Costs of diarrhoea and acute respiratory infection attributable to not handwashing: the case of India and China

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Abstract

OBJECTIVE To estimate the national costs relating to diarrhoea and acute respiratory infections from not handwashing with soap after contact with excreta and the costs and benefits of handwashing behaviour change programmes in India and China.

METHODS Data on the reduction in risk of diarrhoea and acute respiratory infection attributable to handwashing with soap are used, together with WHO estimates of disability adjusted life years (DALYs) due to diarrhoea and acute respiratory infection, to estimate DALYs due to not handwashing in India and China. Costs and benefits of behaviour change handwashing programmes and the potential returns to investment are estimated valuing DALYs at per capita GDP for each country

RESULTS Annual net costs to India from not handwashing are estimated at US$ 23 billion (16– 35) and to China at US$ 12 billion (7-23). Expected net returns to national behaviour change handwashing programmes would be US$ 5.6 billion (3.4-8.6) for India at US$23(16-35) per DALY avoided which represents a 92-fold return to investment, and US$ 2.64 billion (2.08-5.57) for China at US$22(14-31) per DALY avoided– a 35-fold return on investment.

CONCLUSION Our results suggest large economic gains relating to decreases in diarrhoea and acute respiratory infection for both India and China from behaviour change programmes to increase handwashing with soap in households.

KEYWORDS: handwashing; cost; diarrhoea; acute respiratory infection; India; China

Introduction

Handwashing is the most basic and simple element of hygiene and self-care, taught to toddlers and a requisite of many religions, yet studies from both high and low income countries report that as few as 19% of the world's population wash hands with soap following contact with excreta (1).

Handwashing is preventative of many problems including diarrhoea and respiratory infection, two of the leading causes of death in children around the world (2), as well as maternal and neonatal infections acquired during deliveries and the early days of life (3). Walker and colleagues (4) estimate that there were 1.7 billion episodes of diarrhoea in children under five in 2010 (700 000 of which resulted in death) and 120 million episodes of pneumonia (1.3 million resulting in death). Children in emerging economies are at particular risk and diarrhoea in infancy is associated with critical long-term effects on physical and cognitive development (5, 6). Proper handwashing after contact with excreta and before preparing and eating meals can lessen the risk of diarrhoea substantially (7) and may also reduce chronic conditions such as environmental enteropathy and lead to better nutrient uptake, more energy for growth and development, and better attendance at school (8). It has been suggested that the cost-effectiveness of increasing handwashing is low compared with the cost-effectiveness of oral rehydration (9).

Since Jamieson and colleagues in 2006 (10) suggested that handwashing may be *the* most cost-effective intervention to reduce the global burden of disease, there has been little work on the economics of handwashing, or of not handwashing. Bhutta and colleagues (11) state that the cost-effectiveness of interventions to reduce diarrhoea and pneumonia need urgent assessment and economic evaluation could provide valuable information for policy decisions.

This paper addresses the economic issues, summarising recent literature and data on the relationship between handwashing, diarrhoea and acute respiratory infections. It provides estimates of the national costs associated with not washing hands with soap for the world's two most populous countries: India and China, both of which have high rates of these diseases. Data from empirical studies are used to estimate the costs of not handwashing, which are compared with the potential costs and benefits of national behaviour change programmes to increase rates of handwashing. Costs, benefits and returns to investment are presented.

Data sources

The World Health Organisation (WHO) publishes estimates of DALYs for diarrhoea and acute respiratory infection for each country (12). Data from handwashing behaviour change studies in emerging countries allow estimation of DALYs attributable to not handwashing and the financial costs are estimated by valuing each DALY.

$$\text{Cost of not handwashing} = \sum \text{DALYs} \times \text{attributable fraction} \times \text{value per DALY}$$

This paper estimates the health and economic returns to basic handwashing behaviour change programmes based on the effectiveness and costs of the best published handwashing behaviour change studies, as set out below.

The impact of handwashing on the prevalence of disease

Freeman et al (1) reviewed the literature on the health impacts of handwashing, carrying out a random effects meta- analysis from 26 studies. They reported that handwashing with soap results on average in a 40% reduction in risk of diarrhoea (risk ratio 0.60 CI 0.53 – 0.68) (1). The authors were concerned that estimates should be adjusted for any bias due to lack of blinding and made a complex adjustment to 23% (-86%-68%) following the work of Savović (13). The Savovic adjustment was based on very different situations of a wide array of medical interventions, and renders a result which is counter intuitive including a sizable probability of

handwashing increasing the risk of diarrhoea by 86% at the 5% level. We therefore use the 40% estimate here which is based on the observational studies and we think the most reliable.

Ensink (14) noted the links between handwashing and acute respiratory infections (ARIs), specifically the presence of respiratory pathogens on hands and environmental surfaces, including the same enteric viruses which cause diarrhoea. We use the published results of a systematic review by Rabie and Curtis (15), estimating that handwashing with soap would be expected to reduce the relative risk of ARI by 16% (6 – 40%).

Handwashing prevalence

Freeman et al report also that the average rate of handwashing with soap after using the toilet or being in contact with a child's excreta varied from 5% in Tanzania to 72% in New Zealand (1). Estimates for India were 15% and for China, 13%.

Data on the effects of behavioural interventions

Only a proportion of a population are likely to change their behaviour following targeted interventions; reliable estimates of this proportion are essential for assessing the cost-benefit of interventions. A behaviour change intervention in this context refers to hygiene promotion programmes that aim to improve health by driving the uptake of "healthy" behaviours. A well-designed behaviour change intervention should have a clearly defined theory-of-change which specifies the behaviour change techniques utilised and maps how individual intervention components are hypothesised to bring about change in the target behaviour (16, 17). The intervention should gain attention by causing perceptible changes in the environment, which should cause the recipient to experience the behaviour in a new and rewarding way, which should result in increased practice of the target behaviour (18). Sufficient contact should be made with the target audience over an extended period of time (19).

Luby et al (20) reported that every one of the approached households in a study in Karachi Pakistan (20), participated in their intervention; other studies report lower participation rates. Biran et al. conducted a review of the levels of handwashing behaviour change that were achieved and sustained and reported by leading studies (personal communication). Many of the studies reviewed relied on self-report which gives a useful indication of trends, but tends to over-estimate prevalence. Three studies however used rigorous designs as well as

observation of actual handwashing practice. The magnitude of change achieved in these cluster-randomised control trials, and the before-and-after studies were 11% absolute increase (after cleaning a child's bottom) 18 months after a large-scale programme in Bangladesh) (21), 16-18% after using a toilet or cleaning a child after a 3-year intervention in urban Burkina Faso (22), and 28% after using a toilet, cleaning a child's bottom or handling food, sustained after a year in a trial in rural India (23). Post-intervention prevalence of handwashing with soap after toilet use was 30%, 17% and 29%, respectively giving a mean of 25% which we use here.

Economic analysis methodology

A cost analysis simply estimates the monetary costs of a problem or intervention. For example a study of office workers in the UK *by the Centre for Economic and Business Research (CEBR) in* 2014, reported that poor washroom hygiene of workers resulted in a loss of £13.7 billion to the UK economy, which represented nearly one per cent of GDP (24). Cost–effectiveness analysis on the other hand is used to relate costs to a result, such as an extra person washing hands, or reduction of a case of diarrhoea. Costs in terms of units of healthy life outcome, such as per disability adjusted life year (DALY) avoided or quality-adjusted life year (QALY) saved, constitute a cost-utility analysis, in which case the costs and benefits of alternative actions provide a more precise aid to choice, allowing comparisons with cost-utility of other interventions. A cost-benefit analysis compares both costs and benefits in financial terms.

For the present study, we first carry out a cost analysis to estimate the economic cost of (a) each disease, and (b) of not handwashing. We also present (c) a cost-benefit analysis comparing national costs of programmes to increase handwashing, with the DALYs avoided by the programme translated into monetary values. Programme costs include products and personnel, behaviour change training, and costs of financial incentives and media. Benefits, in terms of DALYs avoided, include improved health, quality of life and life expectancy, improvement in

cognitive ability and education for children. Costs and benefits are not easily determined or attributed, but best estimates are made based on results of rigorous empirical studies giving means and 95% confidence intervals.

Disability-Adjusted Life Years or DALYs

The DALY concept was developed by Murray and Lopez as the key measure in the Global Burden of Disease (GBD) studies, each of which presents an assessment of the worldwide health impact of disease, injury and risk factors. In the DALY philosophy, people have an expected number of life years, potentially lived in optimal health, but may lose healthy life years through living with illness and/or through dying before a reference life expectancy (12). DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL =N x L) due to premature mortality in the population and the Years Lost due to Disability (YLD =P x DW) for people living with the health condition or its consequences, so:

Number of DALYs =N x L + P x DW

where:

- N = number of deaths from the disease in the country
- L = standard life expectancy at age of death in years
- P = number of prevalent cases of the health condition in the country in the time period
- DW = disability weight reflecting the severity of the disease on a scale from 0 (perfect health) to 1 (dead) based on estimates from different studies and a specific software tool DisMod.

It is possible to assess the financial burden of DALYs by valuing them in monetary terms and economists do this in a variety of ways. The World Health Report by WHO proposed valuing a DALY at three times the per capita gross domestic product of a country (GDP) (25). Other economists have preferred a more conservative valuation, usually at the per capita GDP, the equivalent of a social capital approach. The WHO Commission on Macroeconomics and Health used this approach, defining interventions that avert one DALY for less than the per capita

GDP as very "cost effective" (26). This approach has been used also by Brown and colleagues (27) and by Rijo and Ross (28).

Relating the value of a DALY to per capita GDP, means that a rich country with fewer DALYs could be estimated to have higher economic loss than to a poor country with more DALYs, so it is useful for comparative purposes to gauge the economic value as a percentage of each country's GDP (28).

We apply this procedure to the cases of India and China, as the countries with the largest global populations, high DALY losses and low handwashing rates. Costs and benefits are given for one year only, but as the benefits are likely to continue for considerably longer than a year – (research by Cairncross et al 2005(29) suggests for ten years, and in their literature review, Freeman et al (1) report that the impact of the intervention on diarrhoea reduced by only 10% per annum - the benefits are therefore clearly underestimated.

Results

India

India had a population of 1.25 billion and a GDP per capita of US$1584 in 2012, 4% of which was spent on health care (one of the lowest rates in the world and only a third of which was provided publicly) (30). It is a young population with 30% under 14 years of age and 113 million under five years of age. Infant mortality is about 5% and India accounts for over one fifth (21%) of the world's burden of disease (12). Globally about 800 000 or one in ten deaths of those under five are due to diarrhoea, and with nearly 200 000 deaths, India accounts for about a quarter (6). This toll increases to 334 000 if the further 140 000 children dying from complications due to diarrhoea are included (6).

WHO reports that in 2012 the DALYs due to diarrhoea in India amounted to 29.77 million, 14.63 million of which were for infants under five years of age and 3.14 million for children 5 -14 years-of-age (12). The estimated global burden of diarrhoea is 99.73 million DALYs, 30.66 for children under five years. India therefore accounts for some 30% of the global loss, including nearly half the burden among children under-five (12). Acute respiratory infections including pneumonia take a similar toll on Indian health, totalling 26.31 million DALYs in 2012, including 17.83 million for infants under five and 2.24 million for children aged 5-14

years. India accounts for 18% of the global burden of 146.86 million DALYs due to acute respiratory infections. (Table 1)

Costs of diarrhoea in India

Indian GDP per capita was US$1584 in 2012 (30), so the economic loss to India from the 29.77 million DALYs due to diarrhoea is estimated at US$47.157 billion **(US**$23.169 billion for children under five years and US$8.955 billion for children 5-14 years).

As part of our study, cross-sectional surveys were conducted in Mumbai and Delhi to supply current estimates of the cost of illness parameters required in our calculations for household level direct and indirect costs of diarrhoea and pneumonia for India. Households were selected within each city using a stratified random sampling plan based on zone and income strata. The survey was administered face-to-face to a female primary caregiver in 202 households with a child under-twelve years of age and where at least one household member had reportedly experienced an episode of diarrhoea or respiratory illness (influenza or cough & cold with fever) in the last two months. Respondents were asked detailed questions on the direct out-of-pocket medical costs, transport and accommodation costs and indirect costs relating to lost working days of patient or carer and time lost travelling for each episode of illness. Data on school absenteeism were also collected. Direct and indirect costs were used to calculate the household cost of diarrhoea and ARI separately in the surveyed population, and extrapolated to the general population. No similar data were available for China, so we constructed best estimates by adjusting the costs for India in proportion to DALYs for each disease and the relative GDP per capita.

We (31) assessed the additional costs of health care for episodes of diarrhoea including treatment, medicines, travel and accommodation and estimated the annual household cost of infection from diarrhoea at US$48.08 (40.3 -55.9), based on the cross-sectional survey conducted in households with at least one child under 12 years-of-age. We have extrapolated these household costs to an estimated national cost for India of US$59.72(46.5 – 72.9) million, based on 1.242 million households with a child under 12 (Government of India, Ministry of home affairs, data accessed 7 September 2016). The total cost of diarrhoea to India including value of DALYs lost and treatment costs is therefore estimated at US$47.22(47.20-47.23) billion.

The behavioural studies in the section above estimate 40% (CI 32 -47%) of diarrhoea is preventable by handwashing with soap at appropriate times (1). 85% of the general population of India are estimated not to already wash hands appropriately (1), but more of the population contracting diarrhoea will not wash hands and we estimate this to be 90.4%. Were they to wash their hands, their risks would fall by 44% (35 – 52%). The cost of diarrhoea by not handwashing is therefore estimated at US$17.07 (13.65 – 20. 05) billion (Table 1).

Acute respiratory infection

From the WHO data on burden of disease from ARI for India (12) given in table 1, we estimate the economic cost of acute respiratory infection at US$41.67 billion. From our survey of costs of disease, Greenland et al (31), we have estimated the annual direct and indirect costs of an episode of acute respiratory infection for a household at US$65.69 (CI $62.89 – 68.49), which we extrapolate to national Indian households with a child under 12 to be US$81.59(CI 80.03 – 83.15) million. The total cost of acute respiratory infection therefore approximates US$41.751 (CI41.750 – 41.753 billion.

As some 16% (6-40%) of acute respiratory infection is preventable by handwashing at appropriate times and we estimate that 87.1% of those contracting ARI do not wash hands appropriately, the cost of ARI in India due to not hand washing is some $6.18(2.44-15.45) billion. (Table 1).

The combined costs of diarrhoea and ARI in India are US$88.9 billion, with the preventable costs of not handwashing US$23.25 (15.97 – 35.50) billion, representing 1.2% (0.8 – 1.8) of the GDP of India.

Behaviour change interventions

The median level of behaviour change in handwashing intervention programmes is shown to be some 25 % (where soap is provided, it may be as high as 50%). A well-designed behaviour change national programme could be expected therefore to reduce the level of diarrhoea and ARI attributable to not handwashing by 25%. Given that an estimated 90.4% of those contracting diarrhoea do not wash hands appropriately, this would represent a cost in DALYs attributable to diarrhoea of 2.69 (2.16-3.16) million valued at US$4.26 (3.42-5.01) billion, and

for ARI of 0.91(0.35-2.30) million DALYs at a value of US$1.44(0.55-3.59) billion. The total gross saving to Indian society would be US$5.70(3.98-8.65) billion (Table 2).

Table 1. Costs of diarrhoea and ARI 2012

	India	China
Population (billion)	**1.25**	**1.38**
DALYs diarrhoea (million)	**29.77**	**2.07**
ARI (million)	**26.31**	**6.32**
Cost of diarrhoea (billion US$)	**47.22**	**15.18**
Cost of ARI (billion US$)	**41.68**	**46.35**
Cost of both (billion US$)	**88.90**	**61.53**
Cost of not handwashing (billion US$) (95%CI) diarrhoea	**17.07(13.65-20.05)**	**5.59 (4.47-6.57)**
ARI	**6.18(2.44-15.45)**	**6.60(2.47-16.50)**
Total	**23.25(15.97-35.50)**	**12.19(6.94-23.07)**
As % GDP (95% CI)	**1.2(0.8-1.7)**	**0.12 (0.07-0.22)**

The cost of a behaviour change programme depends on the approach used and may vary between sectors of the community. Specific handwashing behaviour change interventions have been reported to cost around US$0.6 to US$1 per person (32). The effective SuperAmma study of handwashing behaviour change interventions in 14 villages in India in 2011estimated a similar figure at US$1.15 per villager in 2011 prices (33). There is some evidence that change in behaviour may continue for many years. Prüss-Ustün et al estimate an annual amortised cost of US$0.2 in 2002 (34). At 2012 prices this gives a cost of US$0.25, and at this cost for one member of each Indian household, we estimate that a national programme for India may therefore cost some US$62 million.

The total saving to the Indian economy from a national handwashing behaviour change programme therefore would be a net annual US$5.64 (3.38-8.59) billion, or 0.28% (0.17 – 0.43 %) of the GDP giving a 92-fold return to investment. (Table 2)

Were the programme focussed on the most affected sectors of the population, such as mothers with children under five years of age, the returns could be proportionally very much higher.

Table 2. Potential cost benefit of national handwashing programmes to India and China 2012

	India	China
Cost of National HW programme (million US$)	**62**	**77.72**
Expected reduction in diarr (mill DALYs) (CI)	**2.69(2.16-3.16)**	**0.18(0.14-0.21)**
ARI (million DALYs) (CI)	**0.91 (0.35-2.30)**	**0.19 (0.15-0.56)**
Total (million DALYs) (CI)	**3.60(2.51-5.46)**	**0.37(0.29-0.77)**
Monetary value of reduction (billion US$) (CI)	**5.70(3.98 – 8.65)**	**2.71(2.16-5.65)**
Net benefit to country (billion US$) (CI)	**5.64(3.38-8.59)**	**2.64 (2.08-5.57)**
Net cost as % of GDP (range)	**0.3% (0.2 -0.4)**	**0.03(0.02-0.05)**
Expected return on investment	**92-fold**	**35-fold**

China

With 1.38 billion people, China is the most populous country in the world, comprising nearly one fifth of the world's population. Nominal GDP per capita was US$7333 in 2012 (30). Health care expenditure is 5.4% of GDP, 56% of which is publicly provided. China has had a highly effective policy of improving public health in recent decades (31), and there have been substantial reductions in child and adult mortality and morbidity (31), with neonatal mortality falling from 34 to 10 per thousand between 1990 and 2008, post-natal mortality from 52 – 15 per thousand and mortality of children under 15 years from 65 -18.5 (31), thus meeting the targets of the millennium development goals. The leading causes of neonatal death in 2008 were pneumonia, birth asphyxia and preterm complications (35).

WHO estimates that in 2012 the DALYs due to acute respiratory infections, including pneumonia, totalled 6.32 million, including 3.24 million for infants under five and 0.15 million for children aged 5-14 years (17). China accounts for about 4% of the global burden of acute respiratory infection. (Table 1)

DALYs due to diarrhoea amounted to 2.07 million in 2012 (about one tenth that for India), 1.39 of which were for infants under five years of age and 0.08 for children ages 5 – 14 years of age. China accounts for about 2% of diarrhoea globally including nearly five percent of the burden relating to children under five years of age (12).

Costs of diarrhoea in China

China's GDP per capita was US$7333 in 2012 (30), so the economic loss to China from the 2.07 million DALYs due to diarrhoea is estimated at US$15.18 billion. There were no estimates available as for the India (31) for the additional costs of health care for episodes of diarrhoea, so we estimated likely household costs based on the household costs for India, adjusted for relative DALYs lost and the relative GDP per capita. This suggests estimated national household costs of US$3.21(2.50 – 3.91) million based on 67 million households with children. The total cost of diarrhoea to China including treatment costs is therefore estimated at US$15.183(15.182-15.184) billion.

The behavioural studies estimate that 40% (CI 32 - 47%) of diarrhoea is preventable by handwashing with soap at appropriate times (1). We estimate that 92% of the Chinese who contract diarrhoea do not wash hands. The cost of diarrhoea by these not handwashing is therefore estimated at US$5.59 (4.47 – 6.57) billion (Table 1).

Acute respiratory infection

From the WHO data on burden of disease from ARI for China (12) given in table 1, we estimate the economic cost of acute respiratory infection at US$46.34 billion. We have estimated the national annual direct and indirect costs of acute respiratory infection for households in China to be US$15.14 (CI $14.85 – 15.43) million. The total cost of acute respiratory infection therefore approximates US$46.35 (CI 46.34-46.36) billion.

As some 16% (6-40%) of acute respiratory infection is preventable by handwashing at appropriate times and we estimate that 89.0% of those contracting ARI do not wash hands appropriately, the cost of ARI in China due to not hand washing is therefore some $6.60 (2.47-16.50) billion. (Table 1).

The combined costs of diarrhoea and ARI in China are US$61.63 billion, with the preventable costs of not handwashing of US$12.19 (6.94-23.07) billion, representing 0. 12% (0.07 – 0.22) of the GDP of China.

Behaviour change interventions

Using the same assumption as for India that a well-designed behaviour change national programme could be expected therefore to reduce the level of diarrhoea and ARI attributable to not handwashing by 25% this would represent a cost in DALYs attributable to diarrhoea of 0.18 (0.14-0.21) million valued at US$1.32 (1.03-1.54) billion, and for ARI of 0.19(0.15-0.56) million DALYs at a value of US$1.39(1.10-4.11) billion. The total gross saving to the Chinese society would be US$2.71(2.13-5.65) billion (Table 2).

For the cost of the behaviour change programme we take the cost for one person per household with children as for India increased by the relative GDP per capita. We estimate that a national programme for China may therefore cost some US$77.72million.

The total net saving to the Chinese economy from a national handwashing behaviour change programme therefore would be an annual US$2.64 (2.08-5.57) billion, or 0.03% (0.02 – 0.05%) of the GDP giving a 35-fold return to investment. (Table 2)

Discussion

Handwashing following contact with excreta, the most basic hygiene, is practised by only a fraction of these populations at a high risk in terms of morbidity and mortality from diarrhoea and acute respiratory infections. The longer-term sustainability of interventions that successfully improve handwashing behaviour is rarely studied, but there is some evidence to suggest that high levels of change of 30% can be sustained (19), and that changes can be sustained for many years (1, 25). Investment in such programmes nationally would be highly

advantageous to the health of these populations, and offer high economic returns to investment. They are more effective even than programmes to reduce smoking which with success rates of up to 12% are estimated to be highly cost effective (36).

India and China between them make up nearly a quarter of the world's population and India in particular has much to gain, suffering over one fifth of the world's burden of disease and 30% of the global burden of diarrhoea, including nearly half the diarrhoea burden relating to children under five years-of-age and a quarter of infant deaths due to diarrhoea. It accounts for 18% of DALYs from ARI. This compares with 2% of diarrhoea and 4% of ARI for China. China has seen considerable improvements in public health particularly in child health and in reduction in deaths from diarrhoea (31), but these still represent major losses.

This study uses a methodology to assess losses in terms of mortality and morbidity as measured by WHO DALYs, costs these and assesses the cost due to not washing hands with soap. It then estimates the cost of national programmes to change handwashing behaviour and the savings from such programmes. Not washing hands with soap is shown in this report to cost the Indian economy US$23.25(15.97-35.50) billion or 1.2 % (0.8-1.8 %) of the total GDP of India. For China, the figure is also sizable at US$ 12.19 (6.94-0.23.07) or 0.12% (0.07-0.22) of China's GDP.

Limitations

This report is in essence a modelling exercise based on results from primary empirical studies, literature reviews and meta-analyses. We have estimated 95% confidence intervals where possible, but levels of disease and proportions attributable to not handwashing will depend on other factors including provision of clean water and sanitation and improvements in management and treatment. It is possible that few in the rural areas particularly of India seek medical care and as such the costs of care may be lower, but are in any case only a small proportion of the overall cost. There were no data to adjust for the fact that the highest costs would be for the most severe cases of diarrhoea and that some of the DALYs are for children that die?

The estimates are also dependent on WHO estimates of DALYs lost. The costs and benefits are given for just one year, but as the benefits may be far longer lasting, it is suggested up to ten years from time of behaviour change intervention, the cost benefit and returns to investment are likely to be many times more favourable than reported here. Costs of not

handwashing are underestimated to the extent that we value a DALY at GPD per capita, whereas WHO recommends two to three times GDP per capita. We have included costs for diarrhoea and ARI only and there would be additional benefits from reductions in other diseases, pandemics of influenza and antimicrobial resistant infections, with untold cost consequences. The estimates of treatment costs, are extrapolated from our relatively small local studies, which it would be important to replicate, although these costs are a small proportion of the total costs. In carrying out national programmes there may be some increasing returns to scale, such as from mass media programmes; there may also be pressure on limited resources, which may increase costs or reduce benefits.

Conclusions

Returns to a national handwashing programme in India could be a net US$5**.64(3.38-8.59)**) billion with a ninety-two-fold return to the investment, which represents 0.3% of the entire GDP of India. A similar programme for China could result in a net annual benefit of US$2.64 (2.08-5.57) billion representing a 35-fold return on investment.

With these very high estimates of benefits to costs, well designed national handwashing behaviour change programmes in India and China should substantially reduce the heavy burden of disease and offer excellent value for money.

Declarations of Interest

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