Preventing household financial hardship from severe illness: The role of cash transfers

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Declaration of own work

I William Edward Rudgard, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Student Signature

03/04/2019

Date

Abstract

Background. Severe illness, like that caused by the infectious disease tuberculosis (TB), is associated with direct expenses accessing healthcare, and indirect costs from time away from work. Cash transfers, which provide regular income transfers to eligible vulnerable households, might improve the coping capacity of poor households. This PhD aimed to investigate whether cash transfers prevent household financial hardship from severe illness.

Objectives.

1. Evaluate the effect of cash transfers on changes in household income and consumption in response to severe illness.
2. Assess uptake of social protection and financial hardship amongst drug resistant TB affected households.
3. Evaluate the most effective and affordable approach for delivering cash transfers to prevent household financial hardship related to TB.

Methods. Systematic review of conditional cash transfers, income shocks, and household coping; historical cohort study of self-reported severe illness and changes in household labour income and food consumption; cross-sectional survey of notified drug resistant TB costs; economic modelling of cash transfers and catastrophic TB-related costs in seven countries.

Results. Systematic review identified 5 studies, which together indicate that conditional cash transfers improve households' capacity to safeguard consumption in response to shocks. Panel data analysis found no effect of self-reported severe illness on household labour income or food consumption. Cross-sectional analysis indicated that uptake of social protection, including cash transfers, reduces the likelihood of experiencing financial hardship because of drug resistant TB. In economic modelling, providing cash transfers to defray TB-related costs was more effective and affordable for preventing catastrophic costs than providing cash transfers to reduce poverty amongst households vulnerable to TB.

Conclusion. Cash transfers appear to enhance the capacity of poor households to cope with severe illness. However, it remains unclear if cash transfers as currently implemented are sufficient to ensure that every household is able to meet their basic needs.

Acknowledgements

This thesis focuses on whether cash transfers can protect households from financial hardship related to illness. It was originally planned that the thesis should use linked social and health administrative data. However, when it became known that this wouldn't be possible, other data sources had to be identified. The completion of this thesis would not have been possible without the emotional support and academic guidance of many people, including family, friends, colleagues, study participants, mentors, and members of the broader academic community.

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Publications and presentations this thesis has contributed to

Research conducted as part of this thesis has resulted in two presentations at international conferences, and two publications in international peer-reviewed journals. These are listed below, and included in the thesis supplementary materials, Manuscript S1-S2, Abstract S1-S2. As first author, I took the lead in developing the conceptual arguments, methodological approach, conducting the analysis, and writing up the research. Comments from presentations, and appraisal during peer-review publication processes has provided valuable feedback and helped to strengthen the research in this thesis.

Peer-reviewed journal articles.

William E. Rudgard, Nancy S. das Chagas, et al. Uptake of governmental social protection and financial hardship during drug-resistant tuberculosis treatment in Rio de Janeiro, Brazil. Eur. Respir. J. 2018, 51: 1800274; DOI: 10.1183/13993003.00274-2018

William E. Rudgard, Carlton A. Evans, et al. Comparison of two cash transfer strategies to prevent catastrophic costs for poor tuberculosis-affected households in low- and middle-income countries: An economic modelling study. PLoS Med. 2017, 14(11): e1002418. https://doi.org/10.1371/journal.pmed.1002418

International conference presentations.

William E. Rudgard, Nancy S. das Chagas, Regina C. Gayoso, Mauricio L. Barreto, Laura C. Rodrigues, Knut Lonnroth, Ethel L. N. Maciel, Catastrophic during-treatment costs for drug-resistant tuberculosis patients with and without social protection: a patient survey in Rio de Janeiro, Brazil. In: 48th Union World Conference on Lung Health. 2017 Nov 11-14, Guadalajara, Mexico: IJTLD; 2017. Abstract nr PD-887-14

William E. Rudgard, Sedona Sweeney, Tom Wingfield, et al. Towards zero TB-affected households facing catastrophic costs: the role of governmental cash transfer programmes. In: 47th Union World Conference on Lung Health. 2016 Oct 26-29, Liverpool, UK: IJTLD; 2016. Abstract nr PD-1132-29

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List of Abbreviations

AIBF	Avaliação do Impacto do Bolsa Família
CCT	Conditional Cash Transfer
CHEERS	Consolidated Health Economic Evaluation Reporting Standards
CIDACS	Center for Integration of Data and Health Knowledge
CRPHF	Professor Hélio Fraga Reference Centre
CRESIPT	Community Randomized Evaluation of a Socioeconomic Intervention to Prevent TB
DOT	Directly Observed Therapy
DS	Drug Sensitive
DR	Drug Resistant
ENCEL	Encuesta de Evaluación de los Hogares
ENCELURB	Encuesta de los Hogares Urbanos
HIV	Human Immunodeficiency Virus
IHSN	International Household Survey Network
IQR	Interquartile Range
LRT	Likelihood Ratio Test
LTFU	Loss To Follow Up
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROGRESA	Programa de Educación, Salud, y Alimentación
ROBINS-I	Risk Of Bias In Non-randomised Studies - of Interventions
R$	Brazilian Real
SAGI	Secretary of Evaluation and Information Management

SISBEN	Sistema de Selección de Beneficiarios Para Programas Sociales
SD	Standard Deviation
SITETB	Information System on Special Treatments for Tuberculosis
SMS	Scientific Methods Scale
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
TB	Tuberculosis
UCT	Unconditional Cash Transfer
US$	United States Dollar
$	International Dollars

Chapter 1. Background, aims, and objectives

1.1 Background

1.1.1 Severe illness and household financial hardship

Worldwide, illness is associated with direct medical expenses purchasing healthcare services (e.g. consultations), direct non-medical expenses accessing health services (e.g. transportation and food), and indirect costs from time off work related to disability; or discrimination for diseases that are stigmatized (1–5). Together, these costs are a frequent cause of household financial hardship, and can hinder patients' access to healthcare services and ultimately their recovery from illness (4,6). Enshrined it its founding principle of health being a fundamental human right, the World Health Organization continues to push for international Universal Health Coverage of essential healthcare services at a price that prevents poor and rich households alike from suffering undue financial hardship (7). In response to this drive, concerted efforts have been made to minimize direct medical expenses associated with paying for healthcare services (2,3,8). However, paying for healthcare services is only a part of the financial burden of severe illness. Acknowledging this, some areas of public health, and in particular tuberculosis (TB) control, have also begun to focus on addressing direct non-medical expenses, and indirect costs associated with illness, which can be especially high for longer lasting illnesses (9–12). This approach goes beyond the conventional concept of Universal Health Coverage, and spans both the health and social development sectors (10).

1.1.2 Estimating household financial hardship from severe illness

In order to quantify the financial impact of illness for affected households, two principle approaches are used (5). The first empirical approach evaluates the impact of illness on households' non-medical consumption growth over time, with consumption referring to the sum of the monetary values of all items consumed by a household (including home-grown products) (13). The strengths of this approach are that studies are often able to use a control group, and that consumption is a reliable measure of household welfare (14). Limitations are that illness is often self-reported, and therefore, affected by the subjective perception and cultural background of respondents (15–17). The second empirical approach

used to study the financial impact of illness, is to evaluate whether households' health costs exceed a threshold of affordability considered to be catastrophic (18,19). Thresholds of affordability are usually measured using household income or non-medical consumption (18). The strength of this alternative approach is that it can provide a full breakdown of incurred costs for a particular illness. Limitations are that studies usually take a cross-sectional design, often with small sample sizes and no control group, and thresholds of affordability are often set arbitrarily with little scientific grounding (e.g. 10%, 20%, or 40% of household pre-illness income) (20).

In addition to evaluating changes in household non-medical consumption, or comparing the value of costs relative to a threshold of affordability, studies have also emphasised the importance of assessing households' use of financial coping strategies in response to severe illness (21,22). Defined as strategies to relieve the impact of shocks after they occur, households may use financial coping strategies to defray direct expenses and indirect costs associated with illness, and thus protect their current non-medical consumption, Figure 1 (23). Common coping strategies include seeking favours and gifts from family and friends, drawing on savings, and selling non-productive assets (24). In extreme circumstances, households may resort to more costly coping strategies like borrowing high interest credit, selling productive assets, and withdrawing children from school for work (21,25,26). Whilst helping households to maintain a constant level of current consumption, this second category of coping strategy can compromise households' future livelihood, and lead to long-term intergenerational consequences (22). Understanding households' use of such coping strategies provides crucial detail about the price at which they may maintain a constant level of consumption, Figure 1.

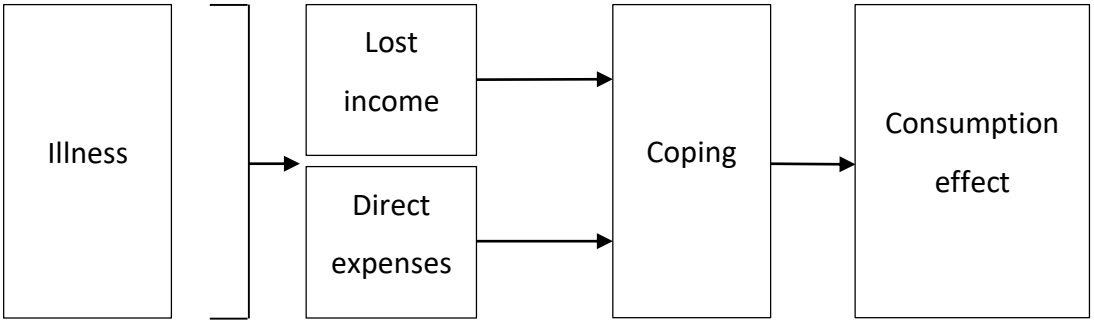

Figure 1. Conceptual framework illustrating the consumption effect of illness.

1.1.3 Preventing household financial hardship from illness

The relationship between poverty, illness, and financial hardship is multi-faceted. It is widely acknowledged that poverty leads to increased risk of illness and worse health outcomes (27). Evidence also suggests that poverty is a key determinant of financial hardship related to illness, as poorer households have limited access to formal insurance initiatives, spare income, savings, or assets that may defray or reimburse either direct expenses or indirect costs associated with illness (12,28). A combination of the known effects of poverty on health, and health on poverty suggests that these factors may be related in a positive feedback loop that households find hard to break out of. Economic models highlight the possible influence of this system, known popularly as the poverty-disease trap, on persistent poverty and economic development (29). Initiatives to reduce poverty and/or enhance poor households' ability to cope with economic shocks may have the potential to break the poverty-disease trap and impact across both Sustainable Development Goal 1: "End poverty in all its forms everywhere", and Sustainable Development Goal 3: "Ensure healthy lives and promote wellbeing for all at all ages" (30).

Designed to protect populations against poverty, livelihood risks, and social exclusion, social protection has a key role to play in both preventing illness, and helping poor households that are affected by illness to cope with the associated financial impact (31,32). There are two dominant forms of delivering social protection: social insurance, and social assistance, Table 1 (33). Social insurance protects beneficiaries against financial hardship related to unexpected sickness, unemployment, disability, and death in exchange for regular payments of premiums known as contributions, Table 1. Coverage of this type of initiative is usually low amongst poor households who find it hard to make regular contributions because of high levels of informal work and irregular income (34–36). In comparison, coverage of social assistance, which is designed to provide regular and predictable support to populations deemed eligible because of deprivation, and thus does not require regular contributions, is much higher (34). Principle social assistance initiatives include: cash transfers, non-contributory social pensions, food and in-kind transfers, school feeding programs, public works, and fee waivers, Table 1 (33).

Table 1. Summary of key social protection initiatives.

Social protection: A set of initiatives that secure protection aimed at preventing or alleviating poverty, livelihood risks and social exclusion (33).
Social insurance: An initiative to provide transfers to households in the event of adverse economic events, conditional on prior contributions and participation in the labour market (33).
Examples: Sickness benefits, unemployment benefits, disability benefits and survivor's benefits.
Social assistance: An initiative to provide transfers to deprived households unconditional on previous payments or contributions (33).
Examples: Cash transfers, in-kind transfers, non-contributory social pensions, and fee waivers.

Households in poverty, and on the margins of poverty have heightened risk of illness, and associated financial hardship, and are therefore, a priority population for protection from direct expenses and indirect costs related to illness (27,28). Healthcare services funded or subsidized by government budgets are the most effective way of reducing the burden of direct medical health expenses for poor households, and many countries are making steady progress towards this goal (2,3). Alternatively, conclusive recommendations for protecting poor households against direct non-medical expenses and indirect costs related to illness are currently lacking. Cash transfers, which are based on regular and predictable income transfers to populations living below a poverty threshold, are one form of social protection that might help in this regard. Cash transfers may be given to beneficiaries with or without conditions. Unconditional cash transfer (UCT) initiatives provide regular income transfers to eligible households with no strings attached; whereas conditional cash transfer (CCT) initiatives make receipt of transfers contingent on utilization of public services (e.g. education and healthcare) as further encouragement for recipients to invest in child education, health, and nutrition (37).

Since the 1990s, cash transfers have been adopted by an increasing number of governments in low- and middle-income countries as central elements of their poverty-

reduction strategies (33). The value of monthly transfers is usually around 20% of pre-transfer monthly household consumption, which for an average household living on the international poverty line is approximately US$ 46 (37,38). Synthesised evidence indicates that cash transfers have the potential to reduce monetary poverty, stimulate health service use, increase school attendance, improve dietary diversity, and foster economic autonomy via accumulation of savings (39). There is also evidence supporting the potential of cash transfers to contribute to disease prevention, and improve health outcomes for affected populations (40–45). The simple design of cash transfer initiatives lends itself to high numbers of beneficiaries like in Brazil and Mexico, where in 2016, anti-poverty cash transfers were distributed to 55 million households, and 26 million households, respectively (46).

The primary objective of governmental anti-poverty cash transfer initiatives is to reduce current poverty by providing immediate income, and reduce future poverty by enabling investments in child education, health, and nutrition (37). Based on evidence demonstrating the potential of cash transfers to achieve these objectives, there are several ways that cash transfers may act on the poverty-disease trap, and ultimately protect households from experiencing financial hardship from severe illness (39). Firstly, by reducing current poverty and associated disease risk factors like undernutrition, they may altogether prevent some households from experiencing poverty-related illnesses and any associated financial hardship, Figure 2 (39,47,48). Secondly, for poor households who continue to experience severe illness, cash transfer initiatives may increase their capacity to cope with this adversity; however, the potential of cash transfers achieving this may vary according to when households begin to receive them (49–51). Specifically, if households receive cash transfers prior to experiencing severe illness, they may benefit from both additional savings/assets which cash transfers have helped them accumulate, as well as the ongoing monthly income effect (49–51), Figure 2. On the other hand, if households uptake cash transfers at the onset of severe illness they may only benefit from their monthly income effect, Figure 2.

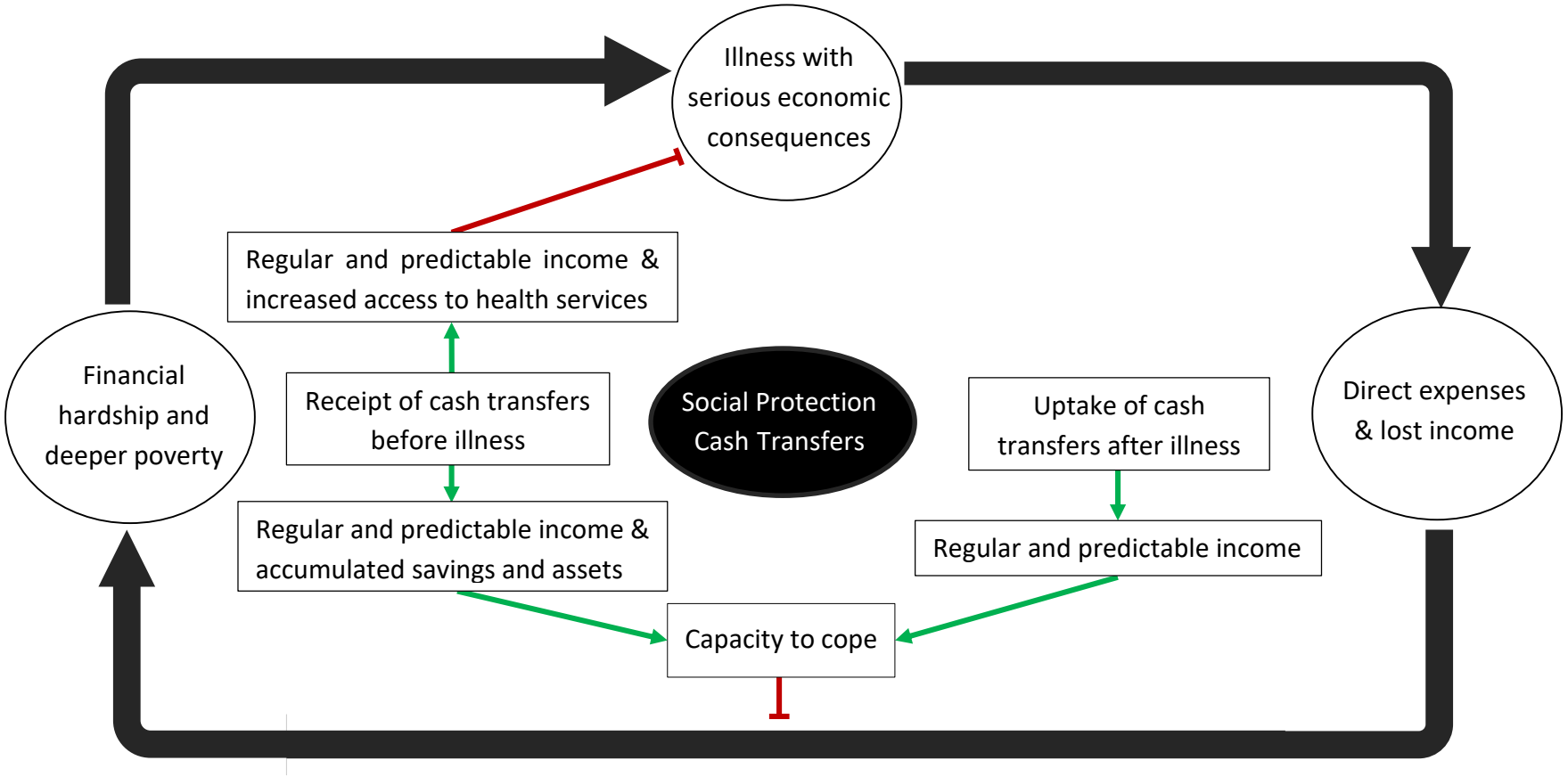

Figure 2. Conceptual framework illustrating the impoverishing effect of illness, and the protective effects of prior or subsequent receipt of cash transfers.

Green arrows indicate a strengthening effect of cash transfers. Red arrows indicate an attenuating effect of cash transfers.

1.1.4 Tuberculosis as a severe illness known to cause household financial hardship

Severe illness that results in patients having to take time off work is known to cause excessive financial hardship. TB is one such illness (4). It is an infectious disease caused by Mycobacterium tuberculosis, which can be contracted by breathing in the air that someone suffering from the disease has contaminated (52). In 2017, an estimated 10 million people fell ill with TB, and it was the leading cause of death from a single infectious agent (52). TB generally affects the lungs but can also affect other parts of the body (52). Without prompt diagnosis and treatment, TB is severely debilitating, causing exhaustion, weight loss, and inability to work (52). The recommended treatment duration for drug sensitive (DS) TB is six months, and for drug resistant (DR) TB is up to 24 months (52). Because the early symptoms of TB - cough and loss of appetite - lack distinctive characteristics, evidence also shows that, on average, patients spend 2 months seeking a TB diagnosis (53).

Most prevalent in low- and middle-income countries, TB disproportionately affects poor households that are least able to afford the burden that TB-related costs represent relative to their income (12,54,55). Even when diagnosis and treatment is available free of direct charges, households affected by TB are known to incur extreme health costs (12). Systematic review of TB-related costs across low- and middle-income countries found that whilst direct expenses are a major component, indirect costs contribute most to the economic impact of TB illness (direct medical expenses: 20%; direct non-medical expenses: 20%; indirect costs: 60%) (12). Addressing households' TB-related costs is essential for ensuring that people with active TB disease are able to complete their treatment successfully without falling into poverty (56). Acknowledging this, the World Health Organization's End TB Strategy includes a high-level financial risk protection milestone for 2020: "zero TB-affected households facing catastrophic costs due to TB" (9).

Social protection initiatives have been endorsed as a key instrument for preventing TB-affected households from experiencing catastrophic costs (9). Appreciating that TB disproportionately affects poor households, pro-poor social assistance initiatives, including cash transfers, are considered a particularly effective form of social protection for TB-affected households. Estimates for coverage of social insurance or social assistance in TB-affected households remain scarce. In Brazil, 13% of notified TB patients have been found to

receive anti-poverty cash transfers, and in South Africa, close to 45% of households affected by multidrug resistant TB access non-contributory disability transfers during treatment (57,58). Evidence for the potential of cash transfers to protect households from experiencing financial hardship in response to TB is also limited. In 2015, a Cochrane review of the use of cash transfers in TB control identified no studies with financial hardship as an outcome (59). Since then, evidence from a randomised control trial in Lima, Peru has demonstrated the effectiveness of cash transfers to defray TB-related catastrophic costs and improve treatment outcomes (45,56).

Table 2. Summary of key background messages for the thesis.

1. Illness is associated with direct medical expenses purchasing healthcare, direct non-medical expenses accessing care, as well as indirect costs from time off work related to disability.
2. Costs associated with illness are a frequent cause of household financial hardship, especially for households in poverty.
3. Social protection has a key role to play in helping households to cope with the financial impact of illness, and social assistance initiatives, including cash transfers, may be most appropriate for households in poverty.
4. TB is an illness known to cause excessive financial hardship for affected households. Indirect costs are a key driver of TB-related financial hardship.
5. Social protection initiatives have been endorsed as a key instrument for preventing TB affected households from experiencing catastrophic costs.

TB, tuberculosis.

1.2 Research gaps and rationale for this work

Ensuring healthy lives, ending poverty, and promoting inclusive and sustainable economic growth are each goals in the 2030 Agenda for Sustainable Development adopted by the 193 United Nations Member States (30). Illness is a common cause of household financial hardship especially for those in poverty. Preventing household financial hardship from illness might improve treatment outcomes, reduce poverty, and support economic growth (56,60).

Previous efforts to prevent household financial hardship from illness have focused primarily on minimising direct medical expenses related to purchasing healthcare services. However, in addition to direct medical expenses, direct non-medical expenses accessing healthcare services, and indirect costs related to time away from work are also important drivers of financial hardship, especially for longer lasting illness (12). Limited research has evaluated the potential of interventions to protect households from these additional cost components (56,61). Cash transfers, are one social protection initiative from beyond the health sector that may help poor households to cope with the economic consequences of severe illness. Three specific research gaps that remain for informing the potential of cash transfers to protect households from financial hardship related to severe illness include:

1. Uncertainty if governmental anti-poverty cash transfers protect poor households from financial hardship related to severe illness.
2. Lack of knowledge as to which governmental social protection initiatives are accessed by TB-affected households during care, and whether they are sufficient to protect against household financial hardship.
3. Doubt whether providing cash transfers to make poor households at risk of TB more resilient to TB-related costs, or to defray poor households' costs after a family member develops TB is more effective and affordable for preventing financial hardship.

1.3 Aim, research objectives, and methodological approach of this thesis

To address the three research gaps outlined above, the overall aim of this thesis was to establish whether cash transfers can prevent poor households from experiencing financial hardship from severe illness, like that caused by the infectious disease TB. In line with this aim, the thesis pursued five research objectives:

1. Summarise existing evidence for the potential of governmental anti-poverty conditional cash transfers to help poor households cope with household-level shocks especially severe illness.
2. Quantify the protective effect of governmental anti-poverty conditional cash transfers on household labour income and food consumption growth in response to self-reported severe illness with serious economic consequences in Brazil.
3. Describe the proportion of households affected by DR TB that uptake social protection during treatment in Rio de Janeiro, Brazil.
4. Evaluate whether uptake of social protection during DR TB treatment protects household from experiencing financial hardship in Rio de Janeiro, Brazil.
5. Assess the most effective and affordable way of providing cash transfers to households affected by TB to prevent them experiencing financial hardship.

The thesis took a predominantly quantitative approach to achieve its aim and objectives. For objective (1), it conducted a systematic literature review of evidence published before December 2016 relating to the impact of conditional cash transfers on both poor households' ability to maintain a constant level of consumption, and their use of coping strategies in response to household-level shocks. For objective (2), it undertook a historical cohort study of 9457 poor Brazilian households using publically available secondary data that was collected in the early years of the Brazilian government's rollout of its renowned Programa Bolsa Família conditional cash transfer program. For objective (3) and (4), it used a cross-sectional survey of 119 DR TB patients in Rio de Janeiro, Brazil. For objective (5), it conducted a country-level economic modelling study in seven countries using secondary data collected from a literature review.

Chapter 2. Review of conditional cash transfers and financial hardship

2.1 Research gaps addressed by reviewing the literature

In line with objective (1) of this thesis, this chapter aimed to summarise existing evidence of the impact of governmental anti-poverty cash transfers on poor households' consumption growth, and use of coping strategies in response to idiosyncratic shocks, such as death, injury, or unemployment. In doing so, this chapter addresses the first research gap identified by the thesis for informing the potential of cash transfers to protect households from financial hardship related to severe illness: Uncertainty if cash transfers protect poor households from financial hardship related to severe illness.

2.2 Key findings from reviewing the literature

The reviewed evidence indicates that cash transfers may protect household consumption growth, as well as reduce household informal borrowing and withdrawal of children from school, all in response to household-level shocks.

2.3 Background to review

Shocks are classified into two broad categories: covariate and idiosyncratic (62,63). Covariate shocks affect communities, regions, or whole countries, and include events like: natural disasters, disease epidemics, and financial crises (63). Idiosyncratic shocks affect particular individuals or households, and include events like: unemployment, illness, death, and loss of crops or livestock (63). In low- and middle-income countries, when faced with shocks, unable or reluctant to access formal insurance, poor households rely on other strategies to maintain a basic level of consumption (21).

How households react to idiosyncratic shocks has been widely studied. Much of this research has focussed on poor households' ability to maintain a constant level of consumption in response to shocks, and in most cases shows that households are unable to do this (13,62,64–66). Furthermore, evidence shows that that when faced with an idiosyncratic shock, households have to use coping strategies to fund their consumption

such as drawing on informal networks or savings, mobilising assets; and even turning to more costly strategies like borrowing high-interest credit, or withdrawing children from school (21,22,24,67,68). The inability of households to cope with idiosyncratic shocks and their reliance on harmful coping strategies is a key driver of poverty worldwide. Formulating policies that build the resilience of poor households is critical. This is formally recognised in target 1.5 of Sustainable Development Goal 1: “End poverty in all its forms everywhere”, which calls for the need to build the resilience of households in poverty to economic, social, and environmental shocks (30).

As a form of social protection, social assistance initiatives are an effective way of supporting poor and vulnerable households. Originating in Brazil and Mexico in the 1990s, and now operated in over 60 countries, conditional cash transfers (CCTs) are a particularly popular social assistance initiative (33,37). They provide regular and predictable income to eligible poor households; and by making receipt of cash transfers contingent on utilization of public services, they incentivise investments in education, health, and nutrition (33,37). Studies consistently show that CCTs increase household income, consumption, and savings (39,61). The last attempt to review the literature for evidence of the effect of CCTs on households’ ability to cope with income shocks was conducted in 2010 (61). The review, which was part of a broader review of the economic impacts of CCTs, concluded that CCTs "protect household consumption and educational patterns during times of crisis" (61). However, the study did not provide an indication of the degree of protection that CCTs might provide, and results were not disaggregated by different types of shock.

There are two mechanisms by which CCTs might help households cope with shocks. They might help households prepare for shocks before they occur by alleviating credit constraints and supporting accumulation of wealth either as formal bank savings, or, in settings where financial institutions such as banks are not readily available, informal savings or assets (49–51). CCTs might also help households respond to shocks after they occur by guaranteeing a continued regular and predictable source of income. Households’ increased ability to mobilise savings and assets together with a guaranteed regular source of income might enable them to avoid using costly coping strategies like borrowing high-interest credit, or withdrawing children from school for work, to finance their consumption, Figure 3.

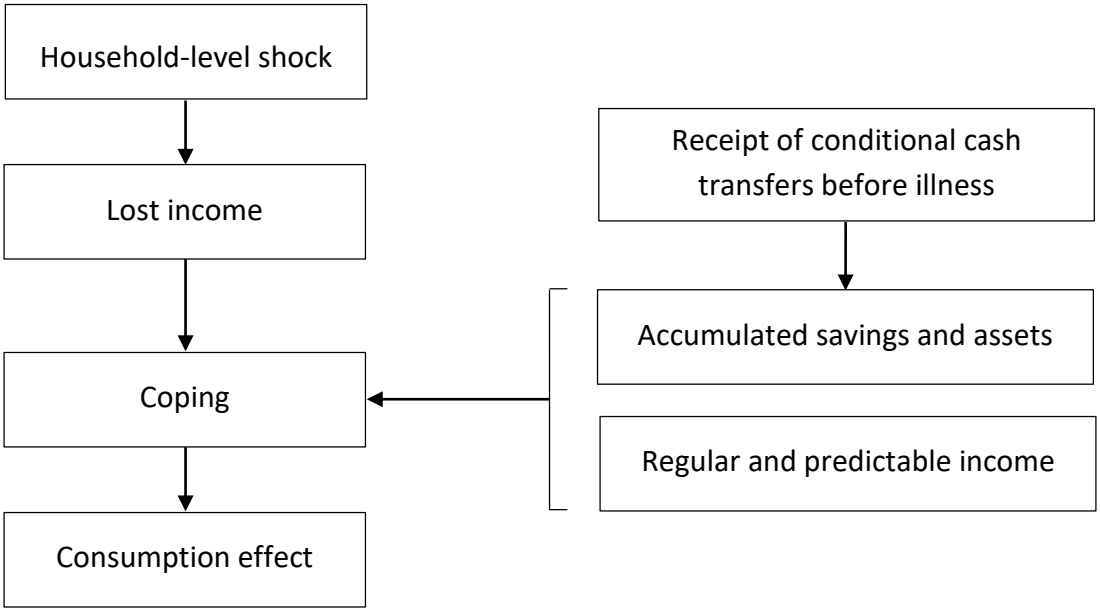

Figure 3. Conceptual framework illustrating the negative consumption effect of idiosyncratic shocks, and the protective effect of prior receipt of conditional cash transfers.

This review aimed to update evidence, and provide a quantitative summary of the impact of CCTs on poor households' capacity to cope with shocks. For transparency, the review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (69).

2.4 Review methodology

2.4.1 Electronic searches

According to the PICO framework for developing literature search strategies, in this review, the population of interest was poor and vulnerable households, the intervention was receipt of CCTs, the comparator no receipt of CCTS, and outcomes of interest were the effect of CCTs on a) household consumption growth, and b) use of coping strategies in response to idiosyncratic shocks (70). This framework was used to develop a search strategy relating to CCTs, idiosyncratic shocks, consumption, and coping strategies. A systematic search strategy was employed using three electronic bibliographic databases: Econlit, Social Policy & Practice, and Global Health. Search terms were entered in English. The full search strategy is included in Table S1.

2.4.2 Types of studies included in the review

The review searched studies published from inception of database to December 2016 reporting original analyses. Randomised and observational studies comparing households by receipt of CCTs, or by situation in a community targeted by CCTs were eligible for inclusion. CCTs were defined as programs transferring cash to poor households on the condition that they make pre-specified investments in the human capital of their children (37). Both peer-reviewed and grey literature studies (e.g. working papers) were eligible for inclusion.

For inclusion, studies had to evaluate a) the change in household consumption in response to a shock; and/or b) household use of coping strategies in response to a shock. Shocks were defined as an idiosyncratic health, economic, or social incident that reduces household wellbeing (71). The impact of CCTs on households' ability to cope with covariate shocks was not studied as unlike for idiosyncratic shocks, this kind of shock has widespread effects on local markets (labour, food, credit etc.), which alters the coping strategies that are available to households (72). Household consumption was defined as the sum of the monetary values of all items (final goods and services) consumed by the household (including home-grown products) during the reference period (73), and coping strategies were defined as strategies to relieve the impact of shocks after their occurrence (23). Studies also had to use a research design corresponding to a score of two or above on the five-point Maryland Scientific Methods Scale (SMS), Table S2 (74). The Maryland SMS ranks policy evaluations from one (least robust) to five (most robust) according to the method used, with robustness referring to the extent to which a study's design attempts to deal with selection and confounding biases inherent to policy evaluations. The Maryland SMS was used to decide on inclusion of studies in a previous review on the economic impact of CCTs (75). Included studies had to be in a low- or middle-income country as defined by the World Bank (76).

2.4.3 Data extraction and management

Information extracted from included studies included: First author, year of publication, peer reviewed publication (Yes/No), study country, study data source, year data source was collected, study design, study sample size, CCT name, CCT target population, shock, and effect of CCTs on household consumption and/or use of coping strategies in response to a shock. As recommended by Cochrane Methods, risk of bias in included studies was assessed

using the Risk Of Bias In Non-randomised Studies - of Interventions (ROBINS-I) assessment tool (77,78). The tool assesses study designs against a hypothetical pragmatic 'target randomised control trial' and focuses on seven domains of potential bias: confounding, selection bias, misclassification, time-varying confounding, missing data, measurement of outcomes, outcome reporting. For this review, the target trial that study designs were compared to was assignment to CCTs versus control. All evaluations were assessed for their dealing of potential confounding by household demographic factors (e.g. household size, household location, and sex, ethnicity, education of household head), and household poverty and labour (e.g. household labour and total income, number of economically active household members, employment of household head, and household access to credit). Evaluations were also assessed for whether they investigated if there was differential receipt of anti-poverty benefits from other social protection policies or initiatives by treatment status. Because the lowest risk of bias judgement in ROBINS-I corresponds to the risk of bias in a high quality randomised control trial, and for comparability across studies, in addition to non-randomised studies, ROBINS-I was also used to assess risk of bias in randomised studies included in the review.

2.4.4 Data synthesis

Extracted effect estimates were summarised using forest plots. A meta-analysis was not conducted as the review returned too few studies, and it was not appropriate to synthesise results across distinct shocks.

2.5 Characteristics of identified studies

The main literature search resulted in 68 citations, Figure 4. After screening of abstracts, 14 full text articles were retrieved (24,79–91), 5 of which were included in the review (79,80,84,85,91), Figure 4.

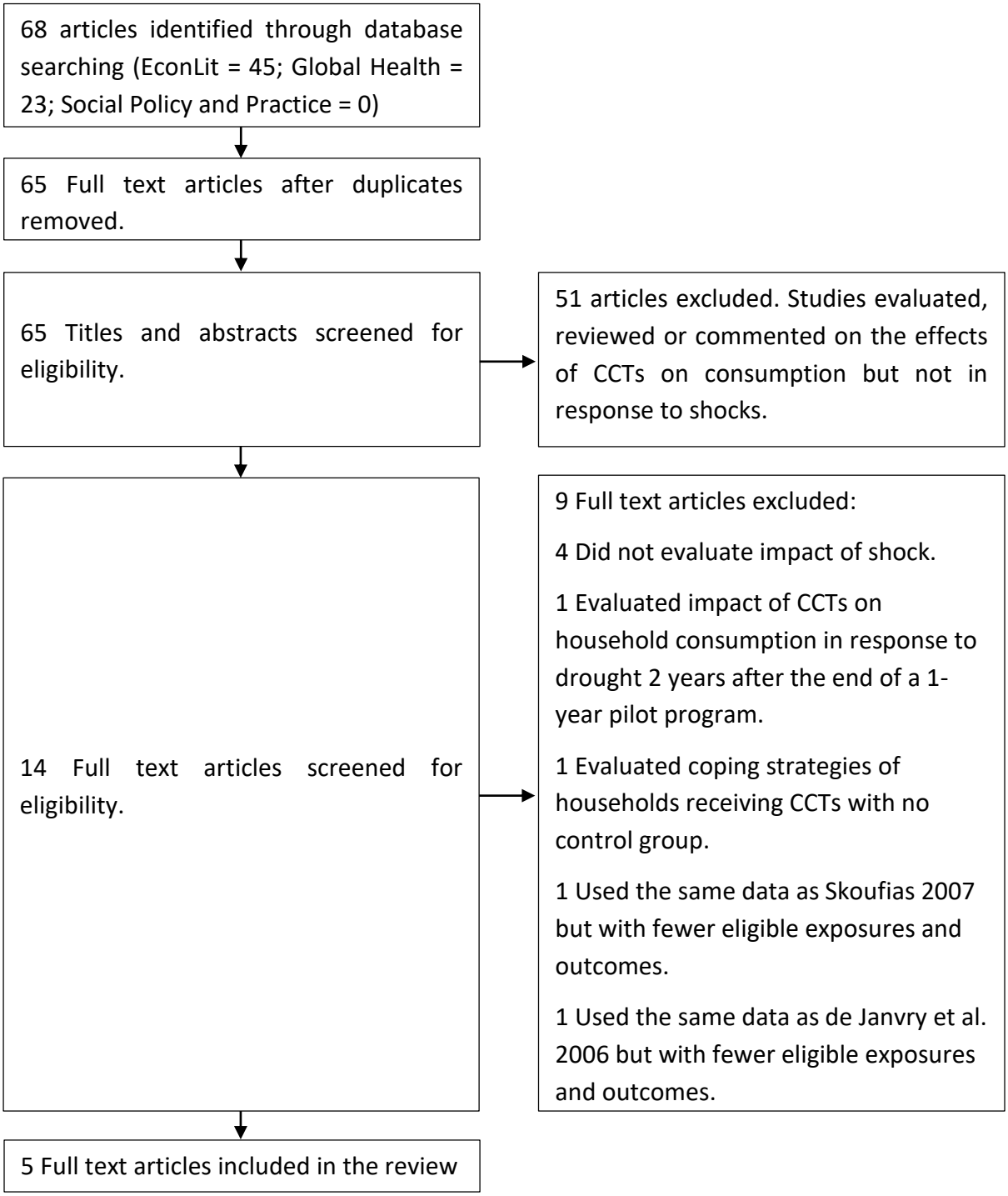

Figure 4. Flow chart of the review process.

CCT, Conditional Cash Transfer.

2.6 Findings from reviewed studies

2.6.1 Conditional cash transfer programmes

Evaluated CCT programmes were: Familias En Acción in Colombia (84), and Programa de Educación, Salud, y Alimentación (PROGRESA)/Oportunidades in Mexico (79,80,85,91). One study focused specifically on the urban component of PROGRESA/Oportunidades (85). The objectives of Familias En Acción and PROGRESA/Oportunidades were both to advance child health and education (37). Both programmes were made up of cash transfers conditional on regular visits to the health clinic for mothers and young children, and cash transfers conditional on child school attendance (37). Eligibility for PROGRESA/Oportunidades was determined using geographical, proxy-means and community targeting, and for Familias en Acción using geographical and proxy-means targeting (37,92). For both programmes, the average value of monthly CCTs received by treatment households was approximately 20% of monthly household total income (37). Included studies measured household exposure to CCTs as either household receipt of CCTs (84,85), or household situation in a community targeted by CCTs (79,80,91). In studies where analyses were conducted at both the household- and community-level, we extracted results from the primary analysis, which in both cases were at the household-level (80,84).

2.6.2 Study designs

Details of included studies are summarised in Table 3. Two studies involved explicit randomisation of treatment and control groups and had a Maryland SMS score of 5 (79,80), two involved comparing outcomes between matched treatment and control groups and had a Maryland SMS score of 3 (84,91), and one was a cross-sectional comparison of treated and control groups and had a Maryland SMS score of 2 (85), Table 3. Both randomised studies evaluated PROGRESA/ Oportunidades and involved the same random and sequential crossover of villages to treatment in 1998 and 2000 (79,80). One restricted the study population to only households eligible to receive CCTs (79). Across the three non-randomised studies, one evaluated PROGRESA/ Oportunidades and used matching to select a group of control villages in 2003 (91). In this study, control villages were crossed-over to treatment between baseline and follow-up. As a result, this study evaluated the effect that duration of receipt of cash transfers had on household consumption growth, rather than the

overall treatment effect of CCTs. Another study evaluated urban PROGRESA/Oportunidades, and using matching to select a control group of eligible/quasi-eligible households (85). The last study evaluated Familias en Acción and used matching to select a group of control municipalities according to region, population size, area, quality of life index, and an index of educational and health infrastructure (84).

2.6.3 Risk of bias assessment

Risk of bias judgements based on ROBINS-I for each evaluation of the effect of CCTs on households' consumption growth, or their use of coping strategies in response to household-level shocks are summarised in Table 4. With regards to evaluations of the effect of CCTs on households' consumption growth in response to an idiosyncratic shock, two of the three studies evaluating this outcome were assessed to have low risk of bias (80,84). The third study was assessed to have moderate risk of bias, as control communities were matched to treatment communities several years after treatment was initiated (91). For evaluations of the effect of CCTs on households' use of coping strategies in response to an idiosyncratic shock, three of the four studies evaluating this outcome were assessed to have low risk of bias (79,80,84). One study was assessed to have serious risk of bias, as participants' treatment status was not recorded at the start of the intervention and could have been influenced by whether they experienced a household-level shock and used a coping strategy (85). Across studies included in the review, there was either poor, or no reporting of information on missing data, which meant that few studies' risk of bias judgements could be informed by this domain.

Table 3. Summary of studies included in the review.

Study	Peer reviewed	Study location	Data source	CCT programme	Measure of shock	Study population
Consumption effect						
Skoufias, 2007	Yes	Mexico	ENCEL (1998, 1999)	PROGRESA/ Oportunidades	(i) 10% household income drop. (ii) Indicators for lost crops, lost livestock, lost land, or lost home related to natural disaster.	506 communities randomly allocated to treatment (n=320) and control (n=186) in May 1998 with sequential cross-over of control communities to treatment in Dec 1999.
Ospina, 2010	No	Colombia	SISBEN (2002, 2003, 2005/06)	Familias en Acción	(i) 10% household income drop. (ii) Indicators for unemployment of household head, illness of household head, death of a household member and crop loss.	Representative stratified sample of treatment municipalities (n=57), and matched sample of control municipalities (n=65).
Uchiyama , 2106	No	Mexico	ENCEL (2003, 2007)	PROGRESA/ Oportunidades	(i) 10% household income drop.	506 communities randomly allocated to treatment (n=320) and control (n=186) in May 1998 with sequential cross-over of control communities to treatment in Dec 1999. An additional group of 151 control communities was matched to treatment communities in 2003, and crossed-over to treatment through 2004.
Coping strategies						

de Janvry, 2006	Yes	Mexico	ENCEL (1998,1999, 2000)	PROGRESA/ Oportunidades	Indicators for unemployment of household head, illness of household head, illness of younger siblings, natural disaster, and lost crops, livestock or land related to natural disaster.	10,855 households eligible to receive CCTs amongst 506 communities randomly allocated to treatment (n=320) and control (n=186) in May 1998 with sequential cross-over of control communities to treatment in Dec 1999.
Skoufias, 2007	Yes	Mexico	ENCEL (1999)	PROGRESA/ Oportunidades	Indicators for lost crops, lost livestock, lost land, or lost home related to natural disaster.	506 communities randomly allocated to treatment (n=320) and control (n=186) in May 1998 with sequential cross-over of control communities to treatment in Dec 1999.
Ospina, 2010	No	Colombia	SISBEN (2002, 2003, 2005/06)	Familias en Acción	Indicators for unemployment of household head, illness of household head, death of family member, and crop loss.	Representative stratified sample of treatment municipalities (n=57), and matched sample of control municipalities (n=65).
Vinay, 2010	Yes	Mexico	ENCELURB (2004)	PROGRESA/ Oportunidades (urban component)	Indicator for death, unemployment, property-damaging fire, loss of a business, accident, illness, marital separation or problems with the law.	3541 households that experienced a shock amongst a representative stratified sample of beneficiary households in treatment areas (n=11,563), and matched sample of eligible/quasi-eligible control households in treatment areas (n=5638).

Abbreviations: CCT, Conditional Cash Transfer; ENCEL, Encuesta de Evaluación de los Hogares; ENCELURB, Encuesta de los Hogares Urbanos; SMS, Scientific Methods Scale; PROGRESA, Programa de Educación, Salud y Alimentación; SISBEN, Sistema de Selección de Beneficiarios Para Programas Sociales.

Table 4. Summary of risk of bias judgements of studies included in the review.

Study	Risk of bias domain							Overall risk of bias
	Confounding	Selection bias	Classification	Deviations	Missing data	Outcome	Reporting	
Consumption effect								
Skoufias, 2007	Low risk	Low risk	Low risk	Low risk	No information	Low risk	Low risk	Low risk
Ospina, 2010	Low risk	Low risk	Low risk	Low risk	Insufficient information	Low risk	Low risk	Low risk
Uchiyama, 2016	Low risk	Moderate risk	Low risk	Low risk	Insufficient information	Low risk	Low risk	Moderate risk
Coping strategies								
de Janvry, 2006	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Skoufias, 2007	Low risk	Low risk	Low risk	Low risk	No information	Low risk	Low risk	Low risk
Ospina, 2010	Low risk	Low risk	Low risk	Low risk	Insufficient information	Low risk	Low risk	Low risk
Vinay, 2010	Low risk	Moderate risk	Serious risk	Low risk	Insufficient information	Low risk	Low risk	Serious risk

2.6.4 Evaluated shocks and coping strategies

Evaluated idiosyncratic shocks included a 10% household income drop controlling for average change in community income (80,84,91), an indicator of "any" self-reported shock (85), and indicators of eight specific self-reported shocks: death of a household member (79,84), illness of household head (79,84), illness of household child (79), unemployment of household head (79,84), loss of harvest (79,80), loss of livestock (79,80), loss of land (79,80), and loss of home (80). Evaluated coping strategies included: reducing household expenditures (84,85), using savings (80,84), using assets (80,84), borrowing informal credit from family or friends (80,84,85), using social support from family and friends (80), getting government help (80), borrowing formal credit (84), increasing household work (80,84), increasing child work (79,84), maintaining child school attendance (79,84).

2.6.5 Conditional cash transfers and consumption in response to shocks

Three studies evaluated the effect of CCTs on family food, non-food and/or total consumption in response to idiosyncratic shocks (80,84,91), Figure 5, Figure 6, and Figure 7. In response to shocks that had a negative effect on family consumption, CCTs had a consistently protective effect (Range of CCT treatment effect: 0.04 % point difference to 14.1 % point difference) (80,84,91). This effect was significant in response to loss of harvest in Colombia ($p<0.1$), and loss of livestock in Mexico ($p<0.1$) (80,84). The largest reduction in family consumption was in response to unemployment of household head (Effect of shock across food, non-food, and total consumption: -15.5%, -28.5%, and -23.6%, respectively), and for this shock, the treatment effect of CCTs was noticeably small (Treatment effect of CCTs across food, non-food, and total consumption: 0.5 % point difference, 7.7 % point difference, and 6.3 % point difference respectively) (84). In response to death of a household member, which had a positive effect on family non-food and total consumption, CCTs also had a significant protective effect (CCT treatment effect: -18.2 % point difference, $p<0.01$; and -19.8 % point difference, $p<0.05$, respectively) (84). Across studies, the treatment effect of CCTs on family consumption was reduced by education and employment-status of household head, and increased by household eligibility for CCTs, and duration of receipt of CCTs (80,91).

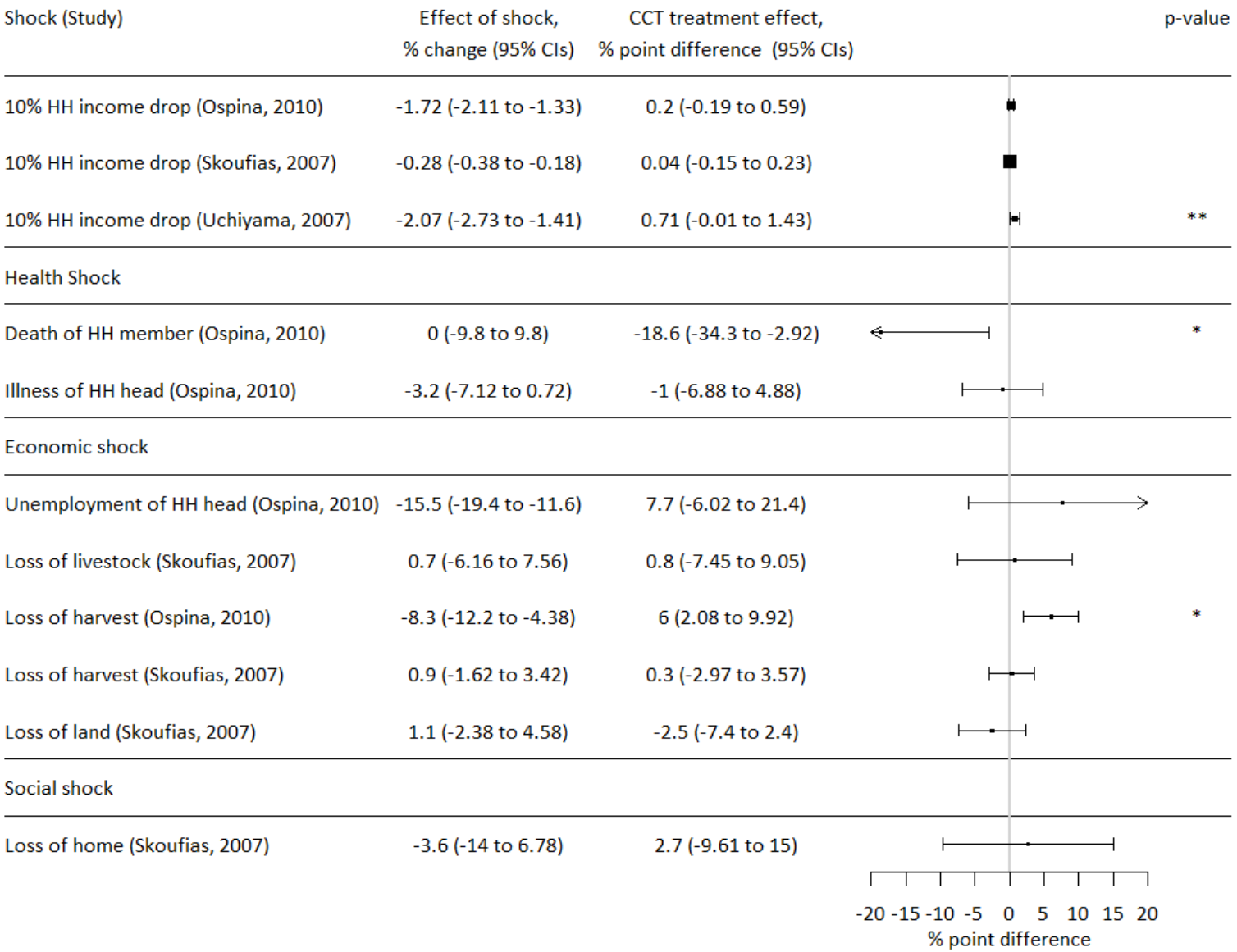

Figure 5. Forest plot summarising the effect of conditional cash transfers on food consumption in response to a shock.

Abbreviations: CCT, Conditional Cash Transfer; HH, Household; CI, Confidence Intervals. Estimates are from ordinary least square model. Box size is based on precision.

*p<0.1, **p<0.05, ***p<0.01.

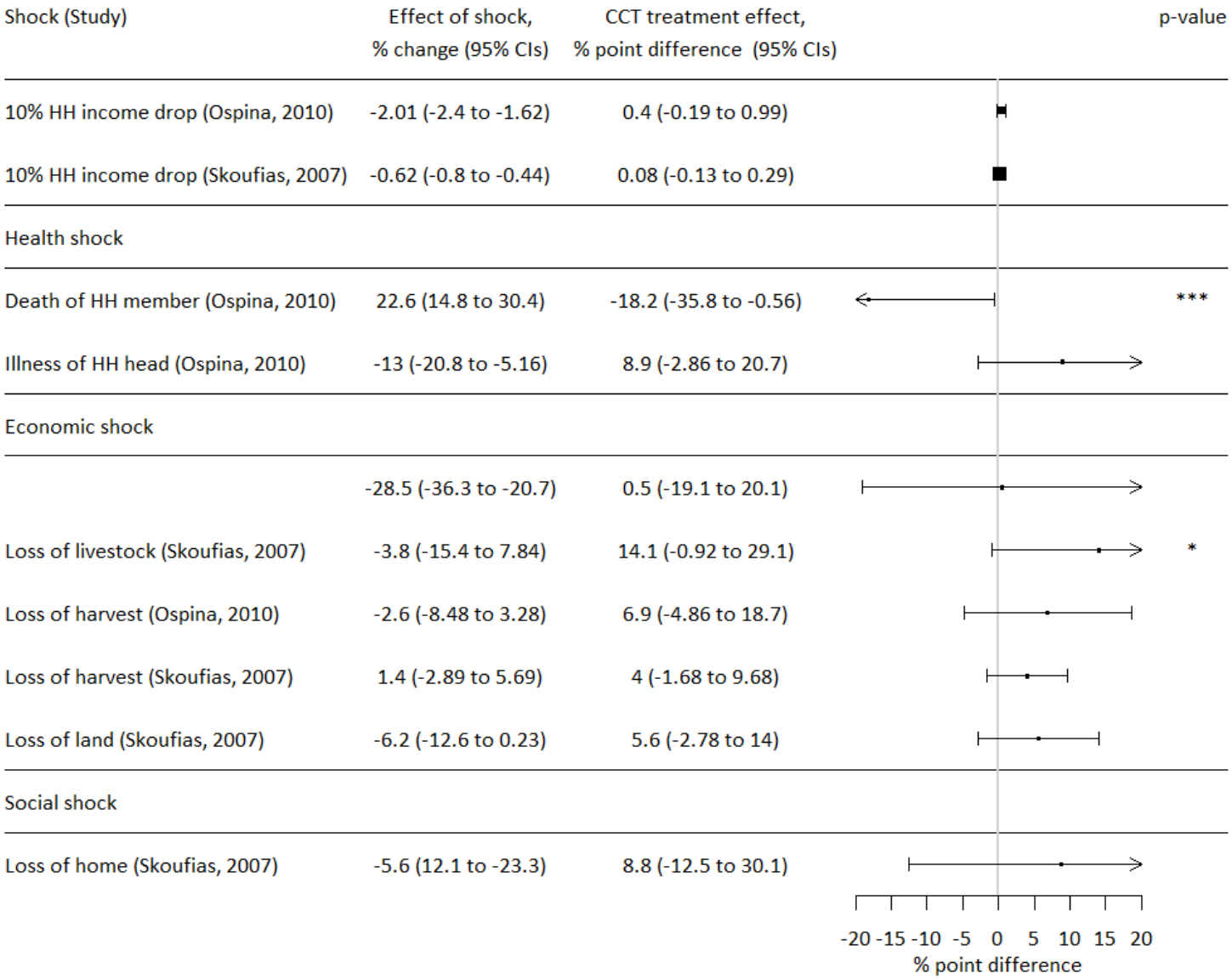

Figure 6. Forest plot summarising the effect of conditional cash transfers on non-food consumption in response to a shock.

Abbreviations: CCT, Conditional Cash Transfer; HH, Household; CI, Confidence Intervals. Estimates are from ordinary least square model. Box size is based on precision.

*p<0.1, **p<0.05, ***p<0.01.

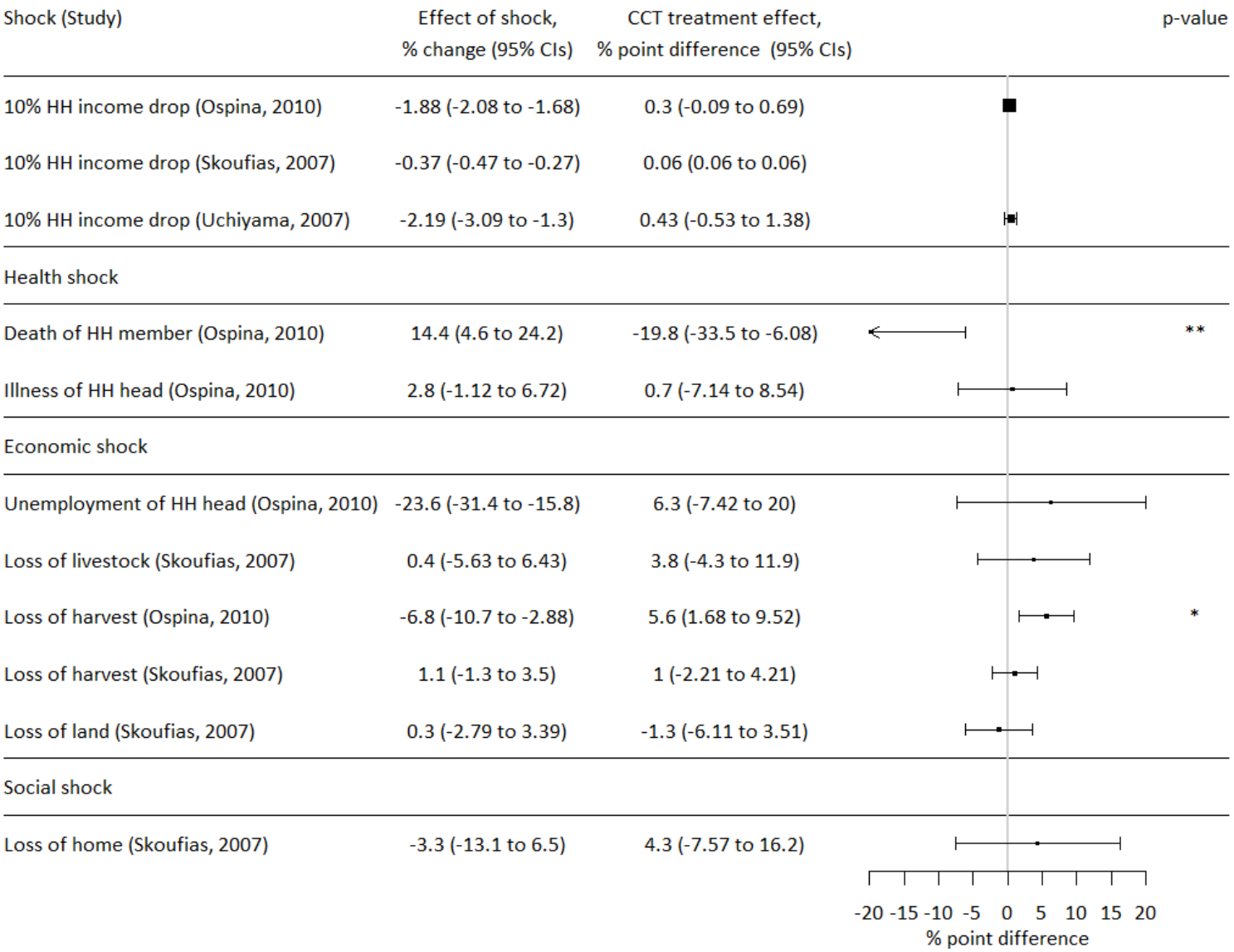

Figure 7. Forest plot summarising the effect of conditional cash transfers on total consumption in response to a shock.

Abbreviations: CCT, Conditional Cash Transfer; HH, Household; CI, Confidence Intervals. Estimates are from ordinary least square model. Box size is based on precision. *p<0.1, **p<0.05, ***p<0.01.

2.6.6 Conditional cash transfers and use of coping strategies in response to shocks

Four studies evaluated the association between CCTs and household use of coping strategies in response to idiosyncratic shocks (79,80,84,85), Figure 8. Shocks were consistently associated with increased informal borrowing from family and friends (Range of effect of shock: 0.003 to 0.265), but to a lesser extent amongst CCT treatment households in response to summary measures of any shock, loss of harvest, or loss of livestock (Range of negative CCT treatment effect: -0.002 to -0.25) (80,84,85). Evidence consistently showed that CCTs were associated with increased probability of child school attendance in response to shocks (Range of positive CCT treatment effect: 0.01 to 0.05) (79,84). Apart from this, there was no obvious trend for an association between CCTs and household use of coping strategies. In response to specific shocks, there was weak evidence for an association between CCTs and increased probability of households reducing spending, using assets, seeking social support from friends and family, getting help from the government, and increasing household work, as well as decreased probability of households using assets, and increasing household work (79,80,84,85). There was stronger evidence for an association between CCTs and child work in response to loss of land, harvest, or livestock, whereby overall this shock was associated with decreased probability of using child work in all groups (Effect of shock: -0.019), but to a lesser extent amongst CCT treatment households (CCT treatment effect: 0.02) (79). Illness of household head, and illness of household child were both associated with increased child work overall, and to no lesser extent amongst CCTs treatment households (79). Studies were underpowered to detect associations between CCTs and use of coping strategies in response to rare shocks like death of a household member (84).

Shock (Study)	Effect of shock, Probability (95% CIs)	CCT treatment effect, Dif. in probability (95% CIs)	p-value
Reduce spending			
Any shock (Vinay, 2010)	~	0.04 (0.01 to 0.08)	*
Illness of HH head (Ospina, 2010)	-0.04 (-0.22 to 0.13)	0.04 (-0.19 to 0.28)	
Death of HH member (Ospina, 2010)	-0.15 (-0.39 to 0.09)	0 (-0.33 to 0.33)	
Loss of harvest (Ospina, 2010)	0.43 (0.27 to 0.59)	-0.02 (-0.27 to 0.24)	
Use savings			
Illness of HH head (Ospina, 2010)	0.14 (-0.04 to 0.31)	0.01 (-0.23 to 0.24)	
Death of HH member (Ospina, 2010)	0.24 (0.04 to 0.43)	-0.04 (-0.38 to 0.29)	
Loss of harvest (Ospina, 2010)	-0.06 (-0.18 to 0.06)	0.08 (-0.09 to 0.26)	
Use assets			
Illness of HH head (Ospina, 2010)	-0.01 (-0.15 to 0.13)	-0.06 (-0.26 to 0.14)	
Death of HH member (Ospina, 2010)	0.11 (-0.11 to 0.32)	-0.19 (-0.51 to 0.12)	
Loss of harvest (Ospina, 2010)	-0.14 (-0.26 to -0.02)	0.14 (0.05 to 0.24)	*
Loss of harvest (Skoufias, 2007)	0.06 (0.05 to 0.06)	-0.001 (-0.004 to 0.002)	
Loss of livestock (Skoufias, 2007)	0.06 (0.08 to 0.04)	-0.004 (-0.01 to -0.002)	*
Loss of land (Skoufias, 2007)	0.01 (0.01 to 0.02)	0.001 (-0.003 to 0.01)	
Loss of home (Skoufias, 2007)	0 (-0.01 to 0.01)	0.01 (-0.002 to 0.03)	
Borrow informal credit			
Any shock (Vinay, 2010)	~	-0.04 (-0.07 to 0)	*
Illness of HH head (Ospina, 2010)	0.13 (-0.01 to 0.27)	0.15 (-0.03 to 0.33)	
Death of HH member (Ospina, 2010)	0.23 (0.02 to 0.45)	0.17 (-0.15 to 0.48)	
Loss of harvest (Ospina, 2010)	0.27 (0.15 to 0.38)	-0.19 (-0.37 to -0.01)	*
Loss of harvest (Skoufias, 2007)	0.1 (0.08 to 0.11)	-0.002 (-0.01 to 0.002)	
Loss of livestock (Skoufias, 2007)	0.02 (0.01 to 0.03)	-0.01 (-0.01 to -0.002)	*
Loss of land (Skoufias, 2007)	0.003 (0 to 0.01)	0 (-0.01 to 0.01)	
Loss of home (Skoufias, 2007)	0.13 (0.1 to 0.17)	0 (-0.01 to 0.02)	
Use social support			
Loss of harvest (Skoufias, 2007)	0.08 (0.01 to 0.16)	-0.003 (-0.01 to 0.002)	
Loss of livestock (Skoufias, 2007)	-0.004 (-0.01 to 0)	0.03 (0 to 0.06)	*
Loss of land (Skoufias, 2007)	0.01 (0 to 0.02)	0.001 (-0.01 to 0.01)	
Loss of home (Skoufias, 2007)	0.03 (0.01 to 0.05)	0 (0 to 0)	
Borrow formal credit			
Any shock (Vinay, 2010)	~	0.01 (-0.02 to 0.05)	
Illness of HH head (Ospina, 2010)	0.3 (0.21 to 0.4)	0.004 (-0.15 to 0.16)	
Death of HH member (Ospina, 2010)	0.3 (0.21 to 0.4)	0.16 (-0.28 to 0.51)	
Loss of harvest (Ospina, 2010)	0.01 (-0.01 to 0.03)	0.05 (-0.13 to 0.22)	

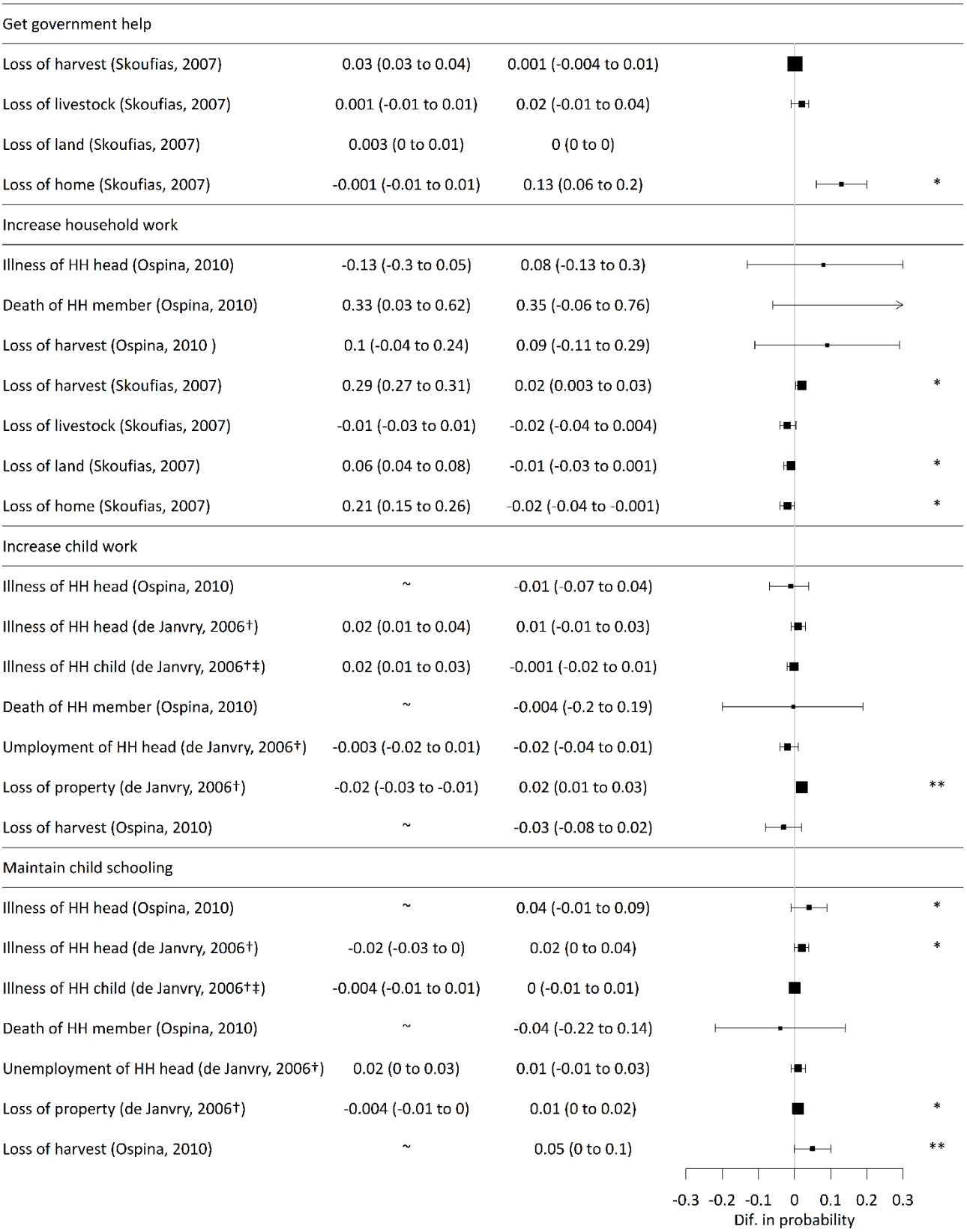

Figure 8. Forest plot summarising the association between conditional cash transfers and household coping strategies in response to a shock.

Abbreviations: CCT, Conditional Cash Transfer; Dif., Difference; HH, Household; Gov, Government. Unless stated, estimates are average marginal effects from probit model. Box size is based on precision. *p<0.1, **p<0.05, ***p<0.01. †Estimates refer to linear probability model; ‡Refers to proportion of children aged 0-5 ill; ~Estimate was not available.

2.7 Discussion of findings

This review identified five studies evaluating the impact of CCTs on the capacity of poor households to cope with idiosyncratic shocks. It suggests that CCTs consistently provide some protection from the negative effects of idiosyncratic shocks on household consumption, especially in response to loss of harvest or livestock. The review indicates that CCTs increase the likelihood of children staying in school when households face idiosyncratic shocks, but in response to illness, they may not protect against children simultaneously working. There was consistent evidence suggesting that CCTs reduce the probability of households borrowing informally from family and friends, and mixed evidence for whether or not CCTs increase the likelihood of households using assets or working more in response to shocks.

The finding that CCTs may increase poor households' capacity to smooth their consumption and respond to some idiosyncratic shocks using assets supports the study conceptual framework, and previous work showing that CCTs help households accumulate wealth (49,51). Evidence for a protective effect of CCTs on child school attendance in response to idiosyncratic shocks also demonstrates that CCTs may be an effective way of ensuring that short-term shocks do not have long-term consequences for child human capital accumulation (79,84). Together these findings add to the growing evidence for the positive effects of CCTs across a wide variety of social, economic, and health outcomes (39).

Whilst there was consistent evidence for a protective effect of CCTs on household consumption in response to idiosyncratic shocks, one study found that CCTs did not fully protect household consumption from unemployment of the household head (84). This shock would be expected to result in at least a 50% drop in household income, which might be too much for the income effect of CCTs to fully compensate (37). Furthermore, when faced with this shock, beneficiary households might prioritise part of the value of CCTs to fund consumption that non-beneficiary households save on. For example, as was found in this review, CCTs are associated with increased likelihood of children staying in school in response to idiosyncratic shocks (79,84). The need to further support poor households in response to more severe shocks was further highlighted by evidence that CCTs might not prevent increased child work in response to illness of the household head (79).

Across various types of idiosyncratic shocks, there was inconclusive evidence for the association between CCTs and households' use of assets as a coping strategy (80,84). Whilst CCTs increase use of assets in response to some idiosyncratic shocks, they also reduce their use in response to others including illness of household head. It is possible that either, CCTs do not support households sufficiently to gather assets that provide adequate return to help them cope with certain shocks; or, households might have difficulty mobilising assets that CCTs help them accumulate, especially if they are difficult to sell quickly (e.g. land), or complex to divide (e.g. assets of microenterprise) (49,51,93,94). Alternatively, if the assets that CCTs help households accumulate are productive and are used to generate income (e.g. livestock), there may be some reluctance to sell them to fund current consumption if that would risk permanently lowering consumption in the future (94). The inconsistent evidence for the effect of CCTs on household use of assets in response to idiosyncratic shocks highlights the need for further research on this issue.

Although informal borrowing from family and friends was found to be a common coping strategy overall, its use was slightly lower amongst CCT treatment households (80,84). Consistent with previous evidence, the wealth effect of CCTs amongst beneficiary households might increase the availability of informal credit for non-beneficiary households, and thus increase their use of this coping strategy in response to idiosyncratic shocks (95). Additionally, CCTs might help beneficiary households to partially replace informal borrowing with other strategies like selling assets (84,96). Reduced reliance on informal loans as a coping strategy is likely to minimize beneficiary households' accumulation of debt, and speed up recovery.

The quality of studies included in this review was medium to high, and only one was assessed to have serious risk of bias (85). Two studies were randomised (79,80), and three matched treatment and control groups on socioeconomic characteristics (84,85,91). Although included studies did not report power calculations, they all had high sample sizes at community- and household-levels. Household-level analyses within community randomised studies may have suffered residual bias from restriction of study samples to only eligible households (79,80). Most studies suffered from some degree of loss to follow up (Range: 16% to 24%), and only one checked for associations between exposure to CCTs and loss to follow up (79). Loss to follow up could have led to bias if poor households were

both more likely to be lost to follow-up, and more likely to experience shocks. Future studies should report characteristics of households lost to follow up, and employ statistical methods to minimise this bias (97).

This review had several limitations. First, the internal validity of findings might be limited from inclusion of only English language studies, as, related to the spread of CCTs across Latin America, an increasing number of studies are published in Spanish and Portuguese (33). Identification of only a few eligible articles meant it was not possible to use a meta-analysis to synthesize a common effect of CCTs on households' capacity to cope with distinct shocks. Whilst valuable, the qualitative approach that was used to synthesise CCT treatment effects did not account for sample size or magnitude of effect. Finally, the external validity of the review's findings is limited by identification and inclusion of studies in only two low- and middle-income countries.

2.8 Further research gaps emerging from the review

The limited evidence identified in this review highlights the need for further research into whether CCTs help poor households cope with idiosyncratic shocks, Table 5. Exploring both of these issues in settings beyond Mexico and Colombia is a priority. Besides PROGRESA/ Oportunidades and Familias En Acción, CCT programmes are ongoing in at least 59 other countries around the world (33). In addition to evaluating whether CCTs help households maintain a constant level of consumption, studies should also estimate whether they help households maintain a level of consumption that guarantees all of their basic needs. This is important, as whilst CCTs might not protect consumption fully, they may provide sufficient protection to prevent households from falling below the poverty line. Studies should also be more specific about the coping strategies that households use, as this will help gauge how severe these strategies are for households. For example, does informal credit received from family or friends need to repaid, and are assets that are sold productive (i.e. have the potential to generate income)? To inform future interventions aimed at helping households cope with idiosyncratic shocks, work should both characterise which households are most vulnerable to these shocks, and estimate how much CCTs would need to be topped up in order to prevent households from having to reduce their consumption, or use costly coping strategies. Studies should also evaluate other modifiers of the treatment effect of CCTs on

households' coping capacity for example, the duration, intensity, and predictability of shocks. Finally, attempts to synthesise evidence on the potential of other forms of social assistance would serve to inform how effective other initiatives might be at helping poor households cope with idiosyncratic shocks (33).

Table 5. Summary of further research gaps emerging from review.

1. Is the level of protection that CCTs provide in response to idiosyncratic shocks sufficient to guarantee all of affected households' basic needs?
2. In addition to preventing less severe borrowing and sale of assets, are CCTs able to prevent households from using harmful forms of borrowing, or sale of assets?
3. How much would CCTs need to be topped up in order to fully protect household consumption from the negative effects of an idiosyncratic shock?
4. Does the duration of time a household has received CCTs modify their potential to help households cope with idiosyncratic shocks?
5. Do other social assistance initiatives provide a similar level of protection against idiosyncratic shocks as CCTs?

2.9 Concluding remarks

Limited evidence indicates that CCTs enhance poor households' capacity to cope with idiosyncratic shocks, and that a policy promoting CCTs is likely to have beneficial effects for households that experience such shocks. However, whether CCTs as currently implemented are sufficient to ensure that all households are able to meet their basic needs in response to such shocks remains uncertain. There is also little knowledge as to how CCTs affect households' use of coping strategies in response to shocks. Such knowledge could usefully inform CCT implementation.

Chapter 3. Conditional cash transfers and the consumption effect of self-reported severe illness in Brazil

3.1 Research gaps addressed with the AIBF historical cohort in Brazil

In line with objective (2) of this thesis, this chapter aimed to evaluate whether poor households are able to safeguard their labour income and food consumption in response to self-reported severe illness with serious economic consequences, and whether receipt of governmental anti-poverty cash transfers helps them do this. In doing so, this chapter addresses the first research gap identified by the thesis for informing the potential of cash transfers to protect households from financial hardship related to severe illness: Uncertainty if cash transfers protect poor households from financial hardship related to severe illness.

3.2 Key findings from historical cohort study in Brazil

Self-reported severe illness with serious economic consequences had surprisingly little effect on poor households' labour income, or food consumption. This finding, which is considered to be largely driven by measurement error, meant that there was limited scope to assess any protective effect of cash transfers, and the observed effects were modest.

3.3 Background to historical cohort study in Brazil

Illness is associated with direct expenses accessing healthcare, and lost income related to incapacity to work or reduced productivity (5). Together, these costs are a frequent cause of welfare loss and financial hardship for affected households (5,4,12,98). The most vulnerable households are those in poverty without access to risk-management strategies like formal insurance, savings, or assets. Consumption is a common measure of household welfare, and vulnerability has often been evaluated as households' ability to maintain a constant level of consumption in response to illness (28). Studies taking this empirical approach have mixed results. Whilst many find that households experience decreased consumption in response to illness, some find that households are able to safeguard consumption in response to this shock (5). When households are found to safeguard their consumption, this is sometimes at the cost of using harmful coping strategies like borrowing high-interest credit, or

withdrawing children from school, which have long-term consequences for household welfare (21,99).

Illnesses affecting the ability of household heads to carry out activities of daily living have the largest impact on household welfare (13,15). Strengthening the ability of poor households to manage and cope with such severe illness is key in trying to break the trap of ill health and poverty (100). Acknowledging this, the International Labour Organization and World Health Organization promote the concept of a social protection floor that provides universal access to essential health care and income security at a nationally defined minimum level (11). Social protection consists of initiatives designed to protect vulnerable populations against poverty, livelihood risks and social exclusion, and can be divided into social assistance, social insurance, and labour market measures (31). High-levels of informal work and irregular income has meant that traditionally, coverage of social insurance has been low amongst poor households (34–36). Designed to provide regular and predictable support to poor populations, and not requiring regular contributions, coverage of social assistance is much higher (34).

Originating in Brazil and Mexico in the 1990s, conditional cash transfers (CCTs) are a particularly popular social assistance initiative (33,37). CCT programs provide monthly income transfers to millions of poor households with two principle objectives: provide beneficiaries with a minimum level of income (reduce *present* poverty); and by making cash transfers conditional on utilization of public services, incentivise their investment in child education, health, and nutrition (reduce *future* poverty for next generations) (37). Synthesised evidence shows that CCTs increase child school attendance and use of health services, and reduce household monetary poverty (39). Providing transfers close to 20% of households' pre-program income, CCTs might also help households prepare for shocks *ex ante* by supporting accumulation of wealth either as savings or assets, and help households cope with shocks *ex post* by guaranteeing a continued regular and predictable source of income (37,49–51). A systematic review in 2010 found some evidence that CCTs protect household consumption and educational patterns during times of crisis (61). More recent evidence also supports this (84,85,91).

Better understanding of poor households' vulnerability to the financial impact of mid- to long-term severe illness is needed to guide the formulation of future policies. We

aimed to evaluate whether poor households in Brazil are able to cope with severe illness, and whether receipt of CCTs helps them with this. We used households' ability to maintain a constant level of consumption as our measure of vulnerability.

3.4 Methodology

3.4.1 Study design

The study was a historical prospective cohort study of Brazilian households, and was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for cohort studies (101). The study population was households across Brazil registered in the national social registry Cadastro Único at study baseline in 2005 (102). Living on the margin of poverty, this population are highly vulnerable to shocks like disabling illness.

3.4.2 Study setting

The setting for this study was Brazil, an upper-middle income country in South America with a population of approximately 200 million (103). Brazil is divided into five great political-administrative regions: Central West, North, Northeast, South, and Southeast. Across Brazil, a historic regional variation in living standards persists today. States in the South and Southeast regions, which include the major cities of São Paulo and Rio de Janeiro, remain generally more urban and industrialised, compared to states in the North and Northeast regions which remain generally more rural and agrarian.

Between 2000 and 2012, Brazil was one of the fastest growing world economies (104). This was accompanied by strengthening of the formal labour market, increases in the minimum wage, and the expansion of social policies; which all contributed to substantial reductions in poverty (Poverty headcount: 25% in 2001; 9% in 2012), and income inequality (Gini index: 58.4 in 2001; 52.6 in 2012) (105,106). In 2013, economic growth decelerated, and in 2014, the country entered a recession, leading to increased unemployment, mainly in low-income populations, and a reversal in previous gains in poverty and inequality reduction (107). Economic growth picked up again in 2017 with an annual GDP growth of 1% (104).

At the beginning of the 2000s, major social protection policies in Brazil included the national Unified Health System, which provides healthcare free at the point of care for all

citizens (108). There was also the non-contributory social assistance programme Benefício de Prestação Continuada, which provides monthly unconditional cash transfers to people with a monthly household income per capita less than US$67, and are either older than 65 years of age, or have a medically approved disability that lasts at least 24 months (109). National social insurance was also available for workers who contributed independently or via their employer (approximately 50% of workers) (110). During the 2000s, Brazil consolidated its existing social protection system by rolling out the national CCT programme Programa Bolsa Família. Designed to reduce levels of poverty, in 2005, Programa Bolsa Família provided monthly CCTs to 8.7 million households (39 million individuals) in extreme poverty (household income per capita < US$ 21), and poverty (household income per capita between US$ 21 and US$ 41) with children or a pregnant/lactating mother registered in the national social registry Cadastro Único (108,109,111,112).

3.4.3 Description of the data source

The Brazilian Ministry of Social Development's Secretary of Evaluation and Information Management (SAGI) publishes microdata from publically funded evaluations (113). The data for this study came from a panel survey of households, known as Avaliação do Impacto do Bolsa Família (AIBF), designed to evaluate the impact of Program Bolsa Família on household labour participation, women's bargaining power, and child education, anthropometry, and health (97). The sampling frame was designed to obtain a ratio of 30%:60%:10% across households receiving Programa Bolsa Família in 2005 vs. households not receiving Programa Bolsa Família but registered in the national social registry Cadastro Único vs. households not receiving Programa Bolsa Família and not registered in Cadastro Único. Households were first surveyed in August 2005 and followed up in October 2009. In each wave, data were collected in the same month for all households. Data were collected in 24 out of the 27 Brazilian states, and included detailed information on household income and consumption, household members' contribution to social insurance, household receipt of social assistance, and exposure to multiple types of income shock. The AIBF panel data was downloaded on the 1st August 2017.

3.4.4 Severe illness with serious economic consequences

The study exposure was a self-reported binary indicator (Yes/No) of severe illness in the family that led to a serious reduction in family patrimony, income, or consumption between 2005 and 2009. The exact phrasing of the question was: "Now, we would like to know more about adverse events (shocks) in the last 4 years. Was the family affected by a severe event – an occurrence that led to a serious reduction in your patrimony, caused substantial reduction in your family income, or resulted in a significant reduction in consumption?" *(Agora, nós gostaríamos de saber mais acerca de eventos adversos (choques) nos últimos 4 anos. Será que a família foi afetada por eventos graves – um acontecimento que levou a uma séria reducao do seu patrimônio, causou um redução substancial da renda familiar, ou resultou emu ma redução significativo no consumo?)*. Respondents could then choose from a list of 30 severe events including: illness of the husband, illness of the wife, illness of another person. Responses to these three questions were combined into a single indicator of severe illness in the family with serious economic consequences between 2005 and 2009.

3.4.5 Food consumption, labour hours, and labour income

The primary study outcome was household per capita monthly food consumption between 2005 and 2009. Monthly food consumption was calculated as the summed value of self-reported consumption of 65 food items purchased in the 7 or 30 days prior to interview. Secondary study outcomes were, household per capita weekly labour hours, and household per capita monthly labour income. Weekly labour hours were measured as the summed value of hours worked by all household members, and monthly labour income was measured as the summed value of individual salaries of all household members. Food consumption and labour income were both measured in Brazilian reais (R$). Household per capita monthly non-food consumption was not included as a study outcome as previous analysis shows that reporting of some non-food expenditure items in 2009 was unreliable.

3.4.6 Receipt of conditional cash transfers

Receipt of CCTs was measured as self-reported receipt of Programa Bolsa Família, or one of Programa Bolsa Família's predecessor programmes: Bolsa Alimentação, Bolsa Escola, Cartao Alimentação, or Programa de Erradicação do Trabalho Infantil in 2005. The characteristics of Programa Bolsa Família and its predecessors were very similar, and were therefore expected

to have a similar effect on study outcomes, Table 6. Households that began to receive CCTs between baseline and follow up were not included in the receivers group as the data was not detailed enough to tell if households experiencing severe illness received their first income transfer before or after illness. Furthermore, if households did begin receiving CCTs before illness it is unlikely that they would have received them for long enough to accrue savings.

3.4.7 Covariates

Covariates summarised, and included in all multivariate regression models were self-reported household exposure to drought or flooding, loss of crops or livestock, and death with serious economic consequences between 2005 and 2009; as well as household baseline region of residence, location of residence, type of residence, number of household members aged 0 to 6 years, number of household members aged 7 to 15 years, self-reported number of household members working and contributing to social insurance, and self-reported total income per capita; as well as household responsible baseline sex, age, ethnicity, literacy, work branch, and self-rated health. Household exposure to unemployment with serious economic consequences between 2005 and 2009 was summarised, but was not adjusted for in multivariate regression models as it lies on the causal pathway between severe illness and financial hardship.

Table 6. Summary of conditional cash transfer programmes received by poor households in Brazil in 2005.

Programme	**Household eligibility criteria**	**Transfer frequency**	**Transfer value**	**Conditionality**
Programa Bolsa Família	Monthly household income per capita < US$ 21 Monthly household income per capita between US$ 21 and US$ 41 and pregnant/lactating mother, or child aged between 0 and 15 years (Up to a maximum of 3).	Monthly	US$ 6 to US$ 39 (US$ 21 base transfer for extreme poor, and US$ 6 per pregnant/lactating mother, or child)	Pregnant mothers must complete ante-natal checks. Children aged 0 to 6 years must be breastfed, and receive all vaccinations. Children aged 0 to 15 must not work and keep an annual school attendance of 85%.
Bolsa Escola	Monthly household income per capita < US$ 37, and child aged between 7 and 15 years (Up to a maximum of 3).	Monthly	US$ 6 to US$ 18 (US$ 6 per child)	Children aged 7 to 15 must not work and keep an annual school attendance of 85%.
Bolsa Alimentação	Monthly household income per capita < US$ 37, and pregnant/lactating mother, or child aged between 0 and 6 years (Up to a maximum of 3).	Monthly	US$ 6 to US$ 18 (US$ 6 per pregnant/lactating mother, or child)	Pregnant mothers must complete ante-natal checks. Children aged 0 to 6 must be breastfed, and receive all vaccinations.
Programa do Cartão Alimentação	Monthly household income per capita < US$ 59	Monthly for 6 months (possible to renew twice)	US$ 39	Benefits must only be spent on food.
Programa de Erradicação do Trabalho Infantil	Child aged 0 to 15 years in or at risk of falling into dangerous, unhealthy or degrading work.	Monthly	US$ 10 in rural areas, and US$ 16 in urban areas.	Children aged 0 to 15 must not work and keep an annual school attendance of 75%.

Abbreviations: US$, United States Dollar.

3.4.8 Bias

Loss to follow up (LTFU) is a concern for any longitudinal study. In 2009, 26% of the original sample surveyed in 2005 could not be located. Predictors of LTFU were investigated using logistic regression. Attrition weights generated in the original Programa Bolsa Família impact evaluation were used to account for LTFU in the analysis. Details of how these attrition weights were estimated are described in the original evaluation's summary report (97).

Missing data is another potential source of bias (115). The extent of missing data was tabulated, and missing patterns were investigated using logistic regression. A combination of methods was used to account for missing data. For food consumption, because food prices are fixed, missing values were imputed using mean local-, regional- or sample-prices. Aside from food consumption, to account for the multi-level structure of the data, missing values were imputed using Markov Chain Monte Carlo hierarchical multiple imputation clustered at the household level (116). Separate interaction terms were included between individuals' type of work and work salary, and their type of work and work hours. Five imputed datasets were created using a total run length of 25 iterations with imputations after every 5^{th} iteration using the 'jomoimpute' command of the 'mitml' package in R (117). Imputation assumed that missing data were missing at random conditional on observed individual and household characteristics.

3.4.9 Study sample size

A basic sample size calculation was used to check if the AIBF data included sufficient participants to investigate the impact of severe illness on this study's primary outcome, change in household per capita monthly food consumption. Based on a mean change in household food consumption per capita of US$ 16 (SD: US$ 37), and 14% prevalence of severe illness, as observed in the AIBF data, to detect a conservative effect of severe illness of US$ 3, with a two-tailed 5% type I error rate, 80% power, a minimum overall sample size of 9,918 was required. This indicates that the AIBF data (N=12,792) was sufficiently powered to investigate the effect of severe illness on change in household per capita food consumption. Given the minimum four-fold increase in sample size required to investigate 2x2 interactions (114), the AIBF data had low power to evaluate whether receipt of CCTs modifies the effect of severe illness on change in household per capita food consumption.

3.4.10 Statistical analysis

Data management. All monetary values were deflated and converted to 2005 United States dollars (US$). In 2005 R$ 1 = US$ 0.41 (118).

Data analysis. Baseline and time-varying characteristics of study participants were summarised overall and by exposure to severe illness. The data analysis was then divided into two parts. First, the overall effect of severe illness on household per capita labour hours, labour income, and food consumption was estimated. The hypothesis was that severe illness reduces affected household members' capacity to work and generate income, and that less disposable labour income reduces household food consumption. For each study outcome, estimates for the effect of severe illness were quantified using a difference in difference estimator, which compared the estimated growth in study outcome between baseline and follow up for households that did and did not experience severe illness.

Second, an evaluation of the effect of severe illness on household per capita labour hours, labour income and food consumption by receipt of CCTs at baseline in 2005 was carried out. The hypothesis was that CCTs help households prepare for shocks *ex ante* by supporting accumulation of wealth, and help them respond to shocks *ex post* by guaranteeing a continued regular and predictable source of income. These effects should result in a lower reduction in food consumption amongst households that experience severe illness. Determinants of receipt of CCTs were summarised using logistic regression. For each study outcome, estimates for the effect of severe illness by receipt of CCTs were quantified using a difference in difference estimator, which contrasted the difference in estimated growth in study outcome between baseline and follow up for households that did and did not experience severe illness across households that did and did not receive CCTs.

Estimates for the effect of severe illness on study outcomes were adjusted for household characteristics that might have confounded the association between the study exposure and outcome. Fitted regression models were used to obtain predictive margins for mean outcomes on their original scale at each time and in each group. Difference in difference estimates were then calculated by linear combination of coefficients.

A natural log transformation was used to obtain an approximately normal distribution for household per capita food consumption. For household per capita labour hours and labour

income, an excess of zero values was encountered. A cube root transformation was used to obtain an approximately normal distribution for non-zero values of household per capita labour hours and labour income. To account for the excess of zeros, estimates for the effect of severe illness on household per capita labour hours and labour income were quantified using a hurdle function as proposed by Cragg (119). In a hurdle model, a binary 0/1 decision model for having household per capita labour hours or labour income equal to 0 is combined with a truncated-at-zero linear model for having household per capita labour hours or labour income above 0.

Throughout the analysis, estimates for the effect of severe illness were pooled across the 5 imputed datasets using Rubin's rule (120). All analyses were done in STATA 15.

Sensitivity analysis. The sensitivity of effect estimates was tested to imputation of missing data by repeating the analysis using only complete cases, and by repeating the analysis using self-reported severe illness with serious economic consequences between 2005 and 2009 that was reported to be worst in 2009 as the study exposure.

3.5 Results

Out of a target 15,418 households interviewed in 2005, 4052 (26%) were LTFU, and of those that were traced, 231 (1%) had no information recorded in 2009 and so were also considered LTFU. The two most common reasons for LTFU were "could not locate address" (64%) and "address located but household moved" (32%). LTFU was more common in urban informal settlements in the Central West, South, and Southeast regions of Brazil, Table S3. Of households that were traced, 1594 (10%) were not registered in the national social registry in 2005 and so were excluded. As a result, 9547 households were included in the study, Figure 9. After reweighting included households using attrition weights, the study sample size was 12,792.

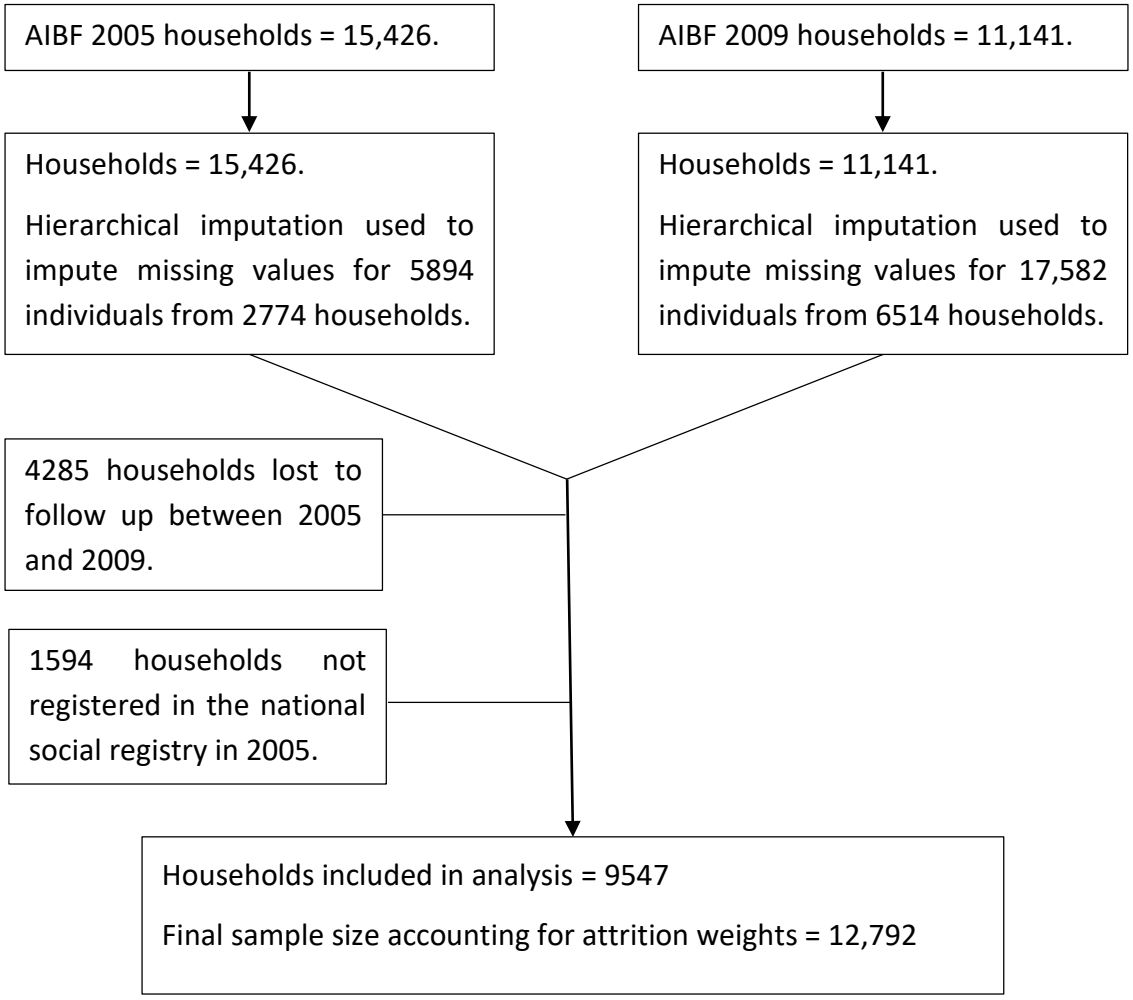

Figure 9. Flow chart for inclusion of AIBF respondents in the historical cohort study.

3.5.1 Missing data

In 2005, 7207 (10%) individuals were missing values, and in 2009, 21,965 (47%) individuals were missing values, Table S3 and Table S4. In 2005, 0.3% of individuals were missing values for more than 3 variables (range: 1 to 12), whilst in 2009, 12.1% of individuals were missing values for more than 3 variables (range: 1 to 36). The two variables with the most missing values in 2005 were individual work salary (5%) and household location (2%); while in 2009, it was individual work salary (14%) and household food consumption (13%), Table S3 and Table S4. In both 2005 and 2009, missing data was most common in male agricultural workers in rural areas, Table S3 and Table S4. In 2005, missing data was more common in the Northeast region of Brazil, and in 2009, it was more common in the Central West and South regions of Brazil, Table S3 and Table S4. In 2005, missing data was more common amongst non-recipients of Programa Bolsa Família; while in 2009, it was more common amongst recipients of Programa Bolsa Família, Table S3 and Table S4.

3.5.2 Characteristics of study participants

Most households were in the Northeast, and Southeast regions of Brazil (Central West: 13%, North: 16%, Northeast: 33%, South: 7%, Southeast: 31%), in detached buildings (Condominium: 19%, informal settlement: 6%, tenement: 11%, detached: 64%), with piped water (81%), in urban areas (79%), Table 6. The mean number of people in a household was 4.6 (SD: 1.8), Table 6. The majority of households had one member working (0: 13%, 1: 47%, 2: 27%, 3+: 13%), and amongst working members nobody contributing to social insurance (0% of workers contributing: 67%, 1% to 50% of workers contributing: 11%, 51% to 100% of workers contributing: 22%), Table 6. The greater part of household responsibles were male (63%), aged 35 to 54 (16 to 34: 27%, 35 to 54: 52%, 55+: 19%), mixed race (Mixed: 54%, white/oriental: 34%, black/indigenous: 12%), literate (77%), worked in a non-agricultural job (Agricultural: 20%, non-agricultural: 50%, unemployed: 31%), and had very good or good self-reported health (Very good/good: 55%, regular: 34%, very bad/bad: 10%, don't know: 1%), Table 6. Overall, median household per capita weekly labour hours were 11.7 hours (IQR: 6.7 hours to 18 hours), monthly labour income was US$ 30.8 (IQR: US$ 15.4 to US$ 51.3), and monthly food consumption was US$ 22.3 (IQR: US$ 14.8 to US$ 32.4), Table 6.

Between 2005 and 2009, 1752 (14%) households experienced severe illness, Table 7. Households exposed to severe illness were more likely to reside in rural areas ($p=0.001$) of the Central West, South, and Southeast regions of Brazil ($p<0.001$), Table 7. They were no more likely to receive CCTs at baseline ($p=0.71$), Table 7. The household responsible was more likely to be male, older than 55 years of age, illiterate, work in agriculture, and have regular, or bad to very bad self-reported health ($p<0.001$), Table 7. Household per capita monthly total income, weekly labour hours, monthly labour income, and monthly food consumption were approximately equal ($p=0.33$, $p=0.53$, $p=0.3$, and $p=0.96$, respectively), Table 7. Households exposed to severe illness, were more likely to experience drought or flood, loss of crops or livestock, unemployment, and death between 2005 and 2009 ($p<0.001$), Table 8. Before adjustment, exposed and unexposed households experienced similar growth in household per capita labour hours, labour income, and food consumption ($p=0.56$, $p=0.49$, and $p=0.17$, respectively), Table 8.

Table 7. Baseline characteristics of the historical cohort.

	Overall n (%) n = 12,792	**No severe illness n (%) n = 11,040**	**Severe illness n (%) n = 1752**	**p-value**
Household characteristics				
Region				<0.001
Central Western	1628 (13)	1361 (12)	267 (15)	
North	2101 (16)	1958 (18)	143 (8)	
Northeast	4203 (33)	3629 (33)	573 (33)	
South	855 (7)	701 (6)	154 (9)	
Southeast	4005 (31)	3390 (31)	615 (35)	
Location				<0.001
Rural	2724 (21)	2281 (21)	443 (25)	
Urban	10,068 (79)	8759 (79)	1309 (75)	
Type				0.2
Condominium	2450 (19)	2100 (19)	351 (20)	
Informal settlement	771 (6)	688 (6)	83 (5)	
Tenement	1371 (11)	1179 (11)	193 (11)	
Detached	8199 (64)	7074 (64)	1125 (64)	
Piped water				0.006
Yes	10,375 (81)	8906 (81)	1469 (84)	
No	2416 (19)	2133 (19)	283 (16)	
Members				0.7
Mean (SD)	4.6 (1.8)	4.6 (1.8)	4.6 (1.8)	
Members aged 0 to 6 years				0.06
None	6949 (54)	5946 (54)	1003 (57)	
1	3736 (29)	3244 (29)	492 (28)	
2	1575 (12)	1373 (12)	202 (12)	
3+	532 (4)	477 (4)	55 (3)	
Members aged 7 to 15 years				0.008
None	3627 (28)	3063 (28)	564 (32)	
1	4534 (35)	3964 (36)	570 (33)	
2	3046 (24)	2647 (24)	400 (23)	
3+	1585 (12)	1366 (12)	219 (12)	
Members working				0.12
0	1715 (13)	1451 (13)	265 (15)	
1	5962 (47)	5189 (47)	773 (44)	
2	3476 (27)	3002 (27)	474 (27)	
3+	1638 (13)	1398 (13)	239 (14)	
Members working contributing to social insurance, %				0.42
0	8607 (67)	7456 (68)	1151 (66)	
1 to 50	1418 (11)	1211 (11)	207 (12)	
51 to 100	2767 (22)	2373 (21)	394 (22)	
Monthly total income PC, US$*				0.33
< 21	2597 (20)	2264 (21)	333 (19)	

21 to 41	4063 (32)	3514 (32)	550 (31)	
42 to 118	5162 (40)	4438 (40)	724 (41)	
> 118	969 (8)	824 (7)	145 (8)	
Weekly labour hours PC; hours				0.53‡
Median (IQR)	12 (6.7 to 18)	12 (6.7 to 18)	11 (5.8 to 18)	
Monthly labour income PC; US$				0.30‡
Median (IQR)	31 (15 to 51)	31 (15 to 51)	31 (14 to 51)	
Monthly food consumption PC; US$				0.96‡
Median (IQR)	22 (15 to 32)	22 (15 to 32)	22 (15 to 33)	
Receipt of CCTs†				0.71
No	5607 (44)	4848 (44)	759 (43)	
Yes	7185 (56)	6192 (56)	993 (57)	
Household responsible characteristics				
Sex				<0.001
Male	8052 (63)	6847 (62)	1205 (69)	
Female	4740 (37)	4192 (38)	547 (31)	
Age, years				<0.001
16 to 34	3484 (27)	3085 (28)	400 (23)	
35 to 54	6820 (53)	5863 (53)	957 (55)	
55+	2487 (19)	2092 (19)	395 (23)	
Ethnicity				0.24
Mixed	6888 (54)	5974 (54)	915 (52)	
White/Oriental	4324 (34)	3695 (33)	629 (36)	
Black/Indigenous	1579 (12)	1371 (12)	208 (12)	
Literate				0.001
Yes	9805 (77)	8525 (77)	1280 (73)	
No	2986 (23)	2515 (23)	472 (27)	
Work branch				<0.001
Agricultural	2493 (19)	2092 (19)	400 (23)	
Non-agricultural	6358 (50)	5604 (51)	754 (43)	
Unemployed	3941 (31)	3343 (30)	598 (34)	
Self-rated health				<0.001
Very good/good	7082 (55)	6220 (56)	862 (49)	
Regular	4396 (34)	3752 (34)	644 (37)	
Very bad/bad	1227 (10)	991 (9)	236 (13)	
Don't know	87 (1)	77 (1)	10 (1)	

Abbreviations: PC, Per Capita; US$, United States Dollar; SD, Standard Deviation; IQR, Interquartile Range; CCT, Conditional Cash Transfer. Data is weighted using attrition weights. Values refer to the first of the five imputed datasets. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.41. *In 2005, extreme poverty: monthly household income per capita < US$ 21, poverty: monthly household income per capita between US$ 21 and US$41, 1 minimum wage: US$ 118. †Refers to receipt of Programa Bolsa Família or one of its predecessors: Bolsa Escola, Bolsa Alimentação, Cartao Alimentação, or Programa de Erradicação do Trabalho Infantil. ‡P-value for Kruskal-Wallis test.

Table 8. Time-varying characteristics of the historical cohort.

	Overall n (%) n = 12,792	**No severe illness n (%) n = 11,040**	**Severe illness n (%) n = 1752**	**p-value**
Household characteristics				
Δ weekly labour hours PC, Hours				0.56
Mean (SD)	1.6 (13.1)	1.6 (13.1)	1.8 (13.2)	
Δ monthly labour income PC, US$				0.49
Mean (SD)	11.2 (52.9)	11.3 (53.2)	10.2 (50.8)	
Δ monthly food consumption PC, US$				0.17
Mean (SD)	15.7 (37.1)	15.5 (37)	17 (37.2)	
Drought or flood				<0.001
No	10,935 (85)	9585 (87)	1351 (77)	
Yes	1856 (15)	1455 (13)	401 (23)	
Loss of crops or livestock				<0.001
No	12,440 (97)	10,790 (98)	1649 (94)	
Yes	352 (3)	249 (2)	103 (6)	
Death				<0.001
No	9334 (73)	8257 (75)	1077 (61)	
Yes	3457 (27)	2782 (25)	675 (39)	
Unemployment				<0.001
No	11,745 (92)	10,267 (93)	1477 (84)	
Yes	1047 (8)	772 (7)	275 (16)	

Abbreviations: Δ, Change in; PC, Per Capita; US$, United States Dollar; SD, Standard Deviation. Data is weighted using attrition weights. Values refer to the first of the five imputed datasets. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

3.5.3 Overall effect of severe illness

In multivariate analysis, there was no significant difference in the growth of household per capita weekly labour hours, monthly labour income, or monthly food consumption according to whether the household experienced severe illness (0.1 hours, 95% CIs: -0.6 hours to 0.9 hours; US$ 1, 95% CIs: US$ -1.8 to US$ 3.7; US$ 2.1, 95% CIs: US$ -0.4 to US$ 4.5, respectively), Table 9.

3.5.4 Determinants of receipt of conditional cash transfers

Receipt of CCTs at baseline was most common amongst households residing in the North and Northeast regions of Brazil (p=0.008), Table 10. In line with the eligibility criteria of Programa Bolsa Família and its predecessor CCT programmes, receipt of CCTs at baseline was more common amongst households in extreme poverty (p<0.001), and with children aged 7 to 15 years (p<0.001), Table 10. Households with 0% of working household members contributing to social insurance were more likely to receive CCTs at baseline (p<0.001), as were households with a responsible who was younger, who was illiterate, or who worked in agriculture (p<0.001), Table 10.

3.5.5 Effect of severe illness by receipt of conditional cash transfers

In multivariate analysis, there was no significant difference in the growth in household per capita weekly labour hours, monthly labour income, or monthly food consumption according to whether the household experienced severe illness and received CCTs or did not receive CCTs (0 hours, 95% CIs: -1.7 hours to 1.8 hours; US$ 1.9, 95% CIs: US$ -3.9 to US$ 7.8; US$ -0.9, 95% CIs: US$ -5.8 to US$ 3.9, respectively), Table 111.

Table 9. Impact of severe illness on household per capita weekly labour hours, monthly labour income, and monthly food consumption.

	No severe illness n (%) n = 11,040	**Severe illness n (%) n = 1752**	**Difference in Difference (95% CIs)**
Weekly labour hours PC, Hours			
2005	9.5 (9.3 to 9.7)	9.4 (8.8 to 9.9)	0.1 (-0.6 to 0.9)
2009	9.7 (9.5 to 10)	9.7 (9.1 to 10.4)	
Monthly labour income PC, US$			
2005	28 (27.3 to 28.7)	27.4 (25.8 to 29)	1 (-1.8 to 3.7)
2009	33.5 (32.4 to 34.6)	33.8 (31.4 to 36.2)	
Monthly food consumption PC, US$			
2005	26.1 (25.6 to 26.5)	26.1 (25 to 27.2)	2.1 (-0.4 to 4.5)
2009	42.2 (41.3 to 43)	44.3 (41.9 to 46.6)	

Abbreviations: CIs, Confidence Intervals; PC, Per Capita; US$, United States Dollar. Selected marginal effects are reported. Data is weighted using attrition weights. Values are pooled across the five imputed datasets using Rubin's rule. All values are mutually adjusted for household region of residence, location of residence, number of household members aged 0 to 6 years, number of household members aged 7 to 15, % of family members working and contributing to social insurance, total income per capita (net of social assistance), and receipt of Programa Bolsa Família or one of its predecessors: Bolsa Escola, Bolsa Alimentação, Cartao Alimentação, or Programa de Erradicação do Trabalho Infantil all at baseline; household responsible sex, age category, age squared, ethnicity, literacy, and self-rated health all at baseline; and, household exposure to drought or flooding, loss of crops or livestock, or death between 2005 and 2009. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

Table 10. Predictors of household receipt of conditional cash transfers at study baseline.

	Baseline receipt of CCTs†			
	No n (%) n = 5607	**Yes n (%) n = 7185**	**OR (95% CI)**	**p-value**
Household characteristics				
Region				0.008
Central Western	737 (13)	892 (12)	1.0	
North	891 (16)	1210 (17)	1.1 (1 to 1.3)	
Northeast	1750 (31)	2453 (34)	1.2 (1 to 1.3)	
South	382 (7)	473 (7)	1 (0.8 to 1.3)	
Southeast	1847 (33)	2157 (30)	1 (0.8 to 1.1)	
Location				0.3
Rural	1248 (22)	1476 (21)	1.0	
Urban	4359 (78)	5709 (79)	1.1 (1 to 1.2)	
Type				0.07
Condominium	1105 (20)	1346 (19)	1.0	
Informal settlement	325 (6)	446 (6)	1.1 (0.9 to 1.4)	
Tenement	552 (10)	819 (11)	1.2 (1 to 1.4)	
Detached home	3625 (65)	4574 (64)	1 (0.9 to 1.2)	
Piped water				<0.001
Yes	4642 (83)	5733 (80)	1.0	
No	965 (17)	1452 (20)	1.2 (1.1 to 1.4)	
Members				<0.001
1	608 (11)	326 (5)	1.0	
2-4	2949 (53)	3114 (43)	2 (1.7 to 2.3)	
5+	2050 (37)	3745 (52)	3.4 (2.9 to 4.1)	
Members aged 0 to 6 years				0.14
None	3093 (55)	3856 (54)	1.0	
1	1638 (29)	2098 (29)	1 (0.9 to 1.1)	
2	668 (12)	907 (13)	1.1 (1 to 1.2)	
3+	208 (4)	324 (5)	1.3 (1 to 1.5)	
Members aged 7 to 15 years				<0.001
None	2312 (41)	1315 (18)	1.0	
1	1939 (35)	2594 (36)	2.4 (2.1 to 2.6)	
2	967 (17)	2080 (29)	3.8 (3.4 to 4.3)	
3+	389 (7)	1195 (17)	5.4 (4.6 to 6.3)	
Members in work				0.47
0	761 (14)	954 (13)	1.0	
1	2637 (47)	3325 (46)	1 (0.9 to 1.1)	
2	1527 (27)	1949 (27)	1 (0.9 to 1.2)	
3+	682 (12)	956 (13)	1.1 (1 to 1.3)	
Members in work contributing to social insurance, %				<0.001
0	3610 (64)	4997 (70)	1.0	
1 to 50	638 (11)	780 (11)	0.9 (0.8 to 1)	
51 to 100	1359 (24)	1408 (20)	0.8 (0.7 to 0.8)	
Monthly total income PC, US$*				<0.001

< 21	880 (16)	1717 (24)	1.0	
21 to 41	1571 (28)	2492 (35)	0.8 (0.7 to 0.9)	
42 to 118	2530 (45)	2633 (37)	0.5 (0.5 to 0.6)	
> 118	626 (11)	343 (5)	0.3 (0.2 to 0.3)	
Drought or flood during follow up				0.34
No	4813 (86)	6122 (85)	1.0	
Yes	794 (14)	1062 (15)	1.1 (0.9 to 1.2)	
Loss of crops or livestock during follow up				0.13
No	5468 (98)	6972 (97)	1.0	
Yes	139 (2)	213 (3)	1.2 (0.9 to 1.5)	
Death during follow up				
No	4072 (73)	5263 (73)	1.0	0.49
Yes	1535 (27)	1922 (27)	1 (0.9 to 1.1)	
Household responsible characteristics				
Sex				0.31
Male	3560 (63)	4493 (63)	1.0	
Female	2048 (37)	2692 (37)	1 (1 to 1.1)	
Age, years				<0.001
16 to 34	1657 (30)	1828 (25)	1.0	
35 to 54	2691 (48)	4129 (57)	1.4 (1.3 to 1.5)	
55+	1259 (22)	1228 (17)	0.9 (0.8 to 1)	
Ethnicity				0.08
Mixed	2974 (53)	3915 (54)	1.0	
White/Oriental	1963 (35)	2361 (33)	0.9 (0.8 to 1)	
Black/Indigenous	670 (12)	909 (13)	1 (0.9 to 1.2)	
Literate				<0.001
Yes	4397 (78)	5408 (75)	1.0	
No	1210 (22)	1776 (25)	1.2 (1.1 to 1.3)	
Work branch				<0.001
Agricultural	992 (18)	1501 (21)	1.0	
Non-agricultural	2831 (50)	3527 (49)	0.8 (0.7 to 0.9)	
Unemployed	1784 (32)	2156 (30)	0.8 (0.7 to 0.9)	
Self-rated health				0.53
Very good/good	3129 (56)	3953 (55)	1.0	
Regular	1892 (34)	2504 (35)	1.1 (1 to 1.2)	
Very bad/bad	552 (10)	674 (9)	1 (0.8 to 1.1)	
Don't know	34 (1)	53 (1)	1.2 (0.8 to 2)	

Abbreviations: CCT, Conditional Cash Transfer; OR, Odds Ratio; CI, Confidence Interval; PC, Per Capita; US$, United States Dollar. Data is weighted using attrition weights. Values refer to the first of the five imputed datasets. All monetary values are deflated to 2005 constant values. *In 2005, extreme poverty: monthly household income per capita < US$ 21, poverty: monthly household income per capita between US$ 21 and US$41, 1 minimum wage: US$ 118. †Programa Bolsa Família or one of its predecessors: Bolsa Escola, Bolsa Alimentação, Cartao Alimentação, or Programa de Erradicação do Trabalho Infantil.

Table 11. Impact of severe illness on household per capita weekly labour hours, monthly labour income, and monthly food consumption, by receipt of conditional cash transfers at study baseline.

	No severe illness n (%) n = 11,040	**Severe illness n (%) n = 1752**	**Difference in difference (95% CIs)**	**Difference in effect of severe illness by receipt of CCTs (95% CIs)**
Weekly labour hours PC, Hours				
No receipt of CCTs				
2005	10.3 (10 to 10.6)	9.3 (8.5 to 10.1)	0.7 (-0.6 to 2)	0 (-1.7 to 1.8)
2009	10.4 (10 to 10.8)	10.1 (9 to 11.2)		
Receipt of CCTs				
2005	9.1 (8.9 to 9.4)	8.5 (7.9 to 9.2)	0.7 (-0.4 to 1.9)	
2009	9.9 (9.5 to 10.2)	10 (9.1 to 10.9)		
Monthly labour income PC, US$				
No receipt of CCTs				
2005	32.2 (31.3 to 33.2)	29.5 (27.2 to 31.8)	0 (-4.5 to 4.5)	1.9 (-3.9 to 7.8)
2009	37.2 (35.6 to 38.9)	34.5 (30.5 to 38.5)		
Receipt of CCTs				
2005	25.5 (24.8 to 26.2)	24 (22.3 to 25.6)	1.9 (-1.7 to 5.6)	
2009	32.8 (31.5 to 34.1)	33.2 (30.2 to 36.2)		
Monthly food consumption PC, US$				
No receipt of CCTs				
2005	28.1 (27.4 to 28.7)	27.4 (25.6 to 29.3)	2.6 (-1.1 to 6.4)	-0.9 (-5.8 to 3.9)
2009	45.3 (43.9 to 46.7)	47.3 (43.3 to 51.3)		
Receipt of CCTs				
2005	24.8 (24.2 to 25.4)	24.3 (23 to 25.6)	1.7 (-1.6 to 4.9)	
2009	39.7 (38.6 to 40.7)	40.9 (37.9 to 43.8)		

Abbreviations: CCT, Conditional Cash Transfer; CI, Confidence Interval; PC, Per Capita; US$, United States Dollar. Selected marginal effects are reported. Data is weighted using attrition weights. Values are pooled across the five imputed datasets using Rubin's rule. All values are mutually adjusted for household region of residence, location of residence, number of household members aged 0 to 6 years, number of household members aged 7 to 15, % of family members working and contributing to social insurance, and total income per capita (net of social assistance) all at baseline; household responsible sex, age category, age squared, ethnicity, literacy, and self-rated health all at baseline; and, household exposure to drought or flooding, loss of crops or livestock, or death between 2005 and 2009. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

3.5.6 Sensitivity analysis

Repeating the analysis with only complete cases resulted in the same results as our main analysis: absence of any difference in the growth of household per capita weekly labour hours, monthly labour income, and monthly food consumption according to whether the household experienced severe illness, and absence of any modifying effect of prior receipt of CCTs, Table S5 and Table S6. Use of self-reported severe illness with serious economic consequences that was reported to be worst in 2009 as the study exposure also resulted in the same results as the main analysis, Table S7 and Table S8.

3.6 Discussion

3.6.1 Summary of main findings

In Brazil, in 2005, two thirds of households registered in the national social registry did not contribute to formal social insurance, putting them at risk of income loss in the event of severe illness. Between 2005 and 2009, 15% of households reported experiencing severe illness that seriously reduced their patrimony, income, or consumption. Households reporting such severe illness were more likely to be located in rural areas of the Central West, South, and Southeast regions of the country, and were more likely to report experiencing other income shocks: drought or flooding, loss of crops or livestock, unemployment, and death. Overall, self-reported severe illness was not associated with reduced growth in household labour hours, labour income, or food consumption. It was found that approximately half of households registered in the national social registry received CCTs, with receipt higher amongst households with children, in extreme poverty, and residing in the North and Northeast regions of Brazil. Contrary to the study hypothesis, the effect of CCTs on household labour hours, labour income, and food consumption in response to severe illness was negligible. However, a basic sample size calculation estimated that the study had low statistical power to investigate this relationship.

3.6.2 Study strengths

A strength of this study was its use of longitudinal data over two time points. Unless participants experienced severe illness with serious economic consequences in the month before follow-up, it is likely that they experienced this exposure before study outcomes. The study minimised potential selection bias by using a representative sample of households

registered in the national social registry, Cadastro Único, in 2005. The large sample size of the AIBF dataset provided a valuable opportunity for evaluating a rare exposure like chronic and disabling illness. Of other known datasets that have been used to evaluate the effect of CCTs in Latin America, AIBF is second only in size to the ENCEL dataset used to evaluate the impact of the PROGRESA/ Oportunidades CCT initiative in Mexico (80,121,122). The study also took steps to account for selection bias from LTFU using attrition weights, and missing data using hierarchical multiple imputation.

3.6.3 Study limitations

The study hypothesised that self-reported severe illness with serious economic consequences would reduce household labour productivity, and that less disposable labour income would lead to reduced growth in household food consumption. In contrast, the measure of severe illness used in this study had no impact on household labour income, or household food consumption. Previous studies highlight two central issues for accurately estimating the welfare impact of illness: how illness is measured, and focus on both households' ability to maintain a constant level of income and consumption, as well as their use of coping strategies in response to this shock (13,15,22,25).

In this study, illness was self-reported as severe, and leading to a serious reduction in family patrimony, income, or consumption. A general concern with self-reported measures of illness, is that they are likely to suffer from measurement error related to the subjective perception and cultural background of respondents (13,15–17). Previous studies show that more objective measures of severe illness like change in the ability to carry out activities of daily living, or long spells of hospitalisation are more reliable for capturing the financial impact of illness compared to self-reported measures of illness, which generally detect minor effects on labour income and food consumption (13,22,64,65,68,84,123,124). In the case of this study, any severe illness may be expected to have a subjectively serious economic impact for households living on the margins of poverty, but not necessarily a sustained one, which is what this study aimed to measure in order to evaluate the protective effect of CCTs. Common self-reported severe illnesses have been found to be: hypertension, typhoid fever, tuberculosis and other lung and respiratory diseases, physical injury, and heart disease (125). With the exception of tuberculosis and heart disease, only the severest forms of these illnesses are likely to lead to a sustained economic impact on poor households in Brazil, where

citizens rarely pay “out-of-pocket” for care, and therefore, only suffer from direct non-medical expenses and lost income related to time off work (108). There are other potential sources of measurement error in this study. Respondents were only asked about their exposure to severe illness in section 14 of the 15 section questionnaire, and by this stage they might have given more perfunctory responses, and/or the interviewer might have asked the question incorrectly (126). In Brazil, where family structures are more encompassing, respondents may also have interpreted the question, which asked about severe illness in a family member, to relate to anyone in their extended family.

Another concern for studies evaluating the welfare impact of severe illness is their focus on coping strategies that households might mobilise in response to such a shock (25). Previous evidence shows that households experiencing severe illness often re-allocate labour, sell livestock or assets, and take out loans to protect their income and consumption (22,68,84,127,128). In this study, it was not possible to evaluate households’ use of these coping strategies as the questionnaire did not collect information on them. Another approach that households have been found to use to safeguard their food consumption is to save on non-food consumption (65). Regrettably, in this study, unreliable reporting of household non-food consumption in 2009 prevented us from evaluating if households used this coping strategy in response to severe illness.

In addition to investigating the economic consequences of severe illness, the study also aimed to quantify whether receipt of CCTs had any protective effect for affected households. A limitation for this secondary analysis was the low statistical power that the study was estimated to have for evaluating 2x2 interactions. Findings were consistent with a policy relevant effect of CCTs between US$ -6 and US$ 4, making it difficult to draw recommendations from this analysis. Low power is an inherent issue when trying to detect small changes in an outcome that varies greatly across a population of interest. Low statistical power increases the risk of falsely concluding there is no effect when in fact there is one, and highlights the need for further research in this field with either a larger sample, or one with more than two time points.

3.6.4 How findings fit with existing literature

Worldwide, and in Brazil, millions of poor households remain without formal income protection against illness (34). Determining ways to protect them against welfare losses related to severe illness may be key for tackling poverty (30). This is the first study in Brazil evaluating the longitudinal welfare impact of severe illness for poor households, and assessing whether it is modified by household receipt of CCTs. It demonstrates that there are still a large proportion of poor households across Brazil without access to formal social insurance in the event of severe illness. Interestingly, it suggests that severe illness with serious economic consequences is more common in the more industrialised Central West, South, and Southeast regions of Brazil, compared to the poorer rural North, and Northeast regions where the burden of general morbidity is known to be higher (129). This finding may either be an artefact of measurement error, or might imply that households in the Central West, South, and Southeast regions are more vulnerable to the economic consequences of illness (123). The study finds that households are able to protect both their labour income and food consumption in response to self-reported severe illness, but does not clarify if they would also be able to safeguard their welfare against a more objective measure of severe illness. Households' dependency on costly coping strategies in response to severe illness also remains unclear. Poorly characterised generally, one study shows that poor households in Brazil are likely to withdraw children from school for work in response to unemployment of the household head (67). This costly coping strategy, which has been found to be more common in poorer households, can have long-term consequences for households, as once children leave school they are less likely to return (79,94,130). The lack of any discernible effect of severe illness on household labour income and food consumption, combined with no information on household coping strategies, as well as low statistical power, meant that this study had little scope to evaluate the existence of a protective effect of CCTs. If, as discussed above, intra-household labour allocation to children is a key strategy for coping with severe illness in Brazil, existing evidence from Colombia and Mexico, shows that CCTs can significantly reduce the likelihood of households withdrawing children from school in response to illness (79,84). It is clear that a number of unknowns remain about the welfare impacts of mid- to long-term severe illness on poor households in Brazil, as well as the protective effect of CCTs on these impacts, and further work is required in this field.

3.7 Concluding remarks

As measured in this study, self-reported severe illness had surprisingly little impact on household labour hours, labour income, or food consumption among poor households in Brazil. Consequently, there was limited scope to assess any protective effect of CCTs, and the observed effects were modest. Further work is needed to better characterise the types of severe illness that have mid- to long-term economic consequences for poor households in Brazil; whether poor households use costly coping strategies in response to such illness; and, whether CCTs protect poor households from adverse consequences related to severe illness with mid- to long-term economic consequences.

Chapter 4. Uptake of governmental social protection and financial hardship from tuberculosis in Rio de Janeiro, Brazil

4.1 Research gaps addressed with survey in Rio de Janeiro, Brazil

In line with objective (3) of this thesis, this chapter describes drug resistant (DR) tuberculosis (TB)-affected households' costs, uptake of social protection, and financial hardship in Rio de Janeiro state, Brazil. In doing so, this chapter addresses the second research gap identified by the thesis for informing the potential of cash transfers to protect households from financial hardship related to severe illness: Lack of knowledge as to which social protection initiatives households affected by TB access during care, and whether they are sufficient to protect them from financial hardship.

4.2 Key findings from the survey in Rio de Janeiro, Brazil

In the study, bacteriologically confirmed DR TB is found to be associated with high total costs during treatment, with the main contributor indirect costs. Uptake of social protection is found to be quite common, in particular sick pay insurance. Uptake of social protection is associated with reduced financial hardship, especially experiencing catastrophic costs, impoverishment, and use of coping strategies simultaneously.

4.3 Background to survey in Rio de Janeiro, Brazil

DR TB is a major public health concern worldwide (131). Controlling DR TB relies on stopping its transmission, which itself depends on universal access to high-quality TB care. Even though most countries provide TB diagnosis and treatment free of charge, TB patients and their households continue to face high costs related to TB illness (12). These TB-related costs include "out-of-pocket" direct medical expenses (e.g. for private consultations), direct non-medical expenses (e.g. for transport, food, and natural remedies), as well as indirect costs from time away from work (12). Combined, these costs hinder patients' access to diagnosis and increase their risk of adverse treatment outcomes, thus increasing the likelihood of TB being transmitted to people with whom they are in close contact (6,132). With a recommended treatment duration of up to 24 months, and with patients unable to

work for most of this time due to disability, treatment side-effects, discrimination in the workplace and/or infection control laws; DR TB patients and their households are especially vulnerable to TB-related costs (6,58,133–136).

Acknowledging the need to improve TB patients access to care, the End TB Strategy mandates that no TB-affected household should face "catastrophic costs" due to TB (9). In this milestone, catastrophic costs refer to a combination of direct medical and non-medical expenses, and indirect costs excessive enough to cause financial hardship. There is still no consensus on an empirical method for measuring financial hardship from catastrophic costs (10). One proposed method is to measure if patients' TB-related costs exceed 20% of their pre-illness annual household income (10). Another is to measure if patients are forced to use a coping strategy like taking out a loan, or selling assets (10,26). A third method might be to measure if patients' TB-related costs push their pre-illness household income below a threshold of absolute poverty. Poverty is a clear indicator of financial hardship, and is known to be associated with adverse treatment outcomes (137).

To protect TB-affected households' from financial hardship, the End TB Strategy calls for Universal Health Coverage initiatives like decentralised care, prepayment and resource pooling aimed at defraying out-of-pocket direct medical expenses, to be complemented with other social protection initiatives aimed at defraying direct non-medical expenses, and reimbursing indirect costs (10,138). In recent years, most Latin American governments have invested in strengthening their social protection systems (139,140). In Brazil, the universal free Unified Health System protects people from paying for medical services, including TB diagnosis and treatment, and three governmental social protection policies Auxílio-Doença, Programa Bolsa Família, and Benefício de Prestação Continuada may help people manage direct non-medical expenses, and indirect costs related to illness. Details of these policies are provided in Table 12.

Reviewing the published literature, DR TB-related costs appear to have been studied in Cambodia, Ecuador, Ethiopia, Indonesia, Kazakhstan, Peru and South Africa, but never in Brazil, and never accounting for patients' receipt of social protection (6,58,133–135). This study aimed to describe DR TB-affected households' costs, uptake of social protection, and financial hardship in Rio de Janeiro state, Brazil.

Table 12. Summary of Brazilian governmental social protection policies: Auxílio-Doença, Programa Bolsa Família, and Benefício de Prestação Continuada. All monetary values are expressed in 2016 US$.

Auxílio-Doença: A governmental social insurance policy that provides sick pay to citizens who are normally employed but temporarily cannot work because of illness. Paid for by contributions from peoples' salaries before they are ill, it only covers workers who contribute to social insurance. To be eligible, people must have contributed to social insurance for at least 12 months. The eligibility of peoples' illness is assessed by a medical doctor. The programme provides a benefit equal to whichever is lowest between beneficiaries' mean monthly salary in the last 12 months versus 91% of their last month's salary (141). In 2014, 39% of Brazilian citizens older than 16 years of age contributed to social insurance and were therefore entitled to receive sick pay from Auxílio-Doença in the event of severe illness (142).

Programa Bolsa Família: A governmental social assistance policy that provides conditional cash transfers to families with a monthly household income per capita less than US$ 41, and children aged 0 to 17; and families with a monthly household income per capita less than US$ 21 regardless of whether they have children, to reduce current poverty and prevent future poverty for younger generations (109). Eligible applicants do not need to have contributed to social insurance. The programme provides variable values of cash transfers to beneficiaries based on family composition (143). In 2014, 15% of Brazilian families received social assistance from Programa Bolsa Família (142).

Benefício de Prestação Continuada: A governmental social assistance policy that provides periodic unconditional cash transfers to citizens that have a monthly household income per capita less than US$ 63, and are older than 65 years of age, or have a disability that lasts at least 24 months (109). Eligible applicants do not need to have contributed to social insurance. The eligibility of peoples' disabilities is assessed by a medical doctor (109). Successful applicants receive a monthly flat cash transfer equal to one minimum monthly salary US$ 251 (109). In 2014, 1% of Brazilian citizens older than 16 years of age received social assistance from Benefício de Prestação Continuada (142).

4.4 Methodology

4.4.1 Study design

The study was a cross-sectional survey between June-October 2016 at the DR TB outpatient clinic of the Professor Hélio Fraga reference centre (CRPHF) in Rio de Janeiro municipality, Rio de Janeiro state, Brazil. The study population was DR TB patients attending the CRPHF outpatient clinic who had been receiving treatment for at least one month. At the time of the study, the CRPHF's catchment area included 40 of 92 municipalities in Rio de Janeiro state, covering approximately 73% of the state's population, Figure 10 (144). In May 2016, there were 1,601 people with DR TB in Brazil (0.77 cases per 100,000 population), with 29% residing in Rio de Janeiro state (145). In Brazil, DR TB treatment is integrated into the government-funded universal healthcare system that provides all diagnostic tests, anti-microbial drugs, and when necessary, hospital services free of charge. National guidelines for DR TB treatment recommend ambulatory care under "directly observed therapy" (DOT), with monthly visits to a reference centre for 6-24 months (146).

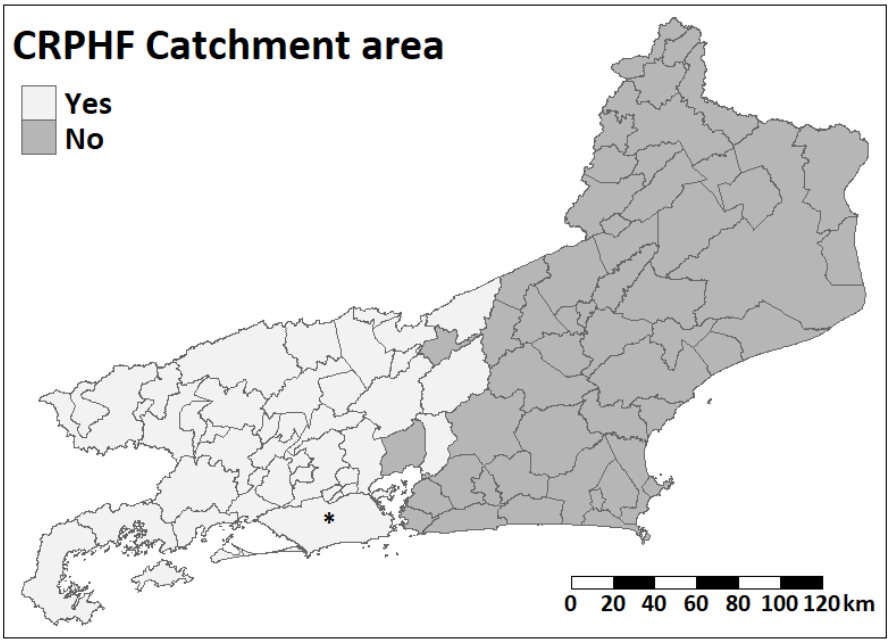

Figure 10. The catchment area of the Professor Hélio Fraga pneumopathy reference centre in Rio de Janeiro state, Brazil.

*The municipality of Rio de Janeiro is divided into 10 programmatic areas of health delivery. The Professor Hélio Fraga reference centre serves programmatic areas 2.1, 4.0, 5.1, 5.2 and 5.3.

4.4.2 Description of the data source

Patients were invited to participate in the study by the healthcare professional they were seeing during their monthly visit to the CRPHF. Structured interviews were conducted by two social workers using a locally adapted version of the World Health Organization's survey tool for estimating TB-related costs (19). The questionnaire was shortened to exclude questions on pre-diagnostic healthcare seeking behaviours, and costs incurred during previous courses of TB treatment because of concerns about respondent fatigue and reporting accuracy for costs incurred far in the past. The final structured questionnaire collected data on participants' demographic and socioeconomic information, direct expenses, indirect costs, use of coping strategies, and uptake of social protection. Participants' clinical information was obtained from the online national registry, SITETB (145). Collected data were entered into Microsoft Excel 2016, and analysed in R version 3.3.0. All monetary values were collected in Brazilian reais (R$), and converted to 2016 United States dollar (US$) (R$ 3.5 = US$ 1.0) (118).

4.4.3 Survey data management

Measurement of DR TB-related costs. Direct expenses were measured as self-reported monthly expenses accessing the community DOT clinic and CRPHF extrapolated over the complete length of their prescribed treatment (mean = 17.6 months), added to any self-reported expenses for transport accessing a hospital, supplementary food related to TB illness (e.g. additional protein) and/or expenses for private healthcare (consultation, exams, imaging, medicines, and other). Monthly expenses accessing the community DOT clinic were estimated as typical expenses for transportation and/or food during a single visit, multiplied by the number of visits typically made in a week, multiplied by the number of weeks in a month (4.3). Monthly direct expenses accessing the CRPHF were estimated as typical expenses for transportation and/or food during a monthly visit. Indirect costs were calculated, using the output-related approach, as the difference in self-reported monthly household income pre-illness versus during-treatment extrapolated over the complete length of participants' prescribed treatment (mean = 17.6 months) (147). Total costs were measured as the sum of direct expenses, and indirect costs after subtracting social protection payments. The burden of DR TB-related costs was measured by expressing them as a percentage of participants' pre-illness annual household income. Cost burdens could be

greater than 100% if the length of participants' DR TB treatment was longer than 12 months and they reported losing close to 100% of their pre-illness monthly income.

Measurement of DR TB-related uptake of social protection. Uptake of social protection was measured as self-reported uptake of sick pay insurance from Auxílio-Doença, or social assistance from Programa Bolsa Família, or Benefício de Prestação Continuada as a result of becoming ill with DR TB. The value of payments received from uptake of social protection was measured as self-reported monthly sick pay insurance from Auxílio-Doença, or social assistance from Programa Bolsa Família, or Benefício de Prestação Continuada extrapolated over the complete length of participants prescribed treatment (mean = 17.6 months).

Measurement of DR TB-related financial hardship. Financial hardship was measured as incurring a cost burden ≥20% of pre-illness annual household income, using a coping strategy (taking a loan, or selling a household item), becoming impoverished, and experiencing all three of these financial hardships. Impoverishment was calculated as DR TB-related costs that pushed participants' pre-illness monthly household income per capita below Brazil's 2016 poverty line (US$ 49 per month) (148).

4.4.4 Statistical analysis

Participants' pre-illness demographic and socioeconomic characteristics, and DR TB clinical characteristics were summarised by count and percent for categorical variables; and mean and standard deviation (SD) for continuous variables. Direct expenses, indirect costs, and total costs were summarised by mean and SD for comparison with other studies, and median and interquartile range (IQR), because the mean is hard to interpret when data are skewed. Proportions were compared with the Pearson's chi-square test and means were compared with the Student's t-test. Means of non-normally distributed variables were compared with the Mann-Whitney U test. Uptake of social protection was summarised by count and percent, and the mean value of social protection received by mean and SD. Financial hardship was summarised by count and percent.

The association between uptake of social protection and financial hardship was investigated by uni- and multivariable logistic regression adjusting for demographic, socioeconomic and clinical variables associated with financial hardship at $p<0.1$, and the two a priori confounding variables sex and age. The likelihood ratio test (LRT) was used to assess the

association of exposure variables with the outcome. Associations between uptake of social protection and each of the four measures of financial hardship were investigated separately. Because previously being in paid employment was a condition for receipt of sick pay insurance from Auxílio-Doença, it was not adjusted for in the final multivariate model. For this analysis the variables race, pre-illness receipt of social protection, and type of resistance were re-grouped because of sparse data. All ordered categorical variables were checked for evidence of a linear trend using the LRT.

4.4.5 Ethical approval

The ethical committee of the Escola Nacional de Saúde Pública Sérgio Arouca approved all components of the study (1.4238.240, CAEE: 53187516.0000.5240). All patients gave written informed consent before participating in the study.

4.5 Results

4.5.1 Characteristics of study participants

A total of 131 DR TB patients were invited to participate in the study, six had not completed one month's treatment, and five did not consent to participate. In the analysis stage, one participant was excluded because of implausible income data. Demographic, socioeconomic and clinical characteristics of the 119 participants included in the final analysis are summarised in Table 13. Most participants were male (68%), and of mixed race (48%). Before DR TB illness, the greater part of participants had a monthly household income per capita less than one minimum salary (63%), and approximately half were the principle household income provider (53%). A minority of participants had a monthly household income (including social protection benefits) per capita below the national poverty line (5%). Most had acquired versus primary DR TB (55%), multi-DR TB (60%), and cavitary DR TB (94%). Uptake of social protection during DR TB treatment was not the norm (38%), and was more likely amongst male participants ($p<0.001$), and participants in paid employment before DR TB ($p=0.08$), Table 13.

4.5.2 DR TB-related costs

Mean direct expenses were US$ 809 (SD: US$ 601), representing 14% (SD: 17%) of annual household income, Table 14. Mean indirect costs were US$ 6,207 (SD: US$ 6,671), representing 81% (SD: 54%) of annual household income, Table 14. Mean social protection

payments were US$ 1,970 (SD: US$ 2,897), Table 14. Mean total costs, after subtracting social protection, were US$ 5,046 (SD: US$ 6,290), representing 64% (SD: 58%) of annual household income, Table 14. Total costs were positively skewed, with 95% of participants incurring costs lower than U$13,595, and the remaining 5% incurring total costs between U$ 13,595 and US$ 42,753, Figure S1. Participants that accessed social protection were more likely to incur lower total costs (p=0.005).

Table 13. Summary of survey participants' pre-illness demographic and socioeconomic characteristics, and DR TB clinical characteristics.

	Study participants n = 119 n (%)	**Social protection uptake during DR TB treatment**		**p-value‡**
		Yes n = 45 n(%)	**No n = 74 n(%)**	
Demographic				
Sex				<0.001
Male	81 (68)	38 (84)	43 (58)	
Age				0.06
Mean (SD)	42 (14)	40 (14)	44 (14)	
Race				0.27
White	27 (23)	12 (27)	15 (20)	
Mixed	57 (48)	16 (36)	18 (24)	
Black	34 (29)	17 (38)	40 (54)	
Indigenous	1 (1)	0 (0)	1 (1)	
Socioeconomic				
Elementary education				0.96
Completed	36 (30)	13 (29)	23 (31)	
Household head				0.16
Yes	63 (53)	28 (62)	35 (47)	
Paid employment				0.08
Yes	108 (91)	44 (98)	64 (86)	
Household income per capita, US$*				0.25
< 126	32 (27)	11 (24)	21 (28)	
126 to 251	42 (35)	20 (44)	22 (30)	
> 251	45 (38)	14 (31)	31 (42)	
Received social protection				0.59
No	100 (84)	39 (87)	61 (82)	
Auxilio-Doença	3 (3)	1 (2)	2 (3)	
Programa Bolsa Família	13 (11)	5 (11)	8 (11)	
Benefício de Prestação Continuada	3 (3)	0 (0)	3 (4)	
Poverty†				0.71
Yes	5 (4)	4 (5)	1 (2)	
Clinical				
Acquired DR TB				0.86
Yes	66 (55)	24 (53)	42 (57)	
Type of DR TB				0.13
Suspected	3 (3)	3 (7)	0 (0)	
Mono-/ Poly-	35 (29)	14 (31)	21 (28)	
Multi-	71 (60)	24 (53)	47 (64)	

Extensively	11 (9)	5 (11)	6 (8)	
Cavitary DR TB				1
Yes	94 (79)	36 (80)	58 (78)	
Treatment model				0.26
Clinic-based DOT	90 (76)	35 (78)	55 (74)	
Home-based DOT	9 (8)	5 (11)	4 (5)	
Self-administered	20 (17)	5 (11)	15 (20)	
Time to DOT clinic (hours)				0.25
Mean (SD)	0.5 (0.6)	0.4 (0.6)	0.6 (0.6)	
Time to CRPHF (hours)				0.22
Mean (SD)	4 (2)	4 (2)	4 (2)	
Month of treatment				0.96
2-6	30 (25)	12 (27)	18 (24)	
7-12	43 (36)	16 (36)	27 (36)	
13+	46 (39)	17 (38)	29 (39)	

Abbreviations US$, United States Dollar; SD, Standard Deviation; DS, Drug Susceptible; DR, Drug Resistant; TB, Tuberculosis; DOT, Directly Observed Therapy; CRPHF, Professor Hélio Fraga Reference Centre. *Refers to pre-illness monthly household income per capita, †Defined using Brazil's 2016 poverty line of monthly household income per capita US$ 49 a month (148), ‡Refers to comparison of participants that do, and do not uptake social protection; proportions were compared with the Pearson's chi-square test and means were compared with Students t-test.

Table 14. Summary of survey participants' direct expenses, indirect costs, and total DR TB-related costs.

	DR TB-related cost US$ n = 119		DR TB-related cost burden % household income† n = 116‡	
	Mean (SD)	**Median (IQR)**	**Mean (SD)**	**Median (IQR)**
Direct expenses				
Patient				
DOT				
Transport	184 (224)	112 (112 to 156)	3 (6)	2 (1 to 2)
Food	179 (161)	112 (112 to 156)	3 (5)	2 (1 to 3)
CRPHF				
Transport	122 (99)	114 (78 to 137)	2 (2)	1 (1 to 2)
Food	34 (40)	26 (0 to 51)	1 (1)	0 (0 to 1)
Hospital				
Transport	6 (31)	0 (0 to 0)	0 (0)	0 (0 to 0)
Private				
Healthcare*	19 (62)	0 (0 to 0)	0 (1)	0 (0 to 0)
Food supplements	25 (30)	14 (1 to 34)	0 (0)	0 (0 to 0)
Family guardian				
DOT				
Transport	87 (203)	0 (0 to 67)	2 (4)	0 (0 to 1)
Food	64 (113)	0 (0 to 134)	1 (2)	0 (0 to 2)
CRPHF				
Transport	64 (55)	76 (0 to 114)	1 (2)	1 (0 to 2)
Food	24 (35)	0 (0 to 40)	0 (1)	0 (0 to 1)
Subtotal	809 (601)	616 (485 to 877)	14 (17)	8 (5 to 16)
Indirect costs				
Patient	5,745 (6,641)	4,526 (1,800 to 7,303)	76 (55)	72 (36 to 131)
Family member	462 (1,412)	0 (0 to 0)	6 (19)	0 (0 to 0)
Subtotal	6,207 (6,671)	4,629 (2,160 to 8,167)	82 (55)	75 (38 to 143)
Social protection				
Subtotal	1,970 (2,897)	0 (0 to 4,526)	31 (51)	0 (0 to 60)
Total	5,046 (6,290)	3,868 (850 to 6,817)	65 (59)	60 (15 to 101)

Abbreviations: US$, United States Dollar; SD, Standard Deviation; IQR, Interquartile Range; DOT, Directly Observed Therapy; CRPHF, Professor Helio Fraga Reference Centre; DR, Drug Resistant; TB, Tuberculosis. *Includes expenses for private consultation, examination, imaging, medicines and other, †Refers to annual household income including social protection, ‡Three participants were excluded because pre-illness annual household income was US$ 0.

4.5.3 Uptake of social protection

Amongst the 45 participants that accessed social protection because of DR TB, the mean value of social protection received was US$ 5,210 (SD: US$ 2,290). Of these participants, 36 (80%) received sick pay insurance from Auxilio-Doença with a mean value of US$ 5,734 (SD: US$ 1,877). 3 (7%) received both sick pay insurance from Auxilio-Doença and social assistance from Programa Bolsa Família with a mean value of US$ 5,833 (SD: US$ 846), 4 (9%) received social assistance from Programa Bolsa Família with a mean value US$ 366 (SD: US$ 149), and 2 (4%) received social assistance from Benefício de Prestação Continuada with a mean value of US$ 4,256 (SD: US$ 0).

4.5.4 Uptake of social protection and financial hardship

Overall, 68% of participants incurred a cost burden ≥20% of household income, 54% used a coping strategy, 24% were impoverished, and 18% experienced all three types of financial hardship, Figure 11. In multivariable logistic regression, uptake of social protection was independently associated with lower risk of incurring total costs ≥20% of household income (OR: 0.37 [95% CI: 0.14 to 0.94], p=0.04); impoverishment (OR: 0.16 [95% CI: 0.04 to 0.54], p=0.002); and, experiencing all three hardships (OR: 0.01 [95% CI: 0.00 to 0.07], p<0.001); but not with using a coping strategy (OR 1.31 [95% CI: 0.50 to 3.47], p=0.58), Table 15. Univariable associations of participants' demographic and socioeconomic, and clinical characteristics with financial hardship are provided in Table S9.

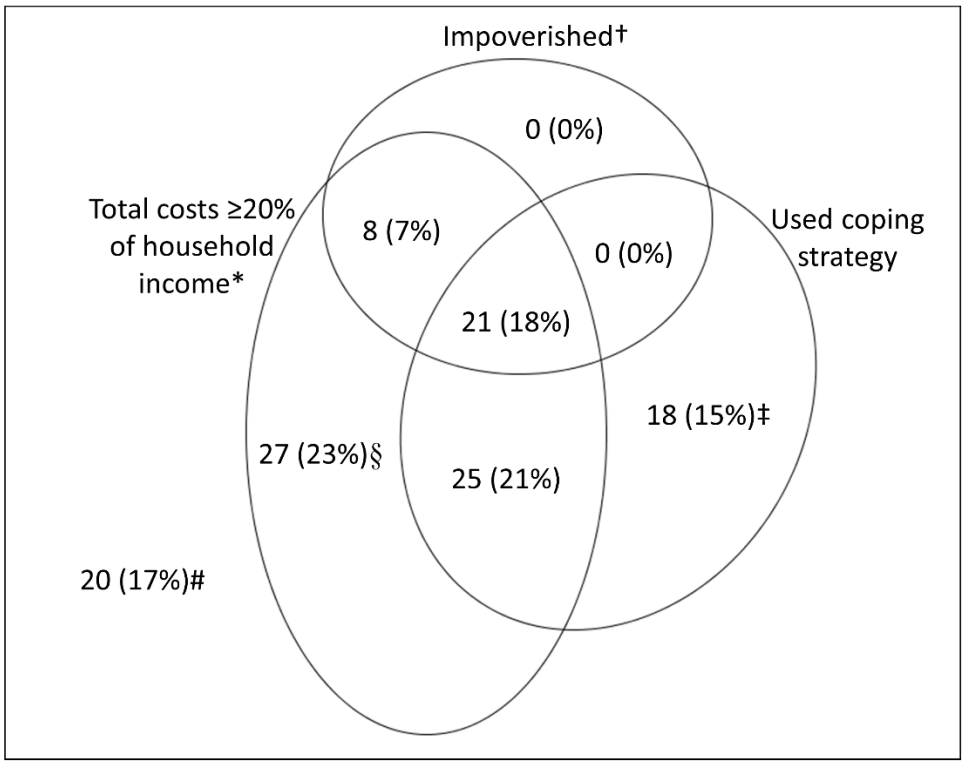

Figure 11. Summary of financial hardship across survey participants.

n = 119. The area of each ellipse is proportional to the number of participants in that set. The area-proportional Venn diagram was drawn using eulerAPE (149). *Refers to pre-illness annual household income, †Defined using Brazil's 2016 poverty line of monthly household income per capita US$ 49 a month (148), ‡Two participants had pre-illness annual household income US$ 0, and were in poverty pre-illness, §One participant had missing data on use of coping strategies, ¶One participant was in poverty pre-illness, #One participant had pre-illness annual household income US$0, and was in poverty pre-illness.

Table 15. Multivariable logistic regression assessing the association between uptake of social protection and financial hardship.

	Multivariable logistic regression	
	OR (95% CIs)	**p-value**
Financial hardship		
Total costs ≥20% of household income*†	0.37 (0.14-0.94)α	0.04
Used coping strategy‡	1.31 (0.50-3.47)β	0.58
Impoverished§¶	0.16 (0.04-0.52)γ	0.002
All three financial hardships#	0.01 (0.00-0.07)δ	<0.001

Abbreviations: OR, Odds Ratio; CI, Confidence Interval. Socioeconomic and clinical characteristics associated (p<0.1) with outcomes in univariable logistic regression were included in multivariable logistic regression models. *Refers to pre-illness annual household income. †Three participants with pre-illness annual household income US$ 0 were excluded, n = 116, ‡One participant with missing data on use of coping strategies was excluded, n = 118, §Five participants in poverty pre-illness were excluded, n = 114, ¶Defined using Brazil's 2016 poverty line of monthly household income per capita US$ 49 a month (148), #Six participants with either pre-illness annual household income US$ 0, missing data on use of coping strategies, or in poverty pre-illness were excluded, n = 113. α Mutually adjusted for sex, age, education, acquired DR TB, and time to DOT clinic; β Mutually adjusted for sex, age, pre-illness household head, pre-illness household income per capita, acquired DR TB, and time to DOT clinic; γ Mutually adjusted for sex, age, education, and pre-illness household income per capita; δ Mutually adjusted for sex, age, pre-illness household head, pre-illness household income per capita, acquired DR TB, and time to DOT clinic.

4.6 Discussion of findings

4.6.1 Summary of main findings

In Rio de Janeiro, Brazil, despite free TB care and a comprehensive social protection floor, total costs incurred by DR TB patients and their households during treatment are high. The main contributor to patients' total costs is indirect costs. Many DR TB affected households experience financial hardship from DR TB-related costs, and some experience multiple kinds simultaneously. Uptake of social protection because of DR TB is not the norm, with sick pay insurance from Auxilio-Doença the most commonly accessed social protection initiative. Social protection reimburses a large proportion of patients' indirect costs, and total costs are lower amongst those who take it up compared to those who don't. Uptake of social protection is associated with reduced financial hardship, especially experiencing multiple kinds simultaneously.

4.6.2 How findings fit with the existing literature

To our knowledge, this study is the first to summarise DR TB-affected households' costs, uptake of social protection and financial hardship in Brazil (6,58,133–135). It is also the first anywhere to evaluate the association between uptake of governmental social protection and financial hardship. In doing so, the study provides crucial evidence informing the World Health Organization's goal of eliminating catastrophic costs (9). The high value of DR TB-related costs in this study matches existing evidence in the seven countries where they have previously been studied, and serves to reiterate the urgent need for research into the potential of governmental social protection to prevent this (6,58,133–135). Results support trial evidence demonstrating the effectiveness of a non-governmental cash transfer intervention in Lima, Peru, and extends it to the context of real-world social protection policies available to TB patients (6). A survey from South Africa is currently the only other study exploring TB patients' uptake of governmental social protection during treatment (58). In South Africa, results showed that less than half of TB patients access social protection, and suggested that patients only accessed social protection later on during treatment (58). Results from Rio de Janeiro, show no association between stage of treatment and uptake of social protection. This may indicate fewer administrative barriers for patients accessing social protection in Brazil.

4.6.3 Study strengths

The study had several strengths. As one of the first studies to account for uptake of social protection when estimating household total costs, it provides a much more accurate estimate of the household-level financial impact of DR TB. The study also used three different measures of household financial hardship related to DR TB, and assessed their overlap using a Venn diagram. This approach provides a useful reference of the overlap of different measures of financial hardship, and helps to estimate the number of households experiencing especially severe financial hardship related to DR TB.

4.6.4 Study limitations

Limitations of this study include its small sample size, which meant it was not possible to stratify the analysis by different social protection policies. Nevertheless, there was adequate power to detect an association between uptake of social protection and financial hardship. Omission of questions relating to costs incurred during previous courses of TB treatment will have underestimated the full value of patients' TB-related costs. However, to avoid recall bias the World Health Organization advises that only new TB cases in the intensive phase of treatment without a previous course of DS TB treatment are asked about these costs, which ex post facto in this study was only 3 people (19). Although there might have been measurement error from patients' self-reported uptake of social protection because of DR TB, this was minimised by asking patients about specific social protection policies they might have received because of DR TB illness. While the 20% cost burden threshold for measuring financial hardship could be seen as arbitrary, the use of three measurements and a combined indicator for financial hardship ensure that the conclusions are robust to any potential misclassification. The cross-sectional design might have underestimated the prevalence of taking a loan or selling assets, as the risk of these activities is likely to accumulate over the duration of treatment (56). However, this will only have affected the association between receipt of social protection and financial hardship if it was differential by receipt of social protection. Finally, the study's cross-sectional design might have underestimated uptake of social protection because of DR TB. Longitudinal follow-up would be necessary to capture patients' uptake over the full duration of treatment.

4.7 Concluding remarks

In Rio de Janeiro, Brazil, financial hardship is common amongst DR TB-affected households. Households that uptake social protection during treatment are less likely to experience financial hardship. Considering that the majority of households do not uptake social protection during treatment, further strategic efforts are needed to protect all DR TB-affected households from financial hardship.

Chapter 5. Comparison of two cash transfer strategies to prevent catastrophic costs for poor tuberculosis-affected households in low- and middle-income countries.

5.1 Research questions addressed by comparing two cash transfer strategies

In line with objective (4) of this thesis, this chapter aimed to assess the most effective and affordable way of providing cash transfers to households affected by TB to prevent them experiencing financial hardship. In doing so, this chapter addresses the second research gap identified by the thesis for informing the potential of cash transfers to protect households from financial hardship related to severe illness: Lack of knowledge about whether making poor households at risk of TB more resilient to TB-related costs, or defraying poor households' costs after a family member develops TB is more effective and affordable for preventing financial hardship.

5.2 Key findings from comparison of two cash transfer strategies

In this chapter, TB-specific cash transfers provided to defray poor households' costs after a family member develops TB were found to prevent TB-related financial hardship in some countries, while TB-sensitive cash transfers provided to make poor households at risk of TB more resilient to TB-related costs were found to achieve this in no countries. In countries where neither TB-specific cash transfers nor TB-sensitive cash transfers would be sufficient to prevent financial hardship, the average value of additional cash transfer needed to achieve this objective would be much lower using a TB-specific approach compared to a TB-sensitive approach. Further, by only targeting poor households with a confirmed TB diagnosis, a TB-specific approach would require a smaller country-level budget than a TB-sensitive approach.

5.3 Background to comparison of two cash transfer strategies

TB disproportionately affects poor households in low- and middle-income countries that are least able to afford the burden that TB-related costs represent relative to their income (150–155). Even when diagnosis and treatment is available free of direct charges, TB-

affected households are known to incur hidden “out of pocket” direct medical expenses (e.g. for consultations) and direct non-medical expenses (e.g. for transport, additional food, and symptomatic medicines), as well as indirect costs from lost income (12,156). Two groups of households that are especially vulnerable to TB-related costs are those in countries’ poorest population quintile, and those affected by drug-resistant (DR) TB (12).

Preventing catastrophic costs for TB-affected households is a priority for facilitating individuals’ access to TB diagnosis and treatment, increasing their likelihood of treatment success, and reducing onwards TB transmission (157). With this objective, the Global TB Programme endorses the use of additional social protection initiatives to complement Universal Health Coverage initiatives like fee waivers, resource pooling and patient-friendly service delivery (10). Cash transfers have become an especially popular social protection initiative in low- and middle-income countries. In the TB literature, evidence from a randomized trial in Peru shows that when provided as incentives to support TB treatment, cash transfers reduce poor TB-affected households’ likelihood of incurring catastrophic costs, as well as improve patients’ likelihood of TB treatment success, and uptake of preventative therapy amongst people they are in close contact with (e.g. family, friends, care giver) (45,56). Outside of the TB literature, synthesised evidence from governmental poverty-reduction policies in several low- and middle-income countries provides evidence that cash transfers increase help poor households to cope with livelihood risks (e.g. illness and unemployment) (61).

Currently, there are at least two alternative approaches proposed in the tuberculosis (TB) literature for providing cash transfers to TB-affected households (158). The first is termed a “TB-specific” approach, whereby cash transfers would be targeted to poor households with a confirmed TB diagnosis to incentivise and enable TB treatment by defraying their TB-related costs (158). This approach is exemplified by the cash transfer component of the Community Randomized Evaluation of a Socioeconomic Intervention to Prevent TB (CRESIPT) trial in Peru (159,160). The second is termed a “TB-sensitive” approach, whereby cash transfers would be targeted to poor households at high risk of developing active TB disease to increase their income, thereby protecting them from poverty-related risk factors for TB infection, progression, and adverse treatment outcomes (e.g. poor living conditions and undernutrition), as well as strengthen their economic resilience to TB-related costs

(158). This approach already exists in many low- and middle-income countries, and is exemplified by governmental poverty-reduction cash transfer programmes like Programa Bolsa Família in Brazil (37,143).

Depending on whether cash transfers are provided with a TB-specific or a TB-sensitive approach, their impact might vary (158). This study aimed to investigate how this might relate to the potential of cash transfers to prevent catastrophic costs. This study built on work conducted as part of my Masters dissertation, which was submitted in September 2015, in part fulfilment for the degree of MSc in Control of Infectious Disease, at the London School of Hygiene and Tropical Medicine (161).

5.4 Research methodology

5.4.1 Study design and implementation

With no known data sources for investigating if the potential of TB-specific and TB-sensitive cash transfers to prevent catastrophic costs varies, an economic modelling study was undertaken using published national average data gathered from a rigorous review of the literature. This economic modelling study was aggregated at the country level. The setting was low- and middle-income countries, where over 95% of TB cases live, and where formal institutions to protect households from the social and economic impacts of illness are weakest (52). The intervention being investigated was cash transfers paid to poor households, and the alternative approaches being compared were: (1) cash transfers provided to defray TB-related costs of households with a confirmed TB diagnosis (termed a "TB-specific" approach); versus (2) cash transfers provided to increase income of households with high TB risk and strengthen their economic resilience (termed a "TB-sensitive" approach). These approaches were compared because of current uncertainty about the potential of each approach to prevent catastrophic costs. For transparency, the study was reported according to the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist (162). The completed checklist is provided in Table S10.

Primary study outcomes were an indicator for catastrophic costs after TB-specific versus TB-sensitive cash transfers, and countries' country-level cash transfer budget needed to prevent catastrophic costs for each of these approaches. Catastrophic costs were estimated over a time horizon from the month prior to TB symptom onset to TB treatment completion.

Countries' country-level cash transfer budget was estimated over a time horizon of one year. In the one country with available data, outcomes were investigated separately for drug-susceptible (DS) TB and DR TB. The reason for this is that treatment of DR TB versus DS TB is longer and more intensive and is therefore associated with much higher TB-related costs (12). Using only TB-related costs incurred by patients, study outcomes were assessed from the patient perspective.

5.4.2 Study population

In this study, the target population for cash transfers provided with a TB-specific approach was households in countries' poorest population quintile with a confirmed TB diagnosis. Guidance is not currently available for which TB-affected households should be targeted with a TB-specific approach. It was chosen to focus on TB-affected households in countries' poorest population quintile because they are typically at greater risk of incurring catastrophic costs (6). Whilst it might have been preferable to focus on all TB-affected households that incur catastrophic costs, at the time of analysis no estimates of the size of this population were available in any countries included in this study. The target population for cash transfers provided with a TB-sensitive approach was households in poverty already targeted by countries' established governmental poverty-reduction cash transfer programme.

5.4.3 Study data

The study used cross-sectional data drawn from secondary sources. Data inputs were countries' mean patient TB-related cost, mean pre-illness household income, mean poverty-reduction cash transfer, and TB-specific versus TB-sensitive target populations. Inputs were retrieved by reviewing TB-related cost and cash transfer literature, and countries' national statistics. Because there was insufficient data across low- and middle-income countries on programmes providing cash transfers with a TB-specific approach, this study compared cash transfers offered by existing governmental poverty-reduction programmes as if they were provided with a TB-specific versus a TB-sensitive approach.

TB-related cost data. Data on mean TB-related costs incurred by patients were sourced from articles identified by two recent publically available systematic reviews (12,156). These reviews were chosen because they provided a comprehensive, peer-reviewed list of TB-

related cost surveys published before March 2013 and February 2015. TB-related cost surveys in identified articles were eligible if they were conducted in a low- or middle-income country, and reported mean total costs calculated from direct expenses and/or indirect costs incurred over the full duration of pre- and/or during- DS TB and/or DR TB treatment. Cost surveys only reporting median total costs were excluded because of difficulties generalising this measure to countries' total population. Cost surveys were also excluded if they were conducted before 2006, the year in which the Global TB Programme recommended that governments should waive direct expenses for basic TB diagnostic tests and medicines (163). If a publication reported TB-related costs from surveys in several different countries, each survey country was checked separately for cash transfer and household income data. Data extracted from eligible TB-related cost surveys comprised: survey country, year of data collection, survey setting, survey sample size, local currency unit exchange rate, methods used to estimate TB-related costs and mean TB-related costs stratified into sub categories of direct, indirect and total TB-related costs. In Brazil and Yemen, where articles reported mean TB-related costs for different patient sub-groups (e.g. directly observed therapy versus self-administered therapy) an un-weighted mean overall estimate was calculated across subgroups (164,165).

Cash transfer data. For countries with an eligible TB-related cost survey, existing poverty-reduction cash transfer programmes operating in respective countries were identified using the publically available social safety net program inventory in the appendix of the World Bank Group publication "The State of Social Safety Nets 2015" (166). None of the identified cash transfer programmes were operated with explicit TB objectives. Cash transfer programmes were eligible if they were directed by a national government with the objective of poverty reduction and promoting family human capital development. Operational data on cash transfer programmes were sourced from the original reference (166) and other publically available online data sources identified from Google by combining the phrase "cash transfer" with the name of the programme and the selected country (50,84,112,167–175). A summary of cash transfer data sources used in the study is provided in Table S11. Cash transfer programmes were excluded if they were targeted uniquely to senior citizens or pregnant women. Data extracted on eligible poverty-reduction cash transfer programmes comprised: name of programme, breakdown of cash transfer benefits, mean cumulative

annual cash transfers, sample size used to summarise mean cumulative annual cash transfers, and the range of cumulative annual cash transfers based on programme regulations.

Household income data. For countries with an eligible TB-related cost survey and existing poverty-reduction cash transfer programme, countries' mean household income or expenditure in the poorest population quintile was used to approximate household income of both TB-specific and TB-sensitive target populations. Publically available summary estimates of household income or expenditure were identified by searching countries' national statistical websites and the International Household Survey Network's (IHSN's) survey catalogue (176). It was assumed that household income and expenditure were approximately similar. Where available, household income was preferred because of its use in the method included by the Global TB Programme in a pilot tool to measure and monitor catastrophic costs of TB-affected households (10). Data extracted from countries' national statistical websites and the IHSN survey catalogue comprised: Coverage in households of country household income or expenditure survey, and mean household income or expenditure in countries' poorest population quintile. When household income data was reported by population decile rather than population quintile, an un-weighted mean overall estimate was recalculated across the two poorest deciles. When national income surveys reported mean monthly or quarterly household income or expenditure, these values were extrapolated to mean annual estimates.

Target population data. For countries with an eligible cost survey, cash transfer programme and household income or expenditure survey, the approximate size of their TB-specific target population was identified using the World Health Organization's publically available TB data (177). Because estimates of the percentage of TB-affected households represented in the poorest population quintile were not available in any countries included in the study, the unweighted mean multiplier for TB prevalence in the poorest population quintile observed in India and South Africa was used to estimate the size of countries' TB-specific target population (55,178). Therefore, countries TB-specific target population was extracted as 40% of countries' estimated 2013 DS TB burden or 2015 DR TB burden. For country estimates of DR TB burden, 2015 estimates were used because 2013 estimates weren't available. It was assumed that each estimated case of active TB disease in the World Health

Organization's TB data represented one household with a confirmed TB diagnosis. The approximate size of countries' TB-sensitive target population was identified using publically available estimates of countries' 2013 poverty-reduction cash transfer programme coverage in households already extracted in the cash transfer data literature review (50,84,112,167–175). Countries' TB-specific and TB-sensitive target populations were also extracted as a percentage of countries' total population in households using publically available census data available in the United Nations demographic yearbook (179).

All data were extracted into Microsoft Excel 2016. To allow comparison of monetary data extracted in different currencies and measured in different years all extracted monetary values were inflated and converted to 2013 international dollars ($) using the purchasing power parity conversion factor that accounts for differences in the cost of living across countries (180,181).

5.4.4 Data management.

Missing values for direct or indirect costs, pre- or during-treatment were imputed. To do this, it was assumed that average TB-related costs followed a make-up of cost components equivalent to the one synthesised by Tanimura et al. in their systematic review of TB-related costs in low- and middle-income countries, which is that direct and indirect costs are equivalent to 40% and 60% of total costs respectively, and pre- and during-treatment costs are each equivalent to 50% of total costs respectively (12). Because only one included cost survey reported the standard deviation of total costs (164), it was also assumed that average TB-related costs had a standard deviation with the same ratio to total costs as the one estimated by Tanimura et al. for average total costs across all low- and middle-income countries, which was 1.1 (12). The assumed standard deviation and sample size of countries' cost surveys were used to calculate 95% CIs for estimated TB-related costs.

5.4.5 Data analysis.

All analyses used published mean national data. To account for uncertainty in the value of extracted TB-related costs, annual household income, and cash transfers, a multiway analysis was conducted that allowed all three of these inputs to vary simultaneously according to their sampling distributions. Sampling distributions were simulated from 10,000 computationally generated random samples, and were all assumed to have normal

distributions according to the central limit theorem. Random samples were generated for TB-related costs using a standard deviation with a ratio of 1.1 to mean estimates, which was the ratio estimated by Tanimura et al. for average total costs across all low- and middle-income countries, and a sample size equivalent to countries' cost surveys (12). For annual household income, a standard deviation with a ratio of 0.8 to mean estimates, and a sample size equivalent to countries' household income surveys was used (182–188). The ratio of 0.8 was the average observed across two studies investigating the household-level income effect of poverty-reduction cash transfer programmes in Brazil and Colombia (84,167). For cash transfers, a standard deviation with a ratio to mean estimates equivalent to a quarter of maximum cash transfers minus minimum cash transfers, and a sample size equivalent to the one reported in studies from which cash transfer data were extracted was used. In Ecuador and Ghana, sampling distributions for cash transfers were not simulated because respectively, all beneficiary households receive the same flat cash transfer, and the mean cash transfer that was extracted was estimated from all beneficiary households. Throughout the analysis, 95% CIs were calculated for model estimates using the quantile method. All analyses were run in R version 3.3.0.

Estimation of TB-related cost burden before cash transfers. To estimate if TB-related costs were catastrophic for poor TB-affected households, each country's TB-related cost burden without cash transfer data was calculated by expressing TB-related costs as a percentage of household income. A TB-related cost burden greater than or equal to 20% was measured as catastrophic, as this threshold has been shown to significantly increase the likelihood of TB patients experiencing an adverse treatment outcome, and their household engaging in damaging financial coping strategies (6,56). In countries where the TB-related cost burden was estimated to be catastrophic, the potential of cash transfers provided with a TB-specific versus a TB-sensitive approach to prevent catastrophic costs was then compared.

Estimation of the potential of TB-specific cash transfers to prevent catastrophic costs. To estimate the potential of cash transfers provided with a TB-specific approach to prevent catastrophic costs, it was considered that cash transfers would be targeted to poor households with a confirmed TB diagnosis to defray TB-related costs incurred pre- and during-treatment. Thus, the value of cash transfers was subtracted from TB-related costs, and then countries' TB-related cost burden was recalculated, Table 15, Equation 1.

Estimation of the potential of TB-sensitive cash transfers to prevent catastrophic costs. To estimate the potential of cash transfers provided with a TB-sensitive approach to prevent catastrophic costs, it was considered that cash transfers would be targeted to poor households at high risk of developing active TB disease, to increase their pre-illness income and protect them from poverty. For any beneficiary households that later developed active TB disease, their cash transfer increased household income would make them more resilient to the burden of TB-related costs incurred pre- and during-treatment. Thus, the value of cash transfers was added to pre-illness annual household income, and then countries' TB-related cost burden was recalculated, Table 15, Equation 2.

Estimation of TB-specific and TB-sensitive cash transfer needed to prevent catastrophic costs. To estimate the total value of cash transfer that would be needed by poor TB-affected households to prevent catastrophic costs with a TB-specific versus a TB-sensitive approach, it was considered that for each approach, an additional cash transfer would be provided to targeted households to achieve this objective. Thus, countries' household-level additional cash transfer needed to prevent catastrophic costs was first estimated by rearranging Equations 1 and 2, fixing countries' TB-related cost burden at 20%, and considering an unknown value of additional cash transfer, Table 16, Equations 3ii and 4ii. Then countries' household-level total cash transfer needed to prevent catastrophic costs was estimated by adding the value of original cash transfer to the estimated value of additional cash transfer needed to prevent catastrophic costs.

Table 16. Summary of equations used in economic modelling analysis.

TB-related cost burden (%)

Equation 1: after TB-specific cash transfers

$$TB\ related\ cost\ burden = \frac{(TB\ related\ cost - cash\ transfer)}{pre\ illness\ HH\ income} * 100$$

Equation 2: after TB-sensitive cash transfers

$$TB\ related\ cost\ burden\ = \frac{TB\ related\ cost}{(pre\ illness\ HH\ income + cash\ transfer)} * 100$$

Additional cash transfer needed to prevent catastrophic costs ($)

Equation 3: TB-specific approach

(i)

$$20 = \frac{(TB\ related\ cost - cash\ transfer - additional\ cash\ transfer)}{pre\ illness\ HH\ income} * 100$$

(ii)

$$additional\ cash\ transfer = (TB\ related\ cost - cash\ transfer) - (pre\ illness\ HH\ income * 0.2)$$

Equation 4: TB-sensitive approach

(i)

$$20\ = \frac{TB\ related\ cost}{(pre\ illness\ HH\ income + cash\ transfer + additional\ cash\ transfer)} * 100$$

(ii)

$$additional\ cash\ transfer = (TB\ related\ cost / 0.2) - (pre\ illness\ HH\ income + cash\ transfer)$$

Estimation of TB-specific and TB-sensitive cash transfer budget needed to prevent catastrophic costs. To estimate the country-level budget that countries would need to prevent catastrophic costs for all poor households targeted with a TB-specific versus a TB-sensitive approach, it considered that for each approach, a value of cash transfer sufficient to prevent catastrophic costs would be provided to all targeted households. Thus, countries' estimated TB-specific and TB-sensitive household-level total cash transfer needed to prevent catastrophic costs were multiplied by the size of each approach's target population, which for a TB-specific approach was all households with a confirmed TB diagnosis in countries' poorest population quintile, and for a TB-sensitive approach was households in poverty already targeted by countries' established governmental poverty-reduction cash transfer programme.

5.4.6 Sensitivity analysis

The sensitivity of study results in Brazil, Colombia, Tanzania and Mexico were tested to imputation of missing DS TB-related cost components by omitting rather than imputing the value of missing DS TB-related cost components (12). The sensitivity of study results was separately tested across all countries included in the study to the use of 20% as the threshold for measuring countries' TB-related cost burden as catastrophic. This was done by repeating the analyses instead using a 10% and 30% threshold.

5.5 Results

Figure 12 is a flow chart of the review process for assessing the eligibility of countries for inclusion in this study. Argentina, Bangladesh, and South Africa had to be excluded after insufficient publicly available background information was identified for eligible cash transfer programmes in these countries. Consequently, seven countries were included in the data analysis.

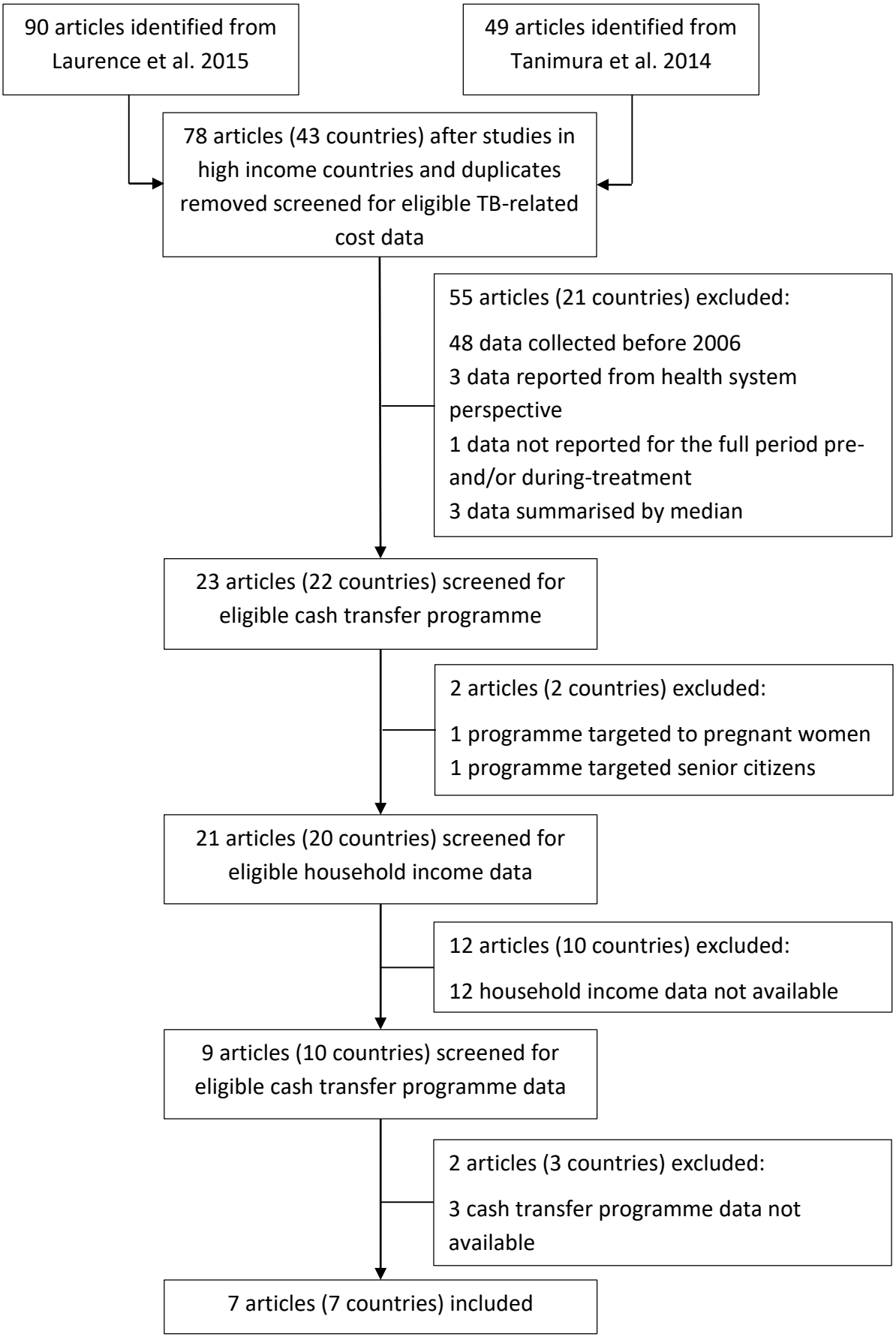

Figure 12. Flow chart of country eligibility and TB-related cost survey inclusion in the economic modelling study.

TB, Tuberculosis.

5.5.1 Summary of extracted data

DS TB-related cost data. Conducted in Brazil, Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen between 2006 and 2012, survey sample sizes ranged from 94 to 320 patients with active DS TB disease, Table 17. Surveys collected data on DS TB-related costs incurred pre- and during-treatment, except in Brazil (164), Colombia (189), and Tanzania (190), where they only collected data during-treatment, Table 17. Surveys collected both direct and indirect cost data, except in Mexico (191) where no data was collected characterising indirect costs, Table 17. In countries where data was collected, methods for estimating indirect costs varied in two ways: 1) reported time lost travelling and waiting to receive TB care was multiplied by patients' reported income (164,192); or 2) reported time lost travelling and waiting to receive TB care was multiplied by an estimate of national average income (gross national income per capita or official wage rate) (133,164,189,190). In Ecuador (133), data was collected on additional costs described in the publication as referring to "loans, paying for additional help and other impacts throughout the course of TB illness". The ambiguity of this cost category meant that it could not be classified as either direct or indirect costs, and was thus reported as its own subcategory. Reported mean DS TB-related total costs for the complete TB illness ranged from $387 to $2,382, Table 17. After imputing missing TB-related cost components in Brazil, Colombia, Mexico and Tanzania, estimated mean DS TB-related total costs ranged from $774 (95% CI: $618 to $930) to $5,954 (95% CI: $4,997 to $6,911), Table 17.

Summary of DR TB-related cost data. Conducted in Ecuador in 2007, the survey sample size was 14 patients with active multidrug-resistant TB disease, Table 17. The survey reported mean DR TB-related costs incurred pre- and during-treatment, Table 17. The survey collected both direct and indirect cost data, Table 17. Cost data was also collected on additional costs. This category of costs was reported as its own subcategory. Indirect costs were estimated by multiplying reported time lost travelling and waiting to receive TB care by the estimated hourly wage in Ecuador. Mean DR TB-related total costs were $16,667 (95% CI: $7,063 to $26,271), Table 17.

Table 17. Summary of TB-related cost surveys included in the economic modelling study.

Cost survey			Reported TB-related costs					Estimated TB-related costs
Country	**Year**	**Number of participants**	**Treatment phase**	**Direct 2013 PPP$**	**Indirect 2013 PPP$**	**Additional 2013 PPP$**	**Total 2013 PPP$**	**Total 2013 PPP$ (95% CIs) ***
DS TB								
Brazil§ (164)	2010	218	During-	182	205		387	774 (618 to 930) †
Ecuador (133)	2007	104	Pre- and during-	846	860	620	2,326	2,326 (1,834 to 2,818)
Yemen§ (165)	2008/09	320	Pre- and during-	631	253		885	885 (778 to 992)
Tanzania (190)	2012	94	During-	506	330		836	1,672 (1,300 to 2,044) †
Ghana (192)	2009	135	Pre- and during-	326	883		1,208	1,208 (984 to 1,432)
Colombia (189)	2010	150	During-				707	1,414 (1,165 to 1,663) †
Mexico (191)	2007/08	180	Pre- and during-	2,382			2,382	5,954 (4,997 to 6,911) ‡
DR TB								
Ecuador (133)	2007	14	Pre- and during-	2,345	4,560	9,762	16,667	16,667 (7,063 to 26,271)

Abbreviations: PPP, Purchasing Power Parity; CI, Confidence Interval; DR, Drug Resistant; DS, Drug Susceptible; TB, Tuberculosis. *According to Tanimura et al., estimated total costs in all countries had a standard deviation with a ratio of 1.1 to their value (12). The probability distribution of TB-related costs was assumed to be normal. This was justified because our analysis was at the national level and mean values were used. †According to Tanimura et al., reported during-treatment costs were assumed to only represent 50% of total TB-related costs (12). ‡According to Tanimura et al., reported direct expenses pre- and during-treatment were assumed to only represent 40% of total TB-related costs (12). §TB-related costs were extracted as an unweighted mean overall estimate calculated across patient subgroups.

Summary of cash transfer data. All extracted cash transfer data refer to programmes' status in 2013. Mean cumulative annual cash transfers were greatest in Brazil, Colombia, Ecuador, Mexico, and Yemen varying between $823 (range: $239 to $1,084) and $1,091 (range: $1,091 to $1,091); and lowest in Ghana and Tanzania where they were $217 (range: $150 to $299) and $451 (range: $349 to $655) respectively, Table 18. Across countries, cash transfers ranged from 8% (95% CI: 8% to 8%) to 43% (95% CI: 42% to 44%) of annual household income. In Colombia, Ecuador, Ghana, Mexico, and Tanzania they varied between 13% (95% CI: 11% to 18%) and 59% (95% CI: 50% to 72%) of DS TB-related costs, and in Brazil and Yemen, respectively, they were 104% (95% CI: 93% to 119%) and 106% (95% CI: 88% to 133%) of DS-TB-related costs, Table 18. In Ecuador, cash transfers represented 7% (95% CI: 4% to 15%) of DR TB-related costs, Table 18. A summary of cash transfer data sources and additional extracted data is provided in Table S11.

Summary of household income data. Conducted between 2005 and 2011, survey sample sizes ranged from 8,687 to 55,970 households (182–188). Surveys reported mean household income, except in Tanzania where mean household expenditure was reported. Estimated mean annual household income in countries' poorest population quintiles was highest in Brazil, Ecuador, and Mexico varying between $4,755 and $8,692, and lowest in Colombia, Ghana, Tanzania, and Yemen varying between $1,617 and $2,812. A summary of annual household income data sources and extracted data is provided in Table S11.

Summary of target population data. For DS TB, the size of countries' estimated TB-specific target population, which was equivalent to 40% of countries' TB burden, ranged from 3,520 to 67,600 households, and the size of countries' estimated TB-sensitive target population, which was equivalent to the number of households in poverty already targeted by countries' established poverty-reduction cash transfer programme, ranged from 70,000 to 26 million households, Table 18. For DR TB, the size of Ecuador's estimated TB-specific target population was 300 households, and the size of its estimated TB-sensitive target population was 450,000 households, Table 18.

Table 18. Summary of poverty-reduction cash transfer programmes included in the economic modelling study and TB-specific versus TB-sensitive target populations.

Poverty-reduction cash transfer programme				Current poverty-reduction cash transfer % of		Target population in households	
Country	**Name**	**Components**	**Current cash transfer 2013 PPP$ (Range)**	**Household income† (95% CIs) §**	**TB-related costs (95% CIs) §**	**TB-specific (% of population)**	**TB-sensitive (% of population)**
DS TB							
Brazil	Programa Bolsa Familia (112,167)	Flat benefit to extremely poor families; and variable benefits to poor families to support child health, child/adolescent education, and pregnant women's health	823 (239 to 1,084)	15 (15 to 16)	106 (88 to 133)	34,800 (0.06)	14,000,000 (25)
Ecuador	Bono de Desarollo Humano (168)	Flat benefit to poor families to support child health and education	1,091 (1,091 to 1,091)	13 (12 to 13)	47 (39 to 59)	3,520 (0.09)	450,000 (12)
Yemen	Social Welfare Fund (169)	Flat benefit to poor families; and variable benefit to poor families for household size	923 (615 to 1,026) ϕ	43 (42 to 44)	104 (93 to 119)	4,800 (0.17)	1,500,000 (35)
Tanzania	Productive Social Safety Net (170–172)	Flat benefit for poor families; and variable benefits to poor families to support child health and education and pregnant women's health	217 (150 to 299)	7.7 (7.6 to 7.9)	13 (11 to 17) ‡	67,600 (0.72)	150,000 (2)
Ghana	Livelihood Empowerment Against Poverty (173)	Variable benefit to poor families for orphans and vulnerable children, disabled and those over 65	451 (349 to 655)	25 (24 to 26)	37 (32 to 46)	17,600 (0.32)	70,000 (1)

Colombia	Mas Familias en Acción (84,174)	Variable benefits to poor families to support child health and child/adolescent education	837 (191 to 1,777)	38 (37 to 39)	59 (50 to 72)	6,000 (0.06)	26,000,000 (25)
Mexico	Oportunidades* (50,175)	Variable benefits to poor families to support family health, child/adolescent education, family nutrition	940 (246 to 2,063)	20 (19 to 20)	16 (14 to 19)	10,000 (0.04)	6,600,000 (27)
DR TB							
Ecuador	Bono de Desarollo Humano (168)	Flat benefit to poor families to support child health and education	1,091 (1,091 to 1,091)	13 (12 to 13)	7.3 (4.2 to 15)	300 (0.01)	450,000 (12)

Abbreviations: PPP, Purchasing Power Parity, CI, Confidence Interval, DR, Drug Resistant; DS, Drug Susceptible; TB, Tuberculosis. Apart from countries' alternative target populations, all data are mean estimates. *Formerly PROGRESA. †Household income refers to average pre-illness annual household income in the poorest population quintile. ‡Household income was extracted as household expenditure in the poorest population quintile. §To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value, all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value, and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers. Probability distributions for all 3 input parameters were assumed to be normal. This was justified because our analysis was at the national level and we used mean values. ϕBecause of changes in cash transfer programme administration in the study year, reported mean cash transfers were higher than the maximum value of cash transfers able to be received by beneficiary households in 2013 (169). Mean cash transfers were assumed to be approximately equivalent to the value that would be received by an average household in the country's poorest population quintile based on household size.

5.5.2 Summary of DS TB-related cost burden before cash transfers

Before cash transfers, estimated DS TB-related cost burdens varied between 15% (95% CI: 12% to 18%) and 125% (95% CI: 105% to 145%) of annual household income, and were catastrophic in Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen where they varied between 27% (95% CI: 21% to 32%) and 125% (95% CI: 105% to 145%) of annual household income, Figure 13.

5.5.3 Summary of the potential of TB-specific cash transfers to prevent DS TB catastrophic costs, and the budget needed for this approach

If cash transfers were applied using a TB-specific approach to defray TB-related costs incurred by households with a confirmed DS TB diagnosis, then on average, they were sufficient to prevent catastrophic costs in Ecuador and Yemen, but insufficient to prevent them in either Colombia, Ghana, Mexico or Tanzania, Figure 13. In Colombia, Ghana, Mexico or Tanzania, the DS TB-related cost burden after TB-specific cash transfers varied between 26% (95% CI: 15% to 38%) and 106% (95% CI: 86% to 126%), and the estimated value of household-level additional TB-specific cash transfer needed to prevent DS TB catastrophic costs varied between $144 (95% CI: $0 to $387) and $4,071 (95% CI: $3,122 to $5,014), Table 19. In the six countries where TB-related costs were originally catastrophic, the estimated value of household-level total TB-specific cash transfer needed to prevent DS TB catastrophic costs varied between $850 (95% CI: $627 to $1,079) and $5,011 (95% CI: $4,063 to $5,952), Table 19. According to the size of countries' TB-specific target populations, this value translated into a TB-specific country-level cash transfer budget needed to prevent DS TB catastrophic costs varying between $4 million (95% CI: $4 million to $4 million) and $75 million (95% CI: $50 million to $100 million), Figure 13.

5.5.4 Summary of the potential of TB-sensitive cash transfers to prevent DS TB catastrophic costs, and the budget needed for this approach

If cash transfers were provided using a TB-sensitive approach to increase pre-illness income of poor households with high risk of developing active TB disease, then on average, for those that later develop active DS TB disease this would not be sufficient to prevent them from incurring catastrophic costs in any of the six countries where DS TB-related costs were originally catastrophic, Figure 13. In these six countries, the DS TB-related cost burden after

TB-sensitive cash transfers varied between 24% (95% CI: 19% to 29%) and 105% (95% CI: 88% to 121%), and the estimated value of household-level additional TB-sensitive cash transfer needed to prevent DS TB catastrophic costs varied between $1,360 (95% CI: $821 to $14,897) and $24,115 (95% CI: $19,374 to $28,817), Table 19. The estimated value of household-level total TB-sensitive cash transfer needed to prevent DS TB catastrophic costs varied between $2,282 (95% CI: $1,743 to $2,819) and $25,055 (95% CI: $20,316 to $29,761), Table 19. According to the size of countries' TB-sensitive target populations, this value translated into a TB-sensitive country-level cash transfer budget needed to prevent DS TB catastrophic costs varying between $298 million (95% CI: $219 million to $378 million) and $165,367 million (95% CI: $134,085 million to $196,425 million), Figure 14.

5.5.5 Summary of the potential of TB-specific versus TB-sensitive cash transfers to prevent DR TB catastrophic costs, and the budget needed for each approach

In Ecuador, the DR TB-related cost burden before cash transfers was 192% (95% CI: 86% to 299%), Figure 13. Here, cash transfers provided with either a TB-specific or a TB-sensitive approach were, on average, insufficient to prevent DR TB catastrophic costs, Figure 13. The estimated value of TB-specific versus TB-sensitive additional cash transfer needed to achieve this objective was $13,782 (95% CI: $4,274 to $23,376) versus $73,275 (95% CI: $25,736 to $121,246); and the estimated value of household-level total TB-specific versus TB-sensitive cash transfers needed was $14,877 (95% CI: $5,365 to $24,467) versus $74,375 (95% CI: $26,827 to $122,337), Table 19. According to the size of Ecuador's DR TB-specific and DR TB-sensitive target population, this value translated into a country-level cash transfer budget needed to prevent DR TB catastrophic costs of $4 million (95% CI: $2 million to $7 million) with a TB-specific approach versus $33,469 million (95% CI: $12,072 million to $55,052 million) with a TB-sensitive approach, Figure 14.

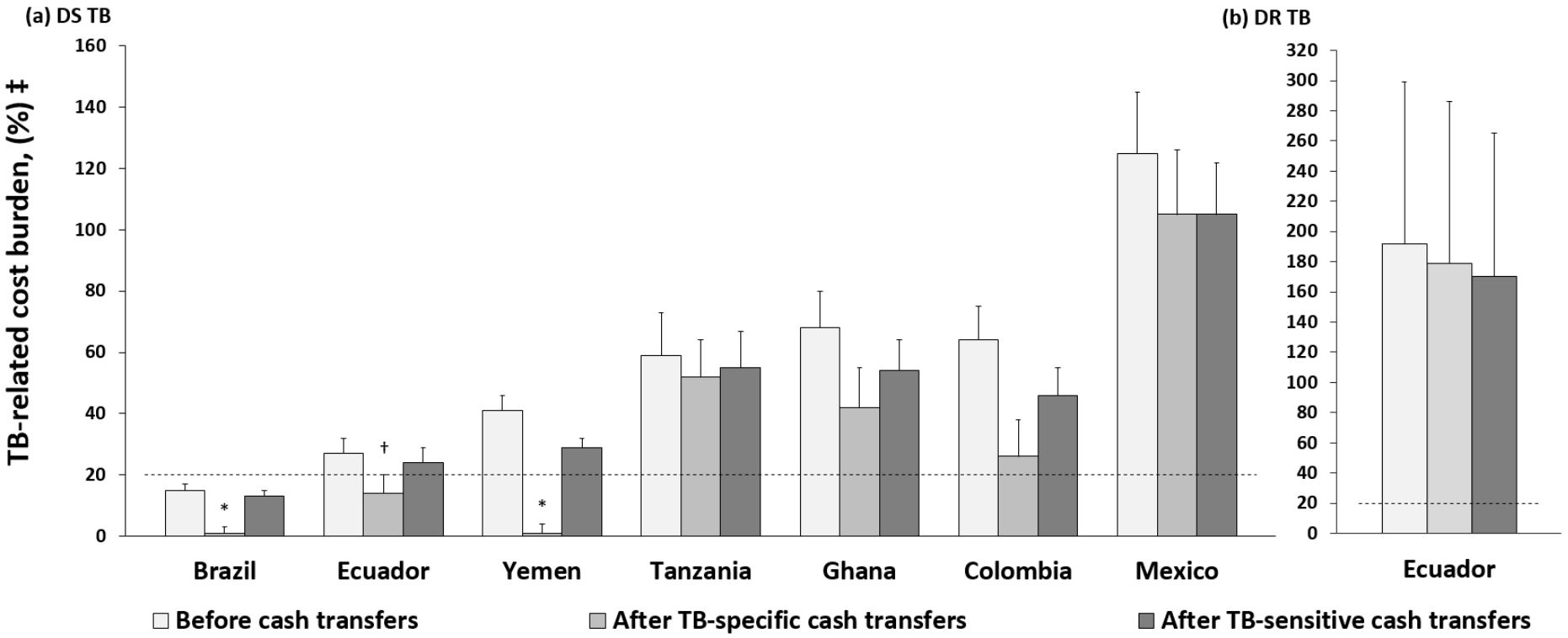

Figure 13. Summary of countries' household-level TB-related cost burden before, and after cash transfers.

Abbreviations: DR, Drug Resistant; DS, Drug Susceptible; TB, Tuberculosis. The "Before cash transfers" bar represents countries' mean TB-related cost burden without cash transfer data. The "After TB-specific cash transfers" bar represents countries' mean TB-related cost burden after cash transfers have been subtracted from TB-related costs. The "After TB-sensitive cash transfers" bar represents countries' mean TB-related cost burden after cash transfers have been added to pre-illness household income. The dotted line guides whether countries' mean TB-related cost burden is above or below 20%. Error bars are 95% CIs calculated using the quantile method. Values summarised in Figure 13 are provided in Table S12. *For clarity, a mean TB-related cost burden of 0% after cash transfers is plotted as 0.9%. †Upper bound of 95% CI = 19.8. ‡To estimate 95% CIs, mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (12), mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (84,167), and mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers. Probability distributions for all 3 model inputs were assumed to be normal. This was justified because our analysis was at the national level and mean values were used.

Table 19. Summary of countries' household-level additional and total cash transfer needed to prevent catastrophic costs.

	Additional cash transfer 2013 PPP$ (95% CIs) *		Total cash transfer 2013 PPP$ (95% CIs) *	
Country	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**
DS TB				
Brazil	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)
Ecuador	0.0 (0.0 to 0.0) †	1,842 (0.0 to 4,281)	1,091 (1,091 to 1,091) †	2,971 (1,091 to 5,372)
Yemen	0.0 (0.0 to 0.0)	1,360 (821 to 1,897)	923 (920 to 926)	2,282 (1,743 to 2,819)
Tanzania	880 (510 to 1,243)	5,322 (3,473 to 7,139)	1,111 (741 to 1,474)	5,553 (3,707 to 7,370)
Ghana	399 (176 to 628)	3,800 (2,683 to 4,945)	850 (627 to 1,079)	4,251 (3,134 to 5,396)
Colombia	144 (0.0 to 387)	4,023 (2,764 to 5,281)	981 (830 to 1,223)	4,860 (3,600 to 6,117)
Mexico	4,071 (3,122 to 5,014)	24,115 (19,374 to 28,817)	5,011 (4,063 to 5,952)	25,055 (20,316 to 29,761)
DR TB				
Ecuador	13,782 (4,274 to 23,376)	73,275 (25,736 to 121,246)	14,877 (5,365 to 24,467)	74,375 (26,827 to 122,337)

Abbreviations: PPP, Purchasing Power Parity, CI, Confidence Interval; DS, Drug Susceptible; DR, Drug Resistant; TB, Tuberculosis. All data are average estimates. For interpretability, negative estimates and confidence intervals are reported as 0. *To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (12), all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (84,167), and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum cash transfers minus minimum cash transfers. Probability distributions for all 3 input parameters were assumed to be normal. This was justified because our analysis was at the national level and mean values were used. †Because data were highly skewed median is reported instead of mean.

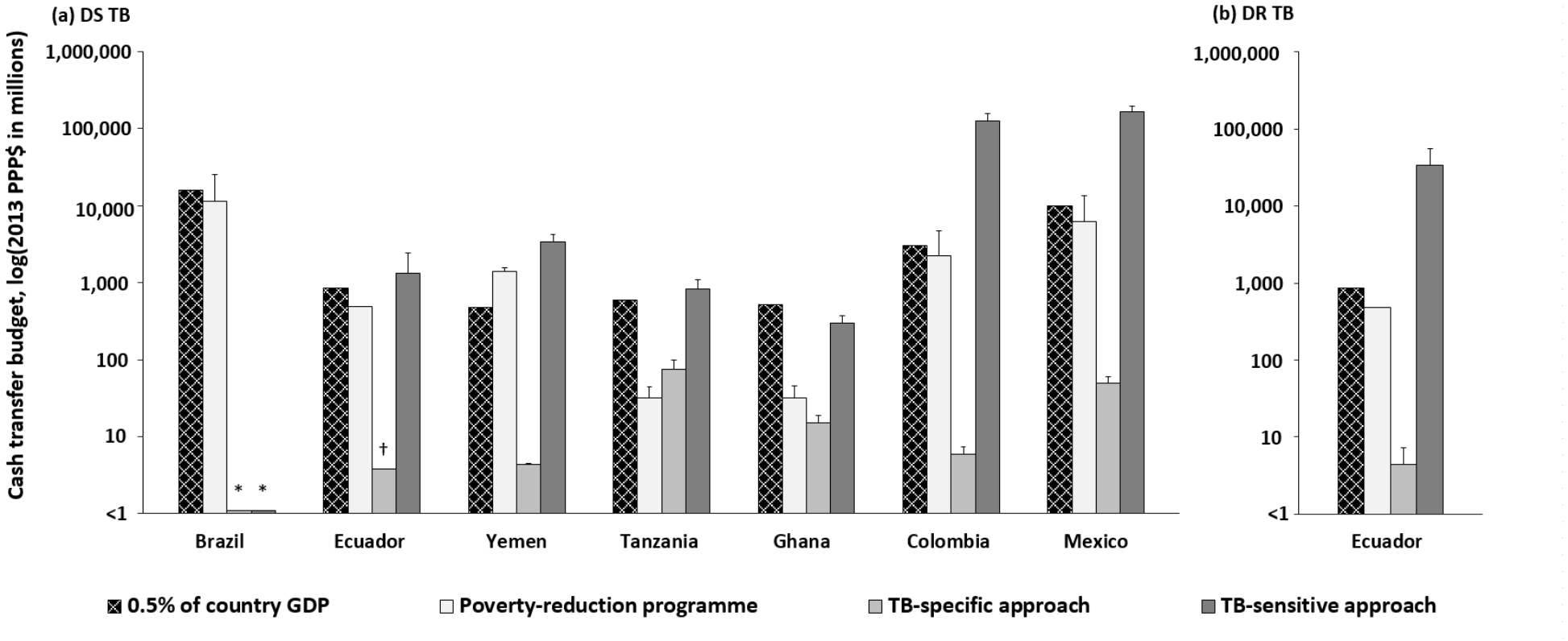

Figure 14. Summary of countries' country-level cash transfer budget needed to prevent catastrophic costs.

Abbreviations: GDP, Gross Domestic Product; DS, Drug Susceptible; DR, Drug Resistant; TB, Tuberculosis. All data are expressed in millions on the $\log_{10}$ scale. 0.5% of countries' GDP and their existing poverty-reduction cash transfer budget are summarised for comparison. The "0.5% of country GDP" bar represents the upper limit that governments in low- and middle-income countries spend on a poverty-reduction cash transfer programme (37). The "poverty-reduction programme" bar represents countries' actual poverty-reduction cash transfer programme budget. The "TB-specific approach" bar represents the mean budget that countries would need to prevent their TB-specific target population from incurring catastrophic costs. The "TB-sensitive approach" bar represents the mean budget that countries would need to prevent their TB-sensitive target population from incurring catastrophic costs. Values summarised in Figure 14 are provided in Table S13. *For clarity, a value of country-level cash transfer budget needed equal to $0 is plotted as $1.1. †Because data were highly skewed median is reported instead of mean.

5.5.6 Sensitivity analysis

Without imputing data. Before cash transfers, the TB-related cost burden remained catastrophic in the same countries as when missing TB-related cost components were imputed, and the only difference after cash transfers was that TB-specific cash transfers prevented catastrophic costs in Colombia, Table S14. Across countries, TB-specific cash transfers remained more affordable at preventing catastrophic costs compared to TB sensitive cash transfers both at the household and country level, Table S15.

With 10% threshold. Before cash transfers, in addition to Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen, the DS TB-related cost burden was also catastrophic in Brazil. In Ecuador, the DR TB-related cost burden before cash transfers remained catastrophic. Across countries, TB-specific cash transfers remained more affordable than TB-sensitive cash transfers for preventing DS and DR TB catastrophic costs both at the household and country level, Table S16.

With 30% threshold. Before cash transfers, the DS TB-related cost burden remained catastrophic in Colombia, Ghana, Mexico, Tanzania, and Yemen, but ceased to be catastrophic in Ecuador. In Ecuador, the DR TB-related cost burden before cash transfers remained catastrophic. Across countries, TB-specific cash transfers remained more affordable than TB-sensitive cash transfers for preventing DS and DR TB catastrophic costs both at the household and country level, Table S17.

5.6 Discussion of findings

5.6.1 Summary of main findings

In the seven countries that met the study inclusion criteria, this analysis of national average data suggests that DS TB-related costs would be catastrophic for the average poor TB-affected household in most low- and middle-income countries. This is concerning, and concordant with the limited evidence that is already available (12). If cash transfers were provided with a TB-specific approach to defray TB-related costs of poor households with a confirmed DS TB diagnosis, then in some low- and middle-income countries, they would likely be sufficient to prevent the average household incurring DS TB catastrophic costs. Alternatively, if the same value of cash transfers were provided with a TB-sensitive approach to increase the income and strengthen the economic resilience of poor households at high

risk of developing active TB disease, then across low- and middle-income countries, they would likely be insufficient to prevent the average household that later developed active DS TB disease incurring DS TB catastrophic costs. In countries where neither TB-specific nor TB-sensitive cash transfers would be sufficient to prevent DS TB catastrophic costs, the average value of household-level additional cash transfer needed to achieve this objective would be much lower using a TB-specific approach compared to a TB-sensitive approach. Further, by only targeting poor households with a confirmed TB diagnosis, a TB-specific approach would, on average, require a much smaller country-level budget than using a TB-sensitive approach to target much larger numbers of poor households at high risk of developing active TB disease.

Although DR TB is rare, it is associated with extreme TB-related costs (12). This analysis found that neither TB-specific nor TB-sensitive cash transfers would be sufficient to prevent DR TB catastrophic costs for the average poor DR TB-affected household. The value of household-level additional cash transfer needed to achieve this objective would be very high. Because few poor households are affected by DR TB, countries' county-level cash transfer budget needed to prevent DR TB catastrophic costs would, on average, be much lower using a TB-specific approach compared to a TB-sensitive approach. Given that so few households are affected by DR TB, it may not be rational for TB-sensitive cash transfer programmes to aim to increase households' annual income sufficiently to make all poor households resilient to the rare and extreme costs associated with DR TB.

5.6.2 How findings fit with existing literature

The study is consistent with, and adds to, individual level evidence supporting the potential of TB-specific cash transfers to prevent catastrophic costs for poor TB-affected households in Peru (56). It also supports individual evidence from Latin America for their ability to improve households' capacity to cope with severe livelihood risks (61). By focussing on preventing catastrophic costs in low- and middle-income countries, it adds another dimension to the 2015 Cochrane review of the use of cash transfers in TB control, which did not find evidence on this outcome and mostly examined the use of cash transfers in the United States (59).

To our knowledge, this study is the first to compare the potential of cash transfers provided with a TB-specific versus a TB-sensitive approach to prevent catastrophic costs. The contrasting effects of defraying TB-related costs using a TB-specific approach versus increasing households' resilience using a TB-sensitive approach has important and novel implications for protecting TB-affected households from catastrophic costs. This study also appears to be the first to compare the country-level cash transfer budget that would be needed to prevent catastrophic costs for poor TB-affected households using a TB-specific versus a TB-sensitive approach. The study shows that by being more effective and aiming to reach fewer households, a TB-specific approach would cost less than a TB-sensitive approach. It is important to emphasize that these findings are only valid when preventing catastrophic costs is the only outcome of interest. Cash transfers provided to poor households with a TB sensitive approach might have far-reaching effects on wellbeing, health promotion, and disease prevention, and further evaluation is needed to study the costs versus benefits of each approach (158,193). Nevertheless, the End TB Strategy prioritises ensuring that zero TB-affected households experience catastrophic costs (9). For achieving this specific milestone, the implications of this study are clear: cash transfers provided with a TB-specific approach are likely to achieve this goal more affordably than if they were provided with a TB-sensitive approach.

This study adds to limited evidence informing the best targeting strategy for cash transfers aimed at enhancing TB care and prevention (158). At the country-level, showing that in Latin America and Central Asia a TB-sensitive approach might reach between 12% and 35% of countries' population, whereas in some parts of sub-Saharan Africa it might only reach between 1% and 2% of countries population, this study supports speculation that the potential of countries to provide cash transfers with a TB-sensitive approach might follow an inverse care law (194), whereby poorer countries with higher TB burdens have less well established poverty-reduction cash transfer programmes (158). Showing also that approximately 40% of TB-affected households might be in the poorest population quintile, this study highlights the need to consider how cash transfers might be targeted to households that incur catastrophic costs but are outside of this population category (55,178). With a TB-specific approach, it would be relatively easy to modify programmes' target population to include more TB-affected households, whilst with a TB-sensitive

approach, it might be harder to modify the target population of existing poverty-reduction programmes, which are usually well established parts of national social protection systems (166).

5.6.3 Study strengths

The economic model used in this study was an inexpensive way to provide preliminary estimates of the potential of TB-specific and TB-sensitive cash transfers to prevent catastrophic TB-related costs. It is also usefully highlights key issues on which judgement must be made in the future namely: who should be targeted for cash transfers?, how much should cash transfers be?, and is this affordable at the national level? The study was rigorously reported according the CHEERS checklist. This ensured that study assumptions were clearly presented and open for critique. Another strength was the study's use of statistical methods to highlight the level of uncertainty around model estimates.

5.6.4 Study limitations

This study has several limitations and conclusions should be drawn cautiously. Insufficient data forced us to estimate the potential of TB-specific versus TB-sensitive cash transfers to prevent catastrophic costs using the value of cash transfers offered by existing governmental poverty-reduction cash transfer programmes. Whilst the only solution, it will have nonetheless under- or overestimated the potential of TB-specific cash transfers depending on how their actual value compares to governmental poverty-reduction cash transfers. Model inputs were all associated with some uncertainty, especially TB–related costs, which were mostly extracted from small subnational cost surveys (133,164,165,189–192). The study attempted to account for this using a multiway analysis that allowed inputs to vary by their simulated sampling distributions. Inconsistent reporting of standard deviations for mean TB-related costs, household income and cash transfers forced us to make assumptions about the amount of variance around extracted values, and to generalise these across countries. Whilst this approach will have ignored any country specific skewness or kurtosis in input parameters, drawing from relevant literature ensured that estimates of variance were as accurate as possible (12,84,167). Inconsistent reporting of TB-related costs disaggregated by income quintile meant that the study had to assume that estimated TB-related costs were representative of those incurred by affected households in countries'

poorest population quintile. Because poorer households usually incur lower TB-related costs compared to less poor households, this is likely to have underestimated the potential of cash transfers to prevent catastrophic costs, and overestimated the country-level budget needed to achieve this (6). Whilst this analysis should provide an accurate estimate of the effect of cash transfers on countries' mean TB-related cost burden, because sample distributions of TB-related costs are known to be positively skewed (12), the aggregate-level nature of the study means that results are unlikely to be representative of the majority of TB-affected households. Two sources of error in this study were imputation of missing TB-related cost components in Brazil (164), Colombia (189), Tanzania (190), and Mexico (191), and measuring catastrophic costs using a threshold TB-related cost burden that still hasn't been assessed to determine its clinical or financial relevance for TB-affected households in any of the countries included in the study. Sensitivity analysis showed that the potential of cash transfers to prevent catastrophic costs was robust to these sources of error, but the precise estimates of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs were dependent on them. Therefore, whilst a TB-specific approach was consistently more effective and affordable for preventing catastrophic costs compared to a TB-sensitive approach in all analyses, further research is needed to precisely estimate the cost of each of these approaches.

5.7 Concluding remarks

Reviewing and analysing the literature on TB-related costs and poverty-reduction cash transfer programmes in low- and middle-income countries, this study compares the potential of cash transfers provided with a TB-specific versus a TB-sensitive approach to prevent catastrophic costs for poor TB-affected households. Findings suggest that providing cash transfers with a TB-specific approach to defray TB-related costs of households with a confirmed TB diagnosis will be more effective and affordable for achieving this objective compared to a TB-sensitive approach that increases the income and strengthens the economic resilience of households at high risk of developing active TB disease. The study also highlights an urgent need for investments to prevent catastrophic costs for households having to confront the severe medical, social, and economic challenges caused by DR TB.

Chapter 6. Conclusion

Severe illness, like that caused by the infectious disease tuberculosis (TB), is known to cause financial hardship for affected households, especially those living in poverty (12,195). Cash transfers are a pro-poor social protection initiative that might help poor households to cope with the financial impact of such severe illness (5,33,37). With the overall aim of establishing whether cash transfers can prevent household financial hardship from severe illness, this thesis addressed three research gaps, Table 20.

Table 20. Summary of research gaps addressed by the thesis.

1) Uncertainty if governmental anti-poverty cash transfers protect poor households from financial hardship related to severe illness.
Methods: Systematic review, historical cohort study.
Findings: Evidence from 5 published studies indicates that cash transfers might improve households' capacity to safeguard consumption in response to shocks that have a negative effect on this measure of welfare. In Brazil, self-reported severe illness with serious economic consequences had little effect on household food consumption, and any modification of this effect by household receipt of cash transfers was modest.
2) Lack of knowledge as to which governmental social protection initiatives households affected by TB access during care, and whether they are sufficient to protect them from financial hardship.
Methods: Cross-sectional survey.
Findings: In Rio de Janeiro, fewer than 50% of households uptake social protection in response to DR TB. Households that uptake social protection, including cash transfers, are significantly less likely to experience financial hardship because of DR TB.
3) Doubt whether providing cash transfers to make poor households at risk of TB more resilient to TB-related costs, or to defray poor households' costs after a family member develops TB is more effective and affordable for preventing financial hardship.
Methods: Economic modelling.
Findings: Providing cash transfers to defray TB-related costs appears to be more effective and affordable for preventing households from experiencing financial hardship than providing cash transfers to reduce poverty amongst households vulnerable to TB.

Focusing on the three research gaps addressed by this thesis, this final chapter recalls the state of the evidence before the thesis, and summarises how research completed as part of the thesis advances that area of research. It also presents priority next steps for further research, discusses the policy implications of the thesis, and ends with an overall concluding statement.

6.1 Governmental conditional cash transfers and household financial hardship from severe illness

6.1.1 What was already known

In settings with low coverage of formal insurance markets, severe illness was known to have detrimental effects on household labour income (12,13). Previous longitudinal studies evaluating the impact of severe illness on household consumption had shown mixed results (5). In some, illness was associated with decreased consumption, but in others it was not (5). More objective measures of severe debilitating illness, for example a long spell in hospital, or a change in individuals' ability to carry out activities of daily living, were consistently associated with decreased household consumption, while self-reported measures of illness were often associated with an insignificant change in household consumption (13,15,22,64,65,68,123,124,195–197). Evidence showed that illness was associated with a greater likelihood of using coping strategies like informal borrowing, using savings, selling assets; and sometimes turning to costly coping strategies like taking out high interest loans, and withdrawing children from school (22,68,99,128,198). There was also evidence showing that the effect of severe illness is worse for households living below and on the poverty line (195).

Social protection initiatives were considered an effective way of protecting households from financial hardship related to illness. For households without access to formal insurance, pro-poor cash transfers were one initiative with considerable potential. Evidence already showed that conditional cash transfers (CCTs) helped households accumulate savings in the form of assets (49–51). Furthermore, in Colombia, evidence suggested that CCTs might help households to safeguard their non-food consumption in response to illness, and in both Colombia and Mexico, evidence indicated that CCTs might also protect child school attendance in response to illness (79,197). Both of these studies

used self-reported measures of illness, and severity was measured as illness affecting the household head (79,197). Evidence from Mexico was published before 2010, and was included in a broad systematic review of the economic effects of CCTs on households in low- and middle-income countries conducted in 2010 (61,79). Whilst, this review studied the potential of CCTs to improve households resilience to shocks, it did not give an indication of the degree of protection that CCTs might provide, and results were not disaggregated by different types of household shock (61).

6.1.2 What this thesis adds

This thesis updates a 2010 systematic review of the literature relating to the effect of governmental anti-poverty CCTs on households' ability to safeguard their consumption against household-level shocks including severe illness. It identifies a total of five studies, three of which were conducted after 2010, and presents quantitative summaries of the effect of CCTs on household consumption and use of coping strategies, including savings and assets, in response to specific shocks. CCTs were found to provide a reasonable degree of protection against reductions in household consumption in response to illness of the household head, but not in response to unemployment of the household head (84). With regards to households' use of coping strategies, the only consistent evidence was for the potential of CCTs to protect child school attendance (79,84). These findings set a new benchmark for the current state of the evidence in this field, and provide new insight into the degree of protection CCTs may grant (61,84,85,91). The review highlights several additional research gaps that should be considered in any future research in the field of disabling illness, financial hardship, and cash transfers. These are highlighted below in the further research section of this chapter.

Building on the updated systematic review, the thesis also presents an original historical cohort study investigating whether governmental CCTs help poor households in Brazil to maintain a constant level of food consumption in response to self-reported severe illness with serious economic consequences. Results provide additional insight into the relationship between severe illness, consumption, and CCTs, which previously had only been investigated in Colombia (197). Attempting to measure the economic effect of a severe illness leading to lost productivity, the study exposure was self-reported severe illness with serious economic consequences in the 4 years between baseline and follow-up in 2009. The

study used a robust design and controlled for potential confounding by household socioeconomic characteristics. Interestingly, it identified no effect of severe illness with serious economic consequences on either household labour income or food consumption. This highlights the need for further thought on ways to measure severe illness that is either temporarily, or permanently disabling. A basic sample size calculation indicated that the study had low statistical power to investigate whether receipt of CCTs modifies the economic consequences of severe illness for poor households. This combined with a lack of any detectable economic impact of severe illness provided little scope for this thesis to evaluate any protective effect of CCTs. With more precise measurement of severe illness leading to lost productivity, as well as a larger sample size it would be possible to evaluate this relationship more conclusively.

6.2 Uptake of governmental social protection and household financial hardship from drug resistant tuberculosis

6.2.1 What was already known

The economic consequences of illness for households affected by TB had long been documented. Two systematic reviews of TB-related costs across low- and middle-income countries provided comprehensive summaries of the make-up of costs, and highlighted that whilst direct expenses are a major component of the economic impact of TB illness, on average, indirect costs contribute most (direct medical expenses: 20%; direct non-medical expenses: 20%; indirect costs: 60%) (12,156). Populations identified as especially vulnerable to the financial impact of TB were households in poverty, and households affected by multidrug-resistant TB (12). The Global TB Programme recommended that TB-related financial hardship be measured as either (a) TB-related costs exceeding 20% of household pre-illness annual household income, or (b) household use of a coping strategy like taking out a loan, or selling assets (10,26).

Social protection initiatives had been endorsed as a key way to address the unaffordable burden of direct expenses and indirect costs experienced by TB-affected households (9). Initiatives recommended to minimize direct medical expenses included fee waivers (163). More recently, other social protection initiatives, including cash transfers had also been recommended to address households' direct non-medical expenses and indirect

costs (9). A survey in South Africa, showed that where governmental cash transfer initiatives are available, as little as half of eligible TB-affected households may access them (58). Furthermore, many of those that do access them, only start doing so later on in their treatment (58). Evidence as to whether cash transfers might protect TB-affected households from catastrophic costs was limited to a randomised control trial in Peru, which supported their use in this way (56). A larger body of evidence indicated that cash transfers improved TB treatment outcomes, but whether they achieved this by protecting households from catastrophic costs was unknown (45,57).

6.2.2 What this thesis adds

This thesis provides a detailed breakdown of costs incurred by DR TB-affected households, and the percentage of households that experience financial hardship during treatment in Rio de Janeiro, Brazil. It adopted a broader measure of financial hardship related to DR TB. In addition to just evaluating whether households experienced TB-related costs exceeding 20% of pre-illness household income, the thesis also considered whether households experienced impoverishment, or used a financial coping strategy separately. This provides a useful reference of the overlap of different types of financial hardship experienced by households. The thesis also considered a combined indicator of all three of these measures of financial hardship. Use of such an indicator helps to distinguish households that experience especially severe economic consequences as a result of DR TB.

A key contribution of this thesis is its assessment of social protection uptake amongst households affected by DR TB. This analysis provides an indication of the prevalence of actual uptake of governmental cash transfers and sick pay insurance in response to DR TB. Because TB is known to be inextricably linked to poverty, the high proportion of households accessing sick pay insurance, which may only be accessed by formally employed workers, was a surprise (55,178). Because household receipt of social protection was evaluated using one self-report question, it is unclear if participants confused sick pay insurance with social assistance disability benefits. Future work should include a more detailed series of questions in order to confirm which social protection initiatives patients access. Further research should also investigate uptake of social protection amongst TB-affected households in the poorer North and Northeast regions of Brazil. Comparing the percentage of households that experience financial hardship and that

uptake social protection provides an indication of how many households should be prioritised for further support. The only characteristic found to differ significantly between households that did, and did not uptake social protection was patient sex, and history of paid employment prior to DR TB diagnosis. A more in-depth qualitative analysis may be able to establish factors that hinder households' access to social protection. This will be key for deciding the type of support that should be provided to households in need of it.

6.3 Comparison of two cash transfer strategies for preventing catastrophic costs for poor tuberculosis-affected households in low- and middle-income countries

6.3.1 What was already known

The TB literature had speculated about two principle implementation models for providing cash transfers to people with TB (158). The first, termed a "TB-specific" approach, would provide cash transfers to poor households with a confirmed TB diagnosis to incentivise and enable TB treatment by defraying their TB-related costs (158). The second, termed a "TB-sensitive" approach, would provide cash transfers to poor households at high risk of developing active TB disease to increase their income, thereby protecting them from poverty-related TB risk factors (e.g. poor living conditions and undernutrition), as well as strengthening their economic resilience to TB-related costs (158). Whilst these two implementation strategies were well described, there was no research informing their potential to prevent households from experiencing catastrophic TB-related costs (158). There was also no attempt to elaborate which households would be targeted by a TB-specific or TB-sensitive approach.

6.3.2 What this thesis adds

This thesis provides a first attempt to estimate whether a TB-specific or a TB-sensitive approach of providing cash transfers is more effective and affordable for protecting TB-affected households from financial hardship. It compared how much each approach reduced the burden of TB-related costs, and estimated how much cash transfers would need to be increased to prevent households experiencing catastrophic TB-related costs. In such a way this thesis explored the concept of defraying costs versus building household resilience to them. That one approach may be more effective than the other for preventing TB-affected

households from experiencing catastrophic costs is an important concept, and not necessarily intuitive. Of course, the study presents a model representation of reality, and the validity of the results will have to be tested using individual-level data. Furthermore, as emphasised in chapter 5, findings that a TB-specific approach might be more effective than a TB-sensitive approach are only valid when preventing catastrophic costs is the only outcome of interest.

This thesis also provides the first attempt to estimate how much it might cost at the country-level to provide cash transfers with either a TB-specific or TB-sensitive approach to prevent households from experiencing catastrophic TB-related costs. To do this, it was necessary to define the population that would be targeted by each cash transfer approach. The thesis considered that a TB-specific approach would target households affected by TB with a household income below the income threshold that classifies countries poorest population quintile, and a TB-sensitive approach would target all households in countries' poorest population quintile. Basic estimates of the number of households in each of these groups could then be used to estimate the budget that would be necessary to provide cash transfers with either approach at the country-level. In the future, further clarification of who should be targeted with either a TB-specific or TB-sensitive approach will help to refine estimates of country-level budgets needed to roll out TB-specific or TB-sensitive cash transfers.

6.4 Further areas for research

The thesis was quite unique in its longitudinal evaluation of the protective effect of CCTs on severe illness with serious economic consequences, cross-sectional analysis of uptake of social protection and financial hardship amongst DR TB-affected households, and comparison of TB-specific versus TB-sensitive cash transfers. The thesis successfully provided further insight into each of the research gaps that it set out to fill. However, it was unable to address all three gaps completely. Furthermore, research conducted as part of this thesis raised additional research questions. Priority areas for further research in this field include:

1. Do governmental cash transfers prevent households from using harmful coping strategies that have long term consequences for their welfare?

In addition to further clarifying if CCTs help households maintain a constant level of consumption in response to disabling illness, it is essential that further research also focuses on understanding the potential of CCTs to prevent households' use of harmful coping strategies like defaulting from treatment, taking out high interest loans, selling productive assets, or withdrawing children from school to work (25). This will help elucidate the potential of cash transfers to prevent both the short-, and long-term financial consequences of severe illness. For this research, as highlighted in this thesis, it will be important that severe illness is measured as precisely as possible. One accurate way of measuring this exposure might be to use a locally validated assessment tool to evaluate changes in working household members' ability to carry out activities of daily living (15,199). Another precise way would be to focus on specific mid- to long-term illnesses, for example, mental health, TB, cancer, heart disease, or trauma leading to loss of mobility. Studies taking this approach should ensure that they have an appropriate control group, and a sample size large enough to investigate the relationship between receipt of different social protection initiatives and financial hardship. Further thought should also be given to the best way to measure households' use of coping strategies. One effective way may be to use a "coping" score (56). Previous research has also differentiated coping strategies according to their severity (24).

Ideally, any future study evaluating the protective effect of governmental CCTs would take a longitudinal form with repeated measures of study participants financial situation and receipt of cash transfers over the course of treatment and recovery (56). It is currently unclear if such a data source exits. Modern data linkage of administrative health and social records might be one suitable source of data for further research in this field. This type of data might be available at the Center for Integration of Data and Health Knowledge (CIDACS) project in Salvador, Brazil, which has already linked health and social records to evaluate the impact of CCTs on notifiable disease incidence (200,201). However, such an approach would only work for outcomes that are collected routinely in administrative data (e.g. income, and consumption). Primary data collection is likely to remain essential for further research into the effect of cash transfers on more specific outcomes like households' use of coping strategies.

2. Do households experience any barriers accessing cash transfers in response to severe illness?

This thesis explored uptake of social protection amongst households affected by DR TB in Rio de Janeiro. It found that some households experiencing financial hardship did not uptake social protection. Therefore, another research priority is to understand if TB-affected households experience barriers accessing social protection initiatives. Most of the social protection accessed by DR TB-affected households in Rio de Janeiro was sick pay insurance. As this is only available to TB patients that have contributed to social insurance for at least 12 months prior to their diagnosis, a future research priority will be to understand factors that support and hinder access of informally employed or unemployed patients to social assistance cash transfers from either Programa Bolsa Família or Benefício de Prestação Continuada. Anecdotal reports from social workers highlight a lack of knowledge amongst TB patients about their rights to social protection. They also point to high levels of discrimination when patients attempt to access social protection. Another potential barrier that is reported in other settings, is the accessibility of social assistance administration centres (202). Research is needed to investigate exclusion rates amongst eligible TB patients, and characterise the prevalence of different access barriers. It will be important that such a study is conducted in a representative way, as household location is likely to be a strong determinant of both the coverage of different social protection initiatives, and barriers faced by households needing to access them.

3. What are the costs versus benefits of providing cash transfers with the specific aim of defraying health costs compared to a broader approach to reduce poverty amongst poor households at risk of severe illness?

Further, more detailed modelling, as well as individual-level research is needed to validate whether providing cash transfers with the specific aim of defraying health costs is more effective for preventing financial hardship compared to a broader approach to reduce poverty amongst poor households at risk of severe illness. For a more complete understanding, it will be important to account for any additional effects of these two approaches on preventing illness, which will in turn avert households from experiencing associated financial hardship. For infectious diseases like TB, preliminary evidence already supports the potential of a broad anti-poverty cash transfer approach to reduce individuals' risk of disease by addressing poverty-related risk factors (e.g. poor living conditions and undernutrition) (203). Both approaches may be expected to prevent disease transmission by

improving treatment adherence (6). Any future comparison of the costs of implementing each approach should also account for the additional human and physical resources that would have to be mobilised from the provider's perspective. A disease-specific approach would require a completely new infrastructure, whereas a broader approach may build on countries' existing national social protection system. Better understanding of the distinct impacts and costs of each cash transfer approach would help to inform a more complete comparison of their costs and benefits.

6.5 Implications for policy

In recent years, public health, and in particular TB control, has emphasised the need to identify initiatives that may protect households from financial hardship related to severe illness (10,11). Before this thesis, limited research had focused on evaluating the potential of cash transfers to achieve this. This thesis contributed original findings which may be used to inform future formulation of policy for the use of cash transfers to prevent financial hardship from illness.

Overall, evidence from across this thesis indicates that cash transfers have the potential to enhance poor households' ability to cope with financial hardship related to severe illness. Specifically, synthesis of published evidence suggested that governmental CCTs may help households to maintain a constant level of consumption in response to household-level shocks. Also in Rio de Janeiro, Brazil, income replacement from either social insurance sick pay, or social assistance cash transfers was associated with a lower likelihood of experiencing financial hardship. Finally, across seven low- and middle-income countries, the value of existing anti-poverty cash transfers available to poor households consistently reduced the burden of catastrophic TB-related costs. From a policy perspective, findings from this thesis also suggested that as currently implemented cash transfers may not provide complete protection against financial hardship from severe illness, and may need to be supplemented or completed with other initiatives (e.g. an additional variable cash transfer, or preferential or automatic access to other social protection initiatives) (39). Existing evidence from Peru shows that microcredit is unlikely to be an effective complementary initiative for supporting poor households affected by severe illness (204). In this thesis, the need for additional support was most apparent for DR TB-affected households. Globally, only 20% of people with DR TB are estimated to begin treatment, and

only 52% of those that start treatment are estimated to successfully complete it (150). Preventing financial hardship for this population may help them complete their treatment and should constitute a “special case” for future investments.

This thesis highlighted that in addition to evaluating whether cash transfers can protect households from financial hardship, it is also essential to consider the ease with which households are able to access them. Findings from this thesis suggest that some households in need of financial support as a result of severe illness may not uptake social protection. Further research is urgently needed to characterise whether these households face specific barriers trying to access governmental initiatives. At this stage, anecdotal evidence suggests that patients have poor knowledge of their right to social protection. Based on this, it might help to provide patients with a flow-diagram of the different social protection initiatives available to them, and ensure that they either have, or know how to acquire all of the formal documentation necessary to apply for social protection. Evidence that some patients in need of support do not access social protection also provides early grounds to engage with authorities that are responsible for social protection implementation to explore whether cash transfer initiatives may be made more inclusive of specific populations like those affected by DR TB.

Findings from this thesis indicate that where preventing financial hardship from severe illness is a priority, providing cash transfers specifically to defray patients’ health costs may be more effective at achieving this than a broader approach to reduce poverty. However, it is rare that achieving this outcome will be the only objective of a public health program. Research has already shown that a broad approach aiming to reduce poverty has positive effects across a range of disease risk factors (e.g. reducing malnutrition, HIV prevalence, and adverse treatment outcomes) (57,205–207,43,208). In the TB field, in addition to a TB-specific or a TB-sensitive approach for providing cash transfers, it has been proposed that one efficient and cost-effective strategy might be to integrate both of these approaches into a so-called “TB-inclusive” approach (158). Findings from this thesis demonstrating the greater potential of TB-specific cash transfers to prevent catastrophic costs, and the existing coverage of TB-sensitive cash transfer programmes, may support this integrated approach. For a TB-inclusive approach, existing poverty-reduction programmes could be adapted to include an additional variable TB-specific benefit, which beneficiary

households would be eligible to receive upon receipt of a confirmed TB diagnosis. To finance such an approach, stakeholders from across TB control, development, and finance sectors could coordinate to determine how much each would be willing to contribute given their separate objectives (209,210). From a TB prevention perspective, such an investment would be expected to reduce delays for TB diagnosis (132), reduce the risk of adverse treatment outcomes (6), and thus potentially contribute to reduced national TB incidence (211). From the perspective of social development, reduced national TB incidence would be expected to enable previously vulnerable households to invest more in human capital, increase their labour productivity, and thus contribute to long-term sustainable economic growth (60). Because households affected by human immunodeficiency virus (HIV), mental health, diabetes and other non-communicable diseases are also known to incur high direct expenses and indirect costs (5,98), any efforts to prevent catastrophic costs for TB-affected households should aim to collaborate with these other areas of public health. Whichever approach for providing cash transfers to prevent TB-related catastrophic costs is chosen, it will be key to ensure that it is not implemented in isolation from Universal Health Coverage initiatives including more decentralised and patient-friendly TB service delivery. Income protection initiatives and Universal Health Coverage initiatives should be developed and implemented hand-in-hand (10).

6.6 Overall conclusions

Evidence from across this thesis indicates that cash transfers have the potential to enhance poor households' ability to cope with financial hardship related to severe illness, and that a policy promoting their use in this way is likely to have beneficial effects for vulnerable households. Preliminary evidence also suggests that the effect and affordability of cash transfers may differ depending on whether they are given to defray health costs of households with a confirmed diagnosis of severe illness, or increase the income and strengthen the economic resilience of households at high risk of becoming severely ill. Further research is now needed to understand 1) if cash transfers as currently implemented are sufficient to ensure that every household is able to meet their basic needs and avoid using costly coping strategies in response to severe illness, 2) whether households experience barriers accessing cash transfers in response to severe illness, 3) the most cost-effective approach of providing cash transfers to address financial hardship from severe

illness. Together, evidence generated from this thesis provides original insights into the potential of cash transfers to protect households from financial hardship related to severe illness, and outlines a clear map for further research.

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Supplementary material

Preventing household financial hardship from severe illness: The role of cash transfers

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Table of Contents

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Full title: Uptake of governmental social protection, and financial hardship during drug-resistant tuberculosis treatment in Rio de Janeiro, Brazil

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End TB Strategy: universal health coverage and social protection for preventing financial hardship.

Despite most countries offering tuberculosis (TB) diagnosis and treatment free of charge, TB-related costs remain an important barrier for accessing TB care [1]. TB-related costs include: direct medical expenses (e.g., consultations), direct non-medical expenses (e.g., transport and food accessing health services), and lost income from time off work related to disability, discrimination, and/or infection control laws [2]. With the treatment duration of drug-resistant (DR) TB lasting up to 24 months, affected households are especially vulnerable to TB-related costs [1]. In Cambodia, Ecuador, Ethiopia, Indonesia, Kazakhstan, and Peru, average DR TB-related costs range between 75%-223% of annual household income [3–7].

The World Health Organization's (WHO's) End TB Strategy mandates that by 2025 nobody should experience financial hardship because of TB [8]. Countries are encouraged to monitor progress towards this milestone by collecting regular estimates of the prevalence of financial hardship due to TB [9]. Financial hardship might be measured as total costs exceeding 20% of pre-illness annual household income; relying on a financial coping strategy (i.e., taking a loan/selling assets); or, total costs that are impoverishing [9, 10].

To prevent financial hardship from TB, countries should facilitate people's access to universal health coverage (UHC) and social protection [9]. Worldwide, Brazil, is increasingly seen as a model country for inclusive social development. Here, the national Unified Health System provides all health services free of charge, and three governmental social protection policies Auxilio-Doenca, Bolsa Familia and Beneficio da Prestacao Continuada (BPC) help people manage financial consequences of illness [11–13]. Currently, it is unknown if these measures protect the most vulnerable TB-affected households, those experiencing DR TB, from financial hardship.

Evaluating uptake of social protection and financial hardship amongst DR TB-affected households in Rio de Janeiro.

In May 2016, there were 1,601 people with DR TB in Brazil (0.77 cases per 100,000 population), with 29% residing in Rio de Janeiro state [14]. To evaluate if uptake of social protection during treatment is associated with reduced risk of experiencing financial hardship, we conducted a cross-sectional survey between June-October 2016. We surveyed people with DR TB who had been receiving treatment for at least one month, and were attending the outpatient clinic of the Professor Helio Fraga reference centre (CRPHF) in Rio de Janeiro state. Ethical approval was obtained from the Escola Nacional de Saúde Pública Sérgio Arouca ethics committee (1.4238.240, CAEE: 53187516.0000.5240). All participants gave written informed consent before participating.

Data were collected by two social workers, using a local adaptation of the field-testing version of the WHO's TB patient cost survey instrument detailed and available online [15]. Questions on pre-diagnostic healthcare-seeking behaviours, and costs incurred during previous courses of TB treatment were excluded because of concerns about reporting accuracy for events experienced far in the past. The revised questionnaire was pretested for clarity on three patients. Monetary values were collected in Brazilian reais (R$), and converted to 2016 United States dollar (US$) (R$3.5=US$1.0) [16].

We measured direct expenses as monthly expenses accessing directly observed therapy (DOT) and the CRPHF extrapolated over participants' prescribed treatment (mean: 17.6 months), added to any expenses for TB-related transport accessing a hospital, supplementary food and/or private healthcare. Lost income was the difference in monthly household income pre-illness versus during-treatment extrapolated over participants' prescribed treatment [17]. Social protection was the monthly value of payments received because of DR TB extrapolated over participants' prescribed treatment. All values were self-reported. Total costs were calculated as direct expenses plus lost income after subtracting social protection.

The exposure variable, was uptake of governmental social protection from Auxilio-Doenca, Bolsa Familia and/or BPC because of DR TB. The outcome, financial hardship, included separately incurring total costs ≥20% of pre-illness annual household income; using a financial coping strategy; incurring total costs that pushed pre-illness monthly household

income per capita below Brazil's 2016 poverty line (US$48.6 a month) [18]; and, experiencing all three situations simultaneously. We investigated the association between uptake of social protection and these four measures of financial hardship by multivariable logistic regression adjusting for socioeconomic and clinical variables associated with the outcome at $p<0.1$, and the two a priori confounding variables sex and age. The likelihood ratio test was used to assess the association of exposure variables with dependent variables.

Summary of social protection uptake and financial hardship amongst DR TB-affected households in Rio de Janeiro.

In the survey period, 131 people were invited to participate in the survey, six had not completed one month's treatment, five did not give consent to participate, and one was excluded from the analysis because of implausible income data, leaving 119 participants (68% male; mean age: 42; ethnicity: 48% brown, 29% black, 23% white, 1% indigenous). Before DR TB, most participants had a pre-illness monthly household income per capita less than one minimum salary (63%), and were the principle household income provider (53%). Some received social protection before DR TB (16%). Most had acquired versus primary DR TB (55%), and multidrug-resistant TB (3% suspected, 29% mono-/poly-resistant, 60% multidrug-resistant, 9% extensively drug-resistant).

Overall, 38% of participants reported uptake of social protection because of DR TB. Amongst them, 80% received Auxilio-Doenca, 7% received Auxilio-Doenca and Bolsa Familia, 9% received Bolsa Familia, and 4% received BPC. Participants taking-up social protection were more likely to be male ($p=0.005$), younger ($p=0.06$), and in paid employment before DR TB ($p=0.08$).

Mean direct expenses were US$809 (SD: US$601), representing 14% (SD: 17%) of annual household income. Mean lost income was US$6,207 (SD: US$6,671), representing 81% (SD: 54%) of annual household income. Mean social protection payments were US$1,970 (SD: US$2,897). Mean total costs, after subtracting social protection, were US$5,046 (SD: US$6,290), representing 64% (SD: 58%) of annual household income. Participants taking-up social protection were more likely to incur lower total costs ($p=0.005$).

Overall, 68% of participants incurred total costs ≥20% of household income, 54% used a coping strategy, 24% were impoverished, and 18% experienced all three hardships, Figure 1. In multivariable logistic regression, uptake of social protection was independently associated with lower risk of incurring total costs ≥20% of household income (p=0.04); impoverishment (p=0.002); and, experiencing all three hardships (p<0.001); but not with using a coping strategy (p=0.58), Table 1.

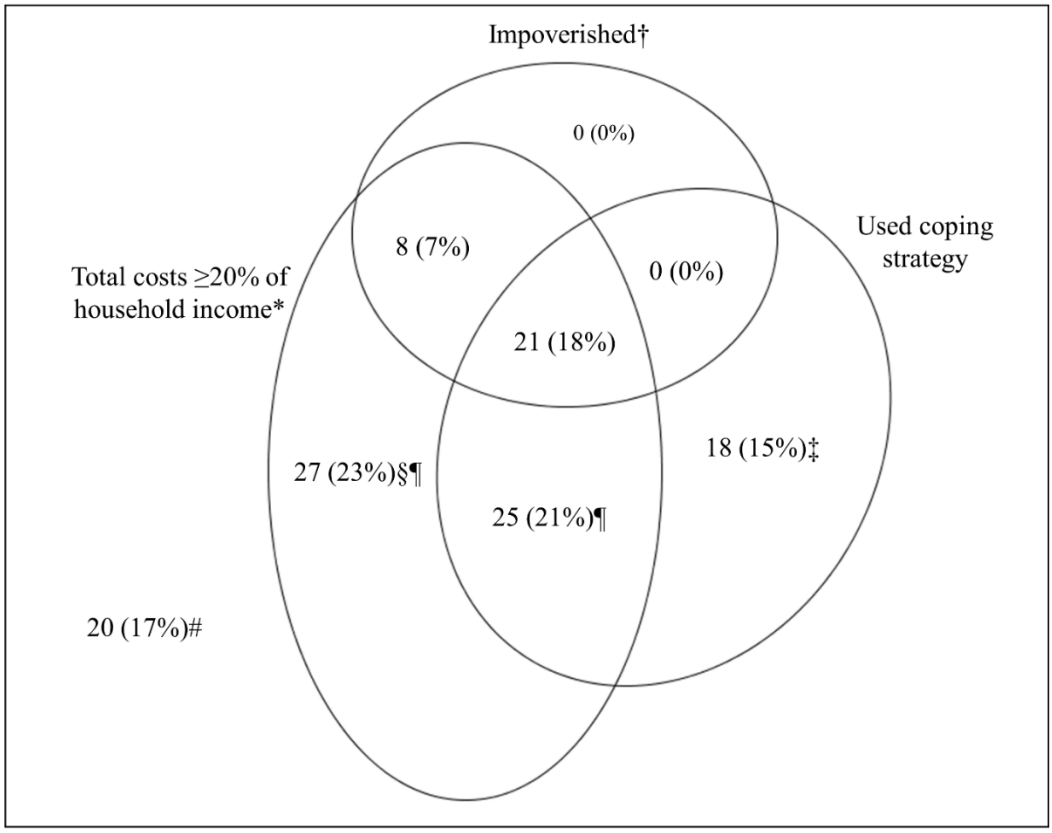

FIGURE 1: Summary of financial hardship across study participants.

n=119. The area of each ellipse is proportional to the number of participants in that set. The area-proportional Venn diagram was drawn using eulerAPE [25]. *Refers to pre-illness annual household income, †Defined using Brazil's 2016 poverty line of monthly household income per capita US$48.6 a month [18], ‡Two participants had pre-illness annual household income US$0, and were in poverty pre-illness, §One participant had missing data on use of coping strategies, ¶One participant was in poverty pre-illness, #One participant had pre-illness annual household income US$0, and was in poverty pre-illness.

TABLE 1 Multivariable logistic regression assessing the association between uptake of social protection and financial hardship.

	Multivariable logistic regression	
	OR (95% CIs)	**p-value**
Financial hardship		
Total costs ≥20% of household income*†	0.37 (0.14-0.94)α	0.04
Used coping strategy‡	1.31 (0.50-3.47)β	0.58
Impoverished§¶	0.16 (0.04-0.54)γ	0.002
All three financial hardships#	0.01 (0.00-0.07)δ	<0.001

Socioeconomic and clinical characteristics associated (p<0.1) with outcomes in univariable logistic regression were included in multivariable logistic regression models. *Refers to pre-illness annual household income. †Three participants with pre-illness annual household income US$0 were excluded, n=116, ‡One participant with missing data on use of coping strategies was excluded, n=118, §Five participants in poverty pre-illness were excluded, n=114, ¶Defined using Brazil's 2016 poverty line of monthly household income per capita US$48.6 a month [18], #Six participants with either pre-illness annual household income US$0, missing data on use of coping strategies, or in poverty pre-illness were excluded, n=113. α Mutually adjusted for sex, age, education, acquired DR TB, and time to DOT clinic; β Mutually adjusted for sex, age, pre-illness household head, pre-illness household income per capita, acquired DR TB, and time to DOT clinic; γ Mutually adjusted for sex, age, education, and pre-illness household income per capita; δ Mutually adjusted for sex, age, pre-illness household head, pre-illness household income per capita, acquired DR TB, and time to DOT clinic. OR, odds ratio; CI, confidence interval.

Summary of lessons learnt, and next steps forward.

In Rio de Janeiro, total costs incurred during treatment result in financial hardship for many DR TB-affected households. The main contributor to total costs is lost income. Uptake of governmental social protection because of DR TB is common, and is associated with reduced likelihood of experiencing financial hardship, especially multiple kinds simultaneously.

To our knowledge, this is the first attempt to evaluate the association between uptake of governmental social protection and financial hardship amongst DR TB-affected households [3–7]. Our results are consistent with trial evidence from Lima, Peru, demonstrating the effectiveness of a non-governmental social protection intervention to defray TB-related catastrophic costs, and extends it to real-world governmental measures [19]. A survey from South Africa explores uptake of governmental social protection amongst people with TB, but does not evaluate its association with financial hardship [5].

Limitations include the survey's small sample size, which barred stratification of our analysis by potential effect modifiers (e.g., uptake of distinct social protection measures). Nevertheless, there was adequate power to detect an association between our exposure and outcome. The survey's cross-sectional design might have underestimated the prevalence of using a coping strategy and uptake of social protection, as the risk of these activities likely accumulates over treatment. Our use of four indicators of financial hardship ensures our conclusions are robust to any potential misclassification.

Our results highlight that even where UHC and social protection measures are available, efforts are still needed to protect all DR TB-affected households from financial hardship. In Rio de Janeiro state, some municipalities provide vouchers to defray patients' transport expenses for CRPHF visits. Sharing of these experiences between municipal authorities should be encouraged. Peoples' access to social protection should also be facilitated, for example, by explicit inclusion of the disabling profile of DR TB in the eligibility criteria of BPC, the government's disability grant. Strengthening of labour unions would also support transitions to a more formal labour market, which would enable greater access to Auxilio-

Doenca [20]. Helping previously employed people to restart work when they are fit would also avoid long absences from work.

Whilst UHC and social protection is available across Brazil, marked socioeconomic differences limits the generalisability of our results to other regions. For a more complete understanding of the association between uptake of social protection and financial hardship there is need for a nationally representative sample of DR TB-affected households. This should be followed up over time to better capture the complex dynamics of financial hardship.

Outside of Brazil, access to UHC and social protection remains low in many countries [21]. Nevertheless, progress is being made on both these fronts worldwide [22, 23]. A country-level modelling study highlights seven other low- and middle-income countries where governmental social protection is available to TB-affected households [24]. Individual-level research is now needed to investigate if TB-affected households are accessing these measures, and like we have done in Rio de Janeiro, evaluate if their uptake is associated with reduced risk of financial hardship.

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Full Title: Comparison of two cash transfer strategies to prevent catastrophic costs for poor tuberculosis-affected households in low- and middle-income countries: An economic modelling study

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Abbreviations: CHEERS, Consolidated Health Economic Evaluation Reporting Standards; CRESIPT, Community Randomized Evaluation of a Socioeconomic Intervention to Prevent TB; DR, drug-resistant; DS, drug-susceptible; HIV, human immunodeficiency virus; IHSN, International Household Survey Network; SPARKS, Social Protection Action Research & Knowledge Sharing; TB, tuberculosis; $, international dollars

Abstract

Background: Illness-related costs for patients with tuberculosis (TB) ≥20% of pre-illness annual household income predict adverse treatment outcomes and have been termed "catastrophic." Social protection initiatives, including cash transfers, are endorsed to help prevent catastrophic costs. With this aim, cash transfers may either be provided to defray TB-related costs of households with a confirmed TB diagnosis (termed a "TB-specific" approach); or to increase income of households with high TB risk to strengthen their economic resilience (termed a "TB-sensitive" approach). The impact of cash transfers provided with each of these approaches might vary. We undertook an economic modelling study from the patient perspective to compare the potential of these 2 cash transfer approaches to prevent catastrophic costs.

Methods and findings: Model inputs for 7 low- and middle-income countries (Brazil, Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen) were retrieved by literature review and included countries' mean patient TB-related costs, mean household income, mean cash transfers, and estimated TB-specific and TB-sensitive target populations. Analyses were completed for drug-susceptible (DS) TB-related costs in all 7 out of 7 countries, and additionally for drug-resistant (DR) TB-related costs in 1 of the 7 countries with available data. All cost data were reported in 2013 international dollars ($). The target population for TB-specific cash transfers was poor households with a confirmed TB diagnosis, and for TB-sensitive cash transfers was poor households already targeted by countries' established poverty-reduction cash transfer programme. Cash transfers offered in countries, unrelated to TB, ranged from $217 to $1,091/year/household. Before cash transfers, DS TB-related costs were catastrophic in 6 out of 7 countries. If cash transfers were provided with a TB-specific approach, alone they would be insufficient to prevent DS TB catastrophic costs in 4 out of 6 countries, and when increased enough to prevent DS TB catastrophic costs would require a budget between $3.8 million (95% CI: $3.8 million–$3.8 million) and $75 million (95% CI: $50 million–$100 million) per country. If instead cash transfers were provided with a TB-sensitive approach, alone they would be insufficient to prevent DS TB-related catastrophic costs in any of the 6 countries, and when increased enough to prevent DS TB catastrophic costs would require a budget between $298 million

(95% CI: $219 million–$378 million) and $165,367 million (95% CI: $134,085 million–$196,425 million) per country. DR TB-related costs were catastrophic before and after TB-specific or TB-sensitive cash transfers in 1 out of 1 countries. Sensitivity analyses showed our findings to be robust to imputation of missing TB-related cost components, and use of 10% or 30% instead of 20% as the threshold for measuring catastrophic costs. Key limitations were using national average data and not considering other health and social benefits of cash transfers.

Conclusions: A TB-sensitive cash transfer approach to increase all poor households' income may have broad benefits by reducing poverty, but is unlikely to be as effective or affordable for preventing TB catastrophic costs as a TB-specific cash transfer approach to defray TB-related costs only in poor households with a confirmed TB diagnosis. Preventing DR TB-related catastrophic costs will require considerable additional investment whether a TB-sensitive or a TB-specific cash transfer approach is used.

Author summary

Why was this study done?

- Household costs related to active drug-susceptible (DS) or drug-resistant (DR) tuberculosis (TB) disease include costs for consultations, transport to and from clinics, increased food needs and lost income. If these costs are greater than or equal to one-fifth (20%) of the household's annual income, then the patient is at risk of unsuccessful TB treatment and these high costs are termed "catastrophic costs."
- The World Health Organization's End TB Strategy prioritises preventing TB-affected households from facing catastrophic costs and proposes cash transfers as one way to achieve this. However, there are at least 2 approaches by which cash transfers could be provided to TB-affected households. In the first, they are provided to defray/reimburse households' TB-related costs (termed a "TB-specific" approach). In the second, they are provided to increase households' pre-illness income to prevent poverty and strengthen their economic resilience (termed a "TB-sensitive" approach).
- Lack of available individual-level data sources has meant that no studies have compared a TB-specific versus a TB-sensitive cash transfer approach. A literature review combined with a secondary data analysis was an effective way to bring together relevant data from several different sources and model the potential of cash transfers provided by these 2 approaches to prevent catastrophic costs.

What did the researchers do and find?

- We performed a rigorous review of public data sources available on the internet, extracting national average data published between 2005 and 2013 for the 7 low- and middle-income economy countries of Brazil, Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen. The data values we extracted included the countries' mean value of TB patient costs, mean household income, mean cash transfers, and the expected size of the population that would be targeted with either TB-specific or TB-sensitive cash transfers. In all 7 countries these analyses were completed for DS TB, and in 1 of the 7 countries we were also able to complete these analyses for DR TB.

- Expressing TB patient costs as a percentage of household income, we found that average DS TB costs were catastrophic in 6 out of the 7 countries included in the study. In these 6 countries, TB-specific cash transfers prevented DS TB catastrophic costs in only 2, whilst TB-sensitive cash transfers did not prevent DS TB catastrophic costs in any of them. In the 1 country with available data, average DR TB costs were catastrophic, and neither TB-specific nor TB-sensitive cash transfers were sufficient to prevent this.
- For both TB-specific and TB-sensitive approaches, we then estimated the total value that cash transfers would need to be increased to in order to prevent the countries' average DS or DR TB costs from being catastrophic for DS or DR TB-affected household. Based on this, we also estimated the average budget that each country would need to prevent catastrophic costs for all DS or DR TB-affected households. We found that a TB-specific approach was much more affordable than a TB-sensitive approach.

What do these findings mean?

- The potential of cash transfers to prevent TB-related catastrophic costs is greater if they are provided to defray/reimburse poor households' costs (TB-specific approach) rather than to increase the income and strengthen the economic resilience of poor households with high TB risk (TB-sensitive approach).
- Where cash transfers are insufficient to prevent catastrophic costs, it will be cheaper to supplement their value to achieve this objective using a TB-specific approach rather than a TB-sensitive approach.
- Important study limitations were that the study was at the country-level, so we might have underestimated the potential of cash transfers to prevent catastrophic costs. Also, we did not assess other health and social benefits of cash transfers, so the impact of TB-specific versus TB-sensitive cash transfers was only judged from the perspective of preventing catastrophic costs.

Introduction

Tuberculosis (TB) disproportionately affects poor households in low- and middle-income countries that are least able to afford the burden that TB-related costs represent relative to their income [1–6]. Even when diagnosis and treatment is available free of direct charges, TB-affected households are known to incur hidden "out of pocket" direct medical costs (e.g., for consultations) and direct nonmedical costs (e.g., for transport, additional food and symptomatic medicines), as well as indirect costs from lost income [7,8]. Combined, these costs can have severe consequences for affected households. They hinder patients' access to care and increase their odds of adverse TB treatment outcomes, which are abandoning or failing treatment, dying during treatment, or having recurrent TB within 30 months of starting TB treatment [9–15]. They also force some households to engage in damaging financial coping strategies, which sometimes referred to collectively as dissaving, include taking out a loan, selling productive assets, reducing consumption expenditure to below basic needs, taking children out of education, and/or taking out large loans [16]. Two groups of households that are especially vulnerable to TB-related costs are those in the countries' poorest population quintile and those affected by drug-resistant (DR) TB [7].

Addressing households' TB-related costs is essential for ensuring that people with active TB disease are able to access TB diagnosis and treatment. Acknowledging this, the World Health Organization's End TB Strategy includes a high-level financial risk protection milestone for 2020: "zero TB-affected households facing catastrophic costs due to TB" [17,18]. In this milestone, "catastrophic costs" refers to a combination of direct medical, direct nonmedical, and indirect costs excessive enough to increase a patient's risk of adverse TB treatment outcome and/or force their household to engage in damaging financial coping strategies [19]. By encompassing all 3 cost components, the term "catastrophic costs" is distinct from the term "catastrophic health expenditure," which only considers direct medical costs and is used to monitor progress towards financial risk protection as part of universal health coverage [19]. As part of the End TB Strategy, research has focussed on developing an empirical measure of catastrophic costs. Recently, total TB-related costs greater than or equal to 20% of TB-affected households' pre-illness annual income have been found to significantly increase the likelihood of TB patients experiencing

an adverse treatment outcome and their household engaging in damaging coping strategies [14,15]. As the only indicator established to be clinically and financially relevant for assessing a household's ability to pay for TB care, this measurement of catastrophic costs has tentatively been included by the Global TB Programme in a pilot tool to monitor catastrophic costs of TB-affected households worldwide [19].

Preventing catastrophic costs for TB-affected households is a priority for facilitating individuals' access to TB diagnosis and treatment, increasing their likelihood of treatment success and reducing onwards TB transmission [18]. With this objective, the Global TB Programme endorses social protection initiatives including cash transfers, food baskets, social insurance and labour market measures to complement universal health coverage initiatives like prepayment, resource pooling, and patient-friendly service delivery [19]. In the TB literature, evidence from a randomized trial in Peru shows that when provided as incentives to support TB treatment, cash transfers reduce poor TB-affected households' likelihood of incurring catastrophic costs, as well as improve patients' likelihood of TB treatment success, and uptake of preventative therapy amongst people they are in close contact with (e.g., family, friends, care giver) [15,20]. Outside of the TB literature, synthesised evidence from governmental poverty-reduction policies in several low- and middle-income countries provides evidence that cash transfers increase poor households' income and consumption expenditure, help them cope with livelihood risks (e.g., illness and unemployment), and support family investments in the human capital of their children (e.g., sending them to school and taking them to regular health checks) [21–23].

Currently, there are at least 2 alternative approaches proposed in the TB literature for providing cash transfers to TB-affected households [24]. The first is termed a "TB-specific" approach, whereby cash transfers would be targeted to poor households with a confirmed TB diagnosis to incentivise and enable TB treatment by defraying their TB-related costs [24]. This approach is exemplified by the cash transfer component of the Community Randomized Evaluation of a Socioeconomic Intervention to Prevent TB (CRESIPT) trial in Peru [25,26]. The second is termed a "TB-sensitive" approach, whereby cash transfers would be targeted to poor households at high risk of developing active TB disease to increase their income, thereby protecting them from poverty-related risk factors for TB infection, progression, and

adverse treatment outcomes (e.g., poor living conditions and undernutrition), as well as strengthen their economic resilience to TB-related costs [24]. This approach already exists in many low- and middle-income countries, and is exemplified by governmental poverty-reduction cash transfer programmes like Programa Bolsa Familia in Brazil [27,28].

Depending on whether cash transfers are provided with a TB-specific or a TB-sensitive approach, their impact might vary [24]. We aimed to investigate how this might relate to the potential of cash transfers to prevent catastrophic costs.

Methods

With no known data sources for investigating if the potential of TB-specific and TB-sensitive cash transfers to prevent catastrophic costs varies, we undertook an economic modelling study using published national average data gathered from a rigorous review of the literature. Our economic modelling study was aggregated at the country level. The setting was low- and middle-income countries where over 95% of TB cases live and where formal institutions to protect households from the social and economic impacts of illness are weakest [29]. The intervention being investigated was cash transfers paid to poor households, and the alternative approaches being compared were: (1) cash transfers provided to defray TB-related costs of households with a confirmed TB diagnosis (termed a "TB-specific" approach); versus (2) cash transfers provided to increase income of households with high TB risk and strengthen their economic resilience (termed a "TB-sensitive" approach). These approaches were compared because of current uncertainty about the potential of each approach to prevent catastrophic costs. Using only TB-related costs incurred by patients, study outcomes were assessed from the patient perspective.

Primary study outcomes were an indicator for catastrophic costs after TB-specific versus TB-sensitive cash transfers, and the countries' country-level cash transfer budget needed to prevent catastrophic costs for each of these approaches. Catastrophic costs were estimated over a time horizon from the month prior to TB symptom onset to TB treatment completion. The countries' country-level cash transfer budgets were estimated over a time horizon of 1 year. In the 1 country with available data, outcomes were investigated separately for drug-

susceptible (DS) TB and DR TB. The reason for this is that treatment of DR TB versus DS TB is longer and more intensive and is therefore associated with much higher TB-related costs [7]. The study used cross-sectional data drawn from secondary sources. Data inputs were countries' mean patient TB-related cost, mean pre-illness household income, mean poverty-reduction cash transfer, and TB-specific versus TB-sensitive target populations. Inputs were retrieved by reviewing TB-related cost and cash transfer literature and countries' national statistics. Because there was insufficient data across low- and middle-income countries on programmes providing cash transfers with a TB-specific approach, this study compared cash transfers offered by existing governmental poverty-reduction programmes as if they were provided with a TB-specific versus a TB-sensitive approach.

For transparency, the study was reported according to the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist [30]. The completed checklist is provided in S1 CHEERS checklist. The study's prospective analysis is provided in S1 Text. In the present analysis, we did not attempt to model the potential of TB-inclusive cash transfers to prevent catastrophic costs, and results from key informant interviews are reported elsewhere [31]. Extraction of cash transfer target population data, estimation of 95% confidence intervals (95% CIs), and our sensitivity analyses were added in the peer review process. Key study definitions are listed in Box 1.

Box 1. Summary of key study definitions

TB-specific cash transfer: Assistance in the form of cash to poor households with a confirmed TB diagnosis to defray their TB-related costs and thus enable their access to TB diagnosis and treatment [24].

TB-sensitive cash transfer: Assistance in the form of cash to poor households at high risk of developing active TB disease to relieve poverty by increasing their income and strengthening their economic resilience [24].

Direct costs: The sum of direct medical costs and direct nonmedical costs [7].

(i) *Direct medical costs:* Expenses paid for medical examinations and TB medicines because of TB illness (e.g., consultation fees, hospitalisation fees, and fees for diagnostic tests).

(ii) *Direct nonmedical costs:* Expenses paid for nonmedical items related to TB illness and care (e.g., patient or guardian transportation, additional food, natural nonprescribed remedies).

Indirect costs: Income estimated to be lost due to time off work because of TB illness and care (e.g., patient or guardian lost income) [7].

Pretreatment costs: The sum of direct and indirect costs incurred between the onset of TB symptoms and receipt of confirmed TB diagnosis.

During-treatment costs: The sum of direct and indirect costs incurred between confirmed TB diagnosis to completion of TB treatment.

Total costs: The sum of pre- and during-treatment costs.

TB-related cost burden: Total TB-related costs expressed as a percentage of annual household income.

Catastrophic costs: A value of total TB-related costs excessive enough to increase a patient's risk of an adverse TB treatment outcome and/or force them to engage in damaging financial coping strategies (e.g., taking out a loan or selling household items) [14].

Adverse TB treatment outcome: Abandoning or failing treatment, dying during treatment, or having recurrent TB within 30 months of starting TB treatment [14].

Study population

In this study, the target population for cash transfers provided with a TB-specific approach was households in countries' poorest population quintile with a confirmed TB diagnosis. Guidance is not currently available for which TB-affected households should be targeted with a TB-specific approach. We chose to focus on TB-affected households in countries' poorest population quintile because they are typically at greater risk of incurring catastrophic costs [14]. Whilst it might have been preferable to focus on all TB-affected households that incur catastrophic costs, at the time of analysis no estimates of the size of this population were available in any countries included in this study. The target population for cash transfers provided with a TB-sensitive approach was households in poverty already targeted by countries' established governmental poverty-reduction cash transfer programme.

Data sources

TB-related cost data. Data on mean TB-related costs incurred by patients were sourced from articles identified by 2 recent publically available systematic reviews [7,8]. These reviews were chosen because they provided a comprehensive, peer-reviewed list of TB-related cost surveys published before March 2013 and February 2015. TB-related cost surveys in identified articles were eligible if they were conducted in a low- or middle-income country and reported mean total costs calculated from direct costs and/or indirect costs incurred over the full duration of pre- and/or during-DS TB and/or DR TB treatment. We excluded cost surveys only reporting median total costs because of difficulties generalising this measure to countries' total population. We also excluded cost surveys that were conducted before 2006, the year in which the Global TB Programme recommended that governments should waive direct costs for basic TB diagnostic tests and medicines [32]. If a publication reported TB-related costs from surveys in several different countries, each survey country was checked separately for cash transfer and household income data. Data extracted from eligible TB-related cost surveys comprised: survey country, year of data collection, survey setting, survey sample size, local currency unit exchange rate, methods used to estimate TB-related costs, and mean TB-related costs stratified into subcategories of direct, indirect, and total TB-related costs. In Brazil and Yemen, where articles reported

mean TB-related costs for different patient subgroups (e.g., directly observed therapy versus self-administered therapy), an unweighted mean overall estimate was calculated across subgroups [33,34].

Cash transfer data. For countries with an eligible TB-related cost survey, existing poverty-reduction cash transfer programmes operating in respective countries were identified using the publically available social safety net program inventory in the appendix of the World Bank Group publication "The State of Social Safety Nets 2015" [35]. None of the identified cash transfer programmes were operated with explicit TB objectives. Cash transfer programmes were eligible if they were directed by a national government with the objective of poverty reduction and promoting family human capital development. Operational data on cash transfer programmes were sourced from the original reference [35] and other publically available online data sources identified from Google by combining the phrase "cash transfer" with the name of the programme and the selected country [36–47]. A summary of cash transfer data sources used in the study is provided in S1 Table. Cash transfer programmes were excluded if they were targeted uniquely to senior citizens or pregnant women. Data extracted on eligible poverty-reduction cash transfer programmes comprised: name of programme, breakdown of cash transfer benefits, mean cumulative annual cash transfers, sample size used to summarise mean cumulative annual cash transfers, and the range of cumulative annual cash transfers based on programme regulations.

Household income data. For countries with an eligible TB-related cost survey and existing poverty-reduction cash transfer programme, we used countries' mean household income or expenditure in the poorest population quintile to approximate household income of both TB-specific and TB-sensitive target populations. Publically available summary estimates of household income or expenditure were identified by searching countries' national statistical websites and the International Household Survey Network's (IHSN's) survey catalogue [48]. We assumed that household income and expenditure were approximately similar. Where available, household income was preferred because of its use in the method included by the Global TB Programme in a pilot tool to measure and monitor catastrophic costs of TB-affected households [19]. Data extracted from countries' national statistical websites and

the IHSN survey catalogue comprised: coverage in households of country household income or expenditure survey, and mean household income or expenditure in countries' poorest population quintile. When household income data was reported by population decile rather than population quintile, an un-weighted mean overall estimate was recalculated across the two poorest deciles. When national income surveys reported mean monthly or quarterly household income or expenditure, these values were extrapolated to mean annual estimates.

Target population data. For countries with an eligible cost survey, cash transfer programme, and household income or expenditure survey, we identified the approximate size of their TB-specific target population using the World Health Organization's publically available TB data [49]. Because estimates of the percentage of TB-affected households represented in the poorest population quintile were not available in any countries included in the study, we used the unweighted mean multiplier for TB prevalence in the poorest population quintile observed in India and South Africa to estimate the size of countries' TB-specific target population [50,51]. Therefore, countries' TB-specific target population was extracted as 40% of the countries' estimated 2013 DS TB burdens or 2015 DR TB burdens. For country estimates of DR TB burden, we used 2015 estimates because 2013 estimates weren't available. We assumed that each estimated case of active TB disease in the World Health Organization's TB data represented 1 household with a confirmed TB diagnosis. We identified the approximate size of countries' TB-sensitive target population using publically available estimates of countries' 2013 poverty-reduction cash transfer programme coverage in households already extracted in the cash transfer data literature review [35–46]. Countries' TB-specific and TB-sensitive target populations were also extracted as a percentage of countries' total population in households using publically available census data available in the United Nations demographic yearbook [52].

All data were extracted into Microsoft Excel 2016.

Currency and price data.

To allow comparison of monetary data extracted in different currencies and measured in different years, all extracted monetary values were inflated and converted to 2013

international dollars using the purchasing power parity conversion factor that accounts for differences in the cost of living across countries [53,54].

Data management.

In countries that had missing values for direct or indirect costs pre- or during-treatment, we estimated their value. To do this, we assumed that average TB-related costs followed a make-up of cost components equivalent to the one synthesised by Tanimura et al. in their systematic review of TB-related costs in low- and middle-income countries, which is that direct and indirect costs are equivalent to 40% and 60% of total costs respectively, and pre- and during-treatment costs are each equivalent to 50% of total costs respectively [7]. Because only 1 included cost survey reported the standard deviation of total costs [33], we also assumed that average TB-related costs had a standard deviation with the same ratio to total costs as the one estimated by Tanimura et al. for average total costs across all low- and middle-income countries, which was 1.1 [7]. We used the assumed standard deviation and the sample size of countries' cost surveys to calculate 95% CIs for estimated TB-related costs.

Data analysis.

All analyses used published mean national data. To account for uncertainty in the value of extracted TB-related costs, annual household income, and cash transfers, we conducted a multiway analysis that allowed all 3 of these inputs to vary simultaneously according to their sampling distributions. Sampling distributions were simulated from 10,000 computationally generated random samples and were all assumed to have normal distributions according to the central limit theorem. Random samples were generated for TB-related costs using a standard deviation with a ratio of 1.1 to mean estimates, which was the ratio estimated by Tanimura et al. for average total costs across all low- and middle-income countries, and a sample size equivalent to countries' cost surveys [7]. For annual household income, we used a standard deviation with a ratio of 0.8 to mean estimates, which was the average observed across 2 studies investigating the household-level income effect of poverty-reduction cash transfer programmes in Brazil and Colombia [37,44] and a sample size equivalent to countries' household income surveys [55–61]. For cash transfers, we used a standard deviation with a ratio to mean estimates equivalent to a quarter of maximum cash transfers

minus minimum cash transfers, and a sample size equivalent to the one reported in studies from which we extracted mean cash transfers. In Ecuador and Ghana, we did not simulate sampling distributions for cash transfers because, respectively, all beneficiary households receive the same flat cash transfer, and the mean cash transfer we extracted was estimated from all beneficiary households. Throughout our analysis, 95% CIs were calculated for model estimates using the quantile method. All analyses were run in R version 3.3.0.

Estimation of TB-related cost burden before cash transfers. To estimate if TB-related costs were catastrophic for poor TB-affected households, we calculated each country's TB-related cost burden without cash transfer data by expressing TB-related costs as a percentage of household income. A TB-related cost burden greater than or equal to 20% was measured as catastrophic, as this threshold has been shown to significantly increase the likelihood of TB patients experiencing an adverse treatment outcome, and their household engaging in damaging financial coping strategies [14,15]. In countries where the TB-related cost burden was estimated to be catastrophic, we then compared the potential of cash transfers provided with a TB-specific versus a TB-sensitive approach to prevent catastrophic costs.

Estimation of the potential of TB-specific cash transfers to prevent catastrophic costs. To estimate the potential of cash transfers provided with a TB-specific approach to prevent catastrophic costs, we considered that cash transfers would be targeted to poor households with a confirmed TB diagnosis to defray TB-related costs incurred pre- and during-treatment. Thus, we subtracted the value of cash transfers from TB-related costs and then recalculated countries' TB-related cost burden (Box 2, Equation 1).

Box 2. Summary of equations used in data analysis

TB-related cost burden (%)

Equation 1: after TB-specific cash transfers

$$TB\ related\ cost\ burden = \frac{(TB\ related\ cost - cash\ transfer)}{pre\ illness\ HH\ income} * 100$$

Equation 2: after TB-sensitive cash transfers

$$TB\ related\ cost\ burden\ = \frac{TB\ related\ cost}{(pre\ illness\ HH\ income + cash\ transfer)} * 100$$

Additional cash transfer needed to prevent catastrophic costs ($)

Equation 3: TB-specific approach

(i)

$$20 = \frac{(TB\ related\ cost - cash\ transfer + additional\ cash\ transfer)}{pre\ illness\ HH\ income} * 100$$

(ii)

$$additional\ cash\ transfer = (TB\ related\ cost - cash\ transfer) - (pre\ illness\ HH\ income * 0.2)$$

Equation 4: TB-sensitive approach

(i)

$$20\ = \frac{TB\ related\ cost}{(pre\ illness\ HH\ income + cash\ transfer + additional\ cash\ transfer)} * 100$$

(ii)

$$additional\ cash\ transfer = (TB\ related\ cost/\ 0.2) - (pre\ illness\ HH\ income + cash\ transfer)$$

Estimation of the potential of TB-sensitive cash transfers to prevent catastrophic costs. To estimate the potential of cash transfers provided with a TB-sensitive approach to prevent catastrophic costs, we considered that cash transfers would be targeted to poor households at high risk of developing active TB disease, to increase their pre-illness income and protect them from poverty. For any beneficiary households that later developed active TB disease, their cash transfer-increased household income would make them more resilient to the burden of TB-related costs incurred pre- and during-treatment. Thus, we added the value of

cash transfers to pre-illness annual household income and then recalculated countries' TB-related cost burden (Box 2, Equation 2).

Estimation of TB-specific and TB-sensitive cash transfer needed to prevent catastrophic costs. To estimate the total value of cash transfer that would be needed by poor TB-affected households to prevent catastrophic costs with a TB-specific versus a TB-sensitive approach, we considered that for each approach, an additional cash transfer would be provided to targeted households to achieve this objective. Thus, we first estimated countries' household-level additional cash transfer needed to prevent catastrophic costs by rearranging Equations 1 and 2, fixing countries' TB-related cost burden at 20%, and considering an unknown value of additional cash transfer (Box 2, Equations 3ii and 4ii). Then we estimated countries' household-level total cash transfer needed to prevent catastrophic costs by adding the value of original cash transfer to our estimated value of additional cash transfer needed to prevent catastrophic costs.

Estimation of TB-specific and TB-sensitive cash transfer budget needed to prevent catastrophic costs. To estimate the country-level budget that countries would need to prevent catastrophic costs for all poor households targeted with a TB-specific versus a TB-sensitive approach, we considered that for each approach a value of cash transfer sufficient to prevent catastrophic costs would be provided to all targeted households. Thus, we multiplied countries' estimated TB-specific and TB-sensitive household-level total cash transfer needed to prevent catastrophic costs by the size of each approach's target population, which for a TB-specific approach was all households with a confirmed TB diagnosis in the countries' poorest population quintile, and for a TB-sensitive approach was households in poverty already targeted by countries' established governmental poverty-reduction cash transfer programme.

Sensitivity analysis.

We tested the sensitivity of our results in Brazil, Colombia, Tanzania, and Mexico to imputation of missing DS TB-related cost components by repeating our analysis omitting rather than imputing the value of missing DS TB-related cost components [7]. We separately tested the sensitivity of our results across all countries included in the study to the use of

20% as the threshold for measuring countries' TB-related cost burden as catastrophic. We did this by repeating our analyses instead using a 10% and 30% threshold.

Results

Fig 1 is a flow chart of the review process for assessing the eligibility of countries for inclusion in this study. Argentina, Bangladesh, and South Africa had to be excluded after insufficient publically available background information was identified for eligible cash transfer programmes in these countries. Consequently, 7 countries were included in the data analysis.

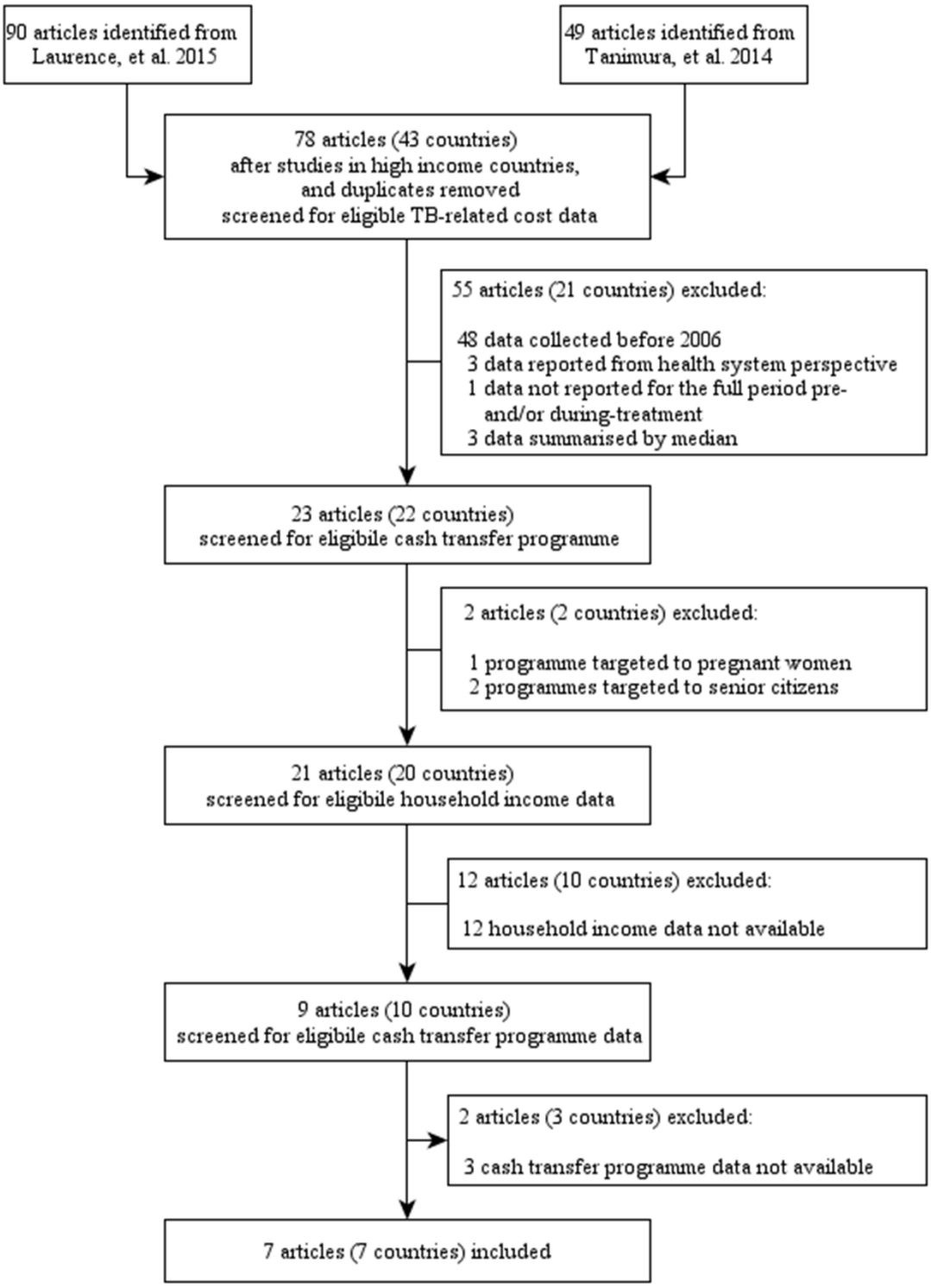

Fig 1. Flow chart of country eligibility and TB-related cost survey inclusion in the study.

TB, Tuberculosis.

Summary of DS TB-related cost data

Conducted in Brazil, Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen between 2006 and 2012, survey sample sizes ranged from 94 to 320 patients with active DS TB disease (Table 1). Surveys collected data on DS TB-related costs incurred pre- and during-treatment, except in Brazil [33], Colombia [62], and Tanzania [63], where they only collected data during-treatment (Table 1). Surveys collected both direct and indirect cost data, except in Mexico [64] where no data was collected characterising indirect costs (Table 1). In countries where data was collected, methods for estimating indirect costs varied in 2 ways: 1) reported time lost travelling and waiting to receive TB care was multiplied by patients' reported income [33,65]; or 2) reported time lost travelling and waiting to receive TB care was multiplied by an estimate of national average income (gross national income per capita or official wage rate) [33,62,63,66]. In Ecuador [66], data was collected on additional costs described in the publication as referring to "loans, paying for additional help and other impacts throughout the course of TB illness." The ambiguity of this cost category meant that it could not be classified as either direct or indirect costs and was thus reported as its own subcategory. Reported mean DS TB-related total costs for the complete TB illness ranged from $387 to $2,382 (Table 1). After imputing missing TB-related cost components in Brazil, Colombia, Mexico and Tanzania, estimated mean DS TB-related total costs ranged from $774 (95% CI: $618–$930) to $5,954 (95% CI: $4,997–$6,911), Table 1.

Table 1. Summary of TB-related cost surveys included in the study

Cost survey			Reported TB-related costs					Estimated TB-related costs
Country	Year	Number of participants	Treatment phase	Direct 2013 PPP$	Indirect 2013 PPP$	Additional 2013 PPP$	Total 2013 PPP$	Total 2013 PPP$ (95% CIs) *
DS TB								
Brazil§ [33]	2010	218	During-	182	205		387	774 (618–930) †
Ecuador [66]	2007	104	Pre- and during-	846	860	620	2,326	2,326 (1,834–2,818)
Yemen§ [34]	2008/09	320	Pre- and during-	631	253		885	885 (778–992)
Tanzania [63]	2012	94	During-	506	330		836	1,672 (1,300–2,044) †
Ghana [65]	2009	135	Pre- and during-	326	883		1,208	1,208 (984–1,432)
Colombia [62]	2010	150	During-				707	1,414 (1,165–1,663) †
Mexico [64]	2007/08	180	Pre- and during-	2,382			2,382	5,954 (4,997–6,911) ‡
DR TB								
Ecuador [66]	2007	14	Pre- and during-	2,345	4,560	9,762	16,667	16,667 (7,063–26,271)

Abbreviations: PPP, Purchasing Power Parity; CI, Confidence Interval; DR, Drug Resistant; DS, Drug Susceptible; TB, Tuberculosis. *According to Tanimura et al., estimated total costs in all countries had a standard deviation with a ratio of 1.1 to their value [7]. The probability distribution of TB-related costs was assumed to be normal. This was justified because our analysis was at the national level and we used mean values. †According to Tanimura et al., reported during-treatment costs were assumed to only represent 50% of total TB-related costs [7]. ‡According to Tanimura et al., reported direct costs pre- and during-treatment were assumed to only represent 40% of total TB-related costs [7]. §TB-related costs were extracted as an unweighted mean overall estimate calculated across patient subgroups.

Summary of DR TB-related cost data

Conducted in Ecuador in 2007, the survey sample size was 14 patients with active multidrug-resistant TB disease, Table 1. The survey reported mean DR TB-related costs incurred pre- and during-treatment (Table 1). The survey collected both direct and indirect cost data (Table 1). Cost data was also collected on additional costs. This category of costs was reported as its own subcategory. Indirect costs were estimated by multiplying reported time lost travelling and waiting to receive TB care by the estimated hourly wage in Ecuador. Mean DR TB-related total costs were $16,667 (95% CI: $7,063–$26,271), Table 1.

Summary of cash transfer data

All extracted cash transfer data refer to programmes' status in 2013. Mean cumulative annual cash transfers were greatest in Brazil, Colombia, Ecuador, Mexico, and Yemen varying between $823 (range: $239–$1,084) and $1,091 (range: $1,091–$1,091); and lowest in Ghana and Tanzania where they were $217 (range: $150–$299) and $451 (range: $349–$655), respectively (Table 2). Across countries, cash transfers ranged from 7.7% (95% CI: 7.6%–7.9%) to 43% (95% CI: 42%–44%) of annual household income. In Colombia, Ecuador, Ghana, Mexico, and Tanzania they varied between 13% (95% CI: 11%–17%) and 59% (95% CI: 50%–72%) of DS TB-related costs, and in Brazil and Yemen, respectively, they were 104% (95% CI: 93%–119%) and 106% (95% CI: 88%–133%) of DS-TB-related costs (Table 2). In Ecuador, cash transfers represented 7.3% (95% CI: 4.2%–15%) of DR TB-related costs (Table 2). A summary of cash transfer data sources and additional extracted data is provided in S1 Table.

Table 2. Summary of poverty-reduction cash transfer programmes included in the study and TB-specific versus TB-sensitive target populations.

Poverty-reduction cash transfer programme				Current poverty-reduction cash transfer % of		Target population, in households	
Country	Name	Components	Current cash transfer 2013 PPP$ (Range)	Household income† (95% CIs) §	TB-related costs (95% CIs) §	TB-specific (% of population)	TB-sensitive (% of population)
DS TB							
Brazil	Programa Bolsa Familia [36,37]	Flat benefit to extremely poor families; and variable benefits to poor families to support child health, child/adolescent education, and pregnant women's health	823 (239–1,084)	15 (15–16)	106 (88–133)	34,800 (0.06)	14,000,000 (25)
Ecuador	Bono de Desarollo Humano [38]	Flat benefit to poor families to support child health and education	1,091 (1,091–1,091)	13 (12–13)	47 (39–59)	3,520 (0.09)	450,000 (12)
Yemen	Social Welfare Fund [39]	Flat benefit to poor families; and variable benefit to poor families for household size	923 (615–1,026) ϕ	43 (42–44)	104 (93–119)	4,800 (0.17)	1,500,000 (35)
Tanzania	Productive Social Safety Net [40–42]	Flat benefit for poor families; and variable benefits to poor families to support child health and education and pregnant women's health	217 (150–299)	7.7 (7.6–7.9)	13 (11–17) ‡	67,600 (0.72)	150,000 (2)
Ghana	Livelihood Empowerment Against Poverty [43]	Variable benefit to poor families for orphans and vulnerable children, disabled and those over 65	451 (349–655)	25 (24–26)	37 (32–46)	17,600 (0.32)	70,000 (1)
Colombia	Mas Familias en Accion [44,45]	Variable benefits to poor families to support child health and child/adolescent education	837 (191–1,777)	38 (37–39)	59 (50–72)	6,000 (0.06)	26,000,000 (25)
Mexico	Oportunidades* [46,47]	Variable benefits to poor families to support family health, child/adolescent education, family nutrition	940 (246–2,063)	20 (19–20)	16 (14–19)	10,000 (0.04)	6,600,000 (27)

DR TB							
Ecuador	Bono de Desarollo Humano [38]	Flat benefit to poor families to support child health and education	1,091 (1,091–1,091)	13 (12–13)	7.3 (4.2–15)	300 (0.01)	450,000 (12)

Apart from countries' alternative target populations, all data are mean estimates. Abbreviations: PPP, purchasing power parity, CI, confidence interval, DR, drug-resistant; DS, drug-susceptible; TB, tuberculosis. *Formerly PROGRESA. †Household income refers to average pre-illness annual household income in the poorest population quintile. ‡Household income was extracted as household expenditure in the poorest population quintile. §To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value, all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value, and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers. Probability distributions for all 3 input parameters were assumed to be normal. This was justified because our analysis was at the national level and we used mean values. ᵠBecause of changes in cash transfer programme administration in the study year, reported mean cash transfers were higher than the maximum value of cash transfers able to be received by beneficiary households in 2013 [39]. We assumed that mean cash transfers were approximately equivalent to the value that would be received by an average household in the country's poorest population quintile based on household size.

Summary of household income data

Conducted between 2005 and 2011, survey sample sizes ranged from 8,687 to 55,970 households [55–61]. Surveys reported mean household income, except in Tanzania where mean household expenditure was reported. Estimated mean annual household income in countries' poorest population quintiles was highest in Brazil, Ecuador, and Mexico varying between $4,755 and $8,692, and lowest in Colombia, Ghana, Tanzania, and Yemen varying between $1,617 and $2,812. A summary of annual household income data sources and extracted data is provided in S1 Table.

Summary of target population data

For DS TB, the size of countries' estimated TB-specific target population, which was equivalent to 40% of countries' TB burden, ranged from 3,520 to 67,600 households, and the size of countries' estimated TB-sensitive target population, which was equivalent to the number of households in poverty already targeted by countries' established poverty-reduction cash transfer programme, ranged from 70,000 to 26 million households (Table 2). For DR TB, the size of Ecuador's estimated TB-specific target population was 300 households, and the size of its estimated TB-sensitive target population was 450,000 households (Table 2).

Summary of DS TB-related cost burden before cash transfers

Before cash transfers, estimated DS TB-related cost burdens varied between 15% (95% CI: 12%–18%) and 125% (95% CI: 105%–145%) of annual household income, and were catastrophic in Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen where they varied between 27% (95% CI: 21%–32%) and 125% (95% CI: 105%–145%) of annual household income (Fig 2).

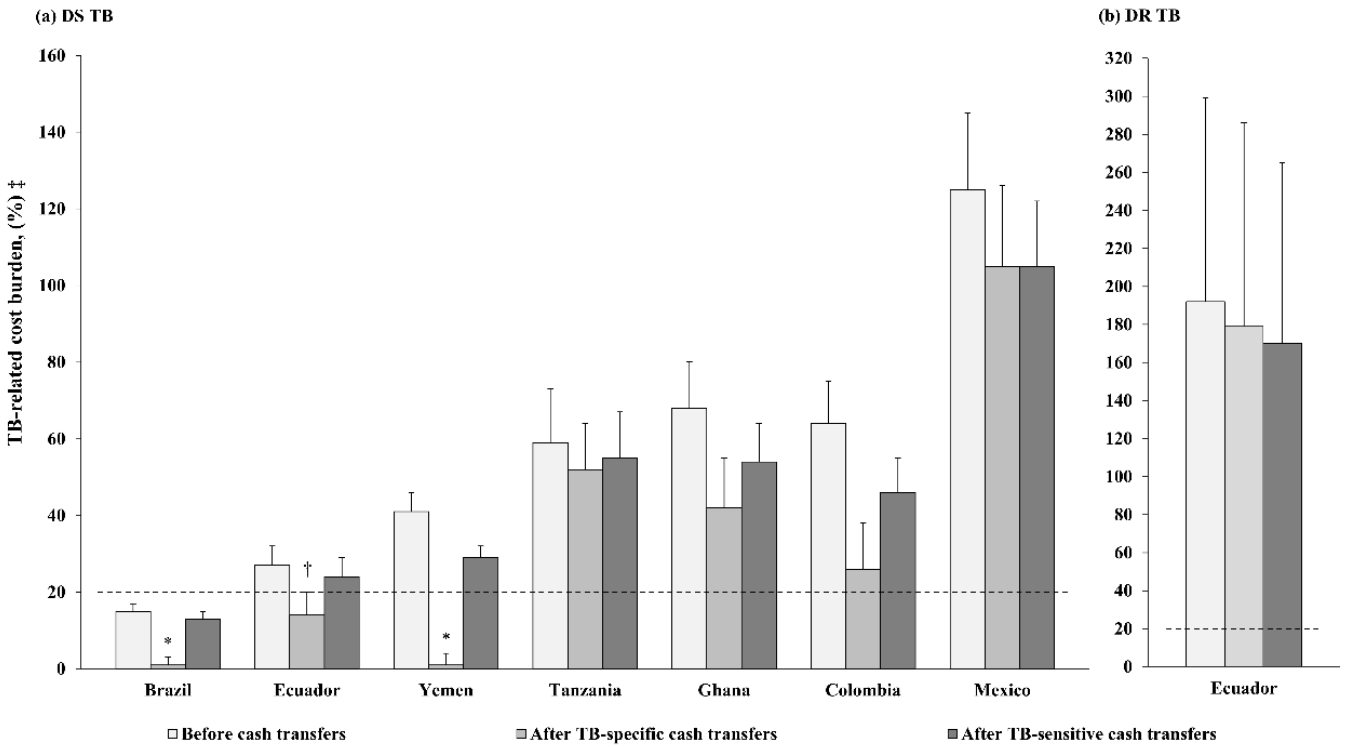

Fig 2. Summary of countries' household-level TB-related cost burden before, and after cash transfers.

The "Before cash transfers" bar represents countries' mean TB-related cost burden without cash transfer data. The "After TB-specific cash transfers" bar represents countries' mean TB-related cost burden after cash transfers have been subtracted from TB-related costs. The "After TB-sensitive cash transfers" bar represents countries' mean TB-related cost burden after cash transfers have been added to countries' pre-illness household income. The dotted line guides whether countries' mean TB-related cost burden is above or below 20%. Error bars represent 95% CIs calculated using the quantile method. The values used to build Fig 2 are provided in S2 Table. *For clarity, a mean TB-related cost burden of 0% after cash transfers is plotted as 0.9%. †Upper bound of 95% CI = 19.8. ‡To estimate 95% CIs, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value [7], all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value [37,44], and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers. Probability distributions for all 3 input parameters were assumed to be normal. This was justified because our analysis was at the national level and we used mean values. DR, drug-resistant; DS, drug-susceptible; TB, tuberculosis.

Summary of the potential of TB-specific cash transfers to prevent DS TB catastrophic costs, and the budget needed for this approach

If cash transfers were applied using a TB-specific approach to defray TB-related costs incurred by households with a confirmed DS TB diagnosis, then on average, they were sufficient to prevent catastrophic costs in Ecuador and Yemen, but insufficient to prevent them in either Colombia, Ghana, Mexico, or Tanzania (Fig 2). In Colombia, Ghana, Mexico, or Tanzania, the DS TB-related cost burden after TB-specific cash transfers varied between 26% (95% CI: 15%–38%) and 106% (95% CI: 86%–126%), and the estimated value of household-level additional TB-specific cash transfer needed to prevent DS TB catastrophic costs varied between $144 (95% CI: $0.0–$387) and $4,071 (95% CI: $3,122–$5,014), Table 3. In the six countries where TB-related costs were originally catastrophic, the estimated value of household-level total TB-specific cash transfer needed to prevent DS TB catastrophic costs varied between $850 (95% CI: $627–$1,079) and $5,011 (95% CI: $4,063–$5,952), Table 3. According to the size of countries' TB-specific target populations, this value translated into a TB-specific country-level cash transfer budget needed to prevent DS TB catastrophic costs varying between $3.8 million (95% CI: $3.8 million–$3.8 million) and $75 million (95% CI: $50 million–$100 million), Fig 3.

Table 3. Summary of countries' household-level additional and total cash transfer needed to prevent catastrophic costs.

	Additional cash transfer, 2013 PPP$ (95% CIs) *		Total cash transfer, 2013 PPP$ (95% CIs) *	
Country	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**
DS TB				
Brazil	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–0.0)
Ecuador	0.0 (0.0–0.0) †	1,842 (0.0–4,281)	1,091 (1,091–1,091) †	2,971 (1,091–5,372)
Yemen	0.0 (0.0–0.0)	1,360 (821–1,897)	923 (920–926)	2,282 (1,743–2,819)
Tanzania	880 (510–1,243)	5,322 (3,473–7,139)	1,111 (741–1,474)	5,553 (3,707–7,370)
Ghana	399 (176–628)	3,800 (2,683–4,945)	850 (627–1,079)	4,251 (3,134–5,396)
Colombia	144 (0.0–387)	4,023 (2,764–5,281)	981 (830–1,223)	4,860 (3,600–6,117)
Mexico	4,071 (3,122–5,014)	24,115 (19,374–28,817)	5,011 (4,063–5,952)	25,055 (20,316–29,761)
DR TB				
Ecuador	13,782 (4,274–23,376)	73,275 (25,736–121,246)	14,877 (5,365–24,467)	74,375 (26,827–122,337)

All data are average estimates. For interpretability, negative estimates and confidence intervals are reported as 0. Abbreviations: PPP, purchasing power parity, CI, confidence interval; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis. *To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value [7], all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value [37,44], and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum cash transfers minus minimum cash transfers. Probability distributions for all 3 input parameters were assumed to be normal. This was justified because our analysis was at the national level and we used mean values. †Because data were highly skewed we reported median instead of mean.

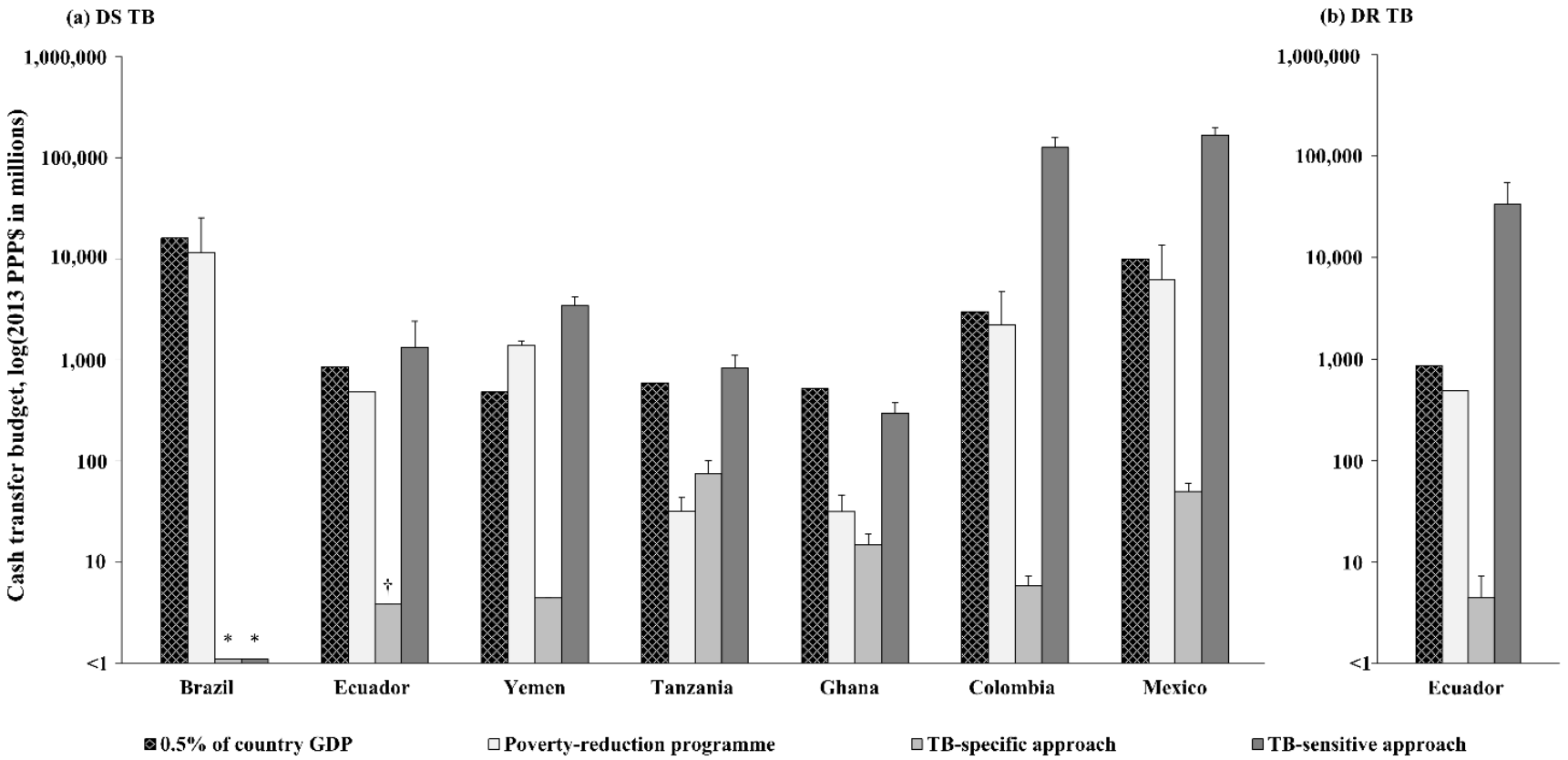

Fig 3. Summary of countries' country-level cash transfer budget needed to prevent catastrophic costs.

All data are expressed in millions on the $\log_{10}$ scale. We summarise 0.5% of countries' GDP and their existing poverty-reduction cash transfer budget for comparison. The "0.5% of country GDP" bar represents the upper limit that governments in low- and middle-income countries spend on a poverty-reduction cash transfer programme [27]. The "poverty-reduction programme" bar represents countries' actual poverty-reduction cash transfer programme budget. The "TB-specific approach" bar represents the mean budget that countries would need to prevent their TB-specific target population from incurring catastrophic costs. The "TB-sensitive approach" bar represents the mean budget that countries would need to prevent their TB-sensitive target population from incurring catastrophic costs. The values used to build Fig 3 are provided in S3 Table. *For clarity, a value of country-level cash transfer budget needed equal to $0 is plotted as $1.1. †Because data were highly skewed we reported median instead of mean. GDP, gross domestic product; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis.

Summary of the potential of TB-sensitive cash transfers to prevent DS TB catastrophic costs, and the budget needed for this approach

If cash transfers were provided using a TB-sensitive approach to increase pre-illness income of poor households with high risk of developing active TB disease, then on average, for those that later develop active DS TB disease, this would not be sufficient to prevent them from incurring catastrophic costs in any of the 6 countries where DS TB-related costs were originally catastrophic (Fig 2). In these 6 countries, the DS TB-related cost burden after TB-sensitive cash transfers varied between 24% (95% CI: 19%–29%) and 105% (95% CI: 88%–121%), and the estimated value of household-level additional TB-sensitive cash transfer needed to prevent DS TB catastrophic costs varied between $1,360 (95% CI: $821–$1,897) and $24,115 (95% CI: $19,374–$28,817), Table 3. The estimated value of household-level total TB-sensitive cash transfer needed to prevent DS TB catastrophic costs varied between $2,282 (95% CI: $1,743–$2,819) and $25,055 (95% CI: $20,316–$29,761), Table 3. According to the size of countries' TB-sensitive target populations, this value translated into a TB-sensitive country-level cash transfer budget needed to prevent DS TB catastrophic costs varying between $298 million (95% CI: $219 million–$378 million) and $165,367 million (95% CI: $134,085 million–$196,425 million), Fig 3.

Summary of the potential of TB-specific versus TB-sensitive cash transfers to prevent DR TB catastrophic costs, and the budget needed for each approach

In Ecuador, the DR TB-related cost burden before cash transfers was 192% (95% CI: 86%–299%), Fig 2. Here, cash transfers provided with either a TB-specific or a TB-sensitive approach were, on average, insufficient to prevent DR TB catastrophic costs (Fig 2). The estimated value of TB-specific versus TB-sensitive additional cash transfer needed to achieve this objective was $13,782 (95% CI: $4,274–$23,376) versus $73,275 (95% CI: $25,736–$121,246); and the estimated value of household-level total TB-specific versus TB-sensitive cash transfers needed was $14,877 (95% CI: $5,365–$24,467) versus $74,375 (95% CI: $26,827–$122,337), Table 3. According to the size of Ecuador's DR TB-specific and DR TB-sensitive target population, this value translated into a country-level cash transfer budget needed to prevent DR TB catastrophic costs of $4.5 million (95% CI: $1.6 million–$7.3 million) with a TB-specific approach versus $33,469 million (95% CI: $12,072 million–$55,052 million) with a TB-sensitive approach (Fig 3).

Sensitivity analysis without imputing data

Before cash transfers, the TB-related cost burden remained catastrophic in the same countries as when missing TB-related cost components were imputed, and the only difference after cash transfers was that TB-specific cash transfers prevented catastrophic costs in Colombia (S4 Table). Across countries, TB-specific cash transfers remained more affordable at preventing catastrophic costs compared to TB-sensitive cash transfers both at the household and country level (S5 Table).

Sensitivity analysis with 10% threshold

Before cash transfers, in addition to Colombia, Ecuador, Ghana, Mexico, Tanzania, and Yemen, the DS TB-related cost burden was also catastrophic in Brazil. In Ecuador, the DR TB-related cost burden before cash transfers remained catastrophic. Across countries, TB-specific cash transfers remained more affordable than TB-sensitive cash transfers for preventing DS and DR TB catastrophic costs both at the household and country level (S6 Table).

Sensitivity analysis with 30% threshold

Before cash transfers, the DS TB-related cost burden remained catastrophic in Colombia, Ghana, Mexico, Tanzania, and Yemen, but ceased to be catastrophic in Ecuador. In Ecuador, the DR TB-related cost burden before cash transfers remained catastrophic. Across countries, TB-specific cash transfers remained more affordable than TB-sensitive cash transfers for preventing DS and DR TB catastrophic costs both at the household and country level (S7 Table).

Discussion

In the 7 countries that met our inclusion criteria, our analysis of national average data suggests that DS TB-related costs would be catastrophic for the average poor TB-affected household in most low- and middle-income countries. This is concerning and concordant with the limited evidence that is already available [7]. If cash transfers were provided with a TB-specific approach to defray TB-related costs of poor households with a confirmed DS TB diagnosis, then in some low- and middle-income countries, they would likely be sufficient to prevent the average household incurring DS TB catastrophic costs. Alternatively, if the same value of cash transfers were provided with a TB-sensitive approach to increase the income and strengthen the economic resilience of poor households at high risk of developing active TB disease, then across low- and middle-income countries, they would likely be insufficient to prevent the average household that later developed active DS TB disease incurring DS TB catastrophic costs. In countries where neither TB-specific nor TB-sensitive cash transfers would be sufficient to prevent DS TB catastrophic costs, the average value of household-level additional cash transfer needed to achieve this objective would be much lower using a TB-specific approach compared to a TB-sensitive approach. Further, by only targeting poor households with a confirmed TB diagnosis, a TB-specific approach would, on average, require a much smaller country-level budget than using a TB-sensitive approach to target much larger numbers of poor households at high risk of developing active TB disease.

Although DR TB is rare, it is associated with extreme TB-related costs [7]. Neither TB-specific nor TB-sensitive cash transfers would be sufficient to prevent DR TB catastrophic costs for the average poor DR TB-affected household. The value of household-level additional cash transfer needed to achieve this objective would be very high. Because few poor households are affected by DR TB, countries' county-level cash transfer budget needed to prevent DR TB catastrophic costs would, on average, be much lower using a TB-specific approach compared to a TB-sensitive approach. Given that so few households are affected by DR TB, it may not be rational for TB-sensitive cash transfer programmes to aim to increase households' annual income sufficiently to make all poor households resilient to the rare and extreme costs associated with DR TB.

To our knowledge, our study is the first to compare the potential of cash transfers provided with a TB-specific versus a TB-sensitive approach to prevent catastrophic costs. The contrasting effects of defraying TB-related costs using a TB-specific approach versus increasing households' pre-illness income using a TB-sensitive approach has important and novel implications for protecting TB-affected households from catastrophic costs. We believe our study is also the first to compare the country-level cash transfer budget that would be needed to prevent catastrophic costs for poor TB-affected households using a TB-specific versus a TB-sensitive approach. We show that by being more effective and aiming to reach fewer households, a TB-specific approach would cost less than a TB-sensitive approach. It is important to emphasize that these findings are only valid when preventing catastrophic costs is the only outcome of interest. Cash transfers provided to poor households with a TB-sensitive approach might have far-reaching effects on wellbeing, health promotion, and disease prevention, and further evaluation is needed to study the costs versus benefits of each approach [24,67]. Nevertheless, the End TB Strategy prioritises ensuring that 0 TB-affected households experience catastrophic costs [17]. For achieving this specific milestone, the implications of our study are clear: cash transfers provided with a TB-specific approach are likely to achieve this goal more affordably than if they were provided with a TB-sensitive approach.

Our study adds to limited evidence informing the best targeting strategy for cash transfers aimed at enhancing TB care and prevention [24]. At the country-level, showing that in Latin America and Central Asia a TB-sensitive approach might reach between 12% and 35% of countries' population, whereas in some parts of sub-Saharan Africa it might only reach between 1% and 2% of countries population, this study supports speculation that the potential of countries to provide cash transfers with a TB-sensitive approach might follow an inverse care law [68], whereby poorer countries with higher TB burdens have less well established poverty-reduction cash transfer programmes [24]. Showing also that approximately 40% of TB-affected households might be in the poorest population quintile, this study highlights the need to consider how cash transfers might be targeted to households that incur catastrophic costs but are outside of this population category [50,51]. With a TB-specific approach, it would be relatively easy to modify programmes'

target population to include more TB-affected households, whilst with a TB-sensitive approach, it might be harder to modify the target population of existing poverty-reduction programmes, which are usually well-established parts of national social protection systems [35].

This study has several limitations, and conclusions should be drawn cautiously. Insufficient data forced us to estimate the potential of TB-specific versus TB-sensitive cash transfers to prevent catastrophic costs using the value of cash transfers offered by existing governmental poverty-reduction cash transfer programmes. Whilst the only solution, it will have nonetheless under- or overestimated the potential of TB-specific cash transfers depending on how their actual value compares to governmental poverty-reduction cash transfers. Our inputs were all associated with some uncertainty, especially TB-related costs, which were mostly extracted from small subnational cost surveys [33,34,62–66]. We attempted to account for this using a multiway analysis that allowed inputs to vary by their simulated sampling distributions. Inconsistent reporting of standard deviations for mean TB-related costs, household income, and cash transfers forced us to make assumptions about the amount of variance around extracted values and to generalise these across countries. Whilst we ensured that our estimates of variance were as accurate as possible by drawing from relevant literature [7,37,44], this approach will have ignored any country-specific skewness or kurtosis in input parameters. Inconsistent reporting of TB-related costs disaggregated by income quintile meant that we had to assume that estimated TB-related costs were representative of those incurred by affected households in countries' poorest population quintile. Because poorer households usually incur lower TB-related costs compared to less poor households, this is likely to have underestimated the potential of cash transfers to prevent catastrophic costs, and overestimated the country-level budget needed to achieve this [14]. Whilst our analysis should provide an accurate estimate of the effect of cash transfers on countries' mean TB-related cost burden, because sample distributions of TB-related costs are known to be positively skewed [7], the aggregate-level nature of our study means that our results are unlikely to be representative of the majority of TB-affected households. Two sources of error in this study were imputation of missing TB-related cost components in Brazil [33], Colombia [62], Tanzania [63], and Mexico [64], and measuring catastrophic costs using a threshold TB-

related cost burden that still hasn't been assessed to determine its clinical or financial relevance for TB-affected households in any of the countries included in the study. Sensitivity analysis showed that the potential of cash transfers to prevent catastrophic costs was robust to these sources of error, but the precise estimates of countries' household-level additional and total cash transfer and country-level cash transfer budget needed to prevent catastrophic costs were dependent on them. Therefore, whilst a TB-specific approach was consistently more effective and affordable for preventing catastrophic costs compared to a TB-sensitive approach in all our analyses, further research is needed to precisely estimate the cost of each of these approaches.

Our study is consistent with, and adds to, individual level evidence supporting the potential of TB-specific cash transfers to prevent catastrophic costs for poor TB-affected households in Peru [15]. Whilst our study questions the ability of TB-sensitive cash transfers to prevent households from engaging in damaging coping strategies, it supports individual evidence from Latin America for their ability to improve households' coping capacity in response to severe livelihood risks [21]. By focussing on preventing catastrophic costs in low- and middle-income countries, it adds another dimension to the 2015 Cochrane review of the use of cash transfers in TB control, which did not find evidence on this outcome and mostly examined the use of cash transfers in the United States [69]. For future research, the validity of our results should be tested using individual-level primary data from future TB-related cost surveys, secondary data that includes information on households' TB exposure, income and social protection status [70], and/or experimental data from interventions like the ongoing CRESIPT trial in Peru [25,26]. This work should also look to explore the effect of TB-specific and TB-sensitive cash transfers on other proxy measures of catastrophic costs like household dissaving (e.g., taking out a loan and/or selling household items) [15,16]. For a more complete understanding of the impact of providing cash transfers with a TB-specific versus a TB-sensitive approach, future research should also aim to incorporate this study's data into an epidemiological model that accounts for their respective effects on TB-related catastrophic costs, and the additional effects of a TB-sensitive approach on individuals' risk of TB infection and progression by addressing poverty-related risk factors (e.g., poor living conditions and undernutrition) [71,72].

In addition to studying the potential of cash transfers to prevent TB-related catastrophic costs, future research should also prioritise investigating the effect of other forms of social protection on this outcome. For example, in Mexico [64], food assistance might effectively defray households' high direct nonmedical food costs [73], and in Ghana [65], facilitating patients' access to sickness benefits and their prompt reintegration into the labour market might help to avoid high indirect costs [74]. Obviously, social protection should not be implemented in isolation of other healthcare initiatives to reduce costs. Further research should also aim to evaluate the complementary effects of social protection and efforts to reduce out of pocket direct medical costs. For example, combining social protection with further investments to maximize ambulatory community-based care might be especially effective for preventing catastrophic costs in Ecuador, where patients incur high direct medical costs for hospitalisation [66,75,76]. Multidisciplinary research platforms like the Health and Social Protection Action Research & Knowledge Sharing (SPARKS) Network will be key for facilitating this sort of research [77].

Our analysis compares cash transfers provided with a TB-specific versus TB-sensitive approach. Interestingly, it has been proposed that one efficient and cost-effective strategy might be to integrate both TB-specific and TB-sensitive approaches into a so-called "TB-inclusive" approach [24]. Results from our study demonstrating the greater potential of TB-specific cash transfers to prevent catastrophic costs, and the existing coverage of TB-sensitive cash transfer programmes, may support this integrated approach. For a TB-inclusive approach, existing poverty-reduction programmes could be adapted to include an additional variable TB-specific benefit, which beneficiary households would be eligible to receive upon receipt of a confirmed TB diagnosis. To finance such an approach, stakeholders from across TB control, development, and finance sectors could coordinate to determine how much each would be willing to contribute given their separate objectives [78,79]. From a TB prevention perspective, such an investment would be expected to reduce delays for TB diagnosis [10], reduce the risk of adverse treatment outcomes [14], and thus potentially contribute to reduced national TB incidence [80]. From the perspective of social development, reduced national TB incidence would be expected to enable previously vulnerable households to invest more in human capital, increase their labour productivity, and thus contribute to long-term sustainable economic growth [81].

Because households affected by human immunodeficiency virus (HIV), mental health issues, diabetes, and other noncommunicable diseases are also known to incur high direct and indirect costs [82,83], any efforts to prevent catastrophic costs for TB-affected households should aim to collaborate with these other areas of public health. Whichever approach for providing cash transfers to prevent TB-related catastrophic costs is chosen, it will be key to ensure that it is not implemented in isolation from universal health coverage initiatives including more decentralised and patient-friendly TB service delivery. Social protection initiatives and universal health coverage initiatives should be developed and implemented hand-in-hand [19].

Our finding that neither a TB-specific nor a TB-sensitive approach might be sufficient to prevent DR TB catastrophic costs highlights the urgent need for considerable investments in social protection and universal health coverage initiatives targeted to households affected by this disease. Globally, only 20% of people with DR TB are estimated to begin treatment, and only 52% of those that start treatment are estimated to successfully complete it [1]. Therefore, DR TB-affected households should constitute a “special case” for future investments to prevent catastrophic costs.

Reviewing and analysing the literature on TB-related costs and poverty-reduction cash transfer programmes in low- and middle-income countries, our study compares the potential of cash transfers provided with a TB-specific versus a TB-sensitive approach to prevent catastrophic costs for poor TB-affected households. Our findings suggest that providing cash transfers with a TB-specific approach to defray TB-related costs of households with a confirmed TB diagnosis will be more effective and affordable for achieving this objective compared to a TB-sensitive approach that increases the income and strengthens the economic resilience of households at high risk of developing active TB disease. Our findings also highlight an urgent need for investments to prevent catastrophic costs for households having to confront the severe medical, social, and economic challenges caused by DR TB.

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Supporting Information

Please note, supporting information listed on pages 184 to 197 relating to Manuscript S2 is included later in the Supplementary Material of this thesis under the same title. For reference, see the Supplementary Material table of contents on pages 1 and 2.

S1 CHEERS checklist.

S1 Text. Prospective analysis plan.

S1 Table. Summary of cash transfer and household income data sources. PPP, purchasing power parity.

S2 Table. Summary of countries' household-level TB-related cost burden before, and after cash transfers. The "Before cash transfers" column represents countries' mean TB-related cost burden without cash transfer data. The "After TB-specific cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been subtracted from TB-related costs. The "After TB-sensitive cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been added to countries' pre-illness household income. CI, confidence interval; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis.

S3 Table. Summary of countries' country-level cash transfer budget needed to prevent catastrophic costs. The "0.5% of country GDP" column represents the upper limit that governments in low- and middle-income countries spend on a poverty-reduction cash transfer programme [27]. The "poverty-reduction programme" column represents countries' actual poverty-reduction cash transfer programme budget. The "TB-specific approach" column represents the mean budget that countries would need to prevent their TB-specific target population from incurring catastrophic costs. The "TB-sensitive approach" column represents the mean budget that countries' would need to prevent their TB-sensitive target population from incurring catastrophic costs. CI, confidence interval; GDP, gross domestic product; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis.

S4 Table. Summary of countries' household-level TB-related cost burden before and after cash transfers without imputation of missing costs components. The "Before cash transfers" column represents countries' mean TB-related cost burden without cash transfer data. The "After TB-specific cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been subtracted from TB-related costs. The "After TB-sensitive cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been added to countries' pre-illness household income. CI, confidence interval; DS, drug-susceptible; TB, tuberculosis.

S5 Table. Summary of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs without imputation of missing costs components. The "additional cash transfer" column represents the additional value of cash transfer that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "total cash transfer" column represents the total value that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "cash transfer budget, in millions" column represents the mean budget that countries would need to prevent catastrophic costs for its TB-specific versus TB-sensitive target populations. PPP, purchasing power parity; CI, confidence interval; DS, drug-susceptible; TB, tuberculosis.

S6 Table. Summary of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs using a 10% threshold TB-related cost burden for measuring catastrophic costs. The "additional cash transfer" column represents the additional value of cash transfer that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "total cash transfer" column represents the total value that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "cash transfer budget, in millions" column represents the mean budget that countries would need to prevent catastrophic costs for

their TB-specific versus TB-sensitive target populations. PPP, purchasing power parity; CI, confidence interval; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis.

S7 Table. Summary of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs using a 30% threshold TB-related cost burden for measuring catastrophic costs. The "additional cash transfer" column represents the additional value of cash transfer that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "total cash transfer" column represents the total value that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "cash transfer budget, in millions" column represents the mean budget that countries' would need to prevent catastrophic costs for their TB-specific versus TB-sensitive target populations. PPP, purchasing power parity; CI, confidence interval; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis.

Abstract S1. Accepted abstract for 48th Union World Conference on Lung Health.

Title: During-treatment Catastrophic Costs for Drug-Resistant Tuberculosis Patients With and Without Social Protection; A Patient Survey in Rio de Janeiro, Brazil.

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Background: Illness-related costs for tuberculosis (TB) patients ≥20% of annual household income predict adverse treatment outcomes so are termed catastrophic. Drug-resistant TB (DR-TB) patients experience especially high costs. In Brazil, two social protection policies, Auxílio-doença and Benefício de Prestação Continuada (BPC), might help to protect them from incurring catastrophic costs. We undertook a patient survey to estimate the proportion of DR-TB patients experiencing catastrophic costs during-treatment amongst those with and without income replacement from these policies.

Methods: From June-October 2016, 120 DR-TB patients being accompanied at the Professor Helio Fraga reference centre in Rio de Janeiro were interviewed about household income and receipt of Auxílio-doença or BPC pre-/during-treatment, and direct and indirect costs incurred during-treatment. Direct costs were calculated from transport, food, private healthcare and non-prescribed remedy costs incurred during-treatment. Indirect costs were

calculated from reported lost income related to TB illness, net of income replacement from Auxílio-doença or BPC. We calculated patients' cost burden as the sum of direct and indirect costs as a proportion of pre-treatment annual household income, and the proportion of patients experiencing catastrophic costs using a threshold cost burden ≥20%. Costs were reported in 2016 US$.

Results: 41 (34%) and 3 (2%) DR-TB patients reported income replacement from Auxílio-doença and BPC during-treatment respectively, with a mean value of US$5,966 (SD: US$1,883). For patients with and without income replacement, mean direct costs were US$774 (SD: US$394) versus US$722 (SD: US$325); and mean net indirect costs were US$3,564 (SD: US$7,578) versus US$4,353 (SD: US$5,782), respectively. In the two groups, the mean cost burden was 42% (SD: 40%) versus 527% (SD: 2,468%), and the proportion experiencing catastrophic costs was 50% (95%CI: 35%-65%) versus 75% (95%CI: 65%-85%), *p*=0.01, respectively.

Conclusion: Social protection policies might prevent catastrophic costs for some DR-TB patients. Further investment is needed to prevent catastrophic costs for all DR-TB patients.

Abstract S2. Accepted abstract for 47th Union World Conference on Lung Health.

Full title: Towards zero TB-affected households facing catastrophic costs: the role of governmental cash transfer programmes.

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Background: Financial costs incurred by Tuberculosis (TB) patients have previously been defined as catastrophic when they exceed 20% of an affected households' annual income. The post-2015 END TB strategy endorses social protection policies, including cash transfer programmes, to eliminate all TB patients' catastrophic costs by 2020.

Methods: We used published data in nine selected countries to estimate the potential of governmental cash transfer programmes to mitigate TB patients' catastrophic costs. Countries were eligible if they had a governmental family targeted cash transfer programme, published TB patient average cost data and had a recent household income and

expenditure survey. The potential of programmes to mitigate catastrophic costs was calculated as: the percentage point (%pt) difference in average TB patient costs as a percentage of countries' average annual household income in the poorest quintile, before and after addition of the total value of cash transfers expected to be received by beneficiary households over one year. Where cash transfers did not reduce average TB patient costs to below 20% of average annual household income, we calculated the additional value of cash necessary to achieve this. For analysis, all monetary values were inflated and converted to 2013 international dollars using purchasing power parity conversion factor.

Results: Before addition of cash transfers, average TB patient costs were catastrophic in six out of nine selected countries. Across countries, the potential of cash transfers received over one year to mitigate TB patients' catastrophic costs by adding to average annual household income varied widely (0.3%pt difference to 31%pt difference). After addition of cash transfers, average TB patient costs remained catastrophic in all six of the countries in which they were originally greater than 20% of average annual household income (22% to 78%). In these countries the value of additional cash necessary to mitigate catastrophic costs ranged from $108 to $6200.

Conclusions: While governmental cash transfer programmes might reduce the severity of TB patients' catastrophic costs, additional innovations may be needed to confront the challenge of eliminating TB catastrophic costs by 2020.

Table S1. Review search terms.

((((cash OR income) AND condition*) AND (benefit* OR transfer*)) AND ((income OR consump* OR expenditure* OR welfare OR idiosyncratic) AND (risk OR shock OR change OR fluctuation OR unemployment OR illness OR death)) AND (mitigat* OR manag* OR insur* OR smooth OR shar* OR protect* OR cope OR coping OR secur* OR compensat* OR remittance* OR loan* OR credit)

Table S2. Maryland Scientific Methods Scale (1).

Maryland SMS level	**Criteria used to score SMS level**
1	Either (a) a cross-sectional comparison of treated groups with untreated groups, or (b) a before-and-after comparison of treated group, without an untreated comparison group. No use of control variables in statistical analysis to adjust for differences between treated and untreated groups or periods.
2	Use of adequate control variables and either (a) a cross-sectional comparison of treated groups with untreated groups, or (b) a before-and-after comparison of treated group, without an untreated comparison group. In (a), control variables or matching techniques used to account for cross-sectional differences between treated and controls groups. In (b), control variables are used to account for before-and-after changes in macro level factors.
3	Comparison of outcomes in treated group after an intervention, with outcomes in the treated group before the intervention, and a comparison group used to provide a counterfactual (e.g. difference in difference). Justification given to choice of comparator group that is argued to be similar to the treatment group. Evidence presented on comparability of treatment and control groups. Techniques such as regression and (propensity score matching may be used to adjust for difference between treated and untreated groups, but there are likely to be important unobserved differences remaining.
4	Quasi-randomness in treatment is exploited, so that it can be credibly held that treatment and control groups differ only in their exposure to the random allocation of treatment. This often entails the use of an instrument or discontinuity in treatment, the suitability of which should be adequately demonstrated and defended.
5	Reserved for research designs that involve explicit randomisation into treatment and control groups, with Randomised Control Trials (RCTs) providing the definitive example. Extensive evidence provided on comparability of treatment and control groups, showing no significant differences in terms of levels or trends. Control variables may be used to adjust for treatment and control group differences, but this adjustment should not have a large impact on the main results. Attention paid to problems of selective attrition from randomly assigned groups, which is shown to be of negligible importance. There should be limited or, ideally, no occurrence of 'contamination' of the control group with the treatment.

Abbreviations: SMS, Scientific Methods Scale.

Table S3. Loss to follow up and missing data in the 2005 Avaliação do Impacto do Bolsa Família dataset.

	Overall n (%) n = 68,395	LTFU			Missing		
		Yes n (%) n = 18,096	OR (95% CIs)	p-value	Yes n (%) n = 7207	OR (95% CIs)	p-value
Household characteristics							
Region				<0.001			<0.001
Central Western	8255 (12)	3348 (19)	1.0		855 (12)	1.0	
North	12,483 (18)	1802 (10)	0.3 (0.2 to 0.3)		1003 (14)	0.8 (0.7 to 0.8)	
Northeast	22,579 (33)	4682 (26)	0.4 (0.4 to 0.4)		3206 (44)	1.4 (1.3 to 1.6)	
South	4024 (6)	1288 (7)	0.7 (0.6 to 0.8)		400 (6)	1 (0.8 to 1.1)	
Southeast	21,054 (31)	6976 (39)	0.7 (0.7 to 0.8)		1743 (24)	0.8 (0.7 to 0.9)	
Location				0.98			<0.001
Rural	12,848 (19)	3395 (19)	1.0		2397 (33)	1.0	
Urban	54,033 (79)	14,282 (79)	1 (1 to 1.1)		3296 (46)	0.3 (0.3 to 0.3)	
Missing	1514 (2)	419 (2)			1514 (21)		
Situation				<0.001			<0.001
Condominium	13,118 (19)	3388 (19)	1.0		1316 (18)	1.0	
Informal settlement	4299 (6)	1316 (7)	1.3 (1.2 to 1.4)		327 (5)	0.7 (0.7 to 0.8)	
Tenement	7172 (10)	1907 (11)	1 (1 to 1.1)		686 (10)	1 (0.9 to 1)	
Detached	43,806 (64)	11,485 (63)	1 (1 to 1.1)		4878 (68)	1.1 (1.1 to 1.2)	
Piped water				<0.001			<0.001
Yes	55,461 (81)	15,390 (85)	1.0		5190 (72)	1.0	
No	12,934 (19)	2706 (15)	0.7 (0.7 to 0.7)		2017 (28)	1.8 (1.7 to 1.9)	
BPC elder				<0.001			<0.001
Yes	490 (1)	96 (1)	1.0		113 (2)	1.0	
No	67,877 (99)	17,997 (99)	1.5 (1.2 to 1.9)		7066 (98)	0.4 (0.3 to 0.5)	
Missing	28 (0)	3 (0)			28 (0)		

BPC disabilty				<0.001			0.31
Yes	549 (1)	107 (1)	1.0		65 (1)	1.0	
No	67,818 (99)	17,986 (99)	1.5 (1.2 to 1.9)		7114 (99)	0.9 (0.7 to 1.1)	
Missing	28 (0)	3 (0)			28 (0)		
Bolsa Alimentação				0.63			0.13
Yes	745 (1)	203 (1)	1.0		91 (1)	1.0	
No	67,622 (99)	17,890 (99)	1 (0.8 to 1.1)		7088 (98)	0.8 (0.7 to 1.1)	
Missing	28 (0)	3 (0)			28 (0)		
Programa Cartao Alimentação				0.32			0.26
Yes	242 (0)	71 (0)	1.0		31 (0)	1.0	
No	68,125 (100)	18,022 (100)	0.9 (0.7 to 1.2)		7148 (99)	0.8 (0.6 to 1.2)	
Missing	28 (0)	3 (0)			28 (0)		
Bolsa Escola				<0.001			0.002
Yes	13,031 (19)	3162 (17)	1.0		1272 (18)	1.0	
No	55,336 (81)	14,931 (83)	1.2 (1.1 to 1.2)		5907 (82)	1.1 (1 to 1.2)	
Missing	28 (0)	3 (0)			28 (0)		
Vale Gas				<0.001			<0.001
Yes	8707 (13)	2005 (11)	1.0		1053 (15)	1.0	
No	59660 (87)	16,088 (89)	1.2 (1.2 to 1.3)		6126 (85)	0.8 (0.8 to 0.9)	
Missing	28 (0)	3 (0)			28 (0)		
PETI				0.007			0.001
Yes	668 (1)	147 (1)	1.0		99 (1)	1.0	
No	67,699 (99)	17,946 (99)	1.3 (1.1 to 1.5)		7080 (98)	0.7 (0.5 to 0.8)	
Missing	28 (0)	3 (0)			28 (0)		
Programa Bolsa Família				<0.001			<0.001
Yes	22,638 (33)	5390 (30)	1.0		1985 (28)	1.0	
No	45,729 (67)	12,703 (70)	1.2 (1.2 to 1.3)		5194 (72)	1.3 (1.3 to 1.4)	
Missing	28 (0)	3 (0)			28 (0)		
Monthly food consumption; US$				<0.001			<0.001

0 to 40	5265 (8)	1750 (10)	1.0		510 (7)	1.0	
41 to 80	17,819 (26)	4890 (27)	0.8 (0.7 to 0.8)		1636 (23)	0.9 (0.9 to 1.1)	
81 to 120	18,018 (26)	4639 (26)	0.7 (0.7 to 0.7)		1598 (22)	0.9 (0.8 to 1)	
121 to 160	11,636 (17)	2777 (15)	0.6 (0.6 to 0.7)		1195 (17)	1.1 (1 to 1.2)	
161+	15,209 (22)	3914 (22)	0.7 (0.7 to 0.7)		1820 (25)	1.3 (1.1 to 1.4)	
Missing	448 (1)	126 (1)			448 (6)		
Individual characteristics							
Household position				<0.001			<0.001
Responsible	15,426 (23)	4285 (24)	1.0		2359 (33)	1.0	
Other	52,969 (77)	13,811 (76)	0.9 (0.9 to 1)		4848 (67)	0.6 (0.5 to 0.6)	
Sex				0.55			<0.001
Male	33,098 (48)	8723 (48)	1.0		4116 (57)	1.0	
Female	35,297 (52)	9373 (52)	1 (1 to 1.1)		3091 (43)	0.7 (0.6 to 0.7)	
Age, years				0.01			<0.001
0 to 16	27,380 (40)	7408 (41)	1.0		1347 (19)		
16 to 34	21,085 (31)	5561 (31)	1 (0.9 to 1)		2907 (40)	3.1	
35 to 54	14,521 (21)	3749 (21)	0.9 (0.9 to 1)		2224 (31)	3.5 (3.3 to 3.8)	
55+	5409 (8)	1378 (8)	0.9 (0.9 to 1)		729 (10)	3 (2.7 to 3.3)	
Ethnicity				<0.001			0.08
White	22,561 (33)	6992 (39)	1.0		2179 (30)	1.0	
Black	6799 (10)	1671 (9)	0.7 (0.7 to 0.8)		699 (10)	1.1 (1 to 1.2)	
Mixed	37,835 (55)	9127 (50)	0.7 (0.7 to 0.7)		3743 (52)	1 (1 to 1.1)	
Oriental	506 (1)	148 (1)	0.9 (0.8 to 1.1)		67 (1)	1.4 (1.1 to 1.8)	
Indigenous	194 (0)	52 (0)	0.8 (0.6 to 1.1)		19 (0)	1 (0.6 to 1.6)	
Missing	500 (1)	106 (1)			500 (7)	0 (0 to 0)	
Literacy				0.15			<0.001
Yes	50,174 (73)	13,348 (74)	1.0		5586 (78)	1.0	
No	18,221 (27)	4748 (26)	1 (0.9 to 1)		1621 (22)	0.8 (0.7 to 0.8)	
Pregnant				0.14			0.03

Yes	593 (1)	173 (1)	1.0		47 (1)	1.0	
No	67,781 (99)	17,920 (99)	0.9 (0.7 to 1)		7139 (99)	1.4 (1 to 1.9)	
Missing	21 (0)	3 (0)			21 (0)		
Self-rated health				<0.001			<0.001
Very good	9578 (14)	2906 (16)	1.0		857 (12)	1.0	
Good	38,991 (57)	10,224 (56)	0.8 (0.8 to 0.9)		3915 (54)	1.1 (1.1 to 1.2)	
Regular	16,181 (24)	4061 (22)	0.8 (0.7 to 0.8)		1962 (27)	1.4 (1.3 to 1.5)	
Bad	2796 (4)	718 (4)	0.8 (0.7 to 0.9)		362 (5)	1.5 (1.3 to 1.7)	
Very bad	604 (1)	139 (1)	0.7 (0.6 to 0.8)		65 (1)	1.2 (0.9 to 1.6)	
Don't know	238 (0)	47 (0)	0.6 (0.4 to 0.8)		39 (1)	2 (1.4 to 2.8)	
Missing	7 (0)	1 (0)			7 (0)		
Chronic health condition				0.003			0.22
Yes	13,284 (19)	3653 (20)	1.0		1361 (19)	1.0	
No	55,111 (81)	14,443 (80)	0.9 (0.9 to 1)		5846 (81)	1 (1 to 1.1)	
Work				0.92			<0.001
Yes	22,325 (33)	5888 (33)	1.0		5503 (76)	1.0	
No	11792 (17)	3134 (17)	1 (1 to 1.1)		502 (7)	0.1 (0.1 to 0.2)	
Never	34,266 (50)	9068 (50)	1 (1 to 1)		1190 (17)	0.1 (0.1 to 0.1)	
Missing	12 (0)	6 (0)			12 (0)		
Work branch				<0.001			<0.001
Agriculture	5613 (8)	1234 (7)	1.0		2637 (37)	1.0	
Industry	1215 (2)	358 (2)	1.5 (1.3 to 1.7)		163 (2)	0.2 (0.2 to 0.2)	
Civil construction	1706 (2)	464 (3)	1.3 (1.2 to 1.5)		215 (3)	0.2 (0.1 to 0.2)	
Trade	2955 (4)	859 (5)	1.5 (1.3 to 1.6)		590 (8)	0.3 (0.3 to 0.3)	
Transport	726 (1)	206 (1)	1.4 (1.2 to 1.7)		128 (2)	0.2 (0.2 to 0.3)	
Other services	8568 (13)	2411 (13)	1.4 (1.3 to 1.5)		1340 (19)	0.2 (0.2 to 0.2)	
Public administration	1258 (2)	283 (2)	1 (0.9 to 1.2)		146 (2)	0.2 (0.1 to 0.2)	
Unemployed	46,070 (67)	12,208 (67)	1.3 (1.2 to 1.4)		1704 (24)	0 (0 to 0.1)	
Missing	284 (0)	73 (0)			284 (4)		

Work hours; hours				<0.001			<0.001
0	46,058 (67)	12,202 (67)	1.0		1692 (23)	1.0	
1 to 24	4107 (6)	924 (5)	0.8 (0.8 to 0.9)		1136 (16)	10 (9.2 to 10.9)	
25 to 48	13,393 (20)	3607 (20)	1 (1 to 1.1)		2546 (35)	6.2 (5.8 to 6.6)	
48+	3639 (5)	1031 (6)	1.1 (1 to 1.2)		635 (9)	5.5 (5 to 6.1)	
Missing	1198 (2)	332 (2)			1198 (17)		
Work salary; US$				<0.001			<0.001
0	46,058 (67)	12,202 (67)	1.0		1692 (23)	1.0	
1 to 59	3758 (5)	869 (5)	0.8 (0.8 to 0.9)		385 (5)	3 (2.7 to 3.4)	
60 to 118	4015 (6)	955 (5)	0.9 (0.8 to 0.9)		391 (5)	2.8 (2.5 to 3.2)	
119 to 236	8972 (13)	2522 (14)	1.1 (1 to 1.1)		996 (14)	3.3 (3 to 3.6)	
237+	2088 (3)	778 (4)	1.7 (1.5 to 1.8)		239 (3)	3.4 (2.9 to 3.9)	
Missing	3504 (5)	770 (4)			3504 (49)		
Social insurance				<0.001			<0.001
Yes	6897 (10)	2068 (11)	1.0		921 (13)	1.0	
No	60,897 (89)	15,855 (88)	0.8 (0.8 to 0.9)		5685 (79)	0.7 (0.6 to 0.7)	
Missing	601 (1)	173 (1)			601 (8)		

Abbreviations: LTFU, Loss to follow up; OR, Odds ratio; CIs, Confidence intervals; BPC, Benficio de Prestação Continuada; PETI, Programa de Erradicação do Trabalho Infantil; US$, United States dollar. In 2005 R$ 1 = US$ 0.4.

Table S4. Missing data in the 2009 Avaliação do Impacto do Bolsa Família dataset.

	Overall n (%) n = 47,010	Missing		
		Yes n (%) n = 21,965	OR (95% CIs)	p-value
Household characteristics				
Region				<0.001
Central Western	4736 (10)	2564 (12)	1.0	
North	9791 (21)	4500 (20)	0.7 (0.7 to 0.8)	
Northeast	16,597 (35)	6958 (32)	0.6 (0.6 to 0.7)	
South	2587 (6)	1495 (7)	1.2 (1.1 to 1.3)	
Southeast	13,299 (28)	6448 (29)	0.8 (0.8 to 0.9)	
Location				0.24
Rural	8887 (19)	4100 (19)	1.0	
Urban	37,132 (79)	16,874 (77)	1 (0.9 to 1)	
Missing	991 (2)	991 (5)		
Situation				<0.001
Condominium	14,121 (30)	6593 (30)	1.0	
Informal settlement	3296 (7)	1399 (6)	0.8 (0.8 to 0.9)	
Tenement	12,363 (26)	5724 (26)	1 (0.9 to 1)	
Detached	17,217 (37)	8236 (37)	1.1 (1 to 1.1)	
Missing	13 (0)	13 (0)		
Piped water				0.66
Yes	39,508 (84)	18,370 (84)	1.0	
No	7341 (16)	3434 (16)	1 (1 to 1.1)	
Missing	161 (0)	161 (1)		
BPC elder				0.65
Yes	389 (1)	176 (1)	1.0	
No	46,330 (99)	21,498 (98)	1.1 (0.9 to 1.3)	
Missing	291 (1)	291 (1)		
BPC disabilty				0.35
Yes	436 (1)	212 (1)	1.0	
No	46,285 (98)	21,464 (98)	0.9 (0.8 to 1.1)	
Missing	289 (1)	289 (1)		
Bolsa Alimentação				0.08
Yes	454 (1)	190 (1)	1.0	
No	45,803 (97)	21,022 (96)	1.2 (1 to 1.4)	
Missing	753 (2)	753 (3)		
Programa Cartao Alimentação				0.66
Yes	28 (0)	14 (0)	1.0	
No	46,230 (98)	21,199 (97)	0.9 (0.4 to 1.8)	
Missing	752 (2)	752 (3)		
Bolsa Escola				<0.001
Yes	1412 (3)	739 (3)	1.0	

No	44,788 (95)	20,416 (93)	0.8 (0.7 to 0.9)	
Missing	810 (2)	810 (4)		
Vale Gas				0.002
Yes	290 (1)	159 (1)	1.0	
No	45,868 (98)	20,954 (95)	0.7 (0.6 to 0.9)	
Missing	852 (2)	852 (4)		
PETI				0.22
Yes	404 (1)	175 (1)	1.0	
No	46,284 (98)	21,468 (98)	1.1 (0.9 to 1.4)	
Missing	322 (1)	322 (1)		
Programa Bolsa Família				<0.001
Yes	24,306 (52)	11,103 (51)	1.0	
No	22,704 (48)	10,862 (49)	1.1 (1.1 to 1.1)	
Monthly food consumption; US$				<0.001
0 to 40	3555 (8)	1437 (7)	1.0	
41 to 80	6025 (13)	2320 (11)	0.9 (0.9 to 1)	
81 to 120	6692 (14)	2447 (11)	0.9 (0.8 to 0.9)	
121 to 160	6443 (14)	2360 (11)	0.9 (0.8 to 0.9)	
161+	17,950 (38)	7056 (32)	1 (0.9 to 1)	
Missing	6345 (13)	6345 (29)		
Husband ill				<0.001
Yes	1887 (4)	965 (4)	1.0	
No	44,771 (95)	20,648 (94)	0.8 (0.8 to 0.9)	
Missing	352 (1)	352 (2)		
Wife ill				<0.001
Yes	1311 (3)	670 (3)	1.0	
No	45,297 (96)	20,893 (95)	0.8 (0.7 to 0.9)	
Missing	402 (1)	402 (2)		
Other member ill				0.001
Yes	3729 (8)	1830 (8)	1.0	
No	42,979 (91)	19,833 (90)	1 (1 to 1.1)	
Missing	302 (1)	302 (1)		
Individual characteristics				
Household position				<0.001
Household responsible	10,801 (23)	5532 (25)	1.0	
Other	35,645 (76)	15,869 (72)	0.8 (0.7 to 0.8)	
Missing	564 (1)	564 (3)		
Sex				<0.001
Male	22,565 (48)	10,902 (50)	1.0	
Female	24,427 (52)	11,045 (50)	0.9 (0.9 to 0.9)	
Missing	18 (0)	18 (0)		
Age, years				<0.001
0 to 16	15,639 (33)	6237 (28)	1.0	
16 to 34	14,905 (32)	7213 (33)	1.4 (1.4 to 1.5)	
35 to 54	11,378 (24)	5936 (27)	1.6 (1.6 to 1.7)	
55+	4899 (10)	2390 (11)	1.4 (1.4 to 1.5)	

Missing	189 (0)	189 (1)		
Ethnicity				<0.001
White	13,984 (30)	6404 (29)	1.0	
Black	5213 (11)	2378 (11)	1 (0.9 to 1.1)	
Mixed	25,593 (54)	11,190 (51)	0.9 (0.9 to 1)	
Oriental	250 (1)	131 (1)	1.3 (1 to 1.7)	
Indigenous	170 (0)	62 (0)	0.7	
Missing	1800 (4)	1800 (8)		
Literacy				<0.001
Yes	37,308 (79)	17,251 (79)	1.0	
No	8820 (19)	3832 (17)	0.9 (0.9 to 0.9)	
Missing	882 (2)	882 (4)		
Pregnant				0.97
Yes	282 (1)	127 (1)	1.0	
No	45,192 (96)	20,302 (92)	1 (0.8 to 1.3)	
Missing	1536 (3)	1536 (7)		
Health state				<0.001
Very good	6669 (14)	2811 (13)	1.0	
Good	27,950 (59)	13,011 (59)	1.2 (1.1 to 1.3)	
Regular	9306 (20)	4339 (20)	1.2 (1.1 to 1.3)	
Bad	1967 (4)	975 (4)	1.4 (1.2 to 1.5)	
Very bad	492 (1)	228 (1)	1.2 (1 to 1.4)	
Don't know	63 (0)	38 (0)	2.1 (1.3 to 3.5)	
Missing	563 (1)	563 (3)		
Chronic health condition				0.08
Yes	7184 (15)	3204 (15)	1.0	
No	38,818 (83)	17,753 (81)	1.1 (1 to 1.1)	
Missing	1008 (2)	1008 (5)		
Work				<0.001
Yes	16,313 (35)	9976 (45)	1.0	
No	6945 (15)	2595 (12)	0.4 (0.4 to 0.4)	
Never	22,583 (48)	8225 (37)	0.4 (0.4 to 0.4)	
Missing	1169 (2)	1169 (5)		
Work branch				<0.001
Agriculture	3446 (7)	2307 (11)	1.0	
Industry	860 (2)	457 (2)	0.6 (0.5 to 0.7)	
Civil construction	981 (2)	535 (2)	0.6 (0.5 to 0.7)	
Trade	2082 (4)	1101 (5)	0.6 (0.5 to 0.6)	
Transport	412 (1)	229 (1)	0.6 (0.5 to 0.8)	
Other services	6185 (13)	3394 (15)	0.6 (0.6 to 0.7)	
Public administration	744 (2)	350 (2)	0.4 (0.4 to 0.5)	
Unemployed	29,528 (63)	10,820 (49)	0.3 (0.3 to 0.3)	
Missing	2772 (6)	2772 (13)		
Work hours; hours				<0.001
0	29,528 (63)	10,820 (49)	1.0	
1 to 24	2770 (6)	1451 (7)	1.9 (1.8 to 2.1)	

25 to 48	7939 (17)	4114 (19)	1.9 (1.8 to 2)	
48+	2496 (5)	1303 (6)	1.9 (1.7 to 2.1)	
Missing	4277 (9)	4277 (19)		
Work salary; US$				<0.001
0	29,528 (63)	10,820 (49)	1.0	
1 to 59	670 (1)	242 (1)	1 (0.8 to 1.2)	
60 to 118	807 (2)	310 (1)	1.1 (0.9 to 1.2)	
119 to 236	1587 (3)	608 (3)	1.1 (1 to 1.2)	
237+	7645 (16)	3212 (15)	1.3 (1.2 to 1.3)	
Missing	6773 (14)	6773 (31)		
Social insurance				<0.001
Yes	5377 (11)	2811 (13)	1.0	
No	38,745 (82)	16,266 (74)	0.7 (0.6 to 0.7)	
Missing	2888 (6)	2888 (13)		

Abbreviations: LTFU, Loss to follow up; OR, Odds ratio; CIs, Confidence intervals; BPC, Benficio de Prestação Continuada; PETI, Programa de Erradicação do Trabalho Infantil; US$, United States dollar. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

Table S5. Complete case analysis of severe illness and household per capita weekly labour hours, monthly labour income, and monthly food consumption.

	Unexposed n (%) n = 5034	**Exposed n (%) n = 638**	**Difference in Difference (95% CIs)**	**p-value**
Weekly labour hours PC, hours				
2005	8.6 (8.3 to 8.9)	8.8 (8 to 9.6)	-0.5 (-1.4 to 0.5)	0.31
2009	8.4 (8.1 to 8.7)	8.2 (7.5 to 8.9)		
Monthly labour income PC, US$				
2005	26.7 (25.8 to 27.6)	26.3 (23.9 to 28.6)	-0.5 (-4.2 to 3.1)	0.77
2009	30.1 (29.1 to 31.1)	29.1 (26.7 to 31.6)		
Monthly food consumption PC, US$				0.98
2005	26.8 (25.7 to 27.8)	28 (25.1 to 30.9)	0.1 (-4.3 to 4.4)	
2009	44 (43 to 45.1)	45.3 (42.4 to 48.2)		

Abbreviations: CIs, Confidence intervals; PC, Per capita; US$, United States dollar. Selected marginal effects are reported. Data is not weighted using attrition weights. All values are mutually adjusted for household region of residence, location of residence, number of household members aged 0 to 6 years, number of household members aged 7 to 15, % of family members working and contributing to social insurance, total income per capita (net of social assistance), and receipt of Programa Bolsa Família or one of its predecessors: Bolsa Escola, Bolsa Alimentação, Cartao Alimentação, or Programa de Erradicação do Trabalho Infantil all at baseline; household responsible sex, age category, age squared, ethnicity, literacy, and self-rated health all at baseline; and, household exposure to drought or flooding, loss of crops or livestock, or death between 2005 and 2009. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

Table S6. Complete case analysis of severe illness and household per capita weekly labour hours, monthly labour income, and monthly food consumption, by receipt of conditional cash transfer at study baseline.

	Unexposed n (%) n = 5034	**Exposed n (%) n = 638**	**Difference in difference (95% CIs)**	**Difference in effect of severe illness by receipt of CCTs (95% CIs)**
Weekly labour hours PC, hours				
No receipt of CCTs				
2005	9 (8.6 to 9.3)	9 (8 to 10.1)	-1 (-2.5 to 0.5)	1.8 (-1.2 to 4.8)
2009	8.6 (8.2 to 8.9)	7.6 (6.7 to 8.6)		
Receipt of CCTs				
2005	8.5 (7.8 to 9.2)	8.1 (6.4 to 9.8)	0.8 (-1.8 to 3.5)	
2009	8.6 (8 to 9.3)	9 (7.2 to 10.8)		
Monthly labour income PC, US$				
No receipt of CCTs				
2005	27.6 (26.5 to 28.6)	26 (23.3 to 28.8)	-2.4 (-6.6 to 1.7)	5.3 (-3.8 to 14.5)
2009	30.8 (29.7 to 32)	26.9 (24.1 to 29.7)		
Receipt of CCTs				
2005	25.4 (23.5 to 27.2)	25.3 (20.5 to 30.1)	2.9 (-5.3 to 11.1)	
2009	31.3 (29.2 to 33.4)	34.2 (28.1 to 40.3)		
Monthly food consumption PC, US$				
No receipt of CCTs				
2005	27.1 (25.9 to 28.3)	28.7 (25.3 to 32)	-1.2 (-6.2 to 3.7)	5 (-5.2 to 15.1)
2009	44.2 (43 to 45.4)	44.6 (41.2 to 48)		
Receipt of CCTs				
2005	26.2 (23.9 to 28.5)	23.4 (17.5 to 29.3)	3.8 (-5.1 to 12.6)	
2009	43.6 (41.3 to 45.8)	44.5 (38.7 to 50.3)		

Abbreviations: CCT, Conditional Cash transfer; PC, Per capita; US$, United States dollar. Selected marginal effects are reported. Data is not weighted using attrition weights. All values are mutually adjusted for household region of residence, location of residence, number of household members aged 0 to 6 years, number of household members aged 7 to 15, % of family members working and contributing to social insurance, and total income per capita (net of social assistance) all at baseline; household responsible sex, age category, age squared, ethnicity, literacy, and self-rated health all at baseline; and, household exposure to drought or flooding, loss of crops or livestock, or death between 2005 and 2009. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

Table S7. Severe illness reported to be worst in 2009 and household per capita weekly labour hours, monthly labour income, and monthly food consumption.

	Unexposed n (%) n = 12,042	**Exposed, n (%) n = 750**	**Difference in Difference (95% CIs)**
Weekly labour hours PC, hours			
2005	9.5 (9.3 to 9.7)	9.2 (8.4 to 10)	1 (-0.1 to 2)
2009	9.7 (9.4 to 9.9)	10.3 (9.4 to 11.3)	
Monthly labour income PC, US$			
2005	28 (27.3 to 28.7)	26.6 (24.1 to 29)	3 (-0.9 to 6.9)
2009	33.4 (32.4 to 34.5)	35 (31.4 to 38.6)	
Monthly food consumption PC, US$			
2005	26 (25.6 to 26.5)	26.8 (24.9 to 28.7)	2.2 (-1.5 to 5.9)
2009	42.3 (41.5 to 43)	45.2 (41.8 to 48.7)	

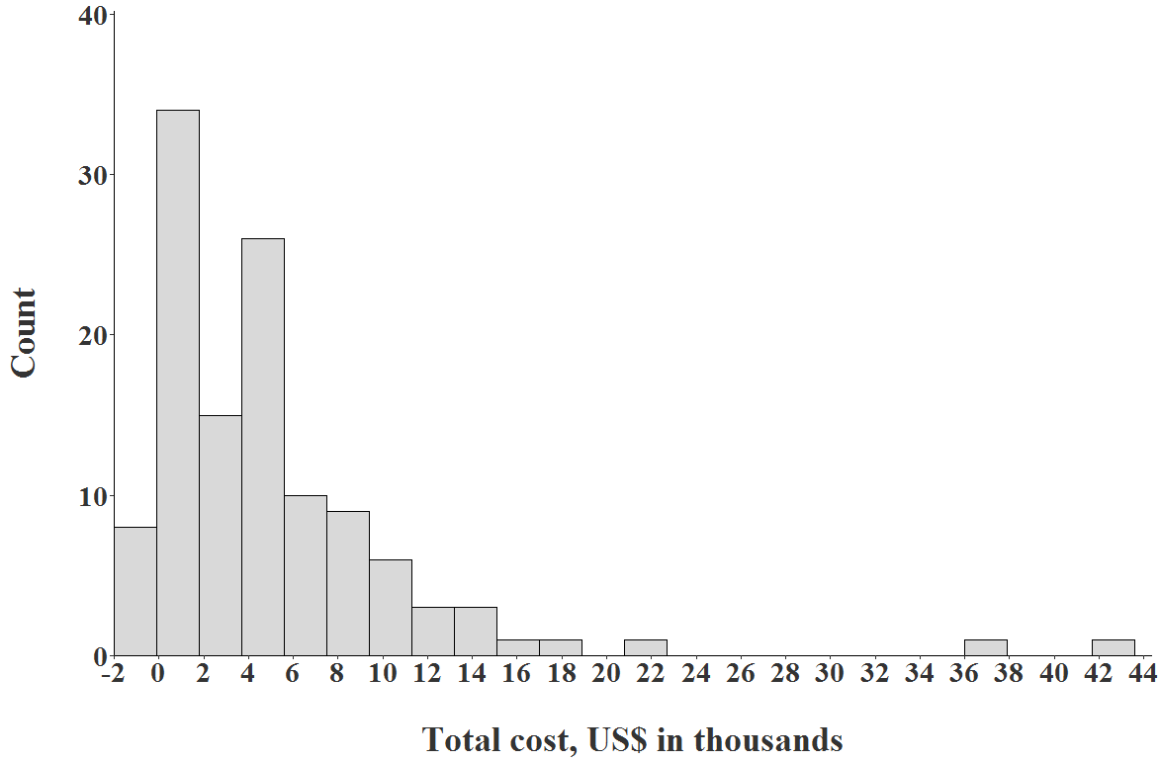
Abbreviations: CIs, Confidence intervals; PC, Per capita; US$, United States dollar. Selected marginal effects are reported. Data is weighted using attrition weights. Values are pooled across the five imputed datasets using Rubin's rule. All values are mutually adjusted for household region of residence, location of residence, number of household members aged 0 to 6 years, number of household members aged 7 to 15, % of family members working and contributing to social insurance, total income per capita (net of social assistance), and receipt of Programa Bolsa Família or one of its predecessors: Bolsa Escola, Bolsa Alimentação, Cartao Alimentação, or Programa de Erradicação do Trabalho Infantil all at baseline; household responsible sex, age category, age squared, ethnicity, literacy, and self-rated health all at baseline; and, household exposure to drought or flooding, loss of crops or livestock, or death between 2005 and 2009. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

Table S8. Severe illness reported to be worst in 2009 and household per capita weekly labour hours, monthly labour income, and monthly food consumption, by receipt of conditional cash transfer at study baseline.

	Unexposed, n (%) n = 12,042	**Exposed, n (%) n = 750**	**Difference in difference (95% CIs)**	**Difference in effect of severe illness by receipt of CCTs (95% CIs)**
Weekly labour hours PC, hours				
No receipt of CCTs				
2005	10.2 (9.9 to 10.5)	9.3 (8 to 10.6)	0.9 (-0.9 to 2.7)	0.8 (-1.7 to 3.2)
2009	10.4 (10 to 10.8)	10.9 (8.8 to 12.1)		
Receipt of CCTs				
2005	9.1 (8.8 to 9.3)	8.5 (7.5 to 9.5)	1.7 (0 to 3.4)	
2009	9.8 (9.5 to 10.2)	10.9 (9.5 to 12.3)		
Monthly labour income PC, US$				
No receipt of CCTs				
2005	32 (31.1 to 33)	28.9 (25.5 to 32.3)	0.6 (-5.5 to 6.7)	4.7 (-3.7 to 13)
2009	37 (35.5 to 38.6)	34.5 (28.6 to 40.4)		
Receipt of CCTs				
2005	25.3 (24.7 to 26)	24.8 (22 to 27.7)	5.3 (-0.5 to 11)	
2009	32.6 (31.3 to 33.8)	37.4 (32.6 to 42.2)		
Monthly food consumption PC, US$				
No receipt of CCTs				
2005	27.9 (27.3 to 28.6)	28.8 (25.7 to 32)	2.9 (-2.5 to 8.4)	-1.2 (-8.8 to 6.3)
2009	45.4 (44.1 to 46.6)	49.2 (44.3 to 54.2)		
Receipt of CCTs				
2005	24.7 (24.1 to 25.2)	25.2 (23 to 27.4)	1.7 (-3.5 to 6.9)	
2009	39.7 (38.7 to 40.7)	42 (37.2 to 46.8)		

Abbreviations: CCT, Conditional Cash transfer; PC, Per capita; US$, United States dollar. Selected marginal effects are reported. Data is weighted using attrition weights. Values are pooled across the five imputed datasets using Rubin's rule. All values are mutually adjusted for household region of residence, location of residence, number of household members aged 0 to 6 years, number of household members aged 7 to 15, % of family members working and contributing to social insurance, and total income per capita (net of social assistance) all at baseline; household responsible sex, age category, age squared, ethnicity, literacy, and self-rated health all at baseline; and, household exposure to drought or flooding, loss of crops or livestock, or death between 2005 and 2009. All monetary values are deflated to 2005 constant values. In 2005 R$ 1 = US$ 0.4.

Figure S1. Sample distribution of total DR TB-related costs.



Abbreviations: US$, United States dollar. n = 119.

Table S9. Summary of univariable association of pre-illness demographic and socioeconomic characteristics, and DR TB clinical characteristics with financial hardship.

	Total costs ≥20% of household income*†		Used coping strategy‡		Impoverishment§¶		All three financial hardships#	
	OR (95% CIs)	p-value	OR (95% CIs)	p-value	OR (95% CIs)	p-value	OR (95% CIs)	p-value
Demographic								
Sex								
Female	1	0.80	1	0.88	1	0.06	1	0.20
Male	0.9 (0.36-2.11)		0.94 (0.43-2.04)		0.43 (0.18-1.04)		0.53 (0.20-1.42)	
Age								
Mean (SD)	1.02 (0.99-1.04)	0.29	1.00 (0.97-1.02)	0.76	1.00 (0.97-1.03)	0.99	0.99 (0.96-1.02)	0.52
Ethnicity								
White	1	0.41	1	0.27	1	0.13	1	0.29
Brown	1.91 (0.65-5.76)		1.94 (0.77-5.03)		1.15 (0.37-4.04)		1.67 (0.45-8.08)	
Black/Indigenous	1.83 (0.69-4.86)		2.18 (0.79-6.21)		2.72 (0.68-9.72)		2.88 (0.76-14.2)	
Socioeconomic								
Elementary education								
Incomplete	1	0.07	1	0.16	1	0.05	1	0.15
Completed	0.47 (0.20-1.08)		0.57 (0.25-1.25)		0.36 (0.11-0.98)		0.44 (0.12-1.31)	
Household head								
No	1	0.77	1	0.02	1	0.16	1	0.02
Yes	1.12 (0.51-2.49)		2.42 (1.16-5.15)		1.86 (0.79-4.59)		3.34 (1.2-10.91)	
Household income per capita (US$)**								
<126	1	0.51	1	0.006	1	0.002	1	0.001
126 to 251	0.81 (0.29-2.2)		0.40 (0.14-1.08)		0.15 (0.05-0.47)		0.13 (0.03-0.44)	
>251	1.39 (0.48-3.95)		0.21 (0.07-0.55)		0.23 (0.08-0.65)		0.16 (0.04-0.51)	

Received social protection								
Yes	1	0.88	1	0.88	1	0.27	1	0.73
No	1.08 (0.35-3.03)		1.08 (0.40-2.91)		2.01 (0.61-9.15)		1.26 (0.37-5.84)	
Clinical								
Aquired DR TB								
No	1	0.001	0.86	0.01	1	0.96	1	0.086
Yes	4.13 (1.81-9.95)		2.57 (1.23-5.50)		1.45 (0.62-3.53)		2.39 (0.89-7.21)	
Type of DR TB								
Suspected/ Mono-/ Poly-	1	0.53	1	0.98	1	0.39	1	0.79
Multi-/ Extensively	1.32 (0.55-3.05)		1.01 (0.46-2.21)		0.98 (0.4-2.52)		1.15 (0.42-3.5)	
Cavitary DR TB								
No	1	0.18	1	0.27	1	0.96	1	0.75
Yes	1.91 (0.74-4.85)		0.60 (0.23-1.47)		1.03 (0.38-3.12)		0.83 (0.28-2.8)	
Time to DOT clinic (hours)								
Mean (SD)	2.36 (1.18-5.17)	0.01	2.23 (1.22-4.29)	0.009	1.68 (0.88-3.21)	0.12	1.91 (0.94-3.94)	0.07
Time to CRPHF (hours)								
Mean (SD)	1.03 (0.84-1.28)	0.75	1.09 (0.90-1.32)	0.40	1.13 (0.9-1.42)	0.29	1.12 (0.87-1.44)	0.38
Month of treatment								
2-6	1	0.93	1	0.46	1	0.70	1	0.98
7-12	0.82 (0.28-2.31)		0.80 (0.31-2.03)		1.57 (0.52-5.13)		1.01 (0.29-3.77)	
13+	0.87 (0.30-2.41)		1.36 (0.54-3.47)		1.15 (0.38-3.76)		1.12 (0.34-4.02)	

Abbreviations: SD, standard deviation; DS, drug susceptible; TB, tuberculosis; DR, drug resistant; DOT, directly observed therapy; CRPHF, Professor Helio Fraga reference centre. *Refers to pre-illness annual household income. †Three participants with pre-illness annual household income US$ 0 were excluded, n=116, ‡One participant with missing data on use of coping strategies was excluded, n=118, §Four participants in poverty pre-illness were excluded, n=115, ¶Defined using Brazil's 2016 national poverty line of US$ 1.34, #Five participants with either pre-illness annual household income US$ 0, missing data on use of coping strategies, or in poverty pre-illness were excluded, n=114,**Refers to pre-illness monthly household income per capita.

Table S10. Consolidated Health Economic Evaluation Reporting Standards checklist for study comparing two cash transfer strategies to prevent catastrophic costs for poor tuberculosis affected households in low- and middle-income countries (2).

Section/item	Item No	Recommendation	Quoted text addressing recommendation
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as “cost-effectiveness analysis”, and describe the interventions compared.	Title: "Comparison of two cash transfer strategies to prevent catastrophic costs for poor tuberculosis-affected households in low- and middle-income countries: An economic modelling study"
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Abstract: "Background. Illness-related costs for patients with tuberculosis (TB) ≥20% of pre-illness annual household income predict adverse treatment outcomes and have been termed “catastrophic”. Social protection initiatives, including cash transfers, are endorsed to help prevent catastrophic costs. With this aim, cash transfers may either be provided to defray TB-related costs of households with a confirmed TB diagnosis (termed a “TB-specific” approach); or to increase income of households with high TB risk to strengthen their economic resilience (termed a “TB-sensitive” approach). The impact of cash transfers provided with each of these approaches might vary. We undertook an economic modelling study from the patient perspective to compare the potential of these two cash transfer approaches to prevent catastrophic costs. Methods and Findings. Inputs in the seven low- and middle-income countries Brazil, Colombia, Ecuador, Ghana, Mexico, Tanzania and Yemen were retrieved by literature review, and included countries' mean patient TB-related costs, mean household income, mean cash transfers, and estimated TB-specific and TB-sensitive target populations. Analyses were completed for drug-susceptible (DS) TB-related costs in all 7/7 countries, and additionally for drug-resistant (DR) TB-related costs in the 1/7 countries with available data. All cost data were reported in 2013 international dollars ($). The target population for TB-specific cash transfers was poor households with a confirmed TB diagnosis, and for TB-sensitive cash transfers was poor households already targeted by countries’ established poverty-reduction

			cash transfer programme. Cash transfers offered in countries, unrelated to TB, ranged from $217 to $1,091/year/household. Before cash transfers, DS TB-related costs were catastrophic in 6/7 countries. If cash transfers were provided with a TB-specific approach, alone they would be insufficient to prevent DS TB catastrophic costs in 4/6 countries, and when increased enough to prevent DS TB catastrophic costs would require a budget between $4 million (95%CI: $4-$4 million) and $50 million (95%CI: $41-$60 million) per country. If instead cash transfers were provided with a TB-sensitive approach, alone they would be insufficient to prevent DS TB-related catastrophic costs in any of the 6 countries, and when increased enough to prevent DS TB catastrophic costs would require a budget between $298 million (95%CI: $219-$378 million) and $165 billion (95%CI: $134-$196 billion) per country. DR TB-related costs were catastrophic before and after TB-specific or TB-sensitive cash transfers in 1/1 countries. Sensitivity analyses showed our findings to be robust to imputation of missing TB-related cost components, and use of 10% or 30% instead of 20% as the threshold for measuring catastrophic costs. Key limitations were using national average data, and not considering other health and social benefits of cash transfers. Conclusions. A TB-sensitive cash transfer approach to increase all poor households' income may have broad benefits by reducing poverty, but is unlikely to be as effective or affordable for preventing TB catastrophic costs as a TB-specific cash transfer approach to defray TB-related costs only in poor households with a confirmed TB diagnosis. Preventing DR TB-related catastrophic costs will require considerable additional investment whether a TB-sensitive or a TB-specific cash transfer approach is used"
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	Introduction, paragraph 4: "Depending on whether cash transfers are provided with a TB-specific or a TB-sensitive approach, their impact might vary. We aimed to investigate how this might relate to the potential of cash transfers provided with either a TB-specific approach or a TB-sensitive approach to prevent catastrophic costs."
Methods			

Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Methods, paragraph 4: "In this study, the target population for cash transfers provided with a TB-specific approach was households in countries' poorest population quintile with a confirmed TB diagnosis. Guidance is not currently available for which TB-affected households should be targeted with a TB-specific approach. We chose to focus on TB-affected households in countries' poorest population quintile because they are typically at greater risk of incurring catastrophic costs (14). Whilst it might have been preferable to focus on all TB-affected households that incur catastrophic costs, at the time of analysis no estimates of the size of this population were available in any countries included in this study. The target population for cash transfers provided with a TB-sensitive approach was households in poverty already targeted by countries' established governmental poverty-reduction cash transfer programme."
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Methods, paragraph 1: "The setting was low- and middle-income countries, where over 95% of TB cases live, and where formal institutions to protect households from the social and economic impacts of illness are weakest."
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Methods, paragraph 1: "Using only TB-related costs incurred by patients, study outcomes were assessed from the patient perspective."
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Methods, paragraph 1: "The intervention being investigated was cash transfers paid to poor households in low- and middle-income countries, and the alternative approaches being compared were cash transfers provided with either a TB-specific or a TB-sensitive approach. These approaches were compared because of current uncertainty about the impact and country-level cost of each approach."
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Methods, paragraph 2: "Catastrophic costs were estimated over a time horizon from the month prior to TB symptom onset to TB treatment completion. Countries' country-level cash transfer budget were estimated over a time horizon of one year."
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	This study did not use a discount rate for costs.

Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	Methods, paragraph 2: "Primary study outcomes were an indicator for catastrophic costs after TB-specific versus TB-sensitive cash transfers, and countries' country-level cash transfer budget needed to prevent catastrophic costs for each of these approaches."
Measurement of effectiveness	11a	Single study-based estimates: Describe fully the design features of the single effectiveness study and why the single features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	This study used single study-based estimates of average TB-related costs, cash transfers and household income as input parameters for the seven countries included in the analysis. Methods, paragraph 5 describes how included TB-related cost data were identified by systematic review. Results, paragraph 2 and 3 provides a summary of TB-related cost data sources used in the study Methods, paragraph 6 describes how included cash transfer data were identified by rigorous review of data from the World Bank Atlas of Social Protection Indicators of Resilience and Equity. Table S11 provides a summary of cash transfer data sources used in the study. Methods, paragraph 7 describes how included household income data were identified by rigorous search of countries' national statistical websites and the international household survey network website. Table S11 provides a summary of household income data sources used in the study.
	11b	Synthesis-based estimates: Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	This study did not use synthesis based estimates for its input parameters.
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	This study did not attempt to elicit preferences for outcomes.

Estimating resources and costs	13a	Single study-based economic evaluation: Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	This study was not a single study-based economic evaluation.
	13b	Model-based economic evaluation: Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Resource use, value and opportunity costs associated with model health states were not estimated in this study.

Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Methods, paragraph 10 describes methods for adjusting included monetary data to a common year and converting it into a common currency: "To allow comparison of monetary data extracted in different currencies and measured in different years all extracted monetary values were inflated and converted to 2013 international dollars ($) using the purchasing power parity conversion factor that accounts for differences in the cost of living across countries."
Choice of model	15	Describe and give reasons for the specific type of decision analytical model used. Providing a figure to show model structure is strongly recommended.	The analytical model used in this study is represented by the quantitative relationship between TB-related costs, household income and cash transfers depending on whether cash transfers are provided with a TB-specific or a TB-sensitive approach. Methods, paragraphs 13-17, give reasons for the specific for the specific type of decision analytical model used. Box 2 provides a summary of how the relationships between TB-related costs, household income and cash transfers is modelled depending on whether cash transfers are provided with a TB-specific or a TB-sensitive approach
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Assumptions were made about the size of countries' TB-specific target population. Methods, paragraph 8 describes this: "Because estimates of the percentage of TB-affected households represented in the poorest population quintile were not available in any countries included in the study, we used the unweighted mean multiplier for TB prevalence in the poorest population quintile observed in India and South Africa to estimate the size of countries' TB-specific target population. Therefore, countries TB-specific target population was extracted as 40% of countries' estimated 2013 DS TB burden or 2015 DR TB burden. For country estimates of DR TB burden, we used 2015 estimates because 2013 estimates weren't available. We assumed that each estimated case of active TB disease in the World Health Organisation's TB data represented one household with a confirmed TB diagnosis." Assumptions were also made about the value of missing cost components of countries TB-related costs. Methods, paragraph 11 describes this: "In countries that had missing values for direct or indirect costs, pre- or during-treatment we estimated their value. To do this, we assumed that average TB-related costs followed a make-up of cost components equivalent to

			the one synthesised by Tanimura *et al.* in their systematic review of TB-related costs in low- and middle-income countries, which is that direct and indirect costs are equivalent to 40% and 60% of total costs respectively, and pre- and during-treatment costs are each equivalent to 50% of total costs respectively" An assumption was made about countries' average household income value. Methods, paragraph 7 describes this: "For countries with an eligible TB-related cost survey and existing poverty-reduction cash transfer programme, we used countries' mean household income or expenditure in the poorest population quintile to approximate household income of both TB-specific and TB-sensitive target populations." Assumptions were made about the standard deviation of included estimates of countries average TB-related costs, cash transfers, and household income. Methods, paragraph 12 describes this: "Random samples were generated for TB-related costs using a standard deviation with a ratio of 1.1 to mean estimates, which was the ratio estimated by Tanimura *et al.* for average total costs across all low- and middle-income countries, and a sample size equivalent to countries' cost surveys (3). For annual household income, we used a standard deviation with a ratio of 0.8 to mean estimates, which was the average observed across two studies investigating the household-level income effect of poverty-reduction cash transfer programmes in Brazil and Colombia (4,5), and a sample size equivalent to countries' household income surveys (6–12). For cash transfers, we used a standard deviation with a ratio to mean estimates equivalent to a quarter of maximum minus minimum cash transfers, and a sample size equivalent to the one reported in studies from which we extracted mean cash transfers. In Ecuador and Ghana, we did not simulate sampling distributions for cash transfers because respectively, all beneficiary households receive the same flat cash transfer, and the mean cash transfer we extracted was estimated from all beneficiary households."
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods;	In this study, missing data was interpolated. Methods, paragraph 11 describes how this was done: "In countries that had missing values for direct or indirect costs, pre- or during-treatment we estimated their value. To do this, we assumed that TB-related costs followed a make-up of cost components equivalent to the one synthesised by Tanimura et al. in their systematic review of TB-related costs in low- and middle-income countries, which is that direct and indirect costs are equivalent to 40% and 60% of total costs respectively, and pre- and during-treatment costs are each equivalent to 50% of total costs respectively."

		methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	In this study a multiway analysis was used to account for uncertainty in input parameters. Methods, paragraph 12 describes how this was done: "To account for uncertainty in the value of extracted TB-related costs, annual household income and cash transfers, we conducted a multiway analysis that allowed all three of these inputs to vary simultaneously according to their sampling distributions. Sampling distributions were simulated from 10,000 computationally generated random samples, and were all assumed normal according to the central limit theorem." In this study, sensitivity analyses were run to test the sensitivity of results to imputation of missing data, and the use of a 20% threshold for defining catastrophic costs. Methods, paragraph 18 describes how this was done: "We tested the sensitivity of our results in Brazil, Colombia, Tanzania and Mexico to imputation of missing TB-related cost components by repeating our analysis omitting rather than imputing the value of missing TB-related cost components. We separately tested the sensitivity of our results across all countries included in the study to the use of 20% as the threshold for measuring countries' TB-related cost burden as catastrophic. We did this by repeating our analyses instead using a 10% and 30% threshold."
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Table 1, Table 2 and Table S12 report values, 95% confidence intervals or ranges, and probability distributions with reasoning for all TB-related cost, cash transfers and household income data used in the study.

Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Figure 2 and Table S12 report included countries TB-related cost burden before cash transfers, and after TB-specific or TB-sensitive cash transfers. Table 3 reports included countries' household-level additional and total cash transfer needed to prevent catastrophic costs. Figure 3 and Table S13 report included countries' total TB-specific or TB-sensitive country-level cash transfer budget needed to prevent catastrophic costs.
Characterising uncertainty	20a	Single study-based economic evaluation: Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	This study was not a single study-based economic evaluation.
	20b	Model-based economic evaluation: Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the	Results, paragraph 11 describes the effects of imputation of missing cost components on the results: "Before cash transfers, the TB-related cost burden remained catastrophic in the same countries as when missing TB-related cost components were imputed, and the only difference after cash transfers was that TB-specific cash transfers prevented catastrophic costs in Colombia, Table S12. Across countries, TB-specific cash transfers remained more affordable at

		structure of the model and assumptions.	preventing catastrophic costs compared to TB sensitive cash transfers both at the household and country level, Table S13." Results, paragraph 12 describes the effects of using a 10% threshold TB-related cost burden for measuring catastrophic costs instead of a 20% threshold: "Before cash transfers, in addition to Colombia, Ecuador, Ghana, Mexico, Tanzania and Yemen, the DS TB-related cost burden was also catastrophic in Brazil. In Ecuador, the DR TB-related cost burden before cash transfers remained catastrophic. Across countries, TB-specific cash transfers remained more affordable than TB-sensitive cash transfers at preventing DS and DR TB catastrophic costs both at the household and country level, Table S16. " Results, paragraph 13 describes the effects of using a 30% threshold TB-related cost burden for measuring catastrophic costs instead of a 20% threshold: "Before cash transfers, the DS TB-related cost burden remained catastrophic in Colombia, Ghana, Mexico, Tanzania and Yemen, but ceased to be catastrophic in Ecuador. In Ecuador, the DR TB-related cost burden before cash transfers remained catastrophic. Across countries, TB-specific cash transfers remained more affordable than TB-sensitive cash transfers at preventing DS and DR TB catastrophic costs both at the household and country level, Table S17: Summary of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs using a 30% threshold TB-related cost burden for measuring catastrophic costs."
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	This study considered differences in costs and outcomes between patients with drug-susceptible and drug-resistant TB. Findings and their implications are consistently reported separately for these two subgroups.

Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Discussion, paragraphs 1 and 2 summarise key study findings. Discussion, paragraph 3 describes how the study's findings support the conclusions reached. Discussion, paragraph 5 discusses the study's limitations. Discussion, paragraph 6 discusses how the study's findings fit with current knowledge.
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	The financial disclosure field describes how the study was funded: "This research and members of the research team were funded by the Medical Research Council (award MR/K006584/1); the charity Innovation For Health And Development (IFHAD); the Joint Global Health Trials consortium (MRC, DFID, & Wellcome Trust award MR/K007467/1); the Bill and Melinda Gates Foundation (award OPP1118545); TB REACH and the Wellcome Trust (award 104473/Z/14/Z). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript."
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Conflicting interests are described in the competing interests field with the disclaimer: "All authors have declared that they have no competing interests. CAE notes that he is an academic editor for PLOS Medicine."

Table S11. Summary of cash transfer and household income data sources.

Country	Cash transfer data			Household income data			
	Poverty-reduction cash transfer programme	**Year of reported data**	**Sample size, in households**	**Household income or expenditure survey**	**Year of reported data**	**Sample size, in households**	**Household income† 2013 PPP$**
Brazil	Programa Bolsa Familia (4,13)	2008 and 2013	9,149	Pesquisa de Orçamentos Familiares (6)	2008	55,970	5,331
Ecuador	Bono de Desarollo Humano (14)	2013	N.A.	Encuesta Nacional de Ingresos y Gastos de los Hogares Urbanos y Rurales (7)	2011	40,932	8,692
Yemen	Social Welfare Fund (15)	2013	3,886	Household Budget Survey (8)	2005	13,136	2,143
Tanzania	Productive Social Safety Net (16–18)	2013, 2014 and 2015	892	Household Budget Survey‡ (9)	2007	10,466	2,812
Ghana	Livelihood Empowerment Against Poverty (19)	2014	72,400	Ghana Living Standards Survey-Round Five (10)	2006	8,687	1,785
Colombia	Mas Familias en Accion (5,20)	2005 and 2013	2,804	Encuesta Nacional de Ingresos y Gastos de los Hogares (11)	2006	42,733	2,214
Mexico	Oportunidades* (21,22)	2004 and 2013	5,055	Encuesta Nacional de Ingresos y Gastos de los Hogares (12)	2010	30,169	4,755

Abbreviations: PPP, purchasing power parity. *Formerly PROGRESA. †Refers to mean annual household income in countries' poorest population quintile.

‡Survey only reported mean household expenditure in country's poorest population quintile.

Table S12. Summary of countries' household-level TB-related cost burden before, and after cash transfers.

	TB-related cost burden (% of annual household income) *		
Country	**Before cash transfers (95% CIs) †‡**	**After TB-specific cash transfers (95% CIs) †‡**	**After TB-sensitive cash transfers (95% CIs) †‡**
DS TB			
Brazil	15 (12 to 18)	0.0 (0.0 to 2.0)	13 (10 to 15)
Ecuador	27 (21 to 32)	14 (8.6 to 20)	24 (19 to 29)
Yemen	41 (36 to 46)	0.0 (0.0 to 3.3)	28 (25 to 32)
Tanzania	59 (46 to 73)	51 (38 to 63)	55 (43 to 67)
Ghana	68 (55 to 80)	42 (30 to 55)	54 (44 to 64)
Colombia	64 (53 to 75)	26 (15 to 38)	46 (38 to 55)
Mexico	125 (105 to 145)	106 (86 to 126)	105 (88 to 121)
DR TB			
Ecuador	192 (86 to 299)	179 (74 to 286)	170 (77 to 265)

Abbreviations: CI, confidence interval; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis. The "Before cash transfers" column represents countries' mean TB-related cost burden without cash transfer data. The "After TB-specific cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been subtracted from TB-related costs. The "After TB-sensitive cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been added to countries' pre-illness household income. *Household income refers to average household income in the poorest population quintile. †For interpretability, negative estimates and confidence intervals were reported as 0. ‡To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (3), all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (4,5), and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers. Probability distributions for all three input parameters were assumed to be normal. This was justified because our analysis was at the national level and we used mean values.

Table S13. Summary of countries' country-level cash transfer budget needed to prevent catastrophic costs.

	Cash transfer budget (2013 PPP$ in millions)			
Country	**0.5% of country GDP**	**Poverty-reduction programme (Range)**	**TB-specific approach (95% CIs) *†**	**TB-sensitive approach (95% CIs) *†**
DS TB				
Brazil	16,061	11,593 (7,835-25,412)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Ecuador	857	485	3.8 (3.8-3.8) ‡	1,337 (491-2,417)
Yemen	483	1,391 (927-1,546)	4.4 (4.4-4.5)	3,424 (2,614-4,228)
Tanzania	588	32 (22-44)	75 (50-100)	833 (556-1,106)
Ghana	518	32 (24-46)	15 (11-19)	298 (219-378)
Colombia	3,009	2,216 (506-4,705)	5.9 (5.0-7.3)	126,352 (93,595-159,037)
Mexico	10,023	6,204 (1,624-13,616)	50 (41-60)	165,367 (134,085-196,425)
DR TB				
Ecuador	857	485	4.5 (1.6-7.3)	33,469 (12,072-55,052)

Abbreviations: CI, confidence interval; GDP, gross domestic product; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis. The "0.5% of country GDP" column represents the upper limit that governments in low- and middle-income countries spend on a poverty-reduction cash transfer programme (23). The "poverty-reduction programme" column represents countries' actual poverty-reduction cash transfer programme budget. The "TB-specific approach" column represents the mean budget that countries would need to prevent their TB-specific target population from incurring catastrophic costs. The "TB-sensitive approach" column represents the mean budget that countries' would need to prevent their TB-sensitive target population from incurring catastrophic costs. *For interpretability, negative estimates and confidence intervals were reported as 0. †To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (3), all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (4,5), and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers. Probability distributions for all three input parameters were assumed to be normal. This was justified because our analysis was at the national level and we used mean values. ‡Because data were highly skewed we reported median instead of mean.

Table S14. Summary of countries' household-level TB-related cost burden before and after cash transfers without imputation of missing costs components.

	Cash transfers (% of)	TB-related cost burden (% of annual household income) *		
Country	**TB-related costs (95% CIs) §**	**Before cash transfers (95% CIs) §**	**After TB-specific cash transfers (95% CIs) §**	**After TB-sensitive cash transfers (95% CIs) §**
DS TB				
Brazil†	215 (177-266)	7.3 (5.8-8.7)	0.0 (0.0-0.0)	6.3 (5.0-7.6)
Tanzania†	28 (23-36)	30 (23-36)	22 (15-28)	28 (20-33)
Colombia†	119 (102-144)	32 (26-38)	0.0 (0.0-0.0)	23 (19-27)
Mexico‡	40 (34-47)	50 (42-58)	30 (22-38)	42 (35-49)

Abbreviations: CI, confidence interval; DS, drug-susceptible; TB, tuberculosis. The "Before cash transfers" column represents countries' mean TB-related cost burden without cash transfer data. The "After TB-specific cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been subtracted from TB-related costs. The "After TB-sensitive cash transfers" column represents countries' mean TB-related cost burden after cash transfers have been added to countries' pre-illness household income. *Household income refers to average household income in the poorest population quintile. †TB-related costs only refer to mean total costs incurred during TB treatment. ‡TB-related costs only refer to mean direct costs. §To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (3), all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (4,5), and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers.

Table S15. Summary of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs without imputation of missing costs components.

	Additional cash transfer 2013 PPP$ (95% CIs) ‡		**Total cash transfer, 2013 PPP$ (95% CIs) ‡**		**Cash transfer budget, 2013 PPP$ in millions (95% CIs) ‡**	
Country	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**
DS TB						
Brazil*	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Tanzania*	63 (0.0-225)	1,136 (209-2,063)	294 (229-459)	1,367 (441-2,294)	20 (16-31)	205 (66-344)
Colombia*	0.0 (0.0-0.0)	495 (0.0-1,097)	837 (823-851)	1,332 (835-1,934)	5.0 (4.9-5.1)	34,637 (21,713-50,288)
Mexico†	490 (109-870)	6,208 (4,314-8,110)	1,430 (1,050-1,810)	7,148 (5,252-9,048)	14 (11-18)	47,176 (34,660-59,717)

Abbreviations: PPP, purchasing power parity; CI, confidence interval; DS, drug-susceptible; TB, tuberculosis. The "additional cash transfer" column represents the additional value of cash transfer that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "total cash transfer" column represents the total value that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "cash transfer budget, in millions" column represents the mean budget that countries would need to prevent catastrophic costs for its TB-specific versus TB-sensitive target populations. *TB-related costs only refer to mean total costs incurred during TB treatment. †TB-related costs only refer to mean direct costs. ‡To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (3), all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (4,5), and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers.

Table S16. Summary of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs using a 10% threshold TB-related cost burden for measuring catastrophic costs.

	Additional cash transfer, 2013 PPP$ (95% CIs) *		**Total cash transfer, 2013 PPP$ (95% CIs) ***		**Cash transfer budget, 2013 PPP$ in millions (95% CIs) ***	
Country	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**
DS TB						
Brazil	0.0 (0.0-0.0)	1,595 (32-3,156)	823 (815-831)	2,424 (855-3,976)	29 (28-29)	33,939 (11,976-55,659)
Ecuador	365 (0.0-854)	13,467 (8,593-18,360)	1,464 (1,091-1,945)	14,558 (9,684-19,451)	5.2 (3.8-6.8)	6,551 (4,358-8,753)
Yemen	0.0 (0.0-0.0)	5,786 (4,711-6,856)	923 (920-926)	6,709 (5,632-7,779)	4.4 (4.4-4.5)	10,064 (8,448-11,669)
Tanzania	1,175 (805-1,540)	13,701 (10,006-17,346)	1,392 (1,022-1,756)	13,918 (10,223-17,562)	94 (69-119)	2,088 (1,533-2,634)
Ghana	578 (355-806)	9,835 (7,609-12,118)	1,029 (806-1,257)	10,286 (8,060-12,569)	18 (14-22)	720 (564-880)
Colombia	356 (106-608)	11,096 (8,579-13,618)	1,193 (942-1,445)	11,933 (9,417-14,448)	7.2 (5.7-8.7)	310,268 (244,845-375,659)
Mexico	4,547 (3,597-5,490)	53,926 (44,445-63,345)	5,487 (4,539-6,428)	54,866 (45,387-64,281)	55 (45-64)	362,118 (299,555-424,258)
DR TB						
Ecuador	14,652 (5,142-24,241)	156,334 (61,239-252,232)	15,744 (6,233-25,332)	157,435 (62,330-253,323)	4.7 (1.9-7.6)	70,846 (28,049-113,995)

Abbreviations: PPP, purchasing power parity; CI, confidence interval; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis. The "additional cash transfer" column represents the additional value of cash transfer that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "total cash transfer" column represents the total value that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "cash transfer budget, in millions" column represents the mean budget that countries would need to prevent catastrophic costs for their TB-specific versus TB-sensitive target populations. *To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (3), all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (4,5), and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers.

Table S17. Summary of countries' household-level additional and total cash transfer, and country-level cash transfer budget needed to prevent catastrophic costs using a 30% threshold TB-related cost burden for measuring catastrophic costs.

	Additional cash transfer 2013 PPP$ (95% CIs) *		**Total cash transfer 2013 PPP$ (95% CIs) ***		**Cash transfer budget 2013 PPP$ in millions (95% CIs) ***	
Country	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**	**TB-specific approach**	**TB-sensitive approach**
DS TB						
Brazil	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Ecuador	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Yemen	0.0 (0.0-0.0)	0.0 (0.0-244)	923 (920-926)	952 (920-1,167)	4.4 (4.4-4.5)	1,428 (1,380-1,751)
Tanzania	612 (242-977)	2,548 (1,314-3,760)	829 (460-1,193)	2,765 (1,533-3,978)	56 (31-81)	415 (230-597)
Ghana	221 (0-449)	1,788 (1,045-2,551)	673 (451-900)	2,239 (1,496-3,002)	12 (7.9-16)	157 (105-210)
Colombia	0.0 (0.0-167)	1,665 (826-2,504)	856 (823-1,002)	2,502 (1,661-3,339)	5.1 (4.9-6.0)	65,046 (43,188-86,807)
Mexico	3,596 (2,646-4,538)	14,179 (11,015-17,317)	4,536 (3,587-5,477)	15,119 (11,958-18,258)	45 (36-55)	99,784 (78,920-120,501)
DR TB						
Ecuador	12,913 (3,410-22,512)	45,589 (13,911-77,584)	14,010 (4,501-23,603)	46,692 (15,002-78,675)	4.2 (1.4-7.1)	21,011 (6,751-35,404)

Abbreviations: PPP, purchasing power parity; CI, confidence interval; DS, drug-susceptible; DR, drug-resistant; TB, tuberculosis. The "additional cash transfer" column represents the additional value of cash transfer that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "total cash transfer" column represents the total value that countries' average TB-affected household would need to prevent catastrophic costs using a TB-specific versus a TB-sensitive approach. The "cash transfer budget, in millions" column represents the mean budget that countries' would need to prevent catastrophic costs for their TB-specific versus TB-sensitive target populations. *To estimate 95% confidence intervals, all mean TB-related costs were assumed to have a standard deviation with a ratio of 1.1 to their value (3), all mean household incomes were assumed to have a standard deviation with a ratio of 0.8 to their value (4,5), and all mean cash transfers were assumed to have a standard deviation equal to a quarter of maximum minus minimum cash transfers.

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