigeria	2	51,622,543	7,976,219	14,878,213	495,447
Nigeria	3	28,071,653	4,656,256	8,692,205	289,284
Nigeria	4	59,789,002	9,541,920	17,807,959	593,372
Nicaragua	1	2,235,573	500,811	937,663	31,193
Nicaragua	2	1,671,928	340,381	632,681	21,124
Nicaragua	3	917,568	190,083	355,496	11,913
Nicaragua	4	1,954,965	422,936	790,201	26,308
Nepal	1	9,915,595	2,499,734	4,665,603	155,339
Nepal	2	7,426,283	1,746,579	3,269,303	108,874
Nepal	3	3,596,042	931,578	1,736,856	57,693
Nepal	4	8,680,619	2,156,185	4,028,306	134,341
Pakistan	1	71,833,291	13,106,615	24,490,691	816,437
Pakistan	2	53,017,173	8,893,216	16,571,106	551,824
Pakistan	3	29,435,592	5,229,563	9,784,165	324,960
Pakistan	4	62,541,662	10,974,825	20,499,025	682,425
Peru	1	11,655,014	3,620,110	6,750,234	224,803
Peru	2	8,460,495	2,403,019	4,479,917	148,873
Peru	3	4,169,861	1,246,737	2,324,155	77,272
Peru	4	10,081,294	3,039,428	5,677,002	188,946

Country	Scenario	Total Number of Cases per Year	Total Number of ICU bed days per Year	Total Number of Non-ICU Bed Days per Year	Total Number of Deaths per Year
Paraguay	1	2,401,205	602,572	1,122,938	37,456
Paraguay	2	1,771,743	398,632	744,467	24,878
Paraguay	3	880,974	208,729	389,899	12,897
Paraguay	4	2,085,255	508,237	946,491	31,507
West Bank and Gaza	1	1,594,004	226,571	422,739	14,105
West Bank and Gaza	2	1,189,223	151,666	281,435	9,407
West Bank and Gaza	3	712,803	95,453	176,326	5,949
West Bank and Gaza	4	1,387,925	190,382	355,232	11,799
Rwanda	1	4,260,092	653,279	1,221,704	40,608
Rwanda	2	3,212,135	457,874	855,830	28,478
Rwanda	3	1,749,170	255,902	479,834	16,022
Rwanda	4	3,746,403	557,317	1,041,050	34,717
Sudan	1	14,419,983	2,514,131	4,680,809	155,985
Sudan	2	10,877,483	1,772,406	3,314,864	110,204
Sudan	3	5,777,423	1,008,372	1,878,301	62,797
Sudan	4	12,629,479	2,164,741	4,038,215	134,409
Senegal	1	5,506,930	943,941	1,765,633	58,634
Senegal	2	4,152,656	688,535	1,284,545	42,863
Senegal	3	2,285,377	427,813	800,324	26,503
Senegal	4	4,809,001	828,514	1,548,750	51,441
Sierra Leone	1	2,630,770	424,740	793,710	26,429
Sierra Leone	2	1,994,333	307,273	574,350	19,120
Sierra Leone	3	1,158,003	191,212	360,302	12,061
Sierra Leone	4	2,319,759	370,962	690,723	22,967
El Salvador	1	2,258,282	726,964	1,354,593	45,161
El Salvador	2	1,664,922	490,166	916,504	30,630
El Salvador	3	908,668	289,894	538,905	17,906
El Salvador	4	1,965,853	619,691	1,156,954	38,540
Sao Tome and Principe	1	72,284	11,232	20,945	696
Sao Tome and Principe	2	54,913	8,014	15,110	500
Sao Tome and Principe	3	29,482	4,448	8,484	284
Sao Tome and Principe	4	63,572	9,662	17,971	607
Eswatini	1	363,364	62,144	115,928	3,869
Eswatini	2	266,346	40,924	76,891	2,558
Eswatini	3	119,568	18,886	35,997	1,187
Eswatini	4	313,533	51,988	96,274	3,204
Syrian Arab Republic	1	5,792,480	989,565	1,847,430	61,580
Syrian Arab Republic	2	4,370,152	718,417	1,339,838	44,443
Syrian Arab Republic	3	2,590,708	461,949	861,860	28,637
Syrian Arab Republic	4	5,101,507	858,728	1,601,690	53,349
Chad	1	5,065,943	601,091	1,124,428	37,285
Chad	2	3,620,550	399,236	745,415	24,835
Chad	3	1,795,298	213,053	398,406	13,124
Chad	4	4,330,614	500,213	933,773	31,055
Togo	1	2,738,322	409,696	766,659	25,516
Togo	2	2,084,482	294,395	549,644	18,294

Country	Scenario	Total Number of Cases per Year	Total Number of ICU bed days per Year	Total Number of Non-ICU Bed Days per Year	Total Number of Deaths per Year
Togo	3	1,117,766	165,864	310,016	10,261
Togo	4	2,416,838	353,372	660,994	21,999
Tajikistan	1	2,980,381	506,624	946,026	31,461
Tajikistan	2	2,132,997	334,989	624,271	20,883
Tajikistan	3	1,073,617	173,478	325,633	10,815
Tajikistan	4	2,558,537	423,792	791,528	26,444
Tunisia	1	4,156,065	1,421,020	2,652,235	88,352
Tunisia	2	2,993,243	934,482	1,744,116	58,014
Tunisia	3	1,711,642	556,561	1,039,231	34,718
Tunisia	4	3,578,598	1,197,556	2,241,228	74,471
Turkey	1	31,029,721	11,408,352	21,265,808	708,020
Turkey	2	23,141,898	7,967,972	14,847,504	495,400
Turkey	3	14,342,055	5,342,495	9,982,584	331,483
Turkey	4	27,262,980	9,879,608	18,427,322	614,391
Tanzania	1	19,439,045	2,891,250	5,398,276	180,023
Tanzania	2	14,683,607	2,076,716	3,872,581	129,155
Tanzania	3	7,943,080	1,196,375	2,231,612	74,240
Tanzania	4	17,106,352	2,514,752	4,689,457	156,668
Uganda	1	14,035,585	2,241,332	4,179,979	139,292
Uganda	2	10,795,699	1,767,713	3,302,957	109,887
Uganda	3	9,634,472	1,547,767	2,892,964	96,320
Uganda	4	12,625,197	2,044,288	3,816,800	126,941
Yemen, Rep.	1	8,978,940	1,189,341	2,223,059	74,108
Yemen, Rep.	2	6,443,446	752,402	1,407,659	46,809
Yemen, Rep.	3	3,134,621	389,461	723,167	23,985
Yemen, Rep.	4	7,619,709	969,123	1,816,361	60,463
South Africa	1	20,484,692	4,996,027	9,320,556	310,572
South Africa	2	15,232,037	3,438,007	6,410,413	213,792
South Africa	3	8,795,217	2,079,589	3,890,085	129,416
South Africa	4	17,929,453	4,284,329	7,988,411	266,130
Zambia	1	5,908,590	719,278	1,341,163	44,603
Zambia	2	4,464,221	514,500	966,758	32,043
Zambia	3	2,130,687	259,718	486,324	16,192
Zambia	4	5,177,648	620,035	1,154,007	38,561
Zimbabwe	1	4,572,304	991,499	1,852,342	61,684
Zimbabwe	2	3,484,742	817,788	1,524,035	50,875
Zimbabwe	3	3,275,359	779,773	1,450,086	48,299
Zimbabwe	4	4,110,615	926,563	1,728,563	57,740

2. Health resource use and costing parameters and assumptions

2.1. Summary

We summarise the main parameters used in the estimates of health resources and costing. Further details and references are then provided in the following sections.

In summary, there are five steps in our calculations:

1. Calculation of unit costs per activity for three base countries: Ethiopia (low-income country or 'LIC'), Pakistan (lower-middle income country or 'lower-MIC') and South Africa (upper-middle income country or 'upper-MIC')
2. Extrapolation of unit costs in base countries to calculate unit costs across LICs, lower-MICs and upper-MICs
3. Calculation of total costs per country using country-specific unit costs, modelled data on the number of cases, hospitalisations and deaths, as well as other epidemiological and economic assumptions
4. Calculation of country-specific costs per capita, as well as costs per capita as a proportion of gross domestic product (GDP) per capita and various measures of health expenditure per capita

2.2 Calculation of unit costs per activity for three base countries

2.2.1 General Approach

A full economic costing was carried out over a one-year time horizon. Costs were constructed using a bottom-up ingredients-based technique. The costing was carried out from a health systems perspective and included both direct (e.g. medicines) and indirect costs (e.g. facility overheads). No above-service delivery costs were included.

The 76 countries chosen met three inclusion criteria: 1) classify as low-income, lower-middle income or upper-middle income by the World Bank (17), 2) be included in the list of 92 countries for which epidemiological modelling data was available from Pearson et al (2020) (2), and 3) have recent available GDP per capita (adjusted for PPP) data in order to carry out cost extrapolation between countries (17).

2.2.2 Intervention costs

We used official WHO guidance to identify areas related to critical preparedness, readiness and response actions for COVID-19 to define a set of interventions involved in a national response to the pandemic (18). We identified 7 priority areas of work and is further sub-divided into 13 activities.

- Emergency response mechanisms at the national level
- Risk communication and community engagement
- Case finding, contact tracing and management
- Surveillance
- Public health measures
- Screening and diagnosis
- Case management

For the first five areas of work we considered only WHO guidance to define the resource use. For case management costs we assumed less resource-intensive activities thought to be more plausible in low- and middle-income settings (‘real-world’). Assumptions on ‘real world’ resource use were based on the clinical expertise of members of the research team and are detailed below.

Following this guidance on areas of work, we generated a list of activities for which we needed to estimate unit costs (see Table SM5). These unit costs were brought together with the COVID epidemiological model to estimate resource needs.

2.2.3 Table SM5: Activities and unit types

Activity	Unit Type
1.a. Emergency Response Mechanisms: National level	Per country per day
1.b. Emergency Response Mechanisms: Training of health staff	One-off per site
2. Risk communication & community engagement	Per country per day
3.a. Case finding, contact tracing and management: Contact tracing	Per person contacted
3.b. Case finding, contact tracing and management: Quarantine of contacts	Per person quarantined
4.a. Surveillance: Case notification	Per positive case
4.b. Surveillance: Reporting (national level)	Per country per week
5. Public health measures: Hygiene education	Per education campaign per month
6. Screening and diagnosis	Per person screened and tested
7.a. Case Management: Home-based care	Per person requiring home-based care
7.b. Case Management: Hospital-based (severe case)	Per day of hospitalisation (severe case)
7.c. Case Management: Hospital-based (critical case)	Per day of hospitalisation (critical case)
7.d. Case Management: Death	Per COVID-related death

2.2.4 Defining inputs, inputs quantities and input costs

In order to calculate a unit cost for each of the abovementioned activities, we used an ingredients-based costing to identify a series of input required. For each input we estimated quantities needed and a country-specific price per quantity (see Table SM6). The costs of each input were identified using a range of sources, according to availability of recent primary cost data and appropriateness of cost estimates to the COVID-19 pattern of care. More details can be found below.

To obtain yearly costs per country, the unit costs below were then multiplied by the number of country-specific units (see Table SM12 for more details).

Example:
In the case of Emergency Response Mechanisms: National level (1a) we aim to calculate a cost per day. We assumed that the three inputs required *per day* are: (i) 10 junior-level government officials, (ii) 10 senior-level government officials, as well as (iii) meeting space and equipment for those 20 people. The salary for one day of work for one junior-level government official in Ethiopia was estimated at US$12.27, for one senior-level government official at US$17.29 and the cost of one day's worth of space and equipment necessary for meetings was estimated at US$13.18 per person. We multiplied inputs by prices: (US$12.27 x 10) + (US$17.29 x 10) + (US$13.18 x 20), which equals US$559.26. This represents the cost per day of the emergency response mechanism at the national level.

In order to determine the annual costs per country, this number was then multiplied by the total number of working days, assumed to be 260 (see Table SM12).

2.2.5 Table SM6: Quantities and unit costs per input per activity per country

Component	Number of Units per Input	Unit Cost per Inputs		
		Ethiopia	Pakistan	South Africa
1.a. Emergency Response Mechanisms: National level				
Working day (junior level govt)	10	$12.27	$13.07	$194.66
Working day (senior level govt)	10	$17.29	$23.94	$256.72
Meeting/ training costs per person per day	20	$13.18	$20.44	$159.17
Total (per country per day):		*$559.26*	*$778.90*	*$7,697.16*
1.b. Emergency Response Mechanisms: Training of health staff				
Working day (health care workers)	250	$4.93	$10.43	$97.58
Working day (junior level govt)	10	$12.27	$13.07	$194.66
Working day (senior level govt)	1	$17.29	$23.94	$256.72
Meeting/ training costs per person per day	261	$13.18	$20.44	$159.17
Total (one-off per site):		*$4,813.58*	*$8,096.53*	*$68,141.36*
2. Risk communication & community engagement				
Working day (junior level govt)	3	$12.27	$13.07	$194.66
Working day (senior level govt)	2	$17.29	$23.94	$256.72
Media costs per day (office space)	1	$2.74	$4.58	$36.00
Total (per country per day):		*$74.14*	*$91.67*	*$1,133.44*
3.a. Case finding, contact tracing and management: Contact tracing				
Working day (junior level govt)	0.1	$12.27	$13.07	$194.66
Contact tracing household visit	0.33	$2.08	$3.02	$13.68
Contact tracing phone call	0.67	$2.34	$0.34	$3.31
Total (per person contacted):		*$3.48*	*$2.54*	*$26.23*
3.b. Case finding, contact tracing and management: Quarantine of contacts				
Working day (health care workers)	0.1	$4.93	$10.43	$97.58
Working day (junior level govt)	0.1	$12.27	$13.07	$194.66
Total (per person quarantined):		*$1.72*	*$2.35*	*$29.22*
4.a. Surveillance: Case notification				
Working day (health care workers)	0.1	$4.93	$10.43	$97.58
Working day (junior level govt)	0.1	$12.27	$13.07	$194.66
Total (per positive case):		*$1.72*	*$2.35*	*$29.22*
4.b. Surveillance: Reporting (national level)				
Working day (health care workers)	0.5	$4.93	$10.43	$97.58
Working day (junior level govt)	0.1	$12.27	$13.07	$194.66
Total (per country per week):		*$3.69*	*$6.52*	*$68.26*
5. Public health measures: Hygiene education				
Working day (junior level govt)	2	$12.27	$10.43	$97.58
Working day (senior level govt)	1	$17.29	$13.07	$194.66
Media costs per day	1	$2.74	$4.58	$36.00
Total (per education campaign per month):		*$44.58*	*$38.51*	*$425.83*
6. Screening and diagnosis				
Ambulance trip	0.0001	$4.80	$9.51	$60.41
Isolation pod/ diagnostic visit	2	$0.49	$0.49	$7.97
Outpatient visit oral history	1	$3.57	$0.47	$8.02
Outpatient visit physical exam	1	$3.57	$0.47	$8.02
Outpatient visit specimen collection	1	$4.88	$1.09	$17.15
COVID19 test (PCR)	1	$23.98	$23.98	$23.98
Total (per person screened and tested):		*$36.97*	*$26.98*	*$73.12*

Component	Number of Units per Input	Unit Cost per Inputs		
		Ethiopia	Pakistan	South Africa
7.a. Case Management: Home-based care				
Home-based care bed-day	5	$0.94	$0.61	$11.65
Community-based care via clinicians visit	2	$9.11	$4.71	$44.16
Total (per person requiring home-based care):		*$22.90*	*$12.45*	*$146.57*
7.b. Case Management: Hospital-based (severe case)				
Inpatient ward bed-day (severe)	1	$29.90	$31.54	$96.66
Diagnostics				
Pulse oximetry	0.125	$0.00	$0.00	$0.00
Chest X-ray	0.125	$27.35	$2.79	$21.86
Full blood count	0.125	$2.37	$2.29	$24.28
Blood urea and electrolyte test	0.125	$4.20	$2.53	$2.87
C-reactive protein test	0.125	$2.34	$0.32	$5.15
HIV test	0.125	$4.38	$3.87	$17.13
COVID19 test (PCR)	0	$23.98	$23.98	$ 23.98
Malaria test	0.125	$0.19	$0.19	$0.19
Haemoglobin test	0.125	$2.29	$2.29	$2.29
Total (per day of hospitalisation (severe case)):		*$35.29*	*$33.32*	*$105.88*
7.c. Case Management: Hospital-based (critical case)				
Inpatient ward bed-day (critical)	0.33	30.65	32.29	97.41
ITU bed-day	0.67	$104.48	$101.99	$662.71
Additional resourcing per COVID-related complication				
Acute respiratory distress syndrome (ARDS)	0.47	$22.46	$22.46	$22.46
Acute kidney injury days	0.04	$10.60	$10.60	$10.60
Acute cardiac injury days	0.06	$46.25	$46.25	$46.25
Liver dysfunction days	0.06	$89.32	$89.32	$89.32
Pneumothorax days	0.01	$6.66	$6.77	$7.02
Hospital-acquired pneumonia days	0.05	$18.85	$18.85	$18.85
Bacteraemia days	0.01	$32.55	$32.55	$32.55
Urinary tract infection days	0.01	$9.03	$9.03	$9.03
Septic shock days	0.05	$0.64	$0.67	$0.75
Diagnostics				
Pulse oximetry	10	$0.00	$0.00	$0.00
Chest X-ray	10	$27.35	$2.79	$21.86
Full blood count	10	$2.37	$2.29	$24.28
Blood urea and electrolyte test	10	$4.20	$2.53	$2.87
C-reactive protein test	10	$2.34	$0.32	$5.15
Venous blood gas test	10	$4.23	$4.23	$4.23
HIV test	0.1	$4.38	$3.87	$17.13
COVID19 test (PCR)	0	$23.98	$23.98	$23.98
Malaria test	0.1	$0.19	$0.19	$0.19
Haemoglobin test	0.1	$2.29	$2.29	$2.29
Total (per day of hospitalisation (critical)):		$505.56	$221.18	$1,081.94
7.d. Case Management: Death				
Body Bag	1	$64.52	$64.52	$64.52
Total (per COVID-related death):		$64.52	$64.52	$64.52

2.2.6 Input quantities

Activities 1-6:
Quantities of working days required for planning and management and communication were estimated from expert consultation as part of the Disease Control Priorities 3-Universal Health Coverage (DCP3-UHC) project (19). For case finding, surveillance and diagnostic activities, quantities were estimated based on requirements for similar activities for tuberculosis (TB) such as contact tracing from the VALUE TB study and previous studies in South Africa (more below) (20, 21).

Activities 7:
The number of days per patient in general ward and in ICU was set at 8 and 10 respectively and was set to match the assumptions in the epidemiological model (2, 14, 22). Following expert clinician advise we assumed that one-third of critical patient bed days would be treated the general ward and two-thirds in the ICU.

The likelihood of additional COVID-related complications (per day) were estimated using evidence on the clinical course of COVID from patients in Wuhan, China (23), as were assumptions on the duration of symptoms (24, 25). The number of diagnostic tests per hospitalisation was carried out in consultation with expert clinicians in essential critical care.

2.2.7 Input unit costs

2.2.7.1 Estimation of non-bed-day costs (Pakistan)

An ingredients-based approach was used to calculate most of the service costs and prices for Pakistan. The data used was collected as part of the Disease Control Priorities 3-Universal Health Coverage (DCP3-UHC) project (19). For other countries primary data from the TB studies was used (see below).

For Pakistan, staff-related costs were constructed using federal-level pay scales. For most outputs, the number of minutes of staff required per activity were estimated via expert opinion obtained from clinicians working in the Health Planning, System Strengthening & Information Analysis Unit (HPSIU) in the Ministry of National Health Services Regulations and Coordination of Pakistan. For outputs where this was unavailable, health economists agreed a plausible assumed value.

Drug regimens were costed using resource use data obtained through expert opinion (HPSIU) and a number of price sources. An assessment of strengths and weaknesses of different price sources was conducted and hierarchy of sources was established. The primary source of price data was the Sindh Health Department Procurement Price list. If a price was unavailable, the Federal Wholesale Price List for Generic Medicines was used as a second option. As a last resort, private sector market prices were used.

Cost on supplies and equipment were similarly constructed. Resource use was determined through expert opinion (HPSIU) and price source hierarchy established. The primary source

was the Medical Emergency Resilience Fund 2019-2020, and a secondary source was private sector market prices.

For all countries, for additional diagnostic and radiology costs (beyond those available from the TB data) were estimated using available literature and market prices. We assessed strengths and weaknesses of different price sources. For example, we used the 'Costing and Pricing of Services in Private Hospitals of Lahore: Summary Report' as our primary source as it contained a methodological appendix that suggested that an ingredients-based approach consistent with ours was followed. If some prices were unavailable we used user fees from the Pakistan Institute of Medical Sciences, procurement prices from the Medical Emergency Resilience Fund procurement prices and user fees from the Aga Khan University Hospital.

Space costs were estimated using data from budget documents from the Federal government (Islamabad Capital Territory Health Infrastructure PC-1).

Oxygen therapy costs per bed-day were calculated by estimating the number of cylinders consumed in 24 hours at different flow rates, assumed to be 10L per minute in the general ward and 30L per minute in the ICU. Cylinder duration (hours) was estimated by dividing pressure by the number of litres per minute, assuming a standard cylinder size of 4.6kg, filled at 1,900 psi pressure (26). Cost per cylinder was obtained from the South African online catalogue of a manufacturer that is active in both South Africa and Pakistan (27).

2.2.7.2 Estimation of non-bed-day costs (Ethiopia and South Africa)

For Ethiopia and South Africa the main source of cost data was the VALUE TB study (20, 21). Cost data were collected from a health provider perspective to estimate the economic costs of TB-related health services. Full costs of health services were estimated. Cost data collection was retrospective, over a one-year period to minimize the risk of bias due to seasonality. Resource use was measured in the VALUE TB study using both top-down and bottom-up methods wherever possible, to allow for comparison. The costs included in the current cost model reflected an average of top-down and bottom-up costs by site. For South Africa, we also used primary data from the XTEND trial (nurses and lay health workers) (28).

Some of the COVID-19 interventions were outside the scope of the VALUE TB and XTEND studies. Values for which a primary unit cost was partially or entirely unavailable from Value TB are listed below. For these interventions, resource use data from Pakistan was used with local Ethiopian or South African prices.

- **Planning & coordination activities:** Working day (mid-level facility); Working day (junior level govt); Working day (senior level govt); Meeting/ training costs per day; Media costs per day; Health hotline (day)
- **Infection control:** Ambulance trip; Isolation pod/ diagnostic visit; Deep clean
- **Home-based care:** Home-based care bed-day; Community-based care via GP
- **Inpatient treatment:** Inpatient ward bed-day including PPE (normative scenario); ICU bed-day, including PPE (normative scenario); Severe case ward bed-day,

including PPE; Critical case ward bed-day, including PPE; ITU bed-day ('real-world scenario'); Body disposal

- **Additional resourcing per COVID related complication:** Acute respiratory distress syndrome (ARDS); Acute kidney injury; Acute cardiac injury; Liver dysfunction; Pneumothorax; Hospital-acquired pneumonia; Bacteraemia; Urinary tract infection; Septic shock
- **Investigations (lab tests):** Pulse oximetry; Venous blood gas; Mid-stream urine test; COVID-19 confirmatory lab test (PCR); Malaria; Haemoglobin

2.2.7.3 Price adjustments

Where Pakistan health care inputs were applied to other settings, we classified them as tradeable or non-tradeable. For tradable inputs, where country-specific price estimates were not available from primary data or from the published literature, the estimate from Pakistan was applied to other countries. For non-tradable inputs, the estimate from Pakistan was adjusted by an amount reflecting the difference in the two countries' GDP (adjusted for purchasing power parity, or PPP) (see Table SM7). The rationale behind this approach is that, while exchange rate may be influenced by government policy, PPP seeks to equalise the purchasing power of different currencies and, as such, may better reflect differentials in non-tradable prices across countries. More details on this method of price adjustment can be found in Section 2.3. Staff costs did not need to be extrapolated as we had country-specific salary information for the three countries.

2.2.7.4 Table SM7: Relative GDP adjustment factors

Country	Exchange rate (US$)	GDP per capita by country (US$ PPP)	Relative GDP (PPP): Pakistan	Relative GDP (PPP): South Africa	Relative GDP (PPP): Ethiopia
Pakistan	155.00	5,567.06	1.00	0.41	2.75
South Africa	32.26	2,022.14	2.46	1.00	6.77
Kenya	76.92	7,762.88	0.62	0.25	1.71
India	104.17	3,467.56	1.39	0.57	3.84
Ethiopia	16.95	13,686.88	0.36	0.15	1.00

2.2.7.5 Estimation of bed-day costs (all countries)

We took an ingredients-based approach to estimating the costs of general ward and ICU ward bed days, as these were major cost drivers in our cost model. We estimated the plausible number of nursing hours per bed day in an LMIC setting through consultation with members of the research team who have expertise in critical care in LMICs. In ICU the assumption of nurse-to-patient ratio would be 1:1; in the general ward the ratio would be 1:6 during the day time and 1:20 in the night.

To understand the full range of inputs required we obtained the underlying costing data set provided by the authors of a recent costing of hospital-based care (29). The paper reports the results of a detailed activity-based costing in a hospital in Karachi, disaggregated by phase of care. We used the cost data for the ward stay phase, removing any supplies or equipment specific to the surgery, to estimate the average generic costs of a bed-day.

All bed-day costs were compared to and validated against available country-specific estimates from the published literature and from ongoing research and WHO CHOICE (see Table SM8). Rapid literature searches were conducted on the Medline, Embase and EconLit databases on 8- 9 April 2020 to identify records reporting on the costs of ICU care in each of the study countries.

We estimated the additional costs of ICU beds compared to standard hospital beds using an ingredients-based approach to cost the equipment and supplies not present in standard hospital wards. We used the procurement price of equipment and assumed depreciation over ten (ventilators and suction pumps) or five years (all other equipment). Supply costs included central and arterial lines, ventilator tubing, and sedatives.

2.2.7.6 COVID-19 specific costs

Finally, we calculated costs of supplies and inputs specific to COVID-19. Personal protective equipment (PPE) per health worker per day (see Table SM8) was calculated and allocated a cost per PPE per minute to clinical staff. We also calculated costs of hygiene per bed day (see Table SM9). We estimated the costs of PPE and hygiene supplies using a list of necessary supplies from a COVID-related budget from the Ministry of Health of Pakistan, which included local prices sourced by the Aga Kahn University. This was complemented for other countries using the WHO's Essential Supplies Forecasting Tool (ESFT) (30). We divided supplies into single-use and disposable. We determined plausible quantities and useful life for supplies following clinical guidelines and expert opinion.

Oxygen supplementation therapy is the main form of treatment for COVID-19. There are different methods of oxygen delivery which utilise different types of supplies, equipment and require different average levels of oxygen flow. We calculated costs for 6 types of oxygen delivery techniques and assumed a distribution across severe and critical patients according to members of our research team with clinical expertise in critical care in LMICs. Table SM10 shows the assumptions used in our model and how they differ from normative standards.

2.2.7.7 Table SM8: PPE costs per general ward bed day and per ICU bed day

Supply	Price US$	Useful life (days)	Quantity per day	Total per member of staff per day US$	Assumptions
PPE for General Ward					
Single Use					
Surgical Gowns	0.20	1	1	0.20	
Nitrile Gloves	0.05	1	10	0.45	
Latex Gloves	0.04	1	10	0.39	
Disposable Head	0.03	1	4	0.10	
Shoe Covers	0.02	1	4	0.06	
Surgical Masks	0.08	1	10	0.77	
Reusable					
Goggles	11.61	90	1.5	0.19	Assuming half a day for washing
Gum Boots	19.35	90	1.5	0.32	Assuming half a day for washing
TOTAL				**2.50**	
PPE for ICU					
Single Use					
N-95 Masks	0.84	1	4	3.35	
Disposable apron	0.20	1	1	0.20	
Nitrile Gloves	0.05	1	10	0.45	
Latex Gloves	0.04	1	10	0.39	
Disposable Head	0.03	1	4	0.10	
Shoe Covers	0.02	1	4	0.06	
Surgical Masks	0.08	1	10	0.77	
Reusable					
Face Shields	27.81	5	1.5	8.34	Assuming half a day for washing
Goggles	11.61	90	1.5	0.19	Assuming half a day for washing
Gum Boots	19.35	90	1.5	0.32	Assuming half a day for washing
TOTAL				**14.19**	

2.2.7.8 Table SM9: Hygiene costs per general ward and ICU bed day

Supply	Price US$	Useful life (days)	Quantity per day	Total per ICU bed per day US$	Assumptions
Single Use					
Hand Sanitizers	47.97	1	0.05	2.40	100ml use per day, price assumed to refer to bottle of 2000ml
Biohazard Bags	0.23	1	1	0.23	
Disposable bed sheets	1.94	1	1	1.94	
Disposable Tissue Boxes	0.65	1	1	0.65	1 box per day, price assumed to refer to 1 box
Disposable Tissue rolls	0.35	1	1	0.35	1 roll per day, price assumed to refer to 1 roll
Disinfectants (1L Dettol)	3.23	1	0.25	0.81	250ml used per day, price refers to bottle of 1000ml
Liquid Soaps (250ml Dettol bottles)	1.74	1	0.2	0.35	50ml used per day, price refers to bottle of 250ml
Ethanol (1L bottles)	16.13	1	0.1	1.61	100ml used per day, price refers to bottle of 1000ml
Liquid Bleach	2.58	1	0.25	0.65	250ml used per day, price assumed to refer to bottle of 1000ml
Reusable					
Waste Bins	15.03	90	1	0.17	
Mackintosh bed sheets	9.68	90	1	0.11	
Mops	2.58	90	1	0.03	
Dusters	0.32	90	1	0.00	
TOTAL				9.28	

2.2.7.9 Table SM10: Oxygen supplementation assumptions

	Normative recommendations		'Real-world' scenario		
	Severe case	**Critical case**	**Severe case**	**Critical case**	
	Severe pneumonia (15% of COVID cases)	Acute respiratory distress syndrome (5% of COVID cases)	Severe pneumonia (15% of COVID cases)	Acute respiratory distress syndrome (5% of COVID cases)	
	General ward	**ICU**	**General ward**	**General ward only**	**ICU**
Supplemental oxygen management type					
% ventilator	0%	100%	0%	0%	50%
% CPAP	0%	0%	0%	0%	25%
% high-flow nasal cannula	0%	0%	0%	0%	25%
% non-rebreather mask	25%	0%	25%	100%	0%
% nasal cannula	50%	0%	50%	0%	0%
% high-concentration mask	25%	0%	25%	0%	0%
% Patients in pathway	**100%**	**100%**	**100%**	**33%**	**67%**

2.3 Extrapolation of unit costs in base countries to calculate unit costs across LICs, Lower-MICs and Upper-MICs

We used the unit costs obtained in our three base countries to extrapolate unit costs to other LICs, Lower-MICs and Upper-MICs. We grouped countries according to income group. Costs for LICs were extrapolated using unit costs from Ethiopia, costs for LMICs were extrapolated from the unit costs from Pakistan, and those for UMICs from the unit costs from South Africa.

In order to carry out the extrapolation, each cost ingredient for each of the unit costs was classified as a tradeable good, non-tradeable good, or staff cost.

Tradeable goods are generally defined as those that can easily be traded in the international market and include goods such as medical or other supplies and medications. The unit costs for our three base countries were initially converted from each local currency into 2019 US$ using market exchange rates. To convert the tradeable good from the base country (e.g. Ethiopia) to a 'second' country (e.g. Afghanistan) we apportioned the percentage of the unit cost that was composed of tradeable goods in 2019 US$ from the base country to the second country.

Non-tradeable goods include buildings, heavy machinery, and other equipment. To convert these costs from a base country to a second country we used purchasing power parity (PPP) conversion rates. We multiplied the proportion of the unit cost that was defined as non-tradeable (in 2019 US$) by the ratio of the GDP per capita (adjusted for PPP) of the second county, divided by the GDP per capita (adjusted for PPP) of the base country. Data on GDP per capita (adjusted for PPP) can be found in the World Bank database (17).

To convert staff costs from a base country to a second country we used conversion rates from Serje et al (2018) (31). Serje et al (2018) use regression analysis on a dataset containing wages from health workers of different skill levels for 193 countries in order to predict wages by country income level relative to GDP per capita. We used the multiples per GDP per capita presented in the paper in order to convert the staff wages from the base country to the second country. See Table SM11.

2.3.1 Table SM11: Health worker earnings as a multiple of GDP per capita

World bank income categories	**Health worker cadre**	**Average earnings index (multiple of GDP per capita)**
High-income countries	Physicians	1.9
	Nurses and midwives	1.5
	Other health workers	0.9
Upper-middle income countries	Physicians	2.7
	Nurses and midwives	2.2
	Other health workers	1.3
Lower-middle income countries	Physicians	5.1
	Nurses and midwives	4.2
	Other health workers	2.4
Lower-income countries	Physicians	7.8
	Nurses and midwives	6.4
	Other health workers	3.7
Global	Physicians	4.4
	Nurses and midwives	3.6
	Other health workers	2.1

2.4 Calculation of country-specific number of units per activity

The unit cost in each of the 76 countries was used to calculate the total costs per activity per country. Table SM12 shows the quantities that those unit costs were multiplied by in order to calculate the total costs per country, as well as their justification and source.

2.4.1 Table SM12: Number of country-specific units per activity

Activity	Unit Type	Quantities per country	Value	Source
1.a. Emergency Response Mechanisms: National level	Per country per day	Number of working days per year	260	Assumption
1.b. Emergency Response Mechanisms: Training of health staff	One-off per site	Total number of clinical sites	Variable per Country	Calculated by assuming one site for every 200 hospital beds available in the country (32)
2. Risk communication & community engagement	Per country per day	Number of calendar days per year	365	N/A
3.a. Case finding, contact tracing and management: Contact tracing	Per person contacted	Total number of COVID19 cases *	Variable by country	See Table SM4
		% cases that are symptomatic *	69%	(33)
		% of symptomatic cases tested *	10%	Assumption
		Average number of contacts per COVID19-positive case	7	(34)
3.b. Case finding, contact tracing and management: Quarantine of contacts	Per person quarantined	Total number of COVID19 cases *	Variable by country	See Table SM4
		% cases that are symptomatic *	69%	(33)
		% of symptomatic cases tested *	10%	Assumption
		Average number of contacts per COVID19-positive case	7	(34)
4.a. Surveillance: Case notification	Per positive case	Total number of COVID19 cases *	Variable per Country	See Table SM4
		% cases that are symptomatic *	69%	(33)

Activity	Unit Type	Quantities per country	Value	Source
		% of symptomatic cases tested *	10%	Assumption
4.b. Surveillance: Reporting (national level)	Per country per day	Total number of clinical sites *	Variable per Country	Calculated by assuming one site for every 200 hospital beds available in the country (32)
		Weeks per year	52	N/A
5. Public health measures: Hygiene education	Per education campaign	Months per year	12	N/A
6. Screening and diagnosis‡	Per person screened and tested	(Total number of COVID19 cases *	Variable per Country	See Table SM4
		% of cases requiring hospitalisation *	18.50%	(2, 14)
		Number of people tested per positive case) +	11.31	See Table SM13
		(Total number of COVID19 cases *	Variable per Country	See Table SM4
		% cases that are symptomatic *	69%	(33)
		% of symptomatic cases tested *	10%	Assumption
		Number of people tested per positive case)	11.31	See Table SM13
7.a. Case Management: Home-based care‡	Per person requiring home-based care	Proportion of borderline mild-to-severe cases	10%	Assumption
7.b. Case Management: Hospital-based (severe case) ‡	Per day of hospitalisation (severe case)	Average number of days of hospitalisation for severe cases	8	(2, 22)
7.c. Case Management: Hospital-based (critical case) ‡	Per day of hospitalisation (critical case)	Average number of days of hospitalisation for critical cases	10	(2, 14)
7.d. Case Management: Death‡	Per COVID-related death	Total number of deaths from COVID19	Variable per Country	See Table SM4

Note: Scenario 1 modelled an unmitigated epidemic. Therefore, only activities marked with ‡ were included in calculating the costs for Scenario 1. Scenarios 2-4 included costs in all the activities mentioned in Table SM13.

2.4.2. Table SM13: Test positivity rate by country and average

Country	% of positive tests	Source
South Africa	0.169	(35)
Kenya	0.103	(34)
Ethiopia	0.0739	(36)
India	0.0612	(37)
Pakistan	0.0351	(38)
Average	**0.08844**	

2.5 Country-specific per capita costs and per capita costs as a proportion of gross domestic product (GDP) per capita and other measures of health expenditure per capita

Total costs per country were used to calculate the COVID-19-related costs per capita per country per scenario by dividing the total costs by the population of the country (17). The cost per capita was then calculated as a proportion of GDP per capita (nominal) (17) and three measures of health expenditure per capita (39): 1) total health expenditure including out-of-pocket payments, 2) total health expenditure excluding out-of-pocket payments, and 3) government health spending per capita. Data on GDP per capita and health expenditure per capita per country can be found in Table SM14.

2.5.1 Table SM14: Population, GDP and health spending per country

Country	Country income classification	Total population per country	Gross Domestic Product per Capita (Nominal) (US$)	Gross Domestic Product per Capita (PPP) (US$)	Total Health Spending per Capita (including out-of-pocket spending) (US$)	Total Health Spending per Capita (excluding out-of-pocket spending) (US$)	Government Health Spending per Capita (US$)
Afghanistan	LIC	37,172,386	$521	$1,955	$57	$102	$3
Albania	Upper-MIC	2,866,376	$5,269	$13,364	$272	$429	$112
Algeria	Upper-MIC	42,228,429	$4,115	$15,482	$260	$341	$176
American Samoa	Upper-MIC	55,465	$11,467	N/A	N/A	N/A	N/A
Angola	Lower-MIC	30,809,762	$3,432	$6,452	$95	$129	$42
Argentina	Upper-MIC	44,494,502	$11,684	$20,611	$955	$1,106	$711
Armenia	Upper-MIC	2,951,776	$4,212	$10,343	$359	$648	$59
Azerbaijan	Upper-MIC	9,942,334	$4,721	$18,044	$268	$480	$54
Bangladesh	Lower-MIC	161,356,039	$1,698	$4,372	$34	$59	$6
Belarus	Upper-MIC	9,485,386	$6,290	$19,995	$318	$432	$195
Belize	Upper-MIC	383,071	$4,885	$8,648	$304	$373	$201
Benin	LIC	11,485,048	$902	$2,425	$30	$44	$6
Bhutan	Lower-MIC	754,394	$3,243	$10,168	$91	$110	$68
Bolivia	Lower-MIC	11,353,142	$3,549	$7,873	$213	$273	$140
Bosnia and Herzegovina	Upper-MIC	3,323,929	$6,066	$14,624	$444	$571	$314
Botswana	Upper-MIC	2,254,126	$8,259	$18,616	$380	$400	$212
Brazil	Upper-MIC	209,469,333	$8,921	$16,096	$1,016	$1,458	$338
Bulgaria	Upper-MIC	7,024,216	$9,273	$21,960	$612	$906	$310
Burkina Faso	LIC	19,751,535	$715	$1,985	$41	$54	$16
Burundi	LIC	11,175,378	$272	$744	$18	$24	$5
Cabo Verde	Lower-MIC	543,767	$3,635	$7,454	$159	$200	$90
Cambodia	Lower-MIC	16,249,798	$1,510	$4,361	$78	$123	$17
Cameroon	Lower-MIC	25,216,237	$1,534	$3,785	$64	$109	$9
Central African Republic	LIC	4,666,377	$476	$860	$16	$23	$2
Chad	LIC	15,477,751	$728	$1,968	$32	$51	$6
China	Upper-MIC	1,392,730,000	$9,771	$18,237	$398	$541	$231
Colombia	Upper-MIC	49,648,685	$6,668	$15,013	$340	$409	$216
Comoros	Lower-MIC	832,322	$1,415	$2,913	$59	$102	$9
Congo, Dem. Rep.	LIC	84,068,091	$562	$932	$21	$28	$3
Congo, Rep.	Lower-MIC	5,244,363	$2,148	$5,662	$70	$105	$30
Costa Rica	Upper-MIC	4,999,441	$12,027	$17,671	$889	$1,086	$664
Cote d'Ivoire	Lower-MIC	25,069,229	$1,716	$4,207	$68	$95	$17
Cuba	Upper-MIC	11,338,138	$8,822	N/A	$971	$1,071	$870
Djibouti	Lower-MIC	958,920	$3,083	N/A	$70	$88	$32
Dominica	Upper-MIC	71,625	$7,691	$11,130	$419	$542	$269
Dominican Republic	Upper-MIC	10,627,165	$8,051	$17,748	$414	$599	$189
Ecuador	Upper-MIC	17,084,357	$6,345	$11,734	$505	$709	$258
Egypt, Arab Rep.	Lower-MIC	98,423,595	$2,549	$12,412	$131	$212	$38
El Salvador	Lower-MIC	6,420,744	$4,058	$8,332	$294	$374	$189
Equatorial Guinea	Upper-MIC	1,308,974	$10,262	$22,744	$281	$486	$66
Eritrea	LIC	N/A	$811	N/A	$30	$48	$9
Eswatini	Lower-MIC	1,136,191	$4,146	$10,638	$221	$242	$153
Ethiopia	LIC	109,224,559	$772	$2,022	$28	$38	$8
Fiji	Upper-MIC	883,483	$6,267	$10,879	$180	$217	$115
Gabon	Upper-MIC	2,119,275	$7,953	$17,876	$220	$270	$142

Country	Country income classification	Total population per country	Gross Domestic Product per Capita (Nominal) (US$)	Gross Domestic Product per Capita (PPP) (US$)	Total Health Spending per Capita (including out-of-pocket spending) (US$)	Total Health Spending per Capita (excluding out-of-pocket spending) (US$)	Government Health Spending per Capita (US$)
Gambia, The	LIC	2,280,102	$716	$2,612	$21	$26	$4
Georgia	Upper-MIC	3,731,000	$4,717	$12,005	$308	$479	$113
Ghana	Lower-MIC	29,767,108	$2,202	$4,747	$68	$93	$26
Grenada	Upper-MIC	111,454	$10,640	$15,558	$516	$815	$213
Guatemala	Upper-MIC	17,247,807	$4,549	$8,462	$241	$370	$90
Guinea	LIC	12,414,318	$879	$2,505	$37	$56	$5
Guinea-Bissau	LIC	1,874,309	$778	$1,799	$39	$53	$17
Guyana	Upper-MIC	779,004	$4,979	$8,641	$192	$260	$113
Haiti	LIC	11,123,176	$868	$1,867	$38	$53	$6
Honduras	Lower-MIC	9,587,522	$2,500	$5,139	$200	$289	$92
India	Lower-MIC	1,352,617,328	$2,010	$7,763	$63	$103	$16
Indonesia	Lower-MIC	267,663,435	$3,894	$13,080	$112	$153	$50
Iran, Islamic Rep.	Upper-MIC	81,800,269	$5,628	N/A	$415	$577	$226
Iraq	Upper-MIC	38,433,600	$5,834	$17,436	$153	$272	$32
Jamaica	Upper-MIC	2,934,855	$5,354	$9,327	$296	$363	$179
Jordan	Upper-MIC	9,956,011	$4,242	$9,479	$224	$286	$141
Kazakhstan	Upper-MIC	18,276,499	$9,813	$27,880	$262	$355	$154
Kenya	Lower-MIC	51,393,010	$1,711	$3,468	$66	$85	$24
Kiribati	Lower-MIC	115,847	$1,625	$2,294	$188	$188	$116
Korea, Dem. People's Rep.	LIC	25,549,819	N/A	N/A	N/A	N/A	N/A
Kosovo	Upper-MIC	1,845,300	$4,302	$11,348	N/A	N/A	N/A
Kyrgyz Republic	Lower-MIC	6,315,800	$1,281	$3,885	$73	$115	$28
Lao PDR	Lower-MIC	7,061,507	$2,542	$7,440	$55	$81	$18
Lebanon	Upper-MIC	6,848,925	$8,270	$13,081	$662	$875	$345
Lesotho	Lower-MIC	2,108,132	$1,299	$3,219	$86	$102	$55
Liberia	LIC	4,818,977	$677	$1,309	$68	$101	$10
Libya	Upper-MIC	6,678,567	$7,242	$20,764	N/A	$115	N/A
Madagascar	LIC	26,262,368	$528	$1,891	$24	$30	$11
Malawi	LIC	18,143,315	$389	$1,311	$30	$33	$8
Malaysia	Upper-MIC	31,528,585	$11,373	$31,782	$362	$497	$182
Maldives	Upper-MIC	515,696	$10,331	$15,308	$1,048	$1,248	$760
Mali	LIC	19,077,690	$900	$2,317	$30	$40	$9
Marshall Islands	Upper-MIC	58,413	$3,788	$3,989	$851	$928	$448
Mauritania	Lower-MIC	4,403,319	$1,189	$4,151	$47	$71	$17
Mauritius	Upper-MIC	1,265,303	$11,239	$23,751	$553	$819	$244
Mexico	Upper-MIC	126,190,788	$9,673	$19,845	$462	$648	$241
Micronesia, Fed. Sts.	Lower-MIC	112,640	$3,568	$3,553	$387	$397	$108
Moldova	Lower-MIC	3,545,883	$3,227	$7,272	$171	$250	$84
Mongolia	Lower-MIC	3,170,208	$4,122	$13,800	$141	$191	$80
Montenegro	Upper-MIC	622,345	$8,844	$20,690	$532	$660	$399
Morocco	Lower-MIC	36,029,138	$3,238	$8,587	$171	$255	$80
Mozambique	LIC	29,495,962	$499	$1,460	$19	$21	$10
Myanmar	Lower-MIC	53,708,395	$1,326	$6,674	$62	$108	$12
Namibia	Upper-MIC	2,448,255	$5,931	$11,102	$403	$434	$249
Nauru	Upper-MIC	12,704	$9,889	$16,504	$1,012	$1,024	$615
Nepal	LIC	28,087,871	$1,034	$3,090	$45	$71	$8

Country	Country income classification	Total population per country	Gross Domestic Product per Capita (Nominal) (US$)	Gross Domestic Product per Capita (PPP) (US$)	Total Health Spending per Capita (including out-of-pocket spending) (US$)	Total Health Spending per Capita (excluding out-of-pocket spending) (US$)	Government Health Spending per Capita (US$)
Nicaragua	Lower-MIC	6,465,513	$2,029	$5,534	$188	$249	$115
Niger	LIC	22,442,948	$414	$1,063	$23	$36	$6
Nigeria	Lower-MIC	195,874,740	$2,028	$5,991	$79	$139	$10
North Macedonia	Upper-MIC	2,082,958	$6,084	$16,359	$328	$444	$208
Pakistan	Lower-MIC	212,215,030	$1,482	$5,567	$40	$65	$11
Papua New Guinea	Lower-MIC	8,606,316	$2,730	$4,336	$55	$59	$39
Paraguay	Upper-MIC	6,956,071	$5,822	$13,600	$327	$451	$169
Peru	Upper-MIC	31,989,256	$6,941	$14,418	$316	$406	$203
Philippines	Lower-MIC	106,651,922	$3,103	$8,951	$129	$199	$41
Romania	Upper-MIC	19,473,936	$12,301	$28,206	$476	$575	$372
Russian Federation	Upper-MIC	144,478,050	$11,289	$27,147	$469	$659	$267
Rwanda	LIC	12,301,939	$773	$2,252	$48	$51	$16
Samoa	Upper-MIC	196,130	$4,183	$6,484	$227	$254	$173
Sao Tome and Principe	Lower-MIC	211,028	$2,001	$3,419	$105	$120	$42
Senegal	Lower-MIC	15,854,360	$1,522	$3,783	$53	$80	$18
Serbia	Upper-MIC	6,982,084	$7,247	$17,435	$494	$695	$287
Sierra Leone	LIC	7,650,154	$534	$1,602	$86	$122	$10
Solomon Islands	Lower-MIC	652,858	$2,138	$2,423	$106	$111	$74
Somalia	LIC	15,008,154	$315	N/A	N/A	N/A	N/A
South Africa	Upper-MIC	57,779,622	$6,374	$13,687	$428	$461	$230
South Sudan	LIC	10,975,920	$1,120	N/A	N/A	N/A	N/A
Sri Lanka	Upper-MIC	21,670,000	$4,102	$13,474	$153	$230	$66
St. Lucia	Upper-MIC	181,889	$10,566	$13,881	$490	$728	$206
St. Vincent and the Grenadines	Upper-MIC	110,210	$7,361	$12,288	$250	$302	$192
Sudan	Lower-MIC	41,801,533	$977	$4,759	$152	$264	$30
Suriname	Upper-MIC	575,991	$6,234	$15,510	$356	$434	$247
Syrian Arab Republic	LIC	16,906,283	$2,033	N/A	N/A	$36	N/A
Tajikistan	LIC	9,100,837	$827	$3,450	$56	$92	$16
Tanzania	LIC	56,318,348	$1,051	$3,227	$35	$43	$14
Thailand	Upper-MIC	69,428,524	$7,274	$19,051	$222	$249	$173
Timor-Leste	Lower-MIC	1,267,972	$2,036	$7,658	$80	$87	$45
Togo	LIC	7,889,094	$679	$1,774	$39	$58	$8
Tonga	Upper-MIC	103,197	$4,364	$6,420	$203	$225	$134
Tunisia	Lower-MIC	11,565,204	$3,448	$12,503	$257	$359	$145
Turkey	Upper-MIC	82,319,724	$9,370	$28,069	$469	$546	$368
Turkmenistan	Upper-MIC	5,850,908	$6,967	$19,304	$423	$745	$78
Tuvalu	Upper-MIC	11,508	$3,701	$4,050	$507	$511	$429
Uganda	LIC	42,723,139	$643	$2,038	$38	$53	$6
Ukraine	Lower-MIC	44,622,516	$3,095	$9,233	$141	$218	$60
Uzbekistan	Lower-MIC	32,955,400	$1,532	$8,556	$135	$206	$62
Vanuatu	Lower-MIC	292,680	$3,124	$3,221	$110	$119	$59
Venezuela, RB	Upper-MIC	28,870,195	$16,054	N/A	N/A	$446	N/A
Vietnam	Lower-MIC	95,540,395	$2,567	$7,448	$123	$178	$58

Country	Country income classification	Total population per country	Gross Domestic Product per Capita (Nominal) (US$)	Gross Domestic Product per Capita (PPP) (US$)	Total Health Spending per Capita (including out-of-pocket spending) (US$)	Total Health Spending per Capita (excluding out-of-pocket spending) (US$)	Government Health Spending per Capita (US$)
West Bank and Gaza	Lower-MIC	4,569,087	$3,199	$5,158	N/A	N/A	N/A
Yemen, Rep.	LIC	28,498,687	$944	$2,575	$72	$130	$7
Zambia	Lower-MIC	17,351,822	$1,540	$4,224	$57	$63	$22
Zimbabwe	Lower-MIC	14,439,018	$2,147	$3,030	$94	$114	$44

2.6 Confirmed cases to date

The table below shows the number of cases confirmed in each country from the start of the pandemic to the end of January 2021, obtained from Dong et al. (2020) (40).

2.6.1 Table SM15: Number of confirmed cases of COVID-19 up to 31 January 2021

Country	**Cases reported to 31 January 2021**
Afghanistan	55,008
Algeria	107,122
Angola	19,782
Argentina	1,922,264
Bangladesh	534,770
Benin	3786
Bolivia	215,397
Botswana	21,293
Brazil	9,176,975
Burkina Faso	10,580
Burundi	1613
Cabo Verde	13,981
Cambodia	465
Cameroon	29,617
Central African Republic	4981
Chad	3347
Colombia	2,086,806
Comoros	2718
Congo, Dem. Rep.	22,604
Congo, Rep.	7887
Costa Rica	193,276
Cote d'Ivoire	28,178
Dominican Republic	212,553
Ecuador	249,779
Egypt, Arab Rep.	165,418
El Salvador	53,989
Equatorial Guinea	5516
Eswatini	15,666
Ethiopia	137,021
Gabon	10,748
Gambia, The	4090
Ghana	65,427
Guatemala	159,118
Guinea	14,475
Guinea-Bissau	2532
Haiti	11,460
Honduras	147,100
India	10,746,174
Iraq	N/A

Country	Cases reported to 31 January 2021
Jordan	325,674
Kenya	100,675
Lebanon	298,913
Lesotho	8649
Liberia	1939
Libya	117,650
Madagascar	18,743
Malawi	23,497
Mali	8069
Mauritania	16,608
Mauritius	569
Mexico	1,857,230
Morocco	470,691
Mozambique	37,705
Namibia	33,832
Nepal	270,854
Nicaragua	6253
Niger	4516
Nigeria	130,557
Pakistan	544,813
Paraguay	132,548
Peru	1,133,022
Rwanda	15,118
Sao Tome and Principe	1256
Senegal	26,213
Sierra Leone	3528
South Africa	1,449,236
Sri Lanka	63,293
Sudan	29,291
Syrian Arab Republic	13,998
Tajikistan	13,308
Tanzania	509
Togo	5041
Tunisia	207,468
Turkey	2,470,901
Uganda	N/A
West Bank and Gaza	N/A
Yemen, Rep.	2120
Zambia	53,352
Zimbabwe	33,273

3. References

1. Backer JA, Klinkenberg D, Wallinga J. Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20-28 January 2020. Euro Surveill. 2020;25(5).
2. Pearson C, van Zandvoort K, Jarvis C, Davies N, Checchi F, CMMID nCov Working Group, et al. Projections of COVID-19 epidemics in LMIC countries. Update: June 2020. 2020 [Available from: https://cmmid.github.io/topics/covid19/LMIC-projection-reports.html.
3. Davies NG, Klepac P, Liu Y, Prem K, Jit M, group CC-w, et al. Age-dependent effects in the transmission and control of COVID-19 epidemics. Nat Med. 2020;26(8):1205-11.
4. Prem K, Cook AR, Jit M. Projecting social contact matrices in 152 countries using contact surveys and demographic data. PLoS Comput Biol. 2017;13(9):e1005697.
5. WorldPop, Center for International Earth Science Information Network, (CIESIN). 2020.
6. Rees EM, Nightingale ES, Jafari Y, Waterlow NR, Clifford S, Pearson CAB, et al. COVID-19 length of hospital stay: a systematic review and data synthesis. medRxiv. 2020:2020.04.30.20084780.
7. Bhatraju PK, Ghassemieh BJ, Nichols M, Kim R, Jerome KR, Nalla AK, et al. Covid-19 in Critically Ill Patients in the Seattle Region - Case Series. N Engl J Med. 2020;382(21):2012-22.
8. Cai Q, Huang D, Ou P, Yu H, Zhu Z, Xia Z, et al. COVID-19 in a designated infectious diseases hospital outside Hubei Province, China. Allergy. 2020;75(7):1742-52.
9. Chen J, Qi T, Liu L, Ling Y, Qian Z, Li T, et al. Clinical progression of patients with COVID-19 in Shanghai, China. J Infect. 2020;80(5):e1-e6.
10. Liu L, Gao J-Y, Hu W-m, Zhang X-x, Guo L, Liu C-q, et al. Clinical characteristics of 51 patients discharged from hospital with COVID-19 in Chongqing,China. medRxiv. 2020:2020.02.20.20025536.
11. Walker PG, Whittaker C, Watson O, Baguelin M, Ainslie K, Bhatia S, et al. The global impact of covid-19 and strategies for mitigation and suppression. WHO Collaborating Centre for Infectious Disease Modelling, MRC Centre for Global Infectious Disease Analysis, Abdul Latif Jameel Institute for Disease and Emergency Analytics, Imperial College London. 2020.
12. Xie H, Zhao J, Lian N, Lin S, Xie Q, Zhuo H. Clinical characteristics of non-ICU hospitalized patients with coronavirus disease 2019 and liver injury: A retrospective study. Liver Int. 2020;40(6):1321-6.
13. Zhao W, Yu S, Zha X, Wang N, Pang Q, Li D, et al. Clinical characteristics and durations of hospitalized patients with COVID-19 in Beijing: a retrospective cohort study. medRxiv. 2020:2020.03.13.20035436.
14. Cao B, Wang Y, Wen D, Liu W, Wang J, Fan G, et al. A Trial of Lopinavir-Ritonavir in Adults Hospitalized with Severe Covid-19. N Engl J Med. 2020;382(19):1787-99.
15. Linton NM, Kobayashi T, Yang Y, Hayashi K, Akhmetzhanov AR, Jung SM, et al. Incubation Period and Other Epidemiological Characteristics of 2019 Novel Coronavirus Infections with Right Truncation: A Statistical Analysis of Publicly Available Case Data. J Clin Med. 2020;9(2).
16. Davies NG, Kucharski AJ, Eggo RM, Gimma A, Edmunds WJ. The effect of non-pharmaceutical interventions on COVID-19 cases, deaths and demand for hospital services in the UK: a modelling study. medRxiv. 2020:2020.04.01.20049908.
17. World Bank. World Bank Open Data. 2020.
18. World Health Organization. COVID-19 Strategic Preparedness and Response Plan: Operational Planning Guidelines to Support Country Preparedness and Response. 2020.
19. Phase DCT. Universal Health Coverage: Essential Package of Health Services for Pakistan: A report for review by the International Advisory Group. Ministry of National Health Services, Government of Pakistan and World Health Organisation,; 2020.
20. Kairu A, Orangi S, Oyando R, Kabia E, Nguhiu P, Ong'ang'o J, et al. The costs of providing TB services in healthcare facilities in Kenya. 51st Union World Conference on Lung Health2020.

21. Chatterjee S, Toshniwal MN, Bhide P, Sachdeva KS, Rao R, Vassall A, et al. Examining the cost of delivering TB prevention, diagnosis and treatment in India, 2018 51st Union World Conference on Lung Health2020.
22. NHSDigital. Hospital admitted patient care activity 2018--19 [Available from: https://digital.nhs.uk/data-andinformation/publications/statistical/hospital-admitted-patient-care-activity/2018-19.
23. Yang X, Yu Y, Xu J, Shu H, Liu H, Wu Y, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. The Lancet Respiratory Medicine. 2020.
24. Li J, al. e. Epidemiology of COVID-19: A Systematic Review and Meta-analysis of Clinical Characteristics, Risk factors and Outcomes. Journal of Medical Virology.
25. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA. 2020;323(11):1061-9.
26. Srivastava U. Anaesthesia gas supply: gas cylinders. Indian J Anaesth. 2013;57(5):500-6.
27. Afrox. Medical Oxygen 2020 [Available from: https://www.afroxshop.co.za/shop/en/za/medical-oxygen.
28. Vassall A, Siapka M, Foster N, Cunnama L, Ramma L, Fielding K, et al. Cost-effectiveness of Xpert MTB/RIF for tuberculosis diagnosis in South Africa: a real-world cost analysis and economic evaluation. Lancet Glob Health. 2017;5(7):e710-e9.
29. Khan RM, Albutt K, Qureshi MA, Ansari Z, Drevin G, Mukhopadhyay S, et al. Time-driven activity-based costing of total knee replacements in Karachi, Pakistan. BMJ Open. 2019;9(5):e025258.
30. WHO. COVID-19 Essential Supplies Forecasting Tool. 29 April 2020 [Available from: https://www.who.int/publications/m/item/covid-19-essential-supplies-forecasting-tool#.
31. Serje J, Bertram MY, Brindley C, Lauer JA. Global health worker salary estimates: an econometric analysis of global earnings data. Cost Eff Resour Alloc. 2018;16:10.
32. World Health Organization. Global Health Observatory (GHO) data [Available from: http://www.who.int/gho/en/.
33. Nishiura H, Linton NM, Akhmetzhanov AR. Serial interval of novel coronavirus (COVID-19) infections. medRxiv. 2020:2020.02.03.20019497.
34. Health KMo. COVID-19 Outbreak in Kenya. Daily Situation Report -78 [updated 3 June 2020. Available from: https://www.health.go.ke/wp-content/uploads/2020/06/Kenya-COVID-19-SITREP-078-03-Jun-2020.pdf.
35. Africa RoS. COVID-19 Corona Virus South African Resource Porta 2020 [Available from: https://sacoronavirus.co.za/.
36. Ethiopia MoHo. Ethiopia COVID 19 Monitoring Platform 2020 [Available from: http://www.moh.gov.et/ejcc/en/node/196.
37. India Go. COVID Statewide Status [Available from: https://www.mygov.in/corona-data/covid19-statewise-status/.
38. Pakistan Go. COVID19 Health Advisory Platform [Available from: http://covid.gov.pk/.
39. Organization WH. WHO Global Health Expenditure Database.
40. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020;20(5):533-4.

Appendix 7.2: Supplementary Results Appendix

Supplemental Results Tables

Table SR1: Unit Costs per Activity per Country

Country	1.a. Emergency Response Mechanisms: National level (per country per day)	1.b. Emergency Response Mechanisms: Training of health staff (one-off per site)	2. Risk communication & community engagement (per country per day)	3.a. Case finding, contact tracing and management: Contact tracing (per person contacted)	3.b. Case finding, contact tracing and management: Quarantine of contacts (per person quarantined)	4.a. Surveillance: Case notification (per positive case)	4.b. Surveillance: Reporting (national level) (per country per week)	5. Public health measures: Hygiene education (per education campaign per month)	6. Screening and diagnosis (per person screened and tested)	7.a. Case Management: Home-based care (per person requiring home-based care)	7.b. Case Management: Hospital-based (severe case) (per day of hospitalisation (severe case)	7.c. Case Management: Hospital-based (critical case) (per day of hospitalisation (critical case)	7.d. Case Management: Death (per COVID-related death)
Afghanistan	$946.00	$6,705.01	$82.56	$2.29	$2.36	$2.36	$5.96	$49.97	$29.40	$14.55	$33.80	$262.79	$64.52
Albania	$3,789.37	$27,990.77	$324.45	$12.58	$9.38	$9.38	$24.29	$196.86	$51.28	$142.99	$104.61	$1,115.20	$64.52
Algeria	$3,295.01	$24,748.13	$281.48	$12.21	$8.19	$8.19	$21.48	$171.15	$52.63	$155.05	$111.21	$1,184.99	$64.52
Angola	$3,912.28	$27,196.03	$345.35	$8.64	$9.82	$9.82	$24.60	$208.91	$35.90	$43.99	$45.96	$322.04	$64.52
Argentina	$7,558.99	$53,724.40	$669.23	$22.98	$19.26	$19.26	$49.36	$405.38	$71.04	$238.55	$155.69	$1,539.72	$64.52
Armenia	$3,070.21	$23,010.80	$257.48	$10.06	$7.44	$7.44	$19.25	$156.20	$45.41	$111.63	$87.77	$967.20	$64.52
Azerbaijan	$3,752.25	$27,941.99	$324.53	$14.02	$9.45	$9.45	$24.79	$197.35	$57.18	$180.13	$124.70	$1,305.33	$64.52
Bangladesh	$2,059.69	$14,725.23	$177.44	$4.64	$5.06	$5.06	$12.76	$107.44	$30.00	$24.18	$35.87	$256.34	$64.52
Belarus	$4,683.68	$34,307.35	$409.84	$16.64	$11.89	$11.89	$31.01	$248.96	$62.27	$205.02	$138.01	$1,416.77	$64.52
Belize	$3,333.58	$24,713.90	$279.96	$10.07	$8.06	$8.06	$20.65	$169.59	$43.97	$100.66	$81.79	$906.83	$64.52
Benin	$1,553.93	$10,800.31	$137.55	$3.65	$3.92	$3.92	$9.84	$83.18	$31.95	$21.93	$38.15	$306.00	$64.52
Bhutan	$3,922.04	$27,434.10	$348.99	$8.79	$9.97	$9.97	$25.27	$211.45	$37.31	$46.65	$46.72	$326.98	$64.52
Bolivia	$4,105.27	$28,551.20	$363.74	$9.10	$10.36	$10.36	$26.03	$220.13	$36.96	$46.88	$47.24	$330.38	$64.52
Bosnia and Herzegovina	$4,276.91	$31,332.89	$369.28	$14.03	$10.67	$10.67	$27.58	$224.00	$54.25	$157.93	$112.61	$1,183.29	$64.52
Botswana	$5,646.94	$40,743.98	$495.58	$18.25	$14.31	$14.31	$36.91	$300.51	$63.18	$203.55	$137.06	$1,393.13	$64.52
Brazil	$5,860.45	$42,075.40	$512.96	$17.88	$14.77	$14.77	$37.87	$310.75	$60.54	$185.49	$127.26	$1,297.35	$64.52
Bulgaria	$6,360.94	$45,703.09	$562.32	$20.86	$16.24	$16.24	$41.97	$341.06	$69.45	$237.46	$155.28	$1,554.18	$64.52
Burkina Faso	$1,244.93	$8,709.59	$109.45	$2.93	$3.12	$3.12	$7.84	$66.19	$30.28	$17.60	$35.44	$274.40	$64.52
Burundi	$499.56	$3,658.28	$41.54	$1.16	$1.18	$1.18	$2.97	$25.12	$25.93	$6.65	$28.43	$189.56	$64.52

Country	1.a. Emergency Response Mechanisms: National level (per country per day)	1.b. Emergency Response Mechanisms: Training of health staff (one-off per site)	2. Risk communication & community engagement (per country per day)	3.a. Case finding, contact tracing and management: Contact tracing (per person contacted)	3.b. Case finding, contact tracing and management: Quarantine of contacts (per person quarantined)	4.a. Surveillance: Case notification (per positive case)	4.b. Surveillance: Reporting (national level) (per country per week)	5. Public health measures: Hygiene education (per education campaign per month)	6. Screening and diagnosis (per person screened and tested)	7.a. Case Management: Home-based care (per person requiring home-based care)	7.b. Case Management: Hospital-based (severe case) (per day of hospitalisation (severe case)	7.c. Case Management: Hospital-based (critical case) (per day of hospitalisation (critical case)	7.d. Case Management: Death (per COVID-related death)
Cabo Verde	$4,169.90	$28,963.40	$369.23	$9.22	$10.51	$10.51	$26.36	$223.41	$36.98	$47.23	$47.50	$332.06	$64.52
Cambodia	$1,870.45	$13,460.69	$160.44	$4.24	$4.58	$4.58	$11.58	$97.18	$29.47	$22.30	$34.88	$249.88	$64.52
Cameroon	$1,863.02	$13,384.27	$159.34	$4.21	$4.54	$4.54	$11.44	$96.46	$29.23	$21.83	$34.73	$248.91	$64.52
Central African Republic	$818.01	$5,797.62	$70.25	$1.85	$2.00	$2.00	$4.98	$42.44	$27.02	$10.15	$30.39	$205.95	$64.52
Chad	$1,264.27	$8,838.47	$111.18	$2.97	$3.17	$3.17	$7.96	$67.23	$30.31	$17.75	$35.50	$274.26	$64.52
China	$6,423.38	$45,963.82	$565.22	$19.78	$16.28	$16.28	$41.78	$342.46	$64.84	$208.24	$139.47	$1,404.02	$64.52
Colombia	$4,615.10	$33,630.30	$400.02	$14.87	$11.55	$11.55	$29.79	$242.57	$55.69	$164.42	$116.07	$1,210.70	$64.52
Comoros	$1,697.25	$12,236.47	$143.81	$3.83	$4.09	$4.09	$10.27	$87.01	$28.45	$19.58	$33.70	$242.18	$64.52
Congo, Dem. Rep.	$953.63	$6,709.71	$82.49	$2.15	$2.34	$2.34	$5.84	$49.83	$27.53	$11.70	$31.28	$214.03	$64.52
Congo, Rep.	$2,580.26	$18,262.28	$225.15	$5.79	$6.42	$6.42	$16.20	$136.33	$31.92	$30.24	$38.84	$275.67	$64.52
Costa Rica	$7,582.00	$53,753.01	$669.15	$22.07	$19.22	$19.22	$49.05	$405.06	$67.34	$215.23	$143.07	$1,420.29	$64.52
Cote d'Ivoire	$2,068.18	$14,774.26	$178.08	$4.66	$5.08	$5.08	$12.78	$107.81	$29.96	$24.15	$35.89	$256.42	$64.52
Dominica	$4,945.79	$35,693.21	$426.96	$14.31	$12.26	$12.26	$31.28	$258.44	$51.63	$136.59	$100.96	$1,063.14	$64.52
Dominican Republic	$5,490.71	$39,653.09	$480.87	$17.63	$13.88	$13.88	$35.78	$291.57	$61.63	$195.05	$132.49	$1,352.33	$64.52
Ecuador	$4,268.78	$31,153.65	$366.44	$13.07	$10.55	$10.55	$27.08	$222.01	$50.53	$134.70	$100.05	$1,064.85	$64.52
Egypt, Arab Rep.	$3,345.86	$23,690.07	$298.93	$7.65	$8.60	$8.60	$22.07	$181.46	$36.55	$42.49	$44.13	$310.14	$64.52
El Salvador	$4,641.54	$32,154.42	$412.24	$10.25	$11.73	$11.73	$29.44	$249.43	$38.61	$52.51	$50.13	$349.22	$64.52
Equatorial Guinea	$6,924.23	$49,535.56	$613.62	$22.32	$17.71	$17.71	$45.67	$372.06	$72.01	$249.34	$161.62	$1,605.38	$64.52
Eswatini	$4,853.50	$33,677.50	$432.99	$10.78	$12.35	$12.35	$31.13	$262.16	$40.06	$56.21	$51.68	$359.30	$64.52
Ethiopia	$804.71	$4,813.58	$74.14	$3.48	$1.72	$1.72	$3.69	$44.58	$36.97	$22.90	$35.29	$505.56	$64.52

Country	1.a. Emergency Response Mechanisms: National level (per country per day)	1.b. Emergency Response Mechanisms: Training of health staff (one-off per site)	2. Risk communication & community engagement (per country per day)	3.a. Case finding, contact tracing and management: Contact tracing (per person contacted)	3.b. Case finding, contact tracing and management: Quarantine of contacts (per person quarantined)	4.a. Surveillance: Case notification (per positive case)	4.b. Surveillance: Reporting (national level) (per country per week)	5. Public health measures: Hygiene education (per education campaign per month)	6. Screening and diagnosis (per person screened and tested)	7.a. Case Management: Home-based care (per person requiring home-based care)	7.b. Case Management: Hospital-based (severe case) (per day of hospitalisation (severe case)	7.c. Case Management: Hospital-based (critical case) (per day of hospitalisation (critical case)	7.d. Case Management: Death (per COVID-related death)
Fiji	$4,181.80	$30,530.23	$357.98	$12.60	$10.30	$10.30	$26.39	$216.83	$49.19	$126.98	$95.89	$1,026.93	$64.52
Gabon	$5,445.87	$39,356.19	$476.93	$17.58	$13.77	$13.77	$35.51	$289.20	$61.67	$195.62	$132.81	$1,356.03	$64.52
Gambia, The	$1,280.15	$8,974.04	$113.08	$3.10	$3.23	$3.23	$8.16	$68.44	$31.54	$19.75	$37.19	$305.66	$64.52
Georgia	$3,425.61	$25,479.11	$290.70	$11.36	$8.41	$8.41	$21.76	$176.38	$48.53	$128.48	$96.82	$1,047.23	$64.52
Ghana	$2,585.83	$18,256.88	$224.96	$5.77	$6.40	$6.40	$16.09	$136.14	$31.59	$29.66	$38.70	$274.73	$64.52
Grenada	$6,737.67	$47,967.95	$591.57	$19.58	$16.99	$16.99	$43.35	$358.09	$62.28	$189.89	$129.50	$1,305.14	$64.52
Guatemala	$3,146.69	$23,445.60	$262.99	$9.61	$7.57	$7.57	$19.44	$159.34	$43.21	$97.32	$80.01	$892.89	$64.52
Guinea	$1,523.11	$10,597.42	$134.84	$3.60	$3.84	$3.84	$9.66	$81.55	$32.02	$21.85	$38.19	$308.79	$64.52
Guinea-Bissau	$1,331.15	$9,278.97	$117.07	$3.09	$3.33	$3.33	$8.35	$70.77	$30.18	$17.93	$35.42	$268.43	$64.52
Guyana	$3,382.85	$25,045.87	$284.39	$10.17	$8.18	$8.18	$20.96	$172.26	$44.10	$101.10	$82.02	$908.21	$64.52
Haiti	$1,473.11	$10,233.43	$129.88	$3.40	$3.69	$3.69	$9.25	$78.50	$30.70	$19.53	$36.33	$276.50	$64.52
Honduras	$2,905.84	$20,412.59	$253.99	$6.46	$7.23	$7.23	$18.14	$153.68	$32.62	$33.10	$40.44	$286.12	$64.52
India	$2,488.27	$14,521.07	$223.48	$13.97	$5.45	$5.45	$11.11	$135.95	$42.99	$72.83	$44.68	$377.77	$64.52
Indonesia	$4,731.35	$32,975.24	$423.84	$10.61	$12.12	$12.12	$30.78	$256.87	$40.63	$56.68	$51.50	$358.17	$64.52
Iraq	$4,306.03	$31,650.34	$373.96	$15.00	$10.84	$10.84	$28.21	$227.08	$57.94	$180.76	$124.95	$1,299.28	$64.52
Jamaica	$3,617.43	$26,657.34	$306.02	$10.89	$8.81	$8.81	$22.56	$185.36	$45.63	$108.93	$86.22	$944.24	$64.52
Jordan	$3,039.43	$22,766.02	$254.08	$9.71	$7.33	$7.33	$18.92	$154.06	$44.22	$104.40	$83.86	$930.81	$64.52
Kazakhstan	$6,963.51	$50,021.67	$620.92	$24.07	$17.99	$17.99	$46.72	$376.95	$78.71	$290.89	$184.08	$1,816.75	$64.52
Kenya	$3,729.58	$19,756.31	$374.01	$9.10	$6.40	$6.40	$12.22	$218.82	$45.69	$46.08	$45.20	$417.83	$64.52
Kiribati	$1,874.79	$13,393.53	$159.29	$4.18	$4.52	$4.52	$11.27	$96.29	$28.71	$20.92	$34.51	$247.46	$64.52
Kosovo	$3,171.75	$23,738.86	$267.36	$10.60	$7.74	$7.74	$20.05	$162.25	$46.99	$120.70	$92.65	$1,011.76	$64.52

Country	1.a. Emergency Response Mechanisms: National level (per country per day)	1.b. Emergency Response Mechanisms: Training of health staff (one-off per site)	2. Risk communication & community engagement (per country per day)	3.a. Case finding, contact tracing and management: Contact tracing (per person contacted)	3.b. Case finding, contact tracing and management: Quarantine of contacts (per person quarantined)	4.a. Surveillance: Case notification (per positive case)	4.b. Surveillance: Reporting (national level) (per country per week)	5. Public health measures: Hygiene education (per education campaign per month)	6. Screening and diagnosis (per person screened and tested)	7.a. Case Management: Home-based care (per person requiring home-based care)	7.b. Case Management: Hospital-based (severe case) (per day of hospitalisation (severe case)	7.c. Case Management: Hospital-based (critical case) (per day of hospitalisation (critical case)	7.d. Case Management: Death (per COVID-related death)
Kyrgyz Republic	$1,615.02	$11,732.46	$137.15	$3.69	$3.92	$3.92	$9.92	$83.09	$28.58	$19.44	$33.45	$240.58	$64.52
Lao PDR	$3,072.00	$21,629.50	$270.63	$6.90	$7.73	$7.73	$19.55	$163.93	$33.94	$36.34	$41.75	$294.63	$64.52
Lebanon	$5,355.43	$38,539.74	$465.28	$15.82	$13.37	$13.37	$34.19	$281.72	$55.27	$156.30	$111.56	$1,156.87	$64.52
Lesotho	$1,597.13	$11,582.04	$135.04	$3.62	$3.85	$3.85	$9.70	$81.76	$28.29	$18.80	$33.23	$239.15	$64.52
Liberia	$1,150.73	$8,047.64	$100.49	$2.63	$2.86	$2.86	$7.14	$60.72	$28.77	$14.73	$33.25	$238.78	$64.52
Libya	$5,226.52	$38,001.32	$459.29	$18.05	$13.31	$13.31	$34.58	$278.84	$64.76	$216.59	$144.18	$1,466.69	$64.52
Madagascar	$952.69	$6,746.95	$83.12	$2.30	$2.37	$2.37	$5.99	$50.30	$29.30	$14.43	$33.68	$259.97	$64.52
Malawi	$710.11	$5,094.95	$60.88	$1.69	$1.74	$1.74	$4.38	$36.84	$27.56	$10.37	$30.95	$223.90	$64.52
Malaysia	$7,995.53	$57,149.41	$716.71	$27.55	$20.75	$20.75	$53.89	$435.06	$86.58	$332.42	$206.38	$2,011.43	$64.52
Maldives	$6,560.96	$46,765.52	$575.47	$19.12	$16.53	$16.53	$42.19	$348.36	$61.47	$186.13	$127.50	$1,288.92	$64.52
Mali	$1,545.24	$10,737.16	$136.69	$3.62	$3.89	$3.89	$9.77	$82.65	$31.73	$21.53	$37.84	$300.53	$64.52
Marshall Islands	$2,505.43	$18,928.40	$201.97	$6.78	$5.78	$5.78	$14.66	$122.13	$35.70	$55.09	$57.28	$688.14	$64.52
Mauritania	$1,536.44	$11,220.00	$130.29	$3.53	$3.73	$3.73	$9.48	$78.97	$28.47	$18.84	$33.09	$238.23	$64.52
Mauritius	$7,493.11	$53,415.36	$665.59	$23.86	$19.20	$19.20	$49.44	$403.49	$74.89	$263.07	$168.95	$1,665.91	$64.52
Mexico	$6,458.46	$46,269.62	$569.56	$20.38	$16.42	$16.42	$42.25	$345.23	$67.00	$221.47	$146.62	$1,470.97	$64.52
Micronesia, Fed. Sts.	$3,892.92	$26,931.86	$341.45	$8.50	$9.67	$9.67	$24.00	$206.29	$34.76	$41.79	$45.30	$317.78	$64.52
Moldova	$3,750.44	$26,153.16	$331.43	$8.33	$9.44	$9.44	$23.73	$200.59	$35.75	$42.95	$45.27	$317.54	$64.52
Mongolia	$4,999.07	$34,796.91	$448.42	$11.20	$12.83	$12.83	$32.56	$271.76	$41.64	$59.84	$53.04	$368.19	$64.52
Montenegro	$6,066.95	$43,665.79	$534.92	$19.82	$15.45	$15.45	$39.90	$324.42	$67.00	$224.35	$148.24	$1,492.23	$64.52
Morocco	$3,831.70	$26,757.16	$339.70	$8.55	$9.69	$9.69	$24.45	$205.70	$36.47	$44.66	$45.94	$321.94	$64.52
Mozambique	$885.81	$6,279.14	$76.79	$2.09	$2.19	$2.19	$5.51	$46.44	$28.32	$12.54	$32.24	$237.00	$64.52

Country	1.a. Emergency Response Mechanisms: National level (per country per day)	1.b. Emergency Response Mechanisms: Training of health staff (one-off per site)	2. Risk communication & community engagement (per country per day)	3.a. Case finding, contact tracing and management: Contact tracing (per person contacted)	3.b. Case finding, contact tracing and management: Quarantine of contacts (per person quarantined)	4.a. Surveillance: Case notification (per positive case)	4.b. Surveillance: Reporting (national level) (per country per week)	5. Public health measures: Hygiene education (per education campaign per month)	6. Screening and diagnosis (per person screened and tested)	7.a. Case Management: Home-based care (per person requiring home-based care)	7.b. Case Management: Hospital-based (severe case) (per day of hospitalisation (severe case)	7.c. Case Management: Hospital-based (critical case) (per day of hospitalisation (critical case)	7.d. Case Management: Death (per COVID-related death)
Myanmar	$1,809.65	$13,162.27	$156.70	$4.19	$4.51	$4.51	$11.59	$95.14	$30.16	$23.30	$35.00	$250.68	$64.52
Namibia	$4,016.96	$29,428.13	$343.30	$12.32	$9.89	$9.89	$25.38	$208.00	$49.02	$127.13	$95.99	$1,030.42	$64.52
Nauru	$6,392.50	$45,680.97	$561.18	$19.15	$16.14	$16.14	$41.31	$339.86	$62.54	$194.05	$131.80	$1,332.12	$64.52
Nepal	$1,792.27	$12,427.73	$159.47	$4.26	$4.55	$4.55	$11.44	$96.46	$33.84	$26.20	$41.06	$345.98	$64.52
Nicaragua	$2,454.02	$17,413.13	$213.71	$5.52	$6.10	$6.10	$15.40	$129.42	$31.52	$28.90	$38.16	$271.21	$64.52
Niger	$734.43	$5,246.75	$62.89	$1.71	$1.79	$1.79	$4.49	$38.02	$27.17	$9.90	$30.46	$212.86	$64.52
Nigeria	$2,477.88	$17,593.74	$216.20	$5.59	$6.17	$6.17	$15.62	$130.96	$31.76	$29.45	$38.37	$272.59	$64.52
North Macedonia	$4,379.64	$32,100.40	$379.80	$14.81	$10.99	$10.99	$28.51	$230.50	$56.76	$172.86	$120.67	$1,257.73	$64.52
Pakistan	$1,040.21	$8,096.53	$91.67	$2.54	$2.35	$2.35	$6.52	$54.66	$26.98	$12.45	$33.32	$221.18	$64.52
Papua New Guinea	$3,093.77	$21,630.47	$270.27	$6.84	$7.67	$7.67	$19.17	$163.43	$32.84	$34.41	$41.27	$291.52	$64.52
Paraguay	$4,093.41	$30,051.30	$352.01	$13.30	$10.17	$10.17	$26.26	$213.49	$52.43	$147.91	$107.22	$1,135.18	$64.52
Peru	$4,727.22	$34,360.81	$409.68	$14.92	$11.81	$11.81	$30.41	$248.33	$55.24	$160.77	$114.07	$1,190.19	$64.52
Philippines	$3,715.60	$25,998.60	$329.55	$8.31	$9.41	$9.41	$23.79	$199.61	$36.28	$43.76	$45.41	$318.44	$64.52
Romania	$8,292.36	$58,997.17	$740.82	$27.01	$21.39	$21.39	$55.21	$449.26	$82.82	$306.72	$192.43	$1,875.29	$64.52
Russian Federation	$7,702.04	$54,970.61	$686.89	$25.41	$19.85	$19.85	$51.30	$416.65	$79.82	$292.36	$184.76	$1,811.91	$64.52
Rwanda	$1,347.77	$9,410.86	$118.90	$3.19	$3.39	$3.39	$8.52	$71.91	$31.06	$19.39	$36.64	$290.68	$64.52
Samoa	$2,847.73	$21,344.19	$234.62	$8.33	$6.74	$6.74	$17.23	$142.05	$39.85	$78.49	$69.88	$801.79	$64.52
Sao Tome and Principe	$2,312.52	$16,369.60	$199.43	$5.15	$5.67	$5.67	$14.17	$120.61	$30.34	$26.03	$37.01	$263.77	$64.52
Senegal	$1,851.05	$13,304.20	$158.26	$4.18	$4.51	$4.51	$11.37	$95.81	$29.20	$21.71	$34.67	$248.50	$64.52
Serbia	$5,050.29	$36,669.46	$440.98	$16.59	$12.74	$12.74	$32.93	$267.49	$60.00	$188.16	$128.83	$1,324.55	$64.52
Sierra Leone	$947.08	$6,696.22	$82.40	$2.24	$2.35	$2.35	$5.91	$49.84	$28.75	$13.55	$32.92	$245.91	$64.52

Country	1.a. Emergency Response Mechanisms: National level (per country per day)	1.b. Emergency Response Mechanisms: Training of health staff (one-off per site)	2. Risk communication & community engagement (per country per day)	3.a. Case finding, contact tracing and management: Contact tracing (per person contacted)	3.b. Case finding, contact tracing and management: Quarantine of contacts (per person quarantined)	4.a. Surveillance: Case notification (per positive case)	4.b. Surveillance: Reporting (national level) (per country per week)	5. Public health measures: Hygiene education (per education campaign per month)	6. Screening and diagnosis (per person screened and tested)	7.a. Case Management: Home-based care (per person requiring home-based care)	7.b. Case Management: Hospital-based (severe case) (per day of hospitalisation (severe case)	7.c. Case Management: Hospital-based (critical case) (per day of hospitalisation (critical case)	7.d. Case Management: Death (per COVID-related death)
Solomon Islands	$2,396.09	$16,881.46	$206.20	$5.29	$5.84	$5.84	$14.53	$124.60	$30.20	$26.17	$37.26	$265.38	$64.52
South Africa	$11,590.43	$68,141.36	$1,133.44	$26.23	$29.22	$29.22	$68.26	$682.05	$73.12	$146.57	$105.88	$1,081.94	$64.52
Sri Lanka	$3,180.67	$23,890.53	$269.72	$11.31	$7.83	$7.83	$20.44	$163.87	$49.74	$137.82	$101.91	$1,098.98	$64.52
St. Lucia	$6,608.38	$47,023.86	$578.70	$18.76	$16.60	$16.60	$42.27	$350.17	$59.77	$175.17	$121.56	$1,232.20	$64.52
St. Vincent and the Grenadines	$4,834.16	$34,990.28	$417.76	$14.45	$12.01	$12.01	$30.75	$253.00	$52.80	$144.76	$105.40	$1,106.71	$64.52
Sudan	$1,356.75	$10,048.11	$114.60	$3.17	$3.30	$3.30	$8.46	$69.57	$28.20	$17.48	$32.27	$232.87	$64.52
Suriname	$4,413.28	$32,290.71	$382.21	$14.61	$11.05	$11.05	$28.59	$231.88	$55.77	$166.40	$117.17	$1,224.19	$64.52
Syrian Arab Republic	$3,155.07	$21,420.41	$279.68	$6.69	$7.90	$7.90	$19.47	$168.67	$31.91	$30.88	$40.45	$244.31	$64.52
Tajikistan	$1,494.31	$10,447.28	$132.96	$3.68	$3.80	$3.80	$9.63	$80.50	$33.68	$24.27	$40.41	$353.10	$64.52
Tanzania	$1,825.32	$12,655.42	$162.54	$4.35	$4.63	$4.63	$11.67	$98.33	$34.19	$26.92	$41.58	$353.69	$64.52
Thailand	$5,151.28	$37,420.12	$451.26	$17.33	$13.05	$13.05	$33.83	$273.84	$62.36	$202.11	$136.36	$1,394.09	$64.52
Timor-Leste	$2,574.86	$18,319.10	$226.15	$5.85	$6.48	$6.48	$16.50	$137.12	$32.65	$31.56	$39.19	$277.97	$64.52
Togo	$1,178.69	$8,256.12	$103.34	$2.76	$2.94	$2.94	$7.39	$62.49	$29.71	$16.34	$34.56	$262.03	$64.52
Tonga	$2,939.45	$21,960.04	$242.84	$8.50	$6.97	$6.97	$17.80	$147.00	$40.02	$78.89	$70.08	$802.30	$64.52
Tunisia	$4,252.55	$29,750.38	$380.41	$9.57	$10.89	$10.89	$27.71	$230.62	$39.09	$51.54	$48.89	$341.14	$64.52
Turkey	$6,740.55	$48,526.20	$600.98	$23.66	$17.42	$17.42	$45.34	$364.94	$78.33	$290.19	$183.74	$1,816.90	$64.52
Turkmenistan	$5,003.13	$36,431.94	$438.10	$17.10	$12.69	$12.69	$32.93	$265.93	$62.27	$202.67	$136.69	$1,399.39	$64.52
Tuvalu	$2,462.60	$18,642.18	$198.16	$6.71	$5.68	$5.68	$14.40	$119.84	$35.66	$55.15	$57.32	$689.16	$64.52
Uganda	$1,137.04	$7,988.99	$99.80	$2.71	$2.85	$2.85	$7.17	$60.37	$30.08	$16.68	$35.01	$273.28	$64.52
Ukraine	$3,723.18	$26,062.40	$330.44	$8.34	$9.44	$9.44	$23.88	$200.18	$36.41	$44.03	$45.50	$319.05	$64.52
Uzbekistan	$2,117.99	$15,309.31	$185.79	$4.91	$5.36	$5.36	$13.81	$112.86	$31.72	$27.65	$36.98	$263.52	$64.52

Country	1.a. Emergency Response Mechanisms: National level (per country per day)	1.b. Emergency Response Mechanisms: Training of health staff (one-off per site)	2. Risk communication & community engagement (per country per day)	3.a. Case finding, contact tracing and management: Contact tracing (per person contacted)	3.b. Case finding, contact tracing and management: Quarantine of contacts (per person quarantined)	4.a. Surveillance: Case notification (per positive case)	4.b. Surveillance: Reporting (national level) (per country per week)	5. Public health measures: Hygiene education (per education campaign per month)	6. Screening and diagnosis (per person screened and tested)	7.a. Case Management: Home-based care (per person requiring home-based care)	7.b. Case Management: Hospital-based (severe case) (per day of hospitalisation (severe case)	7.c. Case Management: Hospital-based (critical case) (per day of hospitalisation (critical case)	7.d. Case Management: Death (per COVID-related death)
Vanuatu	$3,428.98	$23,817.61	$299.54	$7.51	$8.48	$8.48	$21.07	$180.98	$33.36	$36.96	$42.82	$301.56	$64.52
Vietnam	$3,096.65	$21,794.49	$272.85	$6.95	$7.79	$7.79	$19.70	$165.27	$34.01	$36.59	$41.88	$295.48	$64.52
West Bank and Gaza	$3,608.29	$25,105.36	$317.09	$7.95	$9.00	$9.00	$22.50	$191.74	$34.57	$40.08	$44.12	$310.07	$64.52
Yemen, Rep.	$1,627.62	$11,301.00	$144.29	$3.83	$4.11	$4.11	$10.33	$87.26	$32.44	$23.09	$38.92	$315.72	$64.52
Zambia	$1,892.78	$13,603.47	$162.34	$4.29	$4.63	$4.63	$11.70	$98.31	$29.48	$22.43	$34.97	$250.47	$64.52
Zimbabwe	$2,438.05	$17,189.94	$210.42	$5.40	$5.97	$5.97	$14.89	$127.20	$30.54	$27.01	$37.60	$267.56	$64.52

Table SR2. Total Annual Costs per Country per Scenario (2019 US$)

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Afghanistan	$1,311,815,462	$1,177,904,724	$25,590,730	$1,399,789,895
Algeria	$6,603,396,550	$4,797,609,340	$108,875,236	$6,084,882,367
Angola	$1,390,745,332	$1,335,741,419	$32,119,637	$1,567,094,020
Argentina	$15,973,976,990	$12,132,966,200	$297,934,143	$15,001,801,214
Bangladesh	$8,389,029,878	$7,346,626,409	$145,098,719	$8,762,131,868
Benin	$507,979,013	$463,323,321	$9,006,214	$544,803,973
Bolivia	$711,164,156	$607,984,156	$12,278,798	$738,627,623
Botswana	$380,200,596	$303,116,161	$8,450,322	$369,522,644
Brazil	$53,346,806,690	$40,013,304,222	$804,437,570	$49,832,168,384
Burkina Faso	$775,230,046	$719,748,836	$15,228,297	$840,119,232
Burundi	$330,390,715	$304,544,873	$6,022,985	$359,734,439
Cabo Verde	$32,485,358	$28,162,920	$1,977,680	$34,414,567
Cambodia	$678,417,754	$566,274,013	$10,441,999	$690,985,182
Cameroon	$949,939,675	$884,467,637	$18,998,192	$1,043,034,826
Central African Republic	$149,319,610	$137,035,951	$3,386,607	$161,434,468
Chad	$537,334,959	$471,303,516	$10,468,642	$571,410,658
Colombia	$11,249,962,883	$8,475,322,329	$160,659,652	$10,533,617,075
Comoros	$32,394,068	$29,677,244	$1,121,321	$35,281,984
Congo, Dem. Rep.	$2,841,214,584	$2,605,619,705	$46,150,170	$3,067,476,753
Congo, Rep.	$227,099,135	$211,912,215	$6,037,737	$249,919,561
Costa Rica	$1,400,074,702	$1,042,161,571	$22,704,715	$1,305,750,553
Cote d'Ivoire	$986,545,276	$890,204,132	$15,185,093	$1,059,989,337
Dominican Republic	$2,373,818,269	$1,828,777,716	$38,858,617	$2,256,950,992
Ecuador	$3,039,528,826	$2,380,985,925	$47,610,269	$2,908,422,164
Egypt, Arab Rep.	$5,473,593,518	$4,577,530,923	$111,791,634	$5,670,659,187
El Salvador	$518,955,578	$434,268,407	$10,846,582	$530,457,154
Equatorial Guinea	$201,292,014	$178,959,540	$5,834,851	$210,653,340
Eswatini	$61,060,003	$56,029,505	$2,763,892	$67,309,663
Ethiopia	$6,504,466,772	$5,627,795,574	$106,922,008	$6,683,485,989
Gabon	$317,521,713	$268,464,549	$7,663,635	$320,961,919
Gambia, The	$99,167,588	$90,763,358	$2,372,778	$106,107,646
Ghana	$1,357,588,372	$1,221,891,384	$21,852,775	$1,453,846,283
Guatemala	$1,837,045,148	$1,483,251,542	$31,968,720	$1,795,402,698
Guinea	$563,640,662	$509,527,263	$10,664,897	$600,953,264
Guinea-Bissau	$75,923,827	$70,013,569	$1,851,100	$82,337,549
Haiti	$555,317,592	$482,130,225	$9,866,715	$577,852,090
Honduras	$501,268,135	$449,603,344	$10,781,520	$534,058,049
India	$109,620,866,995	$94,845,714,832	$2,103,684,598	$113,697,199,394
Iraq	$5,183,672,685	$4,325,177,524	$90,063,401	$5,178,286,305
Jordan	$927,233,188	$747,309,105	$20,519,181	$908,958,207

Kenya	$3,484,374,138	$3,372,960,785	$80,811,173	$3,829,322,849
Lebanon	$1,487,047,117	$1,169,981,518	$33,200,071	$1,424,189,709
Lesotho	$86,850,141	$73,935,288	$1,834,725	$89,815,951
Liberia	$191,603,380	$174,077,339	$4,107,994	$205,216,814
Libya	$1,193,918,874	$916,036,535	$24,085,390	$1,140,287,493
Madagascar	$1,047,585,263	$929,396,816	$17,329,515	$1,108,391,195
Malawi	$607,876,121	$549,184,096	$10,742,706	$651,787,586
Mali	$710,566,778	$622,492,840	$13,497,485	$755,421,554
Mauritania	$171,731,082	$157,899,063	$4,306,691	$186,164,959
Mauritius	$504,657,186	$370,884,267	$10,115,829	$465,076,712
Mexico	$31,608,715,789	$24,625,827,163	$553,234,603	$30,216,622,750
Morocco	$2,875,202,949	$2,431,152,726	$57,666,385	$2,940,380,785
Mozambique	$1,044,905,442	$940,866,088	$18,016,630	$1,119,434,522
Namibia	$230,201,450	$195,667,209	$5,412,342	$233,404,625
Nepal	$1,794,390,666	$1,521,796,884	$26,163,458	$1,827,252,564
Nicaragua	$327,475,896	$285,335,078	$6,578,531	$342,217,217
Niger	$682,188,023	$599,341,108	$12,782,840	$725,945,647
Nigeria	$8,523,755,754	$7,962,255,548	$163,489,812	$9,326,514,000
Pakistan	$7,911,623,290	$6,868,761,344	$152,483,404	$8,242,469,426
Paraguay	$1,105,713,068	$850,884,034	$16,848,189	$1,053,013,278
Peru	$6,627,248,434	$4,985,660,537	$89,939,295	$6,187,688,798
Rwanda	$522,348,774	$471,398,249	$9,991,356	$558,014,561
Sao Tome and Principe	$8,558,390	$8,669,252	$863,312	$10,042,513
Senegal	$647,876,841	$595,256,052	$13,416,866	$699,179,799
Sierra Leone	$294,071,444	$268,216,325	$5,784,691	$316,044,465
South Africa	$9,845,785,451	$8,334,446,288	$220,526,183	$10,104,268,308
Sri Lanka	$5,352,138,415	$4,065,040,082	$94,898,307	$4,988,596,480
Sudan	$1,622,278,153	$1,465,299,051	$29,202,119	$1,732,370,209
Syrian Arab Republic	$724,943,647	$683,467,982	$19,208,394	$803,740,032
Tajikistan	$436,373,874	$367,451,171	$10,120,562	$449,773,206
Tanzania	$2,701,211,659	$2,456,724,397	$50,005,557	$2,903,091,232
Togo	$310,160,274	$285,340,906	$5,611,456	$334,768,272
Tunisia	$981,411,231	$796,503,718	$21,582,152	$986,577,100
Turkey	$30,665,784,938	$23,659,504,785	$568,757,486	$28,931,632,252
Uganda	$1,674,499,634	$1,588,879,797	$385,265,851	$1,849,941,504
West Bank and Gaza	$211,482,529	$195,636,416	$6,930,262	$233,328,972
Yemen, Rep.	$1,096,736,296	$938,682,001	$21,313,571	$1,141,026,798
Zambia	$607,538,596	$576,387,647	$12,457,162	$675,092,378
Zimbabwe	$643,379,107	$617,966,425	$257,236,447	$715,488,782

Table SR3: Cost per Capita by Country per Scenario (2019 US$)

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Afghanistan	$35.29	$31.69	$0.69	$37.66
Algeria	$156.37	$113.61	$2.58	$144.09
Angola	$45.14	$43.35	$1.04	$50.86
Argentina	$359.01	$272.68	$6.70	$337.16
Bangladesh	$51.99	$45.53	$0.90	$54.30
Benin	$44.23	$40.34	$0.78	$47.44
Bolivia	$62.64	$53.55	$1.08	$65.06
Botswana	$168.67	$134.47	$3.75	$163.93
Brazil	$254.68	$191.02	$3.84	$237.90
Burkina Faso	$39.25	$36.44	$0.77	$42.53
Burundi	$29.56	$27.25	$0.54	$32.19
Cabo Verde	$59.74	$51.79	$3.64	$63.29
Cambodia	$41.75	$34.85	$0.64	$42.52
Cameroon	$37.67	$35.08	$0.75	$41.36
Central African Republic	$32.00	$29.37	$0.73	$34.60
Chad	$34.72	$30.45	$0.68	$36.92
Colombia	$226.59	$170.71	$3.24	$212.16
Comoros	$38.92	$35.66	$1.35	$42.39
Congo, Dem. Rep.	$33.80	$30.99	$0.55	$36.49
Congo, Rep.	$43.30	$40.41	$1.15	$47.65
Costa Rica	$280.05	$208.46	$4.54	$261.18
Cote d'Ivoire	$39.35	$35.51	$0.61	$42.28
Dominican Republic	$223.37	$172.09	$3.66	$212.38
Ecuador	$177.91	$139.37	$2.79	$170.24
Egypt, Arab Rep.	$55.61	$46.51	$1.14	$57.61
El Salvador	$80.82	$67.64	$1.69	$82.62
Equatorial Guinea	$153.78	$136.72	$4.46	$160.93
Eswatini	$53.74	$49.31	$2.43	$59.24
Ethiopia	$59.55	$51.53	$0.98	$61.19
Gabon	$149.83	$126.68	$3.62	$151.45
Gambia, The	$43.49	$39.81	$1.04	$46.54
Ghana	$45.61	$41.05	$0.73	$48.84
Guatemala	$106.51	$86.00	$1.85	$104.09
Guinea	$45.40	$41.04	$0.86	$48.41
Guinea-Bissau	$40.51	$37.35	$0.99	$43.93
Haiti	$49.92	$43.34	$0.89	$51.95
Honduras	$52.28	$46.89	$1.12	$55.70
India	$81.04	$70.12	$1.56	$84.06
Iraq	$134.87	$112.54	$2.34	$134.73
Jordan	$93.13	$75.06	$2.06	$91.30
Kenya	$67.80	$65.63	$1.57	$74.51
Lebanon	$217.12	$170.83	$4.85	$207.94
Lesotho	$41.20	$35.07	$0.87	$42.60
Liberia	$39.76	$36.12	$0.85	$42.59
Libya	$178.77	$137.16	$3.61	$170.74
Madagascar	$39.89	$35.39	$0.66	$42.20

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Malawi	$33.50	$30.27	$0.59	$35.92
Mali	$37.25	$32.63	$0.71	$39.60
Mauritania	$39.00	$35.86	$0.98	$42.28
Mauritius	$398.84	$293.12	$7.99	$367.56
Mexico	$250.48	$195.15	$4.38	$239.45
Morocco	$79.80	$67.48	$1.60	$81.61
Mozambique	$35.43	$31.90	$0.61	$37.95
Namibia	$94.03	$79.92	$2.21	$95.34
Nepal	$63.88	$54.18	$0.93	$65.05
Nicaragua	$50.65	$44.13	$1.02	$52.93
Niger	$30.40	$26.71	$0.57	$32.35
Nigeria	$43.52	$40.65	$0.83	$47.61
Pakistan	$37.28	$32.37	$0.72	$38.84
Paraguay	$158.96	$122.32	$2.42	$151.38
Peru	$207.17	$155.85	$2.81	$193.43
Rwanda	$42.46	$38.32	$0.81	$45.36
Sao Tome and Principe	$40.56	$41.08	$4.09	$47.59
Senegal	$40.86	$37.55	$0.85	$44.10
Sierra Leone	$38.44	$35.06	$0.76	$41.31
South Africa	$170.40	$144.25	$3.82	$174.88
Sri Lanka	$246.98	$187.59	$4.38	$230.21
Sudan	$38.81	$35.05	$0.70	$41.44
Syrian Arab Republic	$42.88	$40.43	$1.14	$47.54
Tajikistan	$47.95	$40.38	$1.11	$49.42
Tanzania	$47.96	$43.62	$0.89	$51.55
Togo	$39.32	$36.17	$0.71	$42.43
Tunisia	$84.86	$68.87	$1.87	$85.31
Turkey	$372.52	$287.41	$6.91	$351.45
Uganda	$39.19	$37.19	$9.02	$43.30
West Bank and Gaza	$46.29	$42.82	$1.52	$51.07
Yemen, Rep.	$38.48	$32.94	$0.75	$40.04
Zambia	$35.01	$33.22	$0.72	$38.91
Zimbabwe	$44.56	$42.80	$17.82	$49.55

Table SR4: Health System Costs of COVID-19 Response per Capita as % of GDP per Capita (Nominal)

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Afghanistan	6.77%	6.08%	0.13%	7.23%
Algeria	3.80%	2.76%	0.06%	3.50%
Angola	1.32%	1.26%	0.03%	1.48%
Argentina	3.07%	2.33%	0.06%	2.89%
Bangladesh	3.06%	2.68%	0.05%	3.20%
Benin	4.91%	4.47%	0.09%	5.26%
Bolivia	1.77%	1.51%	0.03%	1.83%
Botswana	2.04%	1.63%	0.05%	1.98%
Brazil	2.85%	2.14%	0.04%	2.67%
Burkina Faso	5.49%	5.10%	0.11%	5.95%
Burundi	10.88%	10.03%	0.20%	11.85%
Cabo Verde	1.64%	1.42%	0.10%	1.74%
Cambodia	2.76%	2.31%	0.04%	2.82%
Cameroon	2.46%	2.29%	0.05%	2.70%
Central African Republic	6.73%	6.17%	0.15%	7.27%
Chad	4.77%	4.18%	0.09%	5.07%
Colombia	3.40%	2.56%	0.05%	3.18%
Comoros	2.75%	2.52%	0.10%	3.00%
Congo, Dem. Rep.	6.02%	5.52%	0.10%	6.50%
Congo, Rep.	2.02%	1.88%	0.05%	2.22%
Costa Rica	2.33%	1.73%	0.04%	2.17%
Cote d'Ivoire	2.29%	2.07%	0.04%	2.46%
Dominican Republic	2.77%	2.14%	0.05%	2.64%
Ecuador	2.80%	2.20%	0.04%	2.68%
Egypt, Arab Rep.	2.18%	1.82%	0.04%	2.26%
El Salvador	1.99%	1.67%	0.04%	2.04%
Equatorial Guinea	1.50%	1.33%	0.04%	1.57%
Eswatini	1.30%	1.19%	0.06%	1.43%
Ethiopia	7.71%	6.67%	0.13%	7.92%
Gabon	1.88%	1.59%	0.05%	1.90%
Gambia, The	6.07%	5.56%	0.15%	6.50%
Ghana	2.07%	1.86%	0.03%	2.22%
Guatemala	2.34%	1.89%	0.04%	2.29%
Guinea	5.17%	4.67%	0.10%	5.51%
Guinea-Bissau	5.21%	4.80%	0.13%	5.65%
Haiti	5.75%	4.99%	0.10%	5.98%
Honduras	2.09%	1.88%	0.04%	2.23%
India	4.03%	3.49%	0.08%	4.18%
Jordan	2.20%	1.77%	0.05%	2.15%
Kenya	3.96%	3.84%	0.09%	4.36%
Lebanon	2.63%	2.07%	0.06%	2.51%
Lesotho	3.17%	2.70%	0.07%	3.28%
Liberia	5.87%	5.33%	0.13%	6.29%
Libya	2.47%	1.89%	0.05%	2.36%

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Madagascar	7.56%	6.71%	0.13%	8.00%
Malawi	8.60%	7.77%	0.15%	9.23%
Mali	4.14%	3.63%	0.08%	4.40%
Mauritania	3.28%	3.02%	0.08%	3.56%
Mauritius	3.55%	2.61%	0.07%	3.27%
Mexico	2.59%	2.02%	0.05%	2.48%
Morocco	2.46%	2.08%	0.05%	2.52%
Mozambique	7.10%	6.39%	0.12%	7.61%
Namibia	1.59%	1.35%	0.04%	1.61%
Nepal	6.18%	5.24%	0.09%	6.29%
Nicaragua	2.50%	2.18%	0.05%	2.61%
Niger	7.34%	6.45%	0.14%	7.81%
Nigeria	2.15%	2.00%	0.04%	2.35%
Pakistan	2.51%	2.18%	0.05%	2.62%
Paraguay	2.73%	2.10%	0.04%	2.60%
Peru	2.98%	2.25%	0.04%	2.79%
Rwanda	5.49%	4.96%	0.11%	5.87%
Sao Tome and Principe	2.03%	2.05%	0.20%	2.38%
Senegal	2.68%	2.47%	0.06%	2.90%
Sierra Leone	7.20%	6.57%	0.14%	7.74%
South Africa	2.67%	2.26%	0.06%	2.74%
Sri Lanka	6.02%	4.57%	0.11%	5.61%
Sudan	3.97%	3.59%	0.07%	4.24%
Syrian Arab Republic	2.11%	1.99%	0.06%	2.34%
Tajikistan	5.80%	4.88%	0.13%	5.98%
Tanzania	4.56%	4.15%	0.08%	4.91%
Togo	5.79%	5.32%	0.10%	6.25%
Tunisia	2.46%	2.00%	0.05%	2.47%
Turkey	3.98%	3.07%	0.07%	3.75%
Yemen, Rep.	4.07%	3.49%	0.08%	4.24%
Zambia	2.27%	2.16%	0.05%	2.53%
Zimbabwe	2.08%	1.99%	0.83%	2.31%

Table SR5: Health System Costs of COVID-19 Response per Capita as % of Total Health Spending per Capita (excluding out-of-pocket payments)

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Afghanistan	61.64%	55.35%	1.20%	65.78%
Algeria	60.05%	43.63%	0.99%	55.33%
Angola	47.41%	45.53%	1.09%	53.42%
Argentina	37.58%	28.55%	0.70%	35.30%
Bangladesh	151.94%	133.06%	2.63%	158.70%
Benin	145.48%	132.70%	2.58%	156.03%
Bolivia	29.41%	25.14%	0.51%	30.54%
Botswana	44.40%	35.39%	0.99%	43.15%
Brazil	25.07%	18.80%	0.38%	23.42%
Burkina Faso	95.87%	89.01%	1.88%	103.89%
Burundi	160.14%	147.61%	2.92%	174.36%
Cabo Verde	37.56%	32.56%	2.29%	39.79%
Cambodia	53.75%	44.86%	0.83%	54.75%
Cameroon	58.44%	54.41%	1.17%	64.16%
Central African Republic	195.59%	179.50%	4.44%	211.46%
Chad	109.56%	96.10%	2.13%	116.51%
Colombia	66.57%	50.15%	0.95%	62.33%
Comoros	65.97%	60.43%	2.28%	71.85%
Congo, Dem. Rep.	164.72%	151.06%	2.68%	177.84%
Congo, Rep.	61.53%	57.42%	1.64%	67.71%
Costa Rica	31.51%	23.45%	0.51%	29.38%
Cote d'Ivoire	58.24%	52.55%	0.90%	62.58%
Dominican Republic	53.93%	41.55%	0.88%	51.28%
Ecuador	35.25%	27.61%	0.55%	33.73%
Egypt, Arab Rep.	42.46%	35.51%	0.87%	43.99%
El Salvador	27.50%	23.02%	0.57%	28.11%
Equatorial Guinea	54.65%	48.59%	1.58%	57.19%
Eswatini	24.36%	22.36%	1.10%	26.86%
Ethiopia	216.36%	187.20%	3.56%	222.32%
Gabon	67.99%	57.49%	1.64%	68.73%
Gambia, The	207.80%	190.19%	4.97%	222.34%
Ghana	67.56%	60.80%	1.09%	72.35%
Guatemala	44.13%	35.63%	0.77%	43.13%
Guinea	121.20%	109.57%	2.29%	129.23%
Guinea-Bissau	103.72%	95.65%	2.53%	112.48%
Haiti	132.34%	114.90%	2.35%	137.71%
Honduras	26.20%	23.50%	0.56%	27.91%
India	129.22%	111.81%	2.48%	134.03%
Jordan	41.66%	33.58%	0.92%	40.84%
Kenya	102.40%	99.13%	2.37%	112.54%
Lebanon	32.79%	25.80%	0.73%	31.41%
Lesotho	48.17%	41.01%	1.02%	49.82%
Liberia	58.20%	52.88%	1.25%	62.34%

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Libya	57.19%	43.88%	1.15%	54.62%
Madagascar	165.38%	146.73%	2.74%	174.98%
Malawi	113.24%	102.30%	2.00%	121.42%
Mali	125.04%	109.54%	2.38%	132.94%
Mauritania	83.39%	76.67%	2.09%	90.39%
Mauritius	72.11%	53.00%	1.45%	66.46%
Mexico	54.24%	42.26%	0.95%	51.85%
Morocco	46.55%	39.36%	0.93%	47.60%
Mozambique	184.44%	166.07%	3.18%	197.59%
Namibia	23.35%	19.84%	0.55%	23.67%
Nepal	140.55%	119.20%	2.05%	143.13%
Nicaragua	26.92%	23.45%	0.54%	28.13%
Niger	134.00%	117.73%	2.51%	142.60%
Nigeria	54.85%	51.23%	1.05%	60.01%
Pakistan	94.19%	81.78%	1.82%	98.13%
Paraguay	48.58%	37.38%	0.74%	46.26%
Peru	65.47%	49.25%	0.89%	61.13%
Rwanda	88.32%	79.70%	1.69%	94.35%
Sao Tome and Principe	38.58%	39.07%	3.89%	45.26%
Senegal	77.67%	71.37%	1.61%	83.83%
Sierra Leone	44.54%	40.62%	0.88%	47.87%
South Africa	39.80%	33.69%	0.89%	40.84%
Sri Lanka	161.33%	122.53%	2.86%	150.37%
Sudan	25.53%	23.06%	0.46%	27.26%
Syrian Arab Republic	64.83%	61.12%	1.72%	71.88%
Tajikistan	86.09%	72.49%	2.00%	88.73%
Tanzania	135.11%	122.88%	2.50%	145.21%
Togo	101.40%	93.29%	1.83%	109.45%
Tunisia	33.08%	26.85%	0.73%	33.26%
Turkey	79.49%	61.33%	1.47%	74.99%
Yemen, Rep.	53.42%	45.72%	1.04%	55.58%
Zambia	61.92%	58.75%	1.27%	68.81%
Zimbabwe	47.43%	45.56%	18.96%	52.75%

Table SR6: Health System Costs of COVID-19 Response per Capita as % of Total Health Spending per Capita (including out-of-pocket payments)

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Afghanistan	34.75%	31.20%	0.68%	37.08%
Algeria	45.88%	33.33%	0.76%	42.28%
Angola	35.06%	33.67%	0.81%	39.51%
Argentina	32.46%	24.65%	0.61%	30.48%
Bangladesh	88.39%	77.41%	1.53%	92.33%
Benin	101.40%	92.48%	1.80%	108.75%
Bolivia	22.97%	19.64%	0.40%	23.86%
Botswana	42.18%	33.63%	0.94%	41.00%
Brazil	17.46%	13.10%	0.26%	16.31%
Burkina Faso	72.96%	67.74%	1.43%	79.07%
Burundi	122.70%	113.10%	2.24%	133.59%
Cabo Verde	29.80%	25.84%	1.81%	31.57%
Cambodia	33.90%	28.30%	0.52%	34.53%
Cameroon	34.47%	32.10%	0.69%	37.85%
Central African Republic	136.70%	125.45%	3.10%	147.79%
Chad	67.99%	59.63%	1.32%	72.30%
Colombia	55.40%	41.74%	0.79%	51.88%
Comoros	38.10%	34.91%	1.32%	41.50%
Congo, Dem. Rep.	119.85%	109.92%	1.95%	129.40%
Congo, Rep.	41.10%	38.35%	1.09%	45.23%
Costa Rica	25.79%	19.20%	0.42%	24.06%
Cote d'Ivoire	41.56%	37.50%	0.64%	44.65%
Dominican Republic	37.29%	28.73%	0.61%	35.46%
Ecuador	25.09%	19.65%	0.39%	24.01%
Egypt, Arab Rep.	26.21%	21.92%	0.54%	27.15%
El Salvador	21.63%	18.10%	0.45%	22.11%
Equatorial Guinea	31.62%	28.11%	0.92%	33.09%
Eswatini	22.17%	20.34%	1.00%	24.44%
Ethiopia	157.44%	136.22%	2.59%	161.78%
Gabon	55.50%	46.92%	1.34%	56.10%
Gambia, The	168.13%	153.88%	4.02%	179.90%
Ghana	49.02%	44.12%	0.79%	52.49%
Guatemala	28.78%	23.24%	0.50%	28.13%
Guinea	80.93%	73.16%	1.53%	86.29%
Guinea-Bissau	76.60%	70.64%	1.87%	83.07%
Haiti	93.38%	81.07%	1.66%	97.17%
Honduras	18.07%	16.21%	0.39%	19.25%
India	78.52%	67.94%	1.51%	81.44%
Jordan	32.55%	26.24%	0.72%	31.91%
Kenya	80.18%	77.62%	1.86%	88.12%
Lebanon	24.82%	19.52%	0.55%	23.77%
Lesotho	40.52%	34.50%	0.86%	41.90%
Liberia	39.52%	35.91%	0.85%	42.33%
Libya	57.19%	43.88%	1.15%	54.62%

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Madagascar	135.16%	119.91%	2.24%	143.01%
Malawi	101.66%	91.85%	1.80%	109.00%
Mali	92.43%	80.98%	1.76%	98.27%
Mauritania	55.26%	50.81%	1.39%	59.90%
Mauritius	48.67%	35.77%	0.98%	44.85%
Mexico	38.64%	30.10%	0.68%	36.94%
Morocco	31.32%	26.48%	0.63%	32.03%
Mozambique	171.29%	154.24%	2.95%	183.51%
Namibia	21.67%	18.42%	0.51%	21.97%
Nepal	90.42%	76.69%	1.32%	92.08%
Nicaragua	20.36%	17.74%	0.41%	21.27%
Niger	84.54%	74.27%	1.58%	89.96%
Nigeria	31.30%	29.24%	0.60%	34.25%
Pakistan	57.01%	49.49%	1.10%	59.39%
Paraguay	35.24%	27.12%	0.54%	33.56%
Peru	51.03%	38.39%	0.69%	47.65%
Rwanda	83.02%	74.92%	1.59%	88.69%
Sao Tome and Principe	33.72%	34.16%	3.40%	39.57%
Senegal	51.18%	47.02%	1.06%	55.23%
Sierra Leone	31.46%	28.70%	0.62%	33.82%
South Africa	36.93%	31.27%	0.83%	37.90%
Sri Lanka	107.46%	81.62%	1.91%	100.16%
Sudan	14.68%	13.26%	0.26%	15.68%
Syrian Arab Republic	64.83%	61.12%	1.72%	71.88%
Tajikistan	51.84%	43.65%	1.20%	53.43%
Tanzania	110.84%	100.81%	2.05%	119.13%
Togo	67.41%	62.02%	1.22%	72.76%
Tunisia	23.65%	19.19%	0.52%	23.77%
Turkey	68.25%	52.66%	1.27%	64.39%
Yemen, Rep.	29.52%	25.27%	0.57%	30.71%
Zambia	55.23%	52.40%	1.13%	61.37%
Zimbabwe	39.12%	37.58%	15.64%	43.51%

Table SR7: Health System Costs of COVID-19 Response per Capita as % of Government Health Spending per Capita

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Afghanistan	1202.08%	1079.37%	23.45%	1282.69%
Algeria	88.71%	81.75%	1.46%	81.75%
Angola	107.40%	121.02%	2.48%	121.02%
Argentina	50.50%	47.42%	0.94%	47.42%
Bangladesh	846.15%	883.78%	14.64%	883.78%
Benin	708.39%	759.74%	12.56%	759.74%
Bolivia	44.76%	46.49%	0.77%	46.49%
Botswana	79.37%	77.14%	1.76%	77.14%
Brazil	75.45%	70.48%	1.14%	70.48%
Burkina Faso	239.09%	259.10%	4.70%	259.10%
Burundi	549.78%	598.61%	10.02%	598.61%
Cabo Verde	66.14%	70.07%	4.03%	70.07%
Cambodia	246.48%	251.05%	3.79%	251.05%
Cameroon	438.21%	481.16%	8.76%	481.16%
Central African Republic	1316.05%	1422.83%	29.85%	1422.83%
Chad	580.66%	617.48%	11.31%	617.48%
Colombia	104.98%	98.29%	1.50%	98.29%
Comoros	453.20%	493.60%	15.69%	493.60%
Congo, Dem. Rep.	1344.28%	1451.34%	21.84%	1451.34%
Congo, Rep.	145.54%	160.17%	3.87%	160.17%
Costa Rica	42.14%	39.31%	0.68%	39.31%
Cote d'Ivoire	225.98%	242.80%	3.48%	242.80%
Dominican Republic	117.95%	112.14%	1.93%	112.14%
Ecuador	68.85%	65.88%	1.08%	65.88%
Egypt, Arab Rep.	144.91%	150.12%	2.96%	150.12%
El Salvador	42.66%	43.61%	0.89%	43.61%
Equatorial Guinea	232.43%	243.24%	6.74%	243.24%
Eswatini	35.15%	38.75%	1.59%	38.75%
Ethiopia	783.45%	805.02%	12.88%	805.02%
Gabon	105.27%	106.41%	2.54%	106.41%
Gambia, The	1119.18%	1197.51%	26.78%	1197.51%
Ghana	176.13%	188.62%	2.84%	188.62%
Guatemala	118.58%	115.89%	2.06%	115.89%
Guinea	985.52%	1050.76%	18.65%	1050.76%
Guinea-Bissau	234.39%	254.19%	5.71%	254.19%
Haiti	863.00%	898.02%	15.33%	898.02%
Honduras	57.07%	60.80%	1.23%	60.80%
India	508.22%	527.12%	9.75%	527.12%
Jordan	65.90%	64.60%	1.46%	64.60%
Kenya	283.05%	311.08%	6.56%	311.08%
Lebanon	62.90%	60.24%	1.40%	60.24%
Lesotho	75.50%	78.08%	1.59%	78.08%
Liberia	408.55%	437.58%	8.76%	437.58%

Country	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Libya	90.36%	86.30%	1.82%	86.30%
Madagascar	347.06%	367.20%	5.74%	367.20%
Malawi	403.73%	432.89%	7.13%	432.89%
Mali	395.72%	420.70%	7.52%	420.70%
Mauritania	227.51%	246.63%	5.71%	246.63%
Mauritius	163.47%	150.65%	3.28%	150.65%
Mexico	104.02%	99.44%	1.82%	99.44%
Morocco	99.34%	101.59%	1.99%	101.59%
Mozambique	345.76%	370.42%	5.96%	370.42%
Namibia	37.72%	38.24%	0.89%	38.24%
Nepal	756.48%	770.34%	11.03%	770.34%
Nicaragua	43.88%	45.85%	0.88%	45.85%
Niger	551.71%	587.10%	10.34%	587.10%
Nigeria	421.11%	460.77%	8.08%	460.77%
Pakistan	337.64%	351.76%	6.51%	351.76%
Paraguay	94.10%	89.61%	1.43%	89.61%
Peru	102.18%	95.40%	1.39%	95.40%
Rwanda	260.66%	278.46%	4.99%	278.46%
Sao Tome and Principe	96.69%	113.46%	9.75%	113.46%
Senegal	224.71%	242.51%	4.65%	242.51%
Sierra Leone	398.63%	428.42%	7.84%	428.42%
South Africa	74.07%	76.01%	1.66%	76.01%
Sri Lanka	374.37%	348.94%	6.64%	348.94%
Sudan	131.01%	139.90%	2.36%	139.90%
Syrian Arab Republic	143.17%	158.74%	3.79%	158.74%
Tajikistan	301.02%	310.26%	6.98%	310.26%
Tanzania	332.58%	357.44%	6.16%	357.44%
Togo	505.79%	545.92%	9.15%	545.92%
Tunisia	58.41%	58.72%	1.28%	58.72%
Turkey	101.33%	95.60%	1.88%	95.60%
Yemen, Rep.	524.63%	545.82%	10.20%	545.82%
Zambia	161.72%	179.70%	3.32%	179.70%
Zimbabwe	101.99%	113.43%	40.78%	113.43%

Table SR8. Average Cost per Capita by Country Income Category (2019 US$): Sensitivity Analysis on % of Symptomatic Cases Tested

	Scenario 1: No mitigation	Scenario 2: Contact reduction: high symptomatic cases/low general population	Scenario 3: Contact reduction: high symptomatic cases/high general population	Scenario 4: 30-day lockdown + low contact reduction general population
Average Cost per Capita by Country Income Category (2019 US$): 20% of Symptomatic Cases Tested				
Low Income Countries (LIC)	$43.19	$45.54	$1.55	$53.93
Lower-Middle Income Countries (LMIC)	$52.63	$53.89	$1.27	$64.25
Upper-Middle Income Countries (UMIC)	$75.57	$63.65	$1.39	$78.21
Average Cost per Capita by Country Income Category (2019 US$): 40% of Symptomatic Cases Tested				
Low Income Countries (LIC)	$43.19	$59.57	$2.01	$70.32
Lower-Middle Income Countries (LMIC)	$52.63	$69.75	$1.61	$82.78
Upper-Middle Income Countries (UMIC)	$75.57	$74.79	$1.60	$91.38
Average Cost per Capita by Country Income Category (2019 US$): 60% of Symptomatic Cases Tested				
Low Income Countries (LIC)	$43.19	$73.60	$2.46	$86.72
Lower-Middle Income Countries (LMIC)	$52.63	$85.61	$1.95	$101.32
Upper-Middle Income Countries (UMIC)	$75.57	$85.93	$1.81	$104.55
Average Cost per Capita by Country Income Category (2019 US$): 80% of Symptomatic Cases Tested				
Low Income Countries (LIC)	$43.19	$87.63	$2.92	$103.11
Lower-Middle Income Countries (LMIC)	$52.63	$101.48	$2.29	$119.85
Upper-Middle Income Countries (UMIC)	$75.57	$97.08	$2.02	$117.72
Average Cost per Capita by Country Income Category (2019 US$): 100% of Symptomatic Cases Tested				
Low Income Countries (LIC)	$43.19	$101.66	$3.38	$119.50
Lower-Middle Income Countries (LMIC)	$52.63	$117.34	$2.62	$138.38
Upper-Middle Income Countries (UMIC)	$75.57	$108.22	$2.22	$130.89

Chapter 8

Appendix 8.1: Disability-adjusted life years (DALYs) from premature death by age band

See Pearson et al. (2021) [1].

Age band (years)	DALYs
0-4	25.66
5-9	25.00
10-14	23.64
15-19	22.06
20-24	20.85
25-29	19.68
30-34	18.37
35-39	16.98
40-44	15.57
45-49	14.03
50-54	12.37
55-59	10.65
60-64	8.93
65-69	7.35
70-74	6.11
75+	4.19

Appendix 8.2: Number of deaths by age band by severity and type of care

Estimated by using the proportion of number of deaths from COVID-19 by 15-year age bands estimated by the COVIDM model and converting to 5-year age bands by weighting according to demographic data from the World Population Prospects 2019 [2, 3].

(a) Severe case in general ward

Age band (years)	Total deaths
0-4	55
5-9	50
10-14	46
15-19	55
20-24	52
25-29	48
30-34	177
35-39	148
40-44	122
45-49	450
50-54	384
55-59	322
60-64	711
65-69	488
70-74	364
75+	441
Total	3,914

(b) Severe case with no hospital-based care

Age band (years)	Total deaths
0-4	5,512
5-9	5,026
10-14	4,623
15-19	5,473
20-24	5,173
25-29	4,771
30-34	17,723
35-39	14,750
40-44	12,240
45-49	44,998
50-54	38,446
55-59	32,193
60-64	71,087
65-69	48,791
70-74	36,435
75+	44,124
Total	391,367

(c) Critical cases in general ward

Age band (years)	Total deaths
0-4	1,923
5-9	1,754
10-14	1,613
15-19	1,878
20-24	1,775
25-29	1,637
30-34	5,634
35-39	4,689
40-44	3,891
45-49	15,565
50-54	13,299
55-59	11,136
60-64	24,620
65-69	16,898
70-74	12,619
75+	15,282
Total	134,212

(d) Critical cases in intensive care units (ICU)

Age band (years)	Total deaths
0-4	1,448
5-9	1,321
10-14	1,215
15-19	1,414
20-24	1,337
25-29	1,233
30-34	4,243
35-39	3,532
40-44	2,931
45-49	11,722
50-54	10,015
55-59	8,386
60-64	18,542
65-69	12,726
70-74	9,504
75+	11,509
Total	101,077

Appendix 8.3: Interventions in the immediate implementation package (IIP) and COVID-19 care and treatment interventions: evidence and characteristics

Cluster, cost per capita, DALYs averted, incremental cost-effectiveness ratios (ICERs), rule of rescue status and intervention purpose.

DCP3 code	DCP3 intervention name	Cluster	Cost per capita (2019 US$)	DALYs averted	ICER	Rule of rescue	Intervention purpose
C1	Antenatal and postpartum education on birth spacing	RMNCH	$0.01	29,259	40	No	Preventive
C10	Education on handwashing, personal hygiene and safe disposal of children's stool	RMNCH	$0.05	301,962	24	No	Preventive
C11	Pneumococcus vaccination	RMNCH	$0.39	115,050	480	No	Preventive
C12	Rotavirus vaccination	RMNCH	$0.18	4,152	6620	No	Preventive
C16	Childhood vaccination series (diphtheria, pertussis, tetanus, polio, BCG, measles, hepatitis B, HiB, rubella)	RMNCH	$0.35	648,021	85	No	Preventive
C18	Education of schoolchildren on oral health	RMNCH	$0.09	17,964	757	No	Preventive
C19	Vision pre-screening by teachers; vision tests and provision of ready-made glasses on-site by eye specialists	RMNCH	$0.19	186,926	160	No	Preventive
C2	Counselling of mothers on providing thermal care for pre- term new-borns (delayed bath and skin to skin contact)	RMNCH	$0.00	7,374	38	No	Preventive
C27a	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecure households	RMNCH	$0.71	597,161	186	No	Promotive
C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecurity households	RMNCH	$0.48	401,331	186	No	Promotive
C3a	Management of labour and delivery in low-risk women by skilled attendant (CL)	RMNCH	$0.03	4,273,034	1	Yes	Curative
C3b	Basic neonatal resuscitation following delivery (CL)	RMNCH	$0.00	374,040	1	Yes	Curative
C3c	Management of labour and delivery in low-risk women by skilled attendant (PHC)	RMNCH	$0.29	14,082,885	3	Yes	Curative
C3d	Basic neonatal resuscitation following delivery (PHC)	RMNCH	$0.02	3,298,551	1	Yes	Curative
C4	Promotion of breastfeeding and complementary feeding by community health workers	RMNCH	$0.01	52,817	38	No	Promotive
C43	Early detection and treatment of leishmaniasis, dengue, chikungunya, rabies, trachoma and helminthiasis.	Infectious Disease	$0.07	14,136	740	No	Curative
C46	In the context of an emerging infectious outbreak, provide advice and guidance on how to recognize early symptoms and signs and when to seek medical attention	Infectious Disease	$0.09	19,060	757	No	Promotive

DCP3 code	DCP3 intervention name	Cluster	Cost per capita (2019 US$)	DALYs averted	ICER	Rule of rescue	Intervention purpose
C5	Tetanus toxoid immunization among schoolchildren and women attending antenatal care	RMNCH	$0.21	147,921	226	No	Preventive
C51	WASH behaviour change interventions, such as community led total sanitation	NCD & IPC	$0.42	87,040	757	No	Preventive
FLH10	Surgical termination of pregnancy by maternal vacuum aspiration and dilatation & curettage	RMNCH	$0.01	2,238	757	No	Curative
FLH13	Early detection and treatment of early-stage cervical cancer	RMNCH	$0.00	154	390	No	Curative
FLH14	Insertion and removal of contraceptives	RMNCH	$0.00	465	757	No	Preventive
FLH15	Tubal ligation	RMNCH	$0.32	43,385	1150	No	Preventive
FLH16	Vasectomy	RMNCH	$0.00	610	757	No	Preventive
FLH17	Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO guidelines (either short- or long-term regimen)	Infectious Disease	$0.05	37,387	220	No	Curative
FLH18	Evaluation and management of fever in clinically unstable individuals using WHO IMAI guidelines, including empiric parenteral antimicrobials and antimalarial and resuscitative measures for septic shock	Infectious Disease	$0.05	8,535,702	1	No	Curative
FLH23	Medical management of acute heart failure	NCD & IPC	$0.18	147,768	195	Yes	Curative
FLH24	Bowel obstruction management	NCD & IPC	$0.07	209,600	52	Yes	Curative
FLH3	Jaundice management with phototherapy	RMNCH	$0.02	4,121	757	No	Curative
FLH30	Intoxication/poisoning management	NCD & IPC	$0.00	373	757	Yes	Curative
FLH31	Appendectomy	Health Services	$0.66	75,600	1370	Yes	Curative
FLH34	Colostomy for acute bowel obstruction/volvulus and injuries.	Health Services	$0.01	33,120	60	Yes	Curative
FLH35	Escharotomy or fasciotomy	Health Services	$0.05	41,857	193	Yes	Curative
FLH36	Management of non-displaced fractures	Health Services	$0.29	409,528	110	Yes	Curative
FLH38	Hysterectomy for uterine rupture or intractable postpartum haemorrhage	Health Services	$0.02	98,073	30	Yes	Curative
FLH39	Irrigation and debridement of open fractures	Health Services	$0.19	105,664	287	Yes	Curative
FLH4	Eclampsia management with magnesium sulphate, including initial stabilization at health centres	RMNCH	$0.18	277,082	103	Yes	Curative
FLH41a	Management of Septic Arthritis	Health Services	$0.00	2,037	370	Yes	Curative
FLH41 b	Placement of External Fixation and Use of Traction for Fractures	Health Services	$0.10	42,707	370	Yes	Curative

DCP3 code	DCP3 intervention name	Cluster	Cost per capita (2019 US$)	DALYs averted	ICER	Rule of rescue	Intervention purpose
FLH42	Relief of urinary obstruction by catheterization for fractures	Health Services	$1.11	338,923	510	Yes	Curative
FLH43	Removal of gallbladder, including emergency surgery	Health Services	$0.13	86,439	240	Yes	Curative
FLH44	Repair of perforations (for example perforated peptic ulcer, typhoid ileal perforation)	Health Services	$0.04	461,687	12	Yes	Curative
FLH5	Maternal sepsis management	RMNCH	$0.21	34,306	940	Yes	Curative
FLH52	Compression therapy for amputations, burns, and vascular or lymphatic disorders	Health Services	$0.01	2,705	560	No	Curative
FLH6	Management of new-born complications infections, meningitis, septicaemia, pneumonia and other very serious infections requiring continuous supportive care (such as IV fluids and oxygen)	RMNCH	$0.09	531,342	26	Yes	Curative
FLH8	Management of labour and delivery in high-risk women, including operative delivery (CEmONC)	RMNCH	$1.16	69,553	2592	Yes	Curative
HC1	Early detection and treatment of neonatal pneumonia with oral antibiotics	RMNCH	$0.02	103,158	29	No	Curative
HC10	Screening and management of diabetes (gestational diabetes or pre-existing type II diabetes)	RMNCH	$0.00	386	1800	No	Curative
HC11	Management of labour and delivery in low-risk women (BEmONC), including initial treatment of obstetric or delivery complications prior to transfer (Also included in Surgery package of services)	RMNCH	$0.66	553,204	187	Yes	Curative
HC12	Detection and treatment of childhood infections with danger signs (IMCI)	RMNCH	$0.03	248,317	16	Yes	Curative
HC17	Syndromic management of common sexual and reproductive tract infections (for example urethral discharge, genital ulcer and others)	RMNCH	$0.26	316,082	128	No	Curative
HC2	Miscarriage and abortions management	RMNCH	$0.05	9,372	757	Yes	Curative
HC21	Partner notification and expedited treatment for common STIs including HIV	Infectious Disease	$0.15	217,471	109	No	Curative
HC25	Medical male circumcision	Infectious Disease	$0.13	26,759	757	No	Preventive
HC26	For PLHIV and children under five who are close contacts or household members of individuals with active TB, perform symptom screening and chest radiograph; if there is no active TB, provide isoniazid preventive therapy according to current WHO guidelines	Infectious Disease	$0.01	8,859	190	No	Curative
HC27	Diagnosis of TB and first-line treatment	Infectious Disease	$0.17	1,640,077	17	No	Curative
HC3	Management of premature rupture of membranes, including administration of antibiotics	RMNCH	$0.14	10,162	2128	No	Curative
HC30	Fever management for clinically stable	Infectious Disease	$0.06	11,467	757	No	Curative

DCP3 code	DCP3 intervention name	Cluster	Cost per capita (2019 US$)	DALYs averted	ICER	Rule of rescue	Intervention purpose
HC32	Provision of insecticide nets to U5 children and pregnant women attending health centres	Infectious Disease	$0.05	36,089	200	No	Preventive
HC33	Identify and refer for progressive illness **	Infectious Disease	$0.02	3,993	757	No	Curative
HC36	Long-term combination therapy for persons with multiple CVD risk factors, including screening for CVD in community setting using non-lab-based tools to assess overall CVD risk	NCD & IPC	$0.03	5,442	757	No	Curative
HC37	Low-dose inhaled corticosteroids and bronchodilators for asthma and for selected patients with COPD	NCD & IPC	$0.09	834	17626	No	Curative
HC38	Provision of aspirin for all cases of suspected acute myocardial infarction	NCD & IPC	$0.00	1,079	310	Yes	Curative
HC39a	Screening and ACEi or ARBs for kidney disease	NCD & IPC	$0.05	1,287	6116	No	Curative
HC41	Secondary prophylaxis for rheumatic fever	NCD & IPC	$0.00	777	757	No	Preventive
HC42	Treatment of acute pharyngitis for rheumatic fever	NCD & IPC	$0.01	73,558	15	Yes	Curative
HC45	Opportunistic screening for hypertension	NCD & IPC	$0.18	71,296	400	No	Curative
HC4a	Provision of condoms and hormonal contraceptives, including emergency contraceptives	RMNCH	$0.02	14,350	200	No	Promotive
HC4b	Provision of condoms and hormonal contraceptives, including insertion and removal of contraceptives (PHC)	RMNCH	$0.03	21,524	200	No	Promotive
HC50	Management of depression and anxiety disorders with psychological and generic antidepressants therapy	NCD & IPC	$0.17	5,638	4591	No	Curative
HC56	Screening for congenital hearing loss	NCD & IPC	$0.00	488	1300	No	Curative
HC57a	Dental extraction (PHC)	Health Services	$0.42	92,791	700	No	Curative
HC57b	Dental extraction (FLH)	Health Services	$0.36	74,021	757	No	Curative
HC58a	Drainage of dental abscess (PHC)	Health Services	$0.16	13,716	1780	No	Curative
HC59	Drainage of superficial abscess	Health Services	$0.15	16,037	411	No	Curative
HC5a	Counselling on kangaroo care for new-borns (CL)	RMNCH	$0.00	69	301	No	Preventive
HC5b	Counselling on kangaroo care for new-borns (PHC)	RMNCH	$0.00	103	301	No	Preventive
HC6	Management of neonatal sepsis, pneumonia and meningitis using injectable and oral antibiotics	RMNCH	$0.03	64,809	75	No	Curative
HC60	Non-displaced fractures management	Health Services	$0.03	5,353	757	No	Curative
HC61	Resuscitation with basic life support measures	Health Services	$0.00	131	757	No	Curative
HC62	Suturing laceration	Health Services	$0.02	4,503	757	No	Curative

DCP3 code	DCP3 intervention name	Cluster	Cost per capita (2019 US$)	DALYs averted	ICER	Rule of rescue	Intervention purpose
HC63a	Treatment of caries (PHC)	Health Services	$0.27	9,151	4650	No	Curative
HC64	Basic management of MNIs and disorders	Health Services	$0.10	2,005	7583	No	Curative
HC7	Pharmacological termination of pregnancy	RMNCH	$0.01	36,653	59	No	Curative
HC9a	Screening of hypertensive disorders in pregnancy	RMNCH	$0.00	5	92504	No	Curative
HC9b	Screening and management of hypertensive disorders in pregnancy	RMNCH	$0.08	136	92504	No	Curative
P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkages to care (active case finding)	Infectious Disease	$0.31	19,102	2500	No	Curative
RH1	Full supportive care for preterm new-borns	RMNCH	$0.15	394,517	58	Yes	Curative
N/A	COVID-19: CT General ward for severe cases	N/A	$0.47	4,273,181	24	Yes	COVID-19
N/A	COVID-19: CT ICU for critical cases	N/A	$1.68	727,009	865	Yes	COVID-19

Appendix 8.4: Interventions in the immediate implementation package (IIP) and COVID-19 care and treatment interventions: inclusion/exclusion

Inclusion (1) or exclusion (0) per scenario. Fractions denote the proportion of the intervention that could be afforded for interventions at the margin of the budget constraint. IIP= immediate implementation package, CT= COVID-19 care and treatment interventions, RR= 'rule of rescue' interventions, CE=cost-effectiveness.

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
C1	Antenatal and postpartum education on birth spacing	1	1	1	1	0	1	1	1	1
C10	Education on handwashing, personal hygiene and safe disposal of children's stool	1	1	1	1	1	1	1	1	1
C11	Pneumococcus vaccination	1	1	1	1	1	0.69	1	0	1
C12	Rotavirus vaccination	1	0	0	0	1	1	1	0	0
C16	Childhood vaccination series (diphtheria, pertussis, tetanus, polio, BCG, measles, hepatitis B, HiB, rubella)	1	1	1	1	0.91	1	1	1	1
C18	Education of schoolchildren on oral health	1	1	1	0	1	1	1	0	1
C19	Vision pre-screening by teachers; vision tests and provision of ready-made glasses on-site by eye specialists	1	1	1	1	0	1	1	1	1
C2	Counselling of mothers on providing thermal care for pre-term new-borns (delayed bath and skin to skin contact)	1	1	1	1	0	1	1	1	1
C27a	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to	1	1	1	1	1	0	1	1	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
	pregnant women in food-insecure households									
C27b	Provision of iron and folic acid supplementation to pregnant women, and provision of food or caloric supplementation to pregnant women in food-insecurity households	1	1	0	1	1	0	1	0.54	1
C3a	Management of labour and delivery in low-risk women by skilled attendant (CL)	1	1	1	1	1	1	1	1	1
C3b	Basic neonatal resuscitation following delivery (CL)	1	1	0	1	1	1	1	1	1
C3c	Management of labour and delivery in low-risk women by skilled attendant (PHC)	1	1	1	1	1	1	1	1	1
C3d	Basic neonatal resuscitation following delivery (PHC)	1	1	1	1	1	1	1	1	1
C4	Promotion of breastfeeding and complementary feeding by community health workers	1	1	1	1	1	1	1	1	1
C43	Early detection and treatment of leishmaniasis, dengue, chikungunya, rabies, trachoma and helminthiasis.	1	1	1	1	0	1	0	1	1
C46	In the context of an emerging infectious outbreak, provide advice and guidance on how to recognize early symptoms and signs and when to seek medical attention	1	1	1	0.98	1	1	1	0	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
C5	Tetanus toxoid immunization among schoolchildren and women attending antenatal care	1	1	1	1	1	1	1	0	1
C51	WASH behaviour change interventions, such as community led total sanitation	1	1	1	1	1	0	1	0	1
FLH10	Surgical termination of pregnancy by maternal vacuum aspiration and dilatation & curettage	1	1	0	0	0	1	1	1	1
FLH13	Early detection and treatment of early-stage cervical cancer	1	1	1	1	0	1	0	1	1
FLH14	Insertion and removal of contraceptives	1	1	1	0	1	1	1	0	1
FLH15	Tubal ligation	1	1	0	0	0	1	1	0	1
FLH16	Vasectomy	1	1	1	0	0	1	1	0	1
FLH17	Referral of cases of treatment failure for drug susceptibility testing; enrolment of those with MDR-TB for treatment per WHO guidelines (either short- or long-term regimen)	1	1	1	1	1	1	1	1	1
FLH18	Evaluation and management of fever in clinically unstable individuals using WHO IMAI guidelines, including empiric parenteral antimicrobials and antimalarial and resuscitative measures for septic shock	1	1	0	1	1	1	0	1	1
FLH23	Medical management of acute heart failure	1	1	1	1	1	1	0	1	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
FLH24	Bowel obstruction management	1	1	1	1	1	1	1	1	1
FLH3	Jaundice management with phototherapy	1	1	1	0	1	1	1	1	1
FLH30	Intoxication/poisoning management	1	1	0	1	1	1	1	1	1
FLH31	Appendectomy	1	1	0.76	1	1	1	0	1	1
FLH34	Colostomy for acute bowel obstruction/volvulus and injuries.	1	1	0	1	1	1	1	1	1
FLH35	Escharotomy or fasciotomy	1	1	1	1	1	1	0	1	1
FLH36	Management of non-displaced fractures	1	1	1	1	1	1	1	1	1
FLH38	Hysterectomy for uterine rupture or intractable postpartum haemorrhage	1	1	0	1	1	1	1	1	1
FLH39	Irrigation and debridement of open fractures	1	1	1	1	1	1	0	1	1
FLH4	Eclampsia management with magnesium sulphate, including initial stabilization at health centres	1	1	1	1	1	1	1	1	1
FLH41a	Management of Septic Arthritis	1	1	1	1	1	1	0	1	1
FLH41 b	Placement of External Fixation and Use of Traction for Fractures	1	1	1	1	1	1	1	1	1
FLH42	Relief of urinary obstruction by catheterization for fractures	1	1	1	1	1	1	1	1	1
FLH43	Removal of gallbladder, including emergency surgery	1	1	1	1	1	1	1	1	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
FLH44	Repair of perforations (for example perforated peptic ulcer, typhoid ileal perforation)	1	1	1	1	1	1	0	1	1
FLH5	Maternal sepsis management	1	1	1	1	1	1	0	1	1
FLH52	Compression therapy for amputations, burns, and vascular or lymphatic disorders	1	1	1	1	0	1	0	1	1
FLH6	Management of new-born complications infections, meningitis, septicaemia, pneumonia and other very serious infections requiring continuous supportive care (such as IV fluids and oxygen)	1	1	1	1	1	1	1	1	1
FLH8	Management of labour and delivery in high-risk women, including operative delivery (CEmONC)	1	0	1	1	1	1	0	1	1
HC1	Early detection and treatment of neonatal pneumonia with oral antibiotics	1	1	1	1	0	1	0	1	1
HC10	Screening and management of diabetes (gestational diabetes or pre-existing type II diabetes)	1	1	1	0	0	1	0	1	1
HC11	Management of labour and delivery in low-risk women (BEmONC), including initial treatment of obstetric or delivery complications prior to	1	1	1	1	1	1	0	1	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
	transfer (Also included in Surgery package of services)									
HC12	Detection and treatment of childhood infections with danger signs (IMCI)	1	1	1	1	1	1	0	1	1
HC17	Syndromic management of common sexual and reproductive tract infections (for example urethral discharge, genital ulcer and others)	1	1	1	1	0	1	0	1	1
HC2	Miscarriage and abortions management	1	1	1	1	1	1	0	1	1
HC21	Partner notification and expedited treatment for common STIs including HIV	1	1	0	1	1	1	0	1	1
HC25	Medical male circumcision	1	1	1	1	0	1	0	0	1
HC26	For PLHIV and children under five who are close contacts or household members of individuals with active TB, perform symptom screening and chest radiograph; if there is no active TB, provide isoniazid preventive therapy according to current WHO guidelines	1	1	1	1	1	1	1	1	1
HC27	Diagnosis of TB and first-line treatment	1	1	1	1	1	1	0	1	1
HC3	Management of premature rupture of membranes,	1	1	1	0	1	1	0	1	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
	including administration of antibiotics									
HC30	Fever management for clinically stable	1	1	1	0	1	1	1	1	1
HC32	Provision of insecticide nets to U5 children and pregnant women attending health centres	1	1	1	1	0	1	1	0	1
HC33	Identify and refer for progressive illness **	1	1	1	0	1	1	1	1	1
HC36	Long-term combination therapy for persons with multiple CVD risk factors, including screening for CVD in community setting using non-lab-based tools to assess overall CVD risk	1	1	1	0	1	1	0	1	1
HC37	Low-dose inhaled corticosteroids and bronchodilators for asthma and for selected patients with COPD	1	0	1	0	1	1	1	1	0
HC38	Provision of aspirin for all cases of suspected acute myocardial infarction	1	1	0	1	1	1	0	1	1
HC39a	Screening and ACEi or ARBs for kidney disease	1	0	1	0	0	1	0	1	0
HC41	Secondary prophylaxis for rheumatic fever	1	1	1	0	0	1	0	0	1
HC42	Treatment of acute pharyngitis for rheumatic fever	1	1	1	1	1	1	0	1	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
HC45	Opportunistic screening for hypertension	1	1	1	1	1	1	1	1	1
HC4a	Provision of condoms and hormonal contraceptives, including emergency contraceptives	1	1	1	1	1	1	1	0	1
HC4b	Provision of condoms and hormonal contraceptives, including insertion and removal of contraceptives (PHC)	1	1	1	1	0	1	0	0	1
HC50	Management of depression and anxiety disorders with psychological and generic antidepressants therapy	1	0	1	0	0	1	0	1	0
HC56	Screening for congenital hearing loss	1	1	1	0	1	1	0	1	1
HC57a	Dental extraction (PHC)	1	1	1	1	0	0	0	1	1
HC57b	Dental extraction (FLH)	1	1	0	1	0	1	0	1	1
HC58a	Drainage of dental abscess (PHC)	1	1	1	0	1	1	0	1	1
HC59	Drainage of superficial abscess	1	1	1	1	1	1	0	1	1
HC5a	Counselling on kangaroo care for new-borns (CL)	1	1	1	1	1	1	0	0	1
HC5b	Counselling on kangaroo care for new-borns (PHC)	1	1	1	1	1	1	0	0	1
HC6	Management of neonatal sepsis, pneumonia and meningitis using injectable and oral antibiotics	1	1	1	1	1	1	0	1	1

DCP3 code	DCP3 intervention name	(1) IIP	(2a) IIP + CT: CE prioritisation by CE	(2b) IIP + CT: no prioritisation	(3a) IIP + CT + RR: prioritisation by CE	(3b) IIP + CT + RR: no prioritisation	(3c) IIP + CT + RR: by budget impact (low to high)	(3d) IIP + CT + RR: prioritisation by avoidable burden of disease (high to low)	(4) IIP + CT + RR + curative: prioritisation by CE	(5) IIP + CT + RR: expanded fiscal space: prioritisation by CE
HC60	Non-displaced fractures management	1	1	1	0	1	1	0	1	1
HC61	Resuscitation with basic life support measures	1	1	1	0	1	1	0	1	1
HC62	Suturing laceration	1	1	1	0	0	1	0	1	1
HC63a	Treatment of caries (PHC)	1	0	1	0	1	1	0	1	0
HC64	Basic management of MNIs and disorders	1	0	0	0	1	1	0	1	0
HC7	Pharmacological termination of pregnancy	1	1	1	1	1	1	0	1	1
HC9a	Screening of hypertensive disorders in pregnancy	1	0	1	0	1	1	0	1	0
HC9b	Screening and management of hypertensive disorders in pregnancy	1	0	1	0	1	1	0	1	0
P5	Systematic identification of individuals with TB symptoms among high-risk groups and linkages to care (active case finding)	1	0.83	0	0	1	1	0.11	1	0.01
RH1	Full supportive care for preterm new-borns	1	1	1	1	1	1	0	1	1
N/A	COVID-19: CT General ward for severe cases	0	1	1	1	1	1	0	1	1
N/A	COVID-19: CT ICU for critical cases	0	1	1	1	1	1	0	1	1

References

1. Pearson, C.A.B., et al., *COVID-19 vaccination in Sindh Province, Pakistan: A modelling study of health impact and cost-effectiveness.* PLoS Med, 2021. **18**(10): p. e1003815.
2. Affairs, U.N.D.o.E.a.S., *World Population Prospects 2019*. 2019.
3. Pearson, C., et al., *Projections of COVID-19 epidemics in LMIC countries*. 2020.