Estimating health gains from increased access to safely managed drinking-water services following Government of India's Jal Jeevan Mission

Study report

Introduction

Unsafe drinking water has significant direct and indirect health effects, as well as broader societal impacts. The most recent burden of disease analysis suggests that in 2019, globally, unsafe drinking water together with inadequate sanitation and hygiene was responsible for 1.4 million deaths and 74 million DALYs [1].

In India, in 2018, 36% of the national population did not have access to an improved drinking-water source located on premises. The issue is greater in rural areas, where 44% of the population lacks this access[2]. In 2019, the government of India launched the Jal Jeevan Mission (JJM), a nationwide programme designed to provide all households in rural India with safe and adequate drinking-water through individual household tap connections by 2024.

While the JJM does not explicitly define it as such, the level of service that JJM commits to is well aligned with the higher level of drinking water services defined by the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP); 'safely managed drinking water (SMDW) services'[3] to monitor progress on Sustainable Development Goal (SDG) 6.1. With the proposed tap connections, the JJM aims to provide every rural household with (i) adequate water quantity of (ii) prescribed quality on a (iii) regular and long-term basis at (iv) affordable service delivery charges[4]. The first three of these components – quantity, quality and sustainability – map against the three components of the JMP definition of safely managed drinking water services: 'drinking water from an improved water source that is (i) accessible on premises, (ii) available when needed and (iii) free from faecal and priority chemical contamination'[3] .

The World Health Organization (WHO) is the Custodian Agency or co-Custodian Agency for reporting on several SDG indicators, including the proportion of population using safely managed drinking water services (Indicator 6.1.1), and the mortality from unsafe water, sanitation and hygiene (Indicator 3.9.2). In this role, WHO has developed methods and tools to estimate health gains based on the latest available evidence linking water, sanitation and hygiene with mortality and morbidity from diarrhoeal disease as well as other health outcomes.

This report presents initial estimates that draw on WHO methods and tools to project the expected health gains in India due to increased coverage in safely managed drinking-water services following JJM. The analysis focuses on diarrhoeal disease, because this accounts for the majority of the disease burden attributable to unsafe drinking water, sanitation and hygiene[1]. The associated economic benefits are also estimated. Finally, time saved on water collection are also estimated due to the interest of Indian partners in reducing the burden of water carriage from off-premises water supplies, which is predominantly borne by women.

I. Estimating potential health gains

1.1. Methods

WHO estimation of health impacts from environmental risks is based on comparative risk assessment (CRA) methods, which are used extensively in burden of disease assessments[5]. To estimate the impact of the JJM if it achieves its stated aims, we built a model based on CRA methods and employed it to estimate the impact on deaths and disability adjusted life years (DALYs) caused by diarrhoeal disease associated with water supply for two scenarios. In the first scenario - the JJM scenario – we assume that coverage of safely managed drinking water services in India increases linearly from baseline levels in 2018, before the JJM began, to 100% at the end of the programme. In an alternative scenario – the business-as-usual scenario – we assume improvements in coverage in line with historical annual rates of change as published by the JMP. By comparing the two scenarios, we arrived at an estimate of the potential value added of the JJM.

1.1.1 Model

The CRA methodology combines data on exposure, disease burden and the exposure-response relationship to estimate the burden of disease associated with that exposure[6]. CRA draws on exposure data and the exposure-response relationship to calculate the population-attributable fraction (PAF). The PAF is the proportional reduction in population disease or mortality that would occur if exposure to a risk factor were reduced to an alternative ideal exposure scenario. In this case, the risk factor is drinking water that is not safely managed, and the ideal alternative scenario is zero exposure. The CRA methodology combines the PAF with data on the burden of diarrhoeal disease to calculate the disease burden attributable to water supply year on year as the JJM progresses. This methodology has been used extensively to calculate the health gains from improvements in water supply, as well as sanitation and hygiene[7-9].

The following four types of data are required for the estimation:

- Exposure: The proportion of the population with access to safely managed, basic, limited and unimproved drinking water.
- Disease burden: The total number of deaths and DALYs caused by diarrhoeal disease annually.
- Exposure-response relationship: The relative risk, which links exposure with disease.
- Population

1.1.2. Data sources

In order to estimate the potential impact of the JJM, the study uses 2018 figures on exposure, disease burden and exposure-response relationship as the baseline. Data for the JJM scenario are then modelled to provide annual projections for the expected duration of the JJM, between 2019 and 2024. The business-as-usual scenario uses historical annual rates of change to project coverage over the same period.

Population

Population data are drawn from the 26th round of the UN Population Division's revision of the World's Population Prospects[10].

Exposures

Basic drinking water: Basic drinking water is defined by the JMP as 'drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip including queuing'[3]. 2018 exposure data for basic drinking water were calculated from the data collected in the 2018 76th round of India's National Sample Survey (NSS)[2]. Exposures were calculated for urban and rural areas, as well as for all of India.

Safely managed drinking water services: 2018 exposure data for SMDW were calculated using a combination of data from the 2018 NSS survey and data routinely collected by the JJM itself. The NSS collected data on use of 'improved water on premises' and water that is 'available when needed' (improved and sufficiently available throughout the year) for both rural and urban areas, but did not collect data on water that is 'free from contamination'. Data on this component of SMDW was drawn for rural areas from the JJM itself, which reported in 2019 on levels of faecal contamination of drinking water[4]. The JMP calculates SMDW as the minimum of its three components: accessibility on premises, availability when needed, and freedom from contamination[11]. Drawing on the rural data available from the NSS and JJM, it was found that the lowest of the three elements was 'availability when needed', with 'freedom from contamination' having the highest coverage. While no data on water quality were available for urban areas, since the NSS showed that 'availability when needed' was also lower than 'accessibility on premises' in urban areas, it was assumed that this was the limiting factor, rather than 'free from contamination'. Accordingly, the NSS data on 'availability when needed' were used to estimate SMDW in urban areas as well as rural.

Limited/unimproved: Limited drinking water services are defined by the JMP as 'drinking water from an improved source for which collection time exceeds 30 minutes for a roundtrip including queuing'. Unimproved drinking water services are defined as 'drinking water from an unprotected dug well or unprotected spring'[3]. 2018 exposure data for limited and unimproved drinking water services, in both urban and rural areas, were drawn from the NSS.

Projections: Exposure data for the JJM scenario was linearly projected on the assumption that the JJM will achieve its goal of achieving 100% coverage of SMDW in rural areas by 2024. For the business-as-usual scenario, exposure data for this period was projected based on the historical change rate of 0.5 percentage points per year published by the JMP[3].

Disease burden

Diarrhoeal deaths and DALYs: Data on the total number of diarrhoeal deaths and DALYs in India in 2018 were extracted from WHO Global Health Estimates, which reports cause-specific mortality and disease burden by country for 2000-2019[12].

Projections: For both the JJM and the business-as-usual scenarios, data on annual deaths and DALYs from diarrhoeal disease were calculated using the 2018 ratio of deaths and DALYs by diarrhoeal disease to total population and applying these to annual population figures over the programme period.

Exposure-response relationship

The study uses the exposure-response relationship for drinking water and diarrhoea calculated as part of the most recent systematic review on the impact of WASH interventions on diarrhoea[13].

Projections: This was held constant for all years modelled.

1.1.3. Assumptions

A number of assumptions underpin the model and data inputs for the present study.

- We assume that if the JJM is successful in its ambition, 100% of the rural population in India will have access to safely managed drinking water at the end of the programme.
- We assume that the new water connections provided under the JJM will be used by households.
- We assume that the limiting factor for SMDW in urban areas was 'availability when needed', rather than 'free from contamination'.
- We assume that in urban areas access to SMDW would also increase steadily, reaching 100% at the end of the programme.

- When modelling the business-as-usual scenario, we assume that the annual rate of growth documented by the JMP for basic drinking water services (0.5 percentage points) applies also to safely managed drinking water services.
- We assume that the ratio of deaths and DALYs to total population will remain the same over then study period.

1.2. Results

The population in India in 2018 was 1.35 million, and in both JJM and business-as-usual scenarios this population increased by just under 1 percentage point per year over the programme period.

In terms of exposure levels, in 2018, 92.2% of the national population in India had access to at least basic drinking water, and of that 63.6% had access to safely managed drinking water. In the business-as-usual scenario (Table 1), the proportion of the population with access to SMDW increases by 0.5 percentage points year on year, bringing it to 66.6% of the national population at the end of the programme. In the JJM scenario (Table 2) the proportion of the population with access to SMDW increases year on year on a linear trajectory until reaching 100%. Comparing the two scenarios, the JJM scenario would reach an additional 478 million people with SMDW compared to the business-as-usual scenario, which is 50% increase.

Deaths and DALYs caused by diarrhoea were constant across both scenarios. In 2018 diarrhoea was responsible for 687,418 deaths and 24,400,000 DALYs. In line with population increases, these figures were projected to increase to 727,979 and 25,839,751 respectively in 2024.

In 2018, before the launch of the JJM by the Government of India, drinking water that is not safely managed caused an estimated 125,995 diarrhoea deaths in India, and almost 5 million DALYs (4,472,221). According to the projections in the 'business-as-usual' scenario, without efforts to reduce exposure levels, number of diarrhoeal deaths and DALYs attributable to unsafe drinking water would remain quite similar to 2018 (121,429 and 4,310,144 respectively), Over the programme period, cumulative deaths attributable to unsafe water would total 867,162 with over 30 million DALYs.

Study projections for the JJM scenario suggest that if the JJM programme does achieve a steady reduction in exposures associated with water supply, reaching 100% coverage of safely managed drinking water, these diarrhoeal deaths and DALYs would be reduced by almost half (45.4%). This would represent almost 400,000 lives saved and almost 14 million DALYs averted over the programme period.

Table 1: Business-as-usual scenario: Projected distribution of different exposure levels across the national population of India over the programme period, assuming the historical change rate of 0.5 percentage points per year.

Year	National population	Drinking water exposure levels - absolute (proportion)								Deaths and DALYs caused by diarrhoea		Diarrhoea deaths and DALYs attributed to unsafe drinking-water	
		Basic		SMDW		Basic, not SM		Limited or unimproved		Deaths	DALYs	Deaths	DALYs
		Absolute	%	Absolute	%	Absolute	%	Absolute	%				
2018	1,352,642,250	1,247,136,155	92.2	860,280,471	63.6	386,855,684	28.6	105,506,096	7.8	687,418	24,400,000	125,995	4,472,221
2019	1,366,417,750	1,266,669,254	92.7	875,873,778	64.1	390,795,477	28.6	99,748,496	7.3	694,418	24,648,493	125,402	4,451,165
2020	1,380,004,375	1,286,164,078	93.2	891,482,826	64.6	394,681,251	28.6	93,840,298	6.8	701,323	24,893,579	124,741	4,427,715
2021	1,393,409,000	1,305,624,233	93.7	907,109,259	65.1	398,514,974	28.6	87,784,767	6.3	708,135	25,135,382	124,014	4,401,900
2022	1,406,631,750	1,325,047,109	94.2	922,750,428	65.6	402,296,681	28.6	81,584,642	5.8	714,855	25,373,904	123,220	4,373,732
2023	1,419,655,750	1,344,413,995	94.7	938,392,451	66.1	406,021,545	28.6	75,241,755	5.3	721,474	25,608,841	122,359	4,343,167
2024	1,432,456,500	1,363,698,588	95.2	954,016,029	66.6	409,682,559	28.6	68,757,912	4.8	727,979	25,839,751	121,429	4,310,144

Table 2: JJM scenario: Projected distribution of different exposure levels across the national population of India over the programme period, assuming a linear trajectory from 2018 baseline levels to 100% coverage of SMDW.

Year	National population	Drinking water exposure levels - absolute (proportion)								Deaths and DALYs caused by diarrhoea		Diarrhoea deaths and DALYs attributed to unsafe drinking-water	
		Basic		SMDW		Basic, not SM		Limited or unimproved		Deaths	DALYs	Deaths	DALYs
		Absolute	%	Absolute	%	Absolute	%	Absolute	%				
2018	1,352,642,250	1,247,136,155	92.2	860,280,471	63.6	386,855,684	28.6	105,506,096	7.8	687,418	24,400,000	125,995	4,472,221
2019	1,366,417,750	1,277,600,596	93.5	952,393,172	69.7	325,207,425	23.8	88,817,154	6.5	694,418	24,648,493	109,407	3,883,436
2020	1,380,004,375	1,308,244,148	94.8	1,044,663,312	75.7	263,580,836	19.1	71,760,228	5.2	701,323	24,893,579	91,272	3,239,726
2021	1,393,409,000	1,339,066,049	96.1	1,139,808,562	81.8	200,650,896	14.4	54,342,951	3.9	708,135	25,135,382	71,444	2,535,904
2022	1,406,631,750	1,370,059,325	97.4	1,236,429,308	87.9	133,630,016	9.5	36,572,426	2.6	714,855	25,373,904	49,754	1,766,037
2023	1,419,655,750	1,401,200,225	98.7	1,333,056,749	93.9	68,143,476	4.8	18,455,525	1.3	721,474	25,608,841	26,013	923,326
2024	1,432,456,500	1,432,456,500	100	1,432,456,500	100	-	0	-	0	727,979	25,839,751	0	0

Table 3: WASH-attributable diarrhoea deaths averted due to increased coverage of SMDW, assuming a linear trajectory from 2018 baseline levels to 100% coverage of SMDW as per JJM commitment.

Year	National population	Additional population with access to SMDW		Deaths and DALYs caused by diarrhoea		Diarrheoa deaths and DALYs averted due to increased coverage of SMDW	
		Absolute	Proportion	Deaths	DALYs	Deaths	DALYs
2018	1,352,642,250	0	0	687,418	24,400,000	0	0
2019	1,366,417,750	76,519,394	5.6%	694,418	24,648,493	15995	567729
2020	1,380,004,375	153,180,486	11.1%	701,323	24,893,579	33469	1187989
2021	1,393,409,000	232,699,303	16.7%	708,135	25,135,382	52570	1865996
2022	1,406,631,750	313,678,880	22.3%	714,855	25,373,904	73466	2607695
2023	1,419,655,750	394,664,299	27.8%	721,474	25,608,841	96346	3419841
2024	1,432,456,500	478,440,471	33.4%	727,979	25,839,751	121429	4310144

1.3. Limitations

Limitations of our study are as follows. First, no primary data were collected for the study; the modelled scenarios rely on existing data sources, and these are of varying degrees of quality. According to WHO's Global Health Observatory, data on deaths and DALYs in India for 2018 were of limited quality because death registration data are unavailable or unusable. Second, the projected estimates in the JJM scenario for future years have been calculated in the anticipation of the target of JJM; these would need to be validated by survey data to confirm the coverage of SDMW. Third, both scenarios assume that the ratio of deaths and DALYs to total population will remain the same over the programme period, though in all likelihood the improvement in water supply would reduce this ratio.

II. Estimating associated economic cost savings

2.1. Methods

Improving water supply can be associated with significant cost savings from reduced health care costs and increased productive time. There are several approaches to valuing health gains and their associated economic benefits. The most direct measure, if available, is to elicit from the beneficiary of a health intervention their willingness to pay (WTP) for a health benefit. This estimate would ideally include the value to the individual of the health benefit itself as well as other cost savings resulting from better health, such as medical expenditure falling on the beneficiary and other indirect benefits, such as income gains of themselves and carers. However, such studies eliciting WTP are not available for India, and instead a proxy method is used which estimates the monetary value of a DALY. Another commonly used approach is to estimate the value of mortality reductions using the value per statistical life (VSL). However, in this study we are estimating the benefits of averting both morbidity and premature mortality and therefore VSL does not capture the full effect of the water intervention. Furthermore, it is preferable to estimate life years gained (and not just reduced number of deaths) when a policy disproportionately affects a very young population, which is the case for improvements in water supply.

Similar to studies that elicit willingness to pay for a health benefit, a DALY value is assumed to include direct and indirect cost savings enjoyed by the individual or the individual's household. It is also tidy because like the DALY itself, the monetary value of a DALY captures the morbidity impacts (years lived with a disability) and mortality impacts (years of life lost due to premature death) in one single measure.

According to Robinson et al. (2019), the literature on willingness to pay to avert a DALY is not yet well-enough developed to support the use of a valuation function in low- and middle-income countries which reflects the characteristics of the health effect, such as its severity and duration, and the characteristics of those affected[14]. In the interim, the authors conclude that adopting a constant value per DALY is the most feasible and reasonable approach.

The value of a DALY can be estimated in several ways. One approach is to derive it directly from patient questionnaires. Such a study is not available for India. A second approach is to derive it from the willingness to pay to avert premature death using value of statistical life, and estimating the value of a statistical life year (VSLY) based on the average life expectancy. However, as mentioned above, this does not include the value of the morbidity component of the disease burden. A third approach is to approximate the monetary value of a DALY based on a multiple of the GDP per capita of a country. The value of the multiple is a benchmark developed based on prior research. An approach was first described in the 2001 report of the WHO's Commission on Macroeconomics and Health which assign each life year a value of three times GDP per capita: "*According to some estimates, each life year is valued at about three times the annual earnings. This multiple of earnings reflects the value of leisure time in addition to market consumption, the pure longevity effect, and the pain and suffering associated with disease*"[15].

In this analysis, the value per DALY averted from the JJM initiative was estimated based a plausible range, given no DALY value has been previously generated for India. However, while the Commission on Macroeconomics and Health (2001) multiplier value of three times GDP per capita remains frequently used in cost-effectiveness analyses, the research on which it is based is prior to the year 2000 and was not based on research done in low- or middle-income countries[16]. Indeed, recent country-specific studies doing primary research on DALY values have reported values ranging from 1.75 times GDP per capita in China[17] to six times GDP per capita in North America[18]. Other recent studies that have adopted a DALY value have been more conservative and have assumed a DALY value of one times GDP per capita in Kenya[19], the East African Community[20], Mauritius[21]and China[22].

Due to this uncertainty, results are presented under a range of DALY values from 1 times GDP per capita to 3 times GDP per capita. Accordingly, in the base case analysis, each DALY was assigned a value ranging from $2,433 to $7,298 based on a projected GDP per capita for India of $2433 in 2022[23].

2.2. Results

We found that almost 14 million DALYs from diarrhoeal disease could be averted from improved access to safely managed drinking-water under JJM, or 13.8 million DALYs when discounted. This could result in a very significant economic value to beneficiaries, with a range from an estimated $34 billion to $101 (undiscounted) and from $33.6 to $100.8 billion (discounted) (Table 4). As a percent of total GDP of India, these values reflect 1% of total GDP of India when valuing a DALY at one times the GDP per capita of India, and 3% of total GDP of India when valuing a DALY at three times the GDP per capita of India.

Table 4: Potential cost savings from DALYs averted from JJM between 2019 and 2024.

DALYs averted[1] in 2022		GDP per capita for India[2]	Multiplier value[4]	Value of DALYs averted	
Undiscounted	**Discounted[3]**			**Undiscounted**	**Discounted[3]**
13,959,394	13,818,515	$ 2,433	1.0	$ 33,957,828,443	$ 33,615,124,538
13,959,394	13,818,515	$ 2,433	1.75	$ 59,426,199,776	$ 58,826,467,942
13,959,394	13,818,515	$ 2,433	3.0	$ 101,873,485,330	$ 100,845,373,614

[1] Cumulative DALYs averted between 2019 and 2024.
[2] GDP per capita in 2021 converted to 2022 at a GDP per capita growth of 7.8% from 2021 (World Bank)
[3] Discounting using 3% per annum. The baseline year is 2022, hence DALYs prior to 2022 are inflated to 2022 at 3% per year and DALYs after 2022 are discounted to 2022 at 3% per year.
[4] Number of times GDP per capita that a DALY is worth.

III. Estimating time saved on water collection

In 2018, about 42% of rural households, and 20% of urban households, collected water from off-premises supplies (Table 5). Women bear the main burden of this carriage, followed by men.

Table 5: Collection of water in households without on-premises water

	Number of households (millions)			Proportion of households (%)		
	Rural	Urban	All	Rural	Urban	All
Households	178.4	92.7	271.1			
Households without on-premises water	**74.8**	**18.1**	**92.9**	**42%**	**20%**	**34%**
Households where women collect water	55.1	9.1	64.3	31%	10%	24%
Households where men collect water	14.4	6.1	20.6	8%	7%	8%
Households where girls collect water	2.0	0.3	2.3	1%	0%	1%
Households where boys collect water	1.4	0.5	1.8	1%	0%	1%
Households where hired labourers collect water	0.4	1.0	1.4	0%	1%	1%
Households where other people collect water	1.4	1.1	2.5	1%	1%	1%

The time spent per day collecting water, on average, is slightly larger in households where women collect water than in households where men collect water (Table 6): 45.5 minutes compared to 37 minutes). In one in ten households with off-premises water source, women spent at least 80 minutes per day collecting water. This compares to 25 minutes per day on water collection by men in one in ten households without water on premises. Among households with off-premises water, the median time spent collecting water by women is 18 minutes (21 minutes in rural areas), while in most households, men don’t collect water (because women do) so the median collection time for men is zero. Water collection by boys and girls under age 18 is relatively rare.

Table 6: Time spent collecting water from off-premises

	Average time spent collecting water (minutes per household per day)			Total time spent collecting water (millions of hours per day)		
	Rural	Urban	All	Rural	Urban	All
Households without on-premises water	**44.8**	**35.7**	**43.0**	**55.8**	**10.8**	**66.6**
Households where women collect water	45.8	43.5	45.5	42.1	6.6	48.7
Households where men collect water	40.4	29.0	37.0	9.7	3.0	12.7
Households where girls collect water	51.3	44.4	50.4	1.8	0.2	2.0
Households where boys collect water	53.0	35.8	48.7	1.2	0.3	1.5
Households where hired labourers collect water	40.9	21.2	27.4	0.3	0.3	0.6
Households where other people collect water	34.1	18.3	27.1	0.8	0.3	1.1

In total, in 2018 in India 66.6 million hours were spent each day collecting water in households without on-premises water. The great majority of this (55.8 million hours) happened in rural areas, and approximately three quarters of this burden (48.7 million hours) was borne by women. Boys and girls spent a total of 3.5 million hours each day collecting water.

Conclusion

Preliminary research shows that if the JJM aims are achieved, considerable health, social and economic gains will be realized.

References

1. Wolf J, Johnston R, Ambelu A, Arnold B, Bain R, Brauer M et al. Burden of disease attributable to unsafe drinking water, sanitation and hygiene in domestic settings: a global analysis for selected adverse health outcomes. Lancet 2023. 401(10393):2060-2071. https://doi.org/10.1016/S0140-6736(23)00458-0
2. Government of India. (2018). NSS report no.584: Drinking Water, Sanitation, Hygiene and Housing Condition in India, NSS 76th Round (July - December 2018). In M. o. S. P. I. Government of India (Ed.). India. (http://microdata.gov.in/nada43/index.php/catalog/153, accessed 3 March 2023)
3. Joint Monitoring Programme for Water Supply and Sanitation: Progress on Household Drinking Water, Sanitation and Hygiene. 2021. World Health Organization, United Nations Children's Fund. (https://washdata.org/sites/default/files/2022-01/jmp-2021-wash-households_3.pdf, accessed 30 May 2023)
4. Government of India Jal Jeevan Mission (https://jaljeevanmission.gov.in/, accessed 3 March 2023)
5. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ, et al. Selected major risk factors and global and regional burden of disease. Lancet 2002, 360(9343), 1347-1360. https://doi.org/10.1016/S0140-6736(02)11403-6
6. Ezzati M, Hoorn SV, Rodgers A, Lopez AD, Mathers CD, Murray CJ et al. Estimates of global and regional potential health gains from reducing multiple major risk factors. Lancet 2003. 362(9380), 271-280. https://doi.org/10.1016/s0140-6736(03)13968-2
7. Clasen T, Pruss-Ustun A, Mathers CD, Cumming O, Cairncross S & Colford JM. Estimating the impact of unsafe water, sanitation and hygiene on the global burden of disease: evolving and alternative methods. Trop Med Int Health; 2014 19(8), 884-893. https://doi.org/10.1111/tmi.12330
8. Prüss-Ustün A, Bartram J, Clasen T, Colford JM Jr, Cumming O, Curtis V et al. Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a

retrospective analysis of data from 145 countries. Trop Med Int Health 2014. 19(8):894-905. https://doi:10.1111/tmi.12329

9. Prüss-Ustün A, Wolf J, Bartram J, Clasen T, Cumming O, Freeman MC et al. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. Int J Hyg Environ Health; 2019. 222(5):765-777. https://doi:10.1016/j.ijheh.2019.05.004
10. United Nation Population Division. Revision of World Population Prospects 26th Round. Dept of Economic and Social Affairs 2019. https://population.un.org/wpp/
11. Joint Monitoring Programme for Drinking Water and Sanitation (JMP) Methodology: 2017 Update and SDG Baselines. World Health Organization, United Nations Children's Fund. Geneva: World Health Organization (https://washdata.org/report/jmp-methodology-2017-update, accessed 30 May 2023)
12. Global Health Estimates: Life Expectancy and Leading Causes of Death and Disability. Global Health Observatory 2020. Geneva: World Health Organization www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death, accessed 3 March 2023)
13. Wolf J, Hubbard S, Brauer M, Ambelu A, Arnold BF, Bain R et al. Effectiveness of interventions to improve drinking water, sanitation, and handwashing with soap on risk of diarrhoeal disease in children in low-income and middle-income settings: a systematic review and meta-analysis. Lancet. 2022; 400:48–59. https://doi:10.1016/s0140-6736(22)00937-0
14. Robinson LA, Hammitt JK, Cecchini M, Chalkidou K, et al. Reference Case Guidelines for Benefit-Cost Analysis in Global Health and Development. 2019. Funded by the Bill & Melinda Gates Foundation. (https://www.hsph.harvard.edu/wp-content/uploads/sites/2447/2019/05/BCA-Guidelines-May-2019.pdf, accessed 30 May 2023)
15. Commission on Macroeconomics and Health 2001. Macroeconomics and Health: Investing in Health for Economic Development. Prepared for the World Health Organization. (https://apps.who.int/iris/handle/10665/42463, accessed 19 May 2023)
16. Robinson LA, Hammitt JK, Chang AY, Resch S Understanding and improving the one- and three-times GDP per capita cost-effectiveness thresholds. Health Policy Plan 2017. 32(1):141-145. https://doi.org/10.1093/heapol/czw096
17. Ye Z, Abduhilil R, Huang J et al. Willingness to Pay for One Additional Quality Adjusted Life Year: A Population Based Survey from China. Appl Health Econ Health Policy 2022; **20**, 893–904. https://doi.org/10.1007/s40258-022-00750-z
18. Schlander M, Schwarz O, Hernandez D, Schaefer R. PHP161 - New Estimates of the Willingness-to-Pay for a Statistical Life Year: A Systematic Review of the Empirical Economic Literature, Value in Health, 2018; Vol 21, S111. https://doi.org/10.1016/j.jval.2018.04.755
19. Muthuri RNDK & Kirigia JM. The Monetary Value of Disability-Adjusted Life Years in Kenya in 2017. SAGE Open, 2020, 10(4). https://doi.org/10.1177/2158244020970556
20. Kirigia JM & Mwabu GM. The Monetary Value of Disability-Adjusted-Life-Years Lost in the East African Community in 2015. Modern Economy, 2018; 9, 1360-1377.
21. Musango L, Nundoochan A, Wilder PV & Kirigia JM. Monetary value of disability-adjusted-life-years lost from all causes in Mauritius. Research Square; 2019.
22. Zhao J, Jin H, Li X, Jia J, Zhang C, Zhao H, Ma W et al. Disease Burden Attributable to the First Wave of COVID-19 in China and the Effect of Timing on the Cost-Effectiveness of Movement Restriction Policies. Value Health. 2021; 24(5):615-624. https://doi:10.1016/j.jval.2020.12.009
23. World Bank 2022 https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=IN