Unsafe water and lack of sanitation

Problem paper – Copenhagen Consensus 2008

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The problem

In the year 2002, it was reported that 1.1 billion lacked access to improved drinking water sources and 2.6 billion lacked access to improved sanitation [1]. In some less developed world regions, the proportion of the population lacking access to improved water supply and sanitation was disturbingly high, especially for improved sanitation access. In terms of overall numbers, more than 90% of the world's population lacking access is living in Asia and Africa. In fact, around 70% of the 1.1 billion lacking access to improved drinking water sources and around 78% of the 2.6 billion lacking access to improved sanitation access are located in just 11 countries[1] [2].

Unsafe and inaccessible water and sanitation is a human problem for many reasons, covering personal hygiene and dignity, disease risk[2] [3], environmental impact, as well as overall developmental impact related to health status, time use and production decisions. Furthermore, coverage of improved water and sanitation is strongly related to household income and dwelling location, thus indicating severe inequalities in society such as between the rich and the poor, and between rural and urban populations [1].

The real size of the water and sanitation problem is more than past statistics suggest. The human dimensions of unsafe water and lack of sanitation are expected to become worse over time due to unsustainable water consumption, increasing contamination of water sources, changing rainfall patterns, population movements, increased water demands from agriculture, and decaying infrastructure which has not been adequately maintained. These problems are especially critical in many developing regions due to the special geographical and meteorological features which makes them more vulnerable to these predicted changes, as well as their lack of economic resources to mitigate the problems.

The importance of unsafe water and lack of sanitation is underlined in their connection to several of the Millennium Development Goals (MDG) [4]. As well as its 'own' MDG target (goal 7) of improving water access and providing adequate sanitation, water and sanitation are connected closely to health and nutrition targets (goals 1, 4, 5 and 6), environmental sustainability (goal 7), gender equality (goal 3), primary school attendance (goal 2), and overall poverty rates (goal 1). Partly in the recognition of the central importance of water in supporting life on the planet, the UN has declared 2005–2015 the International Decade for Action – Water for Life.

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[1] India, China, Indonesia, Nigeria, Bangladesh, Pakistan, Ethiopia, Vietnam, Brazil, Democratic Republic of Congo, and Afghanistan.

[2] Inadequate water, sanitation and hygiene are a major cause of diarrheal disease, causing annually 2.2 million deaths and 82 million Disability Adjusted Life Years, and helminthes causing an additional 5.9 million DALYs and 26,000 deaths. In addition to these microbial pathogens, unsafe drinking water can result in exposure to chemical contaminants (arsenic, lead, solvents) and vector-borne diseases such as malaria, dengue, trypanosomiasis, and schistosomiasis.

The solution

The solution to the problem is, essentially, to give considerably greater attention to ensuring basic access to improved water and sanitation for the world's unserved population. The MDG target for water and sanitation is one response to the current crisis. It is an important time-limited target, to halve, by 2015[3], the proportion of people without sustainable access to safe drinking water and basic sanitation. In meeting the MDG target, important steps will have been made to improving global sustainable development. However, such a target should be part of a broader long-term vision to increase coverage to universal access. Furthermore, the MDG target has been criticized for the emphasis of the indicator on physical access as opposed to quality aspects. For example, the sanitation indicator focuses on access to improved services such as flush toilets, VIP latrines and simple pit latrines, but does not directly consider whether sewage is treated or properly disposed of, which clearly has environmental as well as human health implications [2]. Likewise, the water indicator focuses on time access to water sources with adequate water quantity, with no consideration for water quality [5].

These concerns aside, it is clear that there exist a number of 'basic' improvements to water supply and sanitation which can be achieved at relatively low cost and in a short space of time, and they can have substantial impacts on the quality of life of underserved populations. For example, evidence shows that having adequate water *quantity* is key for preventing water-washed disease transmission such as scabies or trachoma [5]. However, good water *quality* is key for the prevention of waterborne diseases such as diarrhea, dysentery, or typhoid fever. Four intervention categories are distinguished by Cairncross and Valdmanis[4]:

1. Hygiene (hand washing; education).
2. Sanitation (sanitary pit latrine; septic tank; household sewer connection).
3. Water supply (new water supply or improved distribution in community; piped household water supply).
4. Water quality (treatment at community source; treatment at water plant for household piped water supply; treatment at point of use using chemical, pasteurization, filter, boiling, or solar disinfection techniques – all combined with safe water storage).

In the Rio-Dublin Principles, which form the basis of subsequent efforts to define Integrated Water Resources Management, water is recognized as an economic good: "water has an economic value in all its competing uses". Hence cost-benefit analysis is a relevant tool for choosing between alternative options for water (and sanitation) improvement, as it provides key information on the relative economic efficiency of these options.

However, given the lack of published cost-benefit studies on water and sanitation options, this current study is limited to presenting the results of a global study conducted in 2002 and published in 2004 [6]. This study presented the costs, benefits, and benefit-cost ratios of a range of interventions with a focus on the water and sanitation MDG targets and low-

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[3] Base year for comparison is 1990.

[4] A typology of water supply and sanitation technologies is provided in the UN Millennium Project Taskforce Assessment [4].

cost improvements, as well as access to advanced or high cost options In order to reflect as fully as possible the four main intervention categories above, three scenarios are presented in this current paper: (1) water supply alone; (2) water supply and sanitation combined; and (3) water supply and sanitation combined, plus a low-cost and simple intervention to improve drinking water quality. Hygiene education is implicitly included within these three interventions.

It is important to note that these interventions are all preventive in nature, with a focus on achieving MDG targets and on point-of-use interventions which potentially yield large health gains for limited cost. Other options may be considered, but are excluded from this current paper. One set of options includes 'curative' options, such as disease treatment, which are appropriate for the mitigation of some of the negative side-effects of the overall problem described earlier. However, in the context of water supply and sanitation interventions, such curative approaches only focus on one part of the problem (i.e. disease) at the cost of other problems that are more comprehensively addressed by the preventive options (time use, dignity, etc). A second set of options address some of the underlying issues in water resource management, such as international agreements over water supply and water pollution, or power generation (e.g. hydroelectric dams), which are often not addressed in dealing with 'basic' access issues. In terms of this larger picture, the Millennium Taskforce elaborates on four major factors to address in water management: institutional, political, financial, technological [4]. However, these concerns are not the subject of this current paper, and are addressed in a separate Problem Paper (Number 12).

Cost-benefit analysis

Global cost-benefit assessments of any development intervention risk being over-generalised, non-specific in nature and therefore difficult to interpret for any country-specific decision making context. In order to understand more fully the cost-benefit results presented in this paper, the sources and nature of different costs and benefits are presented separately, before the overall cost-benefit results.

Intervention costs

For a micro-economic evaluation, costs per capita are needed that accurately reflect the full annual cost per capita of the interventions assessed. A number of studies have been conducted to cost the MDG target 10 on water supply and sanitation, reviewed by the World Water Council [7]. Thus various cost estimates are available, ranging from country-specific to region-specific to multi-region. While many sources are available for unit costs and global costs of improving WS&S, a single estimate is needed for cost-benefit analysis. One reliable and globally comprehensive cost data source is the evidence on **intervention costs** available from the WHO and UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation. The latest cost data from the programme were presented in the Assessment Report from the year 2000 [8]. Investment cost per capita in United States Dollars (year 2000) were provided by countries, and aggregated for three developing regions (see Table 1). Given that large variations were observed in cost per capita between countries of similar geographical and economic conditions, regional averages were presented in the JMP report and used in the subsequent cost-benefit analysis [6].

For ***water***, four types of basic improved water source were considered: borehole, standpost, dug well, and rainwater harvesting. These varied in construction cost from US$17 to US$55 per capita. Household piped water supply was considerably more expensive per capita (US$102 in Africa, US$92 in Asia, and US$144 in LA&C) due to the increased hardware and the water production costs. In order to estimate cost-benefit of improved water access, Hutton and Haller make several assumptions about likely recurrent costs and length of life of the different technologies in order to estimate total annual equivalent costs, presented in the final column of Table 1 [6, 9, 10]. When the costs were annualized, the intervention cost per person reached varies between US$1.26 – US$4.95 for Asia, US$1.55 – US$3.62 for Africa, and US$3.17 – US$4.07 for LA&C, depending on intervention choice.

For ***sanitation***, improvement options vary from the relatively simple such as a VIP and small pit latrine, to simple options requiring greater availability of water supply such as pour flush, to more advanced options with partial treatment such as septic tank and sewer connection. The construction cost per capita of these options varies considerably in developing regions, from US$26 to US$91 for basic improvements; US$104-US$160 for septic tank; and US$120-US$160 for sewer connection [8]. The cost differences between basic and advanced sanitation options becomes smaller when annual per capita costs are calculated, due to the longer assumed length of life of septic tank and sewer connection.

Table 1. Estimates of per capita costs from various sources (United States Dollars, year 2000)

	Region	Construction costs per capita (US$) [8]	Annual total costs per capita (US$) [6]
Water supply			
Basic improvement[1]	Asia	17 – 64	1.26 – 4.95
	Africa	21 – 49	1.55 – 3.62
	LA&C	36 - 55	3.17 – 4.07
Household connection[2]	Asia	92	4.78 – 9.95
	Africa	102	5.30 – 12.75
	LA&C	144	7.48 – 15.29
Sanitation			
Basic improvement[3]	Asia	26 – 50	3.92 – 5.70
	Africa	39 – 91	4.88 – 6.21
	LA&C	52 – 60	5.84 – 6.44
Septic tank	Asia	104	9.10
	Africa	115	9.75
	LA&C	160	12.39
Household connection[4]	Asia	154	8.99 – 11.95
	Africa	120	7.01 – 10.03
	LA&C	160	9.34 – 13.38

[1] Borehole, standpost, dug well, rainwater harvesting
[2] Lower estimate: piped water, not regulated; higher estimate: piped water connection, regulated
[3] VIP, small pit latrine, and pour flush
[4] Lower estimate: sewer connection; higher estimate: sewer connection, with partial treatment

While these figures presented by JMP are strongly indicative of the levels of cost per capita expected in these settings, the actual unit costs in specific locations may vary considerably from these. As pointed out by Cairncross and Valdmanis, the local conditions such as size of community to be served and presence of suitable acquifers, can cause tremendous variations in the unit cost of water supply [5]. This is particularly the case for household water and sewerage connections, where most investment in major works is made before house connections can be offered, so the marginal cost of each additional connection is only a fraction of the total cost. Thus unit cost is strongly correlated with the percentage of capacity use of a given facility (returns to size). Furthermore, cost assessments would ideally distinguish between urban and rural areas, given the different population densities and access to resources, and hence unit costs of extending services to additional households.

Intervention benefits

While there is at least some clarity and methodological agreement on which costs should be included and how they are valued, on the **intervention benefit** side there is considerably less clarity and agreement. From a Ministry of Health perspective, the World Health Organization recommends cost-effectiveness analysis, which in practice means comparing the costs of the intervention with health effects, measured in terms of incidence and mortality averted, and preferably converted to an index comparable across disease states and health interventions such as Disability-Adjusted Life-Years (DALY) or healthy life-years (HLY) [11]. WHO also recognizes that health cost savings due to less treatment seeking should be taken into account, and thus recommends deducting these savings from intervention costs to give a net health sector cost. The WHO's CEA results for water and sanitation interventions were presented in the World Health Report 2002, and more comprehensively presented in Haller et al [10].

However, as recognized in a discussion paper of WHO in 2000, many development interventions that have an impact on health also have many other impacts outside the health sector, and thus merit to be included in an analysis [12]. Thus either CEA can be broadened to include productivity effects attributable to the intervention [13], or a full social cost-benefit analysis (SCBA) can be conducted. Since the 1960s, SCBA has been conducted as a matter of routine in many large development projects in developing countries, especially funded by external donors [14, 15]. However, despite large strides in methodological refinement and application, SCBA has been less and less practiced according to fundamental principles, although it is still a part of development bank project appraisals [16]. Furthermore, there is considerable variation in the SCBA methodologies applied, such as which benefits to include and how to value benefits in monetary terms. These days, a dominant approach in development project appraisal is to measure welfare gain for water projects by multiplying the expected price of water by the quantity of water supplied. While this simply aggregates the market value of water traded, it risks omitting some important benefits.

A large range of benefits result from water and sanitation interventions, with differences as well as similarities between water interventions and sanitation interventions. Benefits common to both are health benefits and the related economic benefits and household time savings. Water interventions bring potential gains to households through changing production technology (e.g. small home business), the private sector (water supply as an input to production), as well as agriculture (irrigation). Sanitation interventions likewise can change the development pathway of households, as well as providing raw materials for agriculture (fertiliser). The economic peer-reviewed and project literature has been presented previously, revealing very few studies but also a wide range of economic methodologies [17]. For example, Suarez estimates the costs associated with the cholera epidemic in Peru in 1989-1990, including health care cost savings, productivity savings, value of saved lives (VOSL), tourism and domestic production impact [18]. To estimate the household economic impact of improved water supply in various settings, Whittington and colleagues estimate willingness to pay using contingent valuation and observed wage rates [19-22]. North and Griffin attempt to value the economic impact of improved water source by measuring its influence on house prices [23].

Benefit-cost analysis

To date, there has been one single attempt to measure the social cost-benefit of a range of options for improving water supply and sanitation globally, presented as a WHO report in 2004 [6], which has been revised for academic publication [9, 10] and recently adapted for a background paper for the UNDP Human Development Report 2006[5] [24]. The results reported have been variously used, including the United Nations Commission on Sustainable Development 12 [25, 26], a report for DFID [27], and the Water Challenge paper in the first Copenhagen Consensus in 2004 [28]. Therefore, this current paper presents a selection of results from the most recent version of this analysis, including a one-way sensitivity analysis on four of the most key determinants of cost-benefit [9]. The key study aims and methods are reported below.

The aim of this global benefit-cost analysis was to estimate the equivalent annual costs and benefits – from the base year 2000 to the target year 2015 – associated with improving water supply and sanitation in order to meet, separately and together, the water supply and sanitation millennium development goals and to achieve universal access. Estimates of costs and benefits were made for each developing country separately and aggregated to eleven developing world sub-regions based on WHO classification[6]. Populations with unimproved WS&S were moved to 'improved' coverage, assuming equal proportions of the unserved population moving to a range of intervention options. For example, in the case of water supply, populations to be served received in equal proportions the following interventions: borehole, standpost, dug well, harvested rainwater and household piped water supply. Costs were estimated accordingly, and included both investment and recurrent costs, as reported in Table 1. Benefits included those benefits that were most widespread globally, measurable, and significant, and included averted health care costs due to diarrheal disease, productivity and welfare implications of less diarrheal disease, averted deaths associated with lower diarrheal

[5] This new study estimates the cost-benefit of achieving the MDG targets compared to the predicted coverage in 2015 based on coverage increase trend line since 1990. Hence this new analysis focuses on the countries that are off-target to meet the MDGs.

[6] http://www.who.int/choice/demography/regions/en/index.html

incidence, and time savings of more conveniently located water supply or sanitation facility or less waiting time associated with an improved water supply or sanitation facility. Future costs and benefits were discounted at 3%, a rate that reflects international consensus [11, 29, 30]. For the purpose of this present study for the Copenhagen Consensus Process 2008, benefit-cost ratios were also estimated based on each DALY averted being worth US$1,000 (lower bound) and US$5,000 (higher bound), and in these calculations the valuation of health effects (welfare associated with less morbidity and less mortality) were excluded to avoid double-counting. DALYs averted by WHO sub-region were available from Haller et al [10].

Table 2 presents a summary of the results for the eleven WHO developing country sub-regions and the eleven sub-regions aggregated (final column). All costs and benefits are presented as annual values and in units of millions, while the benefit-cost ratio reflects the expected social welfare return in United States Dollars for every US$1 spent.

The results show that, for the eleven developing sub-regions, an annual US$1.75 billion needs to be spent between the year 2000 and 2015 in order to meet the water supply MDG, increasing to US$11.05 billion for the combined WS&S MDG. To calculate total cost of meeting the MDGs, it is not appropriate to multiply these annual figures by 15 years, given that the increase in coverage will not all be achieved at once. Assuming a linear increase in coverage from the base year (2000) to the target year (2015), the water MDG alone would cost US$13 billion; the sanitation MDG alone US$70 billion; and the combined WS&S MDG a total of US$83 billion. These figures are different to the ranges referred to in the UN Millennium Project Taskforce on Water and Sanitation [4], where the water MDG target costs between US$51 and US$102 billion; and sanitation target MDG target costs between US$24 and US$42 billion.

For universal WS&S access plus disinfection using chlorination technique at the point-of-use, the annual cost is US$26.2 billion. While the actual annual costs required may vary considerably for each sub-region, as presented in Table 2, this global estimate represents a ball park figure. However, it is evident that the sub-region requiring the largest increases in resource allocations is Western Pacific (WPR-B), followed by South and South-East Asia, and Africa.

In terms of economic value of intervention benefits, it is clear from the results that convenience time savings are the greatest contributor to overall benefits, accounting for US$12.96 billion for achieving the water supply MDG, compared with US$546 million for health cost savings, US$1.15 billion for morbidity savings and US$677 million for VOSL.

Using these economic benefit values, the benefit-cost ratio for 11 developing country sub-regions is 8.8, ranging from 4.4 (AFR-D) to 31.6 (AMR-D). When health-related time gains are valued at US$1,000 per DALY instead of GNI per capita, the benefit-cost ratio is little changed at 8.6, ranging from 5.1 (AFR-D) to 28.5 (AMR-D). At the higher DALY value of US$5,000, the benefit-cost ratio increases to a global average of 12.1, ranging from 8.5 (WPR-B) to 29.8 (AMR-D). Under the DALY valuation scenario, it is interesting to note the increase in benefit-cost ratio in low-income countries, especially AFR and SEAR-D, compared to higher income regions where the GNI per capita is closer to the US$1,000 value. However, the standardization of the DALY value across sub-regions does not greatly narrow the differences between regions with high GNI per capita (e.g. AMR) and low GNI per capita (e.g. AFR). This is because the major differences in economic benefit are from the different time valuations between region, which is directly based on the GNI per capita.

In terms of the benefit-cost results for the other interventions presented in Table 2, it is important to note the increase in the economic attractiveness when sanitation is added, signified by a rising benefit-cost ratio. Globally the BCR jumps from 8.8 for water supply alone to 11.0 for WS&S combined, ranging from 5.5 (AFR-D) to 45.5 (AMR-B). By including disinfection at the point of use (POU) does not greatly change the BCR, at 11.0 globally, given that the contribution of the increased health gains to overall economic benefit is still relatively small. Note, however, the dramatic increase in health-related economic gains when POU treatment is included. For example, when POU treatment is added to universal WS&S, the number of DALYs averted increases from 10.0 million to 27.6 million annually, and the combined productivity and VOSL gain from US$10.5 billion to US$37.5 billion annually.

<u>Sensitivity analysis</u>

Due to the high level of uncertainty in the costs as well as the benefits in such a global study, sensitivity analysis was conducted to give an indication of how much the base case benefit cost results are affected by changes in the values taken by some key parameters. Table 3 presents the results of a one-way sensitivity analysis, with the effects of uncertainty in each parameter assessed independently of the others. The extreme values in Table 3 are therefore not unrealistic for some settings within the sub-regions, and furthermore the values may be even higher or lower than these values when combining more than one type of uncertainty:

- In SA1, based on different assumptions about the calculation of recurrent costs and hardware length of life, unit cost inputs varied quite considerably and therefore had a considerable effect on the benefit-cost ratios, more than halving it in the pessimistic scenario and more than doubling it in the optimistic scenario.
- In SA2, when time savings were valued at 30% of GNI per capita instead of 100%, the impact was even greater, such as reducing BCR from 6.0 to 2.0 in AFR-E.
- In SA3, when convenience time savings were given realistic upper and lower values [5, 9, 31], the impact was also considerable, such as reducing the BCR from 6.0 to 3.5 in AFR-E.
- In SA4, the effect of changes in starting values for diarrheal disease incidence had less impact on the BCR due to the relatively less important contribution of health benefits compared to non-health benefits.

Table 2. Results of global cost-benefit analysis: costs, benefits and benefit-cost by developing world sub-regions

Interventions and variables	Africa		The Americas		E Mediterran.		Europe		S + SE Asia		W Pacific	Developing World
	AFR-D	**AFR-E**	**AMR-B**	**AMR-D**	**EMR-B**	**EMR-D**	**EUR-B**	**EUR-C**	**SEAR-B**	**SEAR-D**	**WPR-B**	
Total population in 2015 (million)	487	481	531	93	184	189	238	223	473	1,689	1,488	**6,076**
Diarrhea cases (million)	620	619	459	93	133	153	87	43	304	1,491	1,317	**5,319**
1. Water supply MDG alone (all figures annually in <u>millions</u>)												
1.1 Costs (US$)	222	268	133	38	24	33	52	8	121	282	566	**1,748**
1.2 DALYs averted (DALY)	0.388	0.328	0.042	0.027	0.004	0.101	0.010	0.000	0.027	0.447	0.170	**1.544**
1.3 Health cost savings (US$)	78	77	82	29	7	24	6	1	22	76	145	**546**
1.4 Productivity (morbidity) (US$)	86	112	375	41	18	33	13	2	53	108	308	**1,148**
1.5 VOSL (mortality) (US$)	148	174	74	16	22	33	9	0	15	153	33	**677**
1.6 Time savings (US$)	671	952	3,680	320	442	305	743	77	957	1,023	3,789	**12,958**
1.7 CBR1 (DALY at US$1,000)	5.1	5.1	28.5	9.8	18.6	13.1	14.4	10.2	8.3	5.5	7.3	**8.6**
1.8 CBR2 (DALY at US$5,000)	12.1	9.9	29.8	12.7	19.2	25.5	15.2	10.4	9.2	11.8	8.5	**12.1**
1.9 CBR3 (Productivity & VOSL)	4.4	4.9	31.6	10.6	20.1	12.1	14.7	10.4	8.6	4.8	7.6	**8.8**
2. Water supply and sanitation MDG combined (all figures annually in <u>millions</u>)												
2.1 Costs (US$)	947	1,074	631	157	100	163	186	71	466	3,628	3,621	**11,047**
2.2 DALYs averted (DALY)	0.816	0.789	0.104	0.057	0.023	0.223	0.024	0.002	0.062	2.305	0.517	**4.923**
2.3 Health cost savings (US$)	231	237	249	83	30	70	20	3	64	405	477	**1,870**
2.4 Productivity (morbidity) (US$)	269	340	1,137	118	69	95	48	9	162	574	1,059	**3,880**
2.5 VOSL (mortality) (US$)	460	528	225	47	71	95	33	1	44	846	111	**2,461**
2.6 Time savings (US$)	4,271	5,341	27,124	2,023	2,463	2,132	3,596	1,457	5,054	22,408	45,191	**121,060**
2.7 CBR1 (DALY at US$1,000)	5.6	5.9	43.5	13.7	25.1	14.9	19.5	20.5	11.1	6.9	12.8	**11.6**
2.8 CBR2 (DALY at US$5,000)	9.1	8.9	44.2	15.2	26.0	20.4	20.1	20.6	11.6	9.5	13.3	**13.4**
2.9 CBR3 (Productivity & VOSL)	5.5	6.0	45.5	14.4	26.3	14.7	19.8	20.6	11.4	6.7	12.9	**11.7**
3. WS&S universal access + disinfection at point of use (all figures annually in <u>millions</u>)												
3.1 Costs (US$)	2,216	2,466	1,613	376	322	450	530	290	1,245	8,371	8,347	**26,225**
3.2 DALYs averted (DALY)	4.307	4.313	0.896	0.348	0.406	2.067	0.301	0.069	0.509	11.948	2.475	**27.638**
3.3 Health cost savings (US$)	840	853	1,791	387	402	490	200	93	385	2,078	2,216	**9,735**
3.4 Productivity (morbidity) (US$)	1,168	1,577	8,023	591	1,317	773	552	303	1,495	2,938	5,361	**24,098**
3.5 VOSL (mortality) (US$)	2,011	2,419	1,596	262	852	831	355	47	342	4,271	502	**13,487**
3.6 Time savings (US$)	8,542	10,682	54,248	4,047	4,925	4,265	7,192	2,913	10,107	44,817	90,382	**242,120**
3.7 CBR1 (DALY at US$1,000)	6.2	6.4	35.3	12.7	17.8	15.2	14.5	10.6	8.8	7.0	11.4	**10.7**
3.8 CBR2 (DALY at US$5,000)	14.0	13.4	37.5	16.4	22.8	33.6	16.8	11.6	10.5	12.7	12.6	**14.9**
3.9 CBR3 (Productivity & VOSL)	5.7	6.3	40.7	14.1	23.3	14.1	15.7	11.6	9.9	6.5	11.8	**11.0**

BCR: cost-benefit ratio; VOSL: value of a saved life; DALY: disability-adjusted life-year

The impact of changes in the discount rate from the base case value of 3% was not assessed quantitatively in terms of impact on BCR. The main implication of changing the discount rate is to affect the value of a saved life (VOSL) and the annual cost per capita of the interventions. For example, when a discount rate of 6% was applied to the cost of capital, the annual cost per person covered increased by 30%, 42%, and 54% depending on length of life assumed of 20, 30 and 40 years, respectively. Hence, a considerably higher discount rate than 3% could have a large impact on the BCR. For the value of future years of work lost calculation for VOSL, the greater impact is for the younger age group (0-4 years) who are still many years from entering the labour force, with a decline in value of 54%. For children (5-14 years) the reduction is 41% while for adults (15+) the reduction is 20%. Hence the overall impact on the BCR is likely to be large considering that the majority (>75% in all sub-regions) of deaths averted are in the 0-4 year age group.

Table 3. Sensitivity of benefit-cost ratios to model assumptions in five selected developing regions (WS&S MDG targets)

Parameter	Scenario	AFR-E	AMR-D	EMR-D	SEAR-D	WPR-B
SA1: Intervention costs	Pessimistic	2.7	6.4	6.7	3.2	6.0
	Base	*6.0*	*14.4*	*14.7*	*6.7*	*12.9*
	Optimistic	14.7	35.5	36.0	16.3	31.6
SA2: Time value	Pessimistic	2.0	4.7	4.7	2.1	4.0
	Base	*6.0*	*14.4*	*14.7*	*6.7*	*12.9*
	Optimistic	10.8	9.6	32.8	7.3	6.6
SA3: Time savings	Pessimistic	3.5	7.9	8.0	3.6	6.6
	Base	*6.0*	*14.4*	*14.7*	*6.7*	*12.9*
	Optimistic	9.4	23.0	23.3	10.1	20.3
SA4: Diarrheal disease incidence rate	Pessimistic	5.5	13.6	13.9	6.4	12.7
	Base	*6.0*	*14.4*	*14.7*	*6.7*	*12.9*
	Optimistic	6.5	15.2	15.5	6.9	13.2

Implications and outlook

Cost-benefit analysis not only indicates likely returns on investment, but also can contribute to identifying ways of financing interventions through an understanding of the beneficiaries of the interventions. At household level, families with ‘unimproved’ water sources already pay for some services, whether it is paying a water vendor, purchasing bottled water, or buying materials and energy for water purification; households also pay for water sources in-kind through their time for water collection and waiting. In some instances, this is also true of unimproved sanitation, where households pay for sewage to be removed or in-kind through travel and waiting time. Hence, by switching to an alternative and improved water source or sanitation choice, households can save on some costs which contribute to meeting the cost of the improved source. In some contexts, it is even possible that the new source is cheaper in financial terms than the old source, as it has been documented widely that households can pay high prices to access adequate water supply from vendors.

However, there exist several barriers to accessing the improved water and sanitation options. A major barrier is the financial constraint of paying up-front the costs of improved WS&S options. Interventions requiring large investments, such as household connection to water or sewerage systems, is one such financial barrier as households may not be able to pay these costs, and bank loans may not be an attractive or available option for financing such an investment. Recurrent costs such as paying bills to piped water providers may also be a high cost, especially as water use may increase substantially after a piped water connection is made. Hence, when examining the financial requirements for household connections, some households may be dissuaded from improving their water supply or sanitation for these and other financial reasons. Cost-benefit analysis can, however, be used as a source of information which helps advocate for improved water and sanitation, as it takes into account not only financial implications but also likely impacts on quality of life (e.g. health) and economic situation, through time savings and household production opportunities.

In addition to financing issues, there remain questions over the feasibility of expanding access to improved water and sanitation, especially in resource constrained settings, covering not only financial resources but also water resources. As noted earlier, a large proportion of those targeted to meet the water and sanitation MDG target are living in eleven countries, which either have very low income per capita and government spending (e.g. Bangladesh, Pakistan, Ethiopia) and/or have very weak institutions to oversee the expansion of water supply (e.g. Nigeria, Democratic Republic of Congo, Afghanistan). These eleven countries also tend to be countries with large populations, where it is questionable that governments have the willingness and capacity to substantially improve the situation in a time period of less than 10 years (e.g. India, Indonesia, or Brazil).

However, as well as promoting the routine business of drilling wells, constructing dams and infrastructure, there are also some quick wins and innovative ways of working to hasten the coverage of the more vulnerable populations and to target certain impacts that can be achieved at low cost. These options include the mobilization of the health sector to improve household water purification at the point of use or in the community; hygiene education in the community; health promotion and latrine building in schools and health centres; and extending micro-credit to households to allow them to invest in water and sanitation improvement. Furthermore, improved advocacy of the benefits of water and sanitation could be supported by country-level and sub-national studies that help convince government departments as well as the population that water and sanitation are worth investing in.

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