Costs of healthcare acquired infections due to inadequate water, sanitation and hygiene (WASH) in healthcare facilities in Ethiopia

Summary

The number of healthcare associated infections (HAI) in Ethiopia (population: 120 million) is conservatively estimated at 506,000 cases in 2022, with 52,400 excess deaths in a year. The increasing rate of antimicrobial resistance causes worse health outcomes and higher costs of treating HAIs. Monetary estimates were aggregated from the healthcare costs, the productivity losses and the premature deaths associated with HAIs, including antimicrobial resistance. The total economic costs of HAIs in Ethiopia in 2022 is US$ 762 million. This equates with 0.68% of Gross Domestic Product in 2022. The financial costs of providing healthcare to treat HAIs is US$ 173 million in 2022, or 4.8% of total health expenditure. When comparing the medical costs per capita in Ethiopia of US$ 1.44 per year with the cost per capita needed to provide basic water, sanitation and hygiene (WASH), waste management and environmental cleaning in healthcare facilities in low-income countries (US$ 0.3 per capita for capital cost and starting at US$ 0.7 recurrent cost) it is likely that the spending will be more than covered by the savings in medical costs.

In addition to HAIs, cleanliness, availability of drinking water and a clean toilet are key determinants of patient satisfaction. These aspects are particularly important to people when they are at their most vulnerable, such as during surgery, during labour and delivery, and neonates in the first moments of their lives. Experiences of poor quality of care and inconvenience can impact future treatment-seeking behaviour and they also impact healthcare worker job satisfaction and absenteeism. WASH and infection prevention and control (IPC) should be essential interventions implemented by the health sector in Ethiopia to reduce HAIs and improve the quality of healthcare and patient satisfaction across the country.

Key messages

- The total economic costs of healthcare associated infections (HAI) in Ethiopia in 2022 was US$ 762 million.
- This equates to 0.68% of Gross Domestic Product.
- The financial costs of providing healthcare to treat HAIs is US$ 173 million in 2022, or 4.8% of total health expenditure.
- It is feasible that the spending to provide basic WASH, waste management and environmental cleaning in healthcare facilities in Ethiopia (less than US$ 1 per capita) will be contributed to by the savings in medical costs of over US$ 0.72 per capita per year if HAI rates can be halved.

This methodology was developed by the World Bank with support from Global Water Security and Sanitation Partnership as published in policy research working paper: Hutton,Guy; Chase,Claire; Kennedy-Walker,Ruth Jane. Costs of Health Care Associated Infections from Inadequate Water and Sanitation in Health Care Facilities in Eastern and Southern Africa (English). Policy Research working paper ; no. WPS 10708; PLANET Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/099428002212438578/IDU1fd9af37311cfe143471843c1e9de76a93d7e

WaterAid

Introduction

The lack of adequate water, sanitation and hygiene (WASH), waste management and environmental cleanliness in healthcare facilities poses a significant health risk to patients and healthcare workers in Ethiopia, and it seriously impacts quality of care and satisfaction with health services.

In Ethiopia there are hundreds of thousands of healthcare associated infections (HAI)[1] each year, and tens of thousands of resulting deaths. These infections impact patients, their families and healthcare facilities by causing illness, prolonged hospital stays, potential disability, excess costs and sometimes death. Furthermore, HAIs affect people when they are at their most vulnerable – during surgery, women during pregnancy, labor and delivery, and neonates in the first moments of their lives.

The problem caused by HAIs has been long recognised by the Ministry of Health in Ethiopia, which has taken steps to improve infection prevention and control (IPC). In September 2020, Ethiopia launched updated national IPC guidelines for COVID-19 for emergency response (Ethiopia Public Health Institute, 2020), and the Ministry of Health WASH in Healthcare Facilities Guideline in 2021 (Ministry of Health, 2021a) and the WASH and Environmental Health Strategy in 2022 (Ministry of Health, 2022). Ethiopia has a national technical working group that oversees the implementation of IPC practices at facilities. IPC data is collected at the national and facility level. The working group has drafted resources that are implemented nationally, including a National IPC Training Manual that was developed in October 2019 for program managers and healthcare service providers (Ministry of Health, 2019).

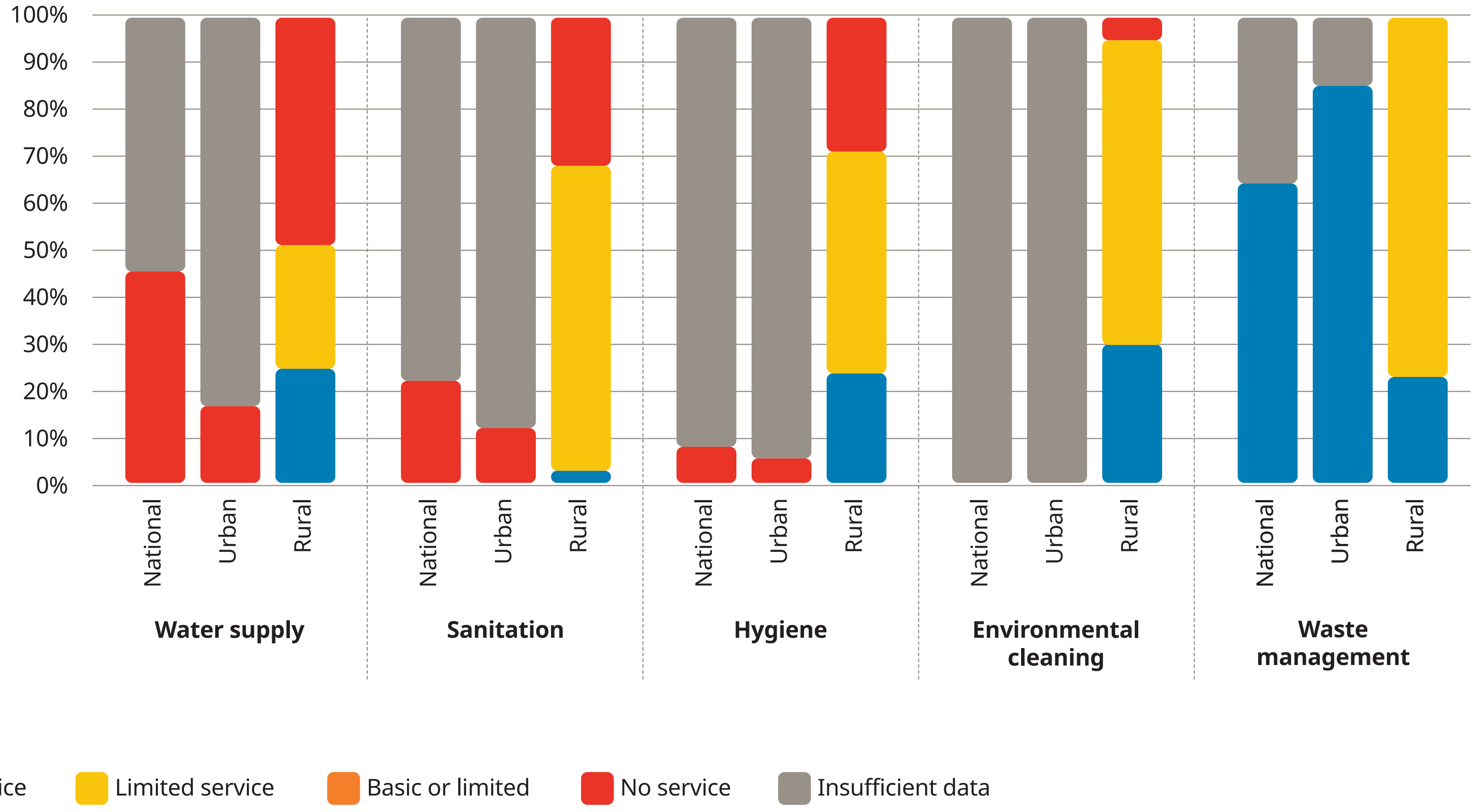
A growing proportion of HAIs are resistant to antimicrobials, leading to a worse health outcome for the patient and making them more costly to treat and requiring longer to recover and restart normal life, including productive activities. Antimicrobial resistance (AMR) rates vary across drugs and across settings within Ethiopia, but available estimates suggest that a majority of HAIs will be resistant to first-line drugs. As a response, Ethiopia's current approach includes the Strategy for the Prevention and Containment of Anti-microbial Resistance 2021-2025 (Ministry of Health, 2021b).

The major transmission pathway for HAIs is a lack of cleanliness and hygiene measures provided during medical care and recovery time. The most common HAIs are surgical site infections, bloodstream infections, and respiratory tract infections, including pneumonia. The highest rates are found in intensive care units (ICUs), neonatal wards or ICUs, and pediatric medical wards. Some HAIs originate in the endogenous native microflora of the patients themselves, and hence cause infection following surgery or catheter-associated urinary tract infections.

Figure 1 shows data compiled by the WHO/UNICEF Joint Monitoring Programme (JMP) for WASH in healthcare facilities in Ethiopia .. Basic or limited sanitation services are available in 68% of healthcare facilities in rural areas, whilst 51% have basic or limited water supplies. Basic handwashing materials at point of care are available in one quarter of rural healthcare facilities. There is insufficient data for national and urban estimates for environmental cleaning, however 95% of rural healthcare facilities have basic or limited.

1. An HAI is a condition resulting from an adverse reaction to an infectious agent or its toxins acquired from healthcare settings that was not incubating or symptomatic at the time of admission.

Figure 1. Coverage of WASH, waste management and environmental cleaning in healthcare facilities in Ethiopia in 2021



Source: WHO/UNICEF Joint Monitoring Programme (2021): https://washdata.org

Methods

This study uses a cost-of-illness methodology developed for a recent World Bank study on the costs of HAIs in nine countries of Eastern and Southern Africa. See Hutton et al, (2023) where full methods and data sources are available. A quantitative model was constructed to estimate (1) healthcare costs, (2) patients' productivity losses, and (3) mortality costs due to HAIs in Ethiopia, including additional costs of treating antimicrobial resistant infections. Variables and data inputs are summarised in Table 1. The calculations are as follows:

- **Healthcare costs:** the number of HAIs across three health facility levels (health centre, district hospital and higher-level hospital such as regional, referral or teaching hospital), multiplied by the average cost per inpatient day at each level, multiplied by the average length of stay, and with the total drug cost per HAI added.
- **Productivity costs:** (a) the number of HAIs multiplied by the proportion of adults working multiplied by the daily opportunity cost of time (proxied by the agricultural wage), plus (b) the number of HAIs multiplied by the proportion of patients not working (including children) multiplied by the daily opportunity cost of time for non-working people (30% of the daily GDP per capita). All calculations are made separately for male and female.
- **Mortality costs:** the number of deaths due to HAIs (= the number of HAIs multiplied by the excess case fatality rate due to HAIs) multiplied by the value of life.

Table 1. Variables, data needs and sources for damage cost estimation of HAIs

Cost variable	Data needs	Ethiopia data value (in brackets range used in sensitivity analysis)	Data source
Healthcare cost			
Annual healthcare associated infections (HAIs)	Average % of admissions infected with HAI	17% (14.1% to 19.8%) [a]	Alemu et al (2020)
	Proportion of anti-microbial resistance in HAIs	50% (25% to 75%) [b]	Berhe et al (2021), Murray et al (2022)
	No. of annual hospital admissions	2.47 admissions per 100 population	DHIS2 report (2022)
Additional cost of treating a patient with an HAI [c]	Average hospital cost per day ('hotel' cost)	US$ 11.2 health centre, US$ 17.7 district hospital, US$ 31.4 higher hospital [d]	Extrapolated from Uganda – IHME (2015)
	Cost of drugs and laboratory tests per HAI	US$ 22.2 health centre, US$ 53.3 district hospital, US$ 244.8 higher hospital[e]. Double for AMR	Aerts et al (2022), Gidey et al (2023), Bocoum et al (2019)
	Additional length of stay	5 days [f] (10 days AMR) [g]	Fenny et al (2020) Otieku et al (2023)

Cost variable	Data needs	Ethiopia data value (in brackets range used in sensitivity analysis)	Data source
Productivity cost			
Annual HAIs	Same as Healthcare cost		
Additional days for recovery after HAI	Additional recovery time	2 days (2 days AMR)	Assumption
Loss in value-added of workers	Productivity loss (value-added in agriculture)	US$ 4.6 per day (US$ 23 per day in industry)	World Bank statistics
	Proportion of adult HAI patients	60%	Assumption
	Labour force participation rate	57.6% (female) 79.2% (male)	ILOSTAT (2023)
	Proportion of HAIs suffered by women	60%	Assumption
Loss of time spent in non-productive activities (opportunity cost	Average daily value	30% of the agricultural value-added	Assumption
Mortality cost			
Annual HAIs	Same as Healthcare cost		
Case fatality rate	HAI case fatality rate	6.9% (4% to 15%) [h] 13.8% (AMR)	7 studies
Value of a premature death	Value of a statistical life	US$ 10,604 (high value US$ 39,902) [i]	Calculation based on Banzhaf (2022)

Notes: See Annex 1.

Several impacts were excluded due to lack of data and lack of methods to quantify in monetary values[2]. Hence, the estimates presented in this study will significantly underestimate the true economic and social costs of HAIs in Ethiopia[3].

2. For example, unoccupied beds due to isolation (loss of capacity and revenue), extended length of stay in an intensive care unit (ICU), non-standard surgical prophylaxis in infected patients, infection prevention and control interventions such as screening at hospital admission or before surgery, long-term consequences of AMR infection, training of health care professionals and communication, HAIs of healthcare workers. Out-of-pocket expenditures by patients and their carers were also excluded. Financial burden on the government such as disability benefits were excluded.

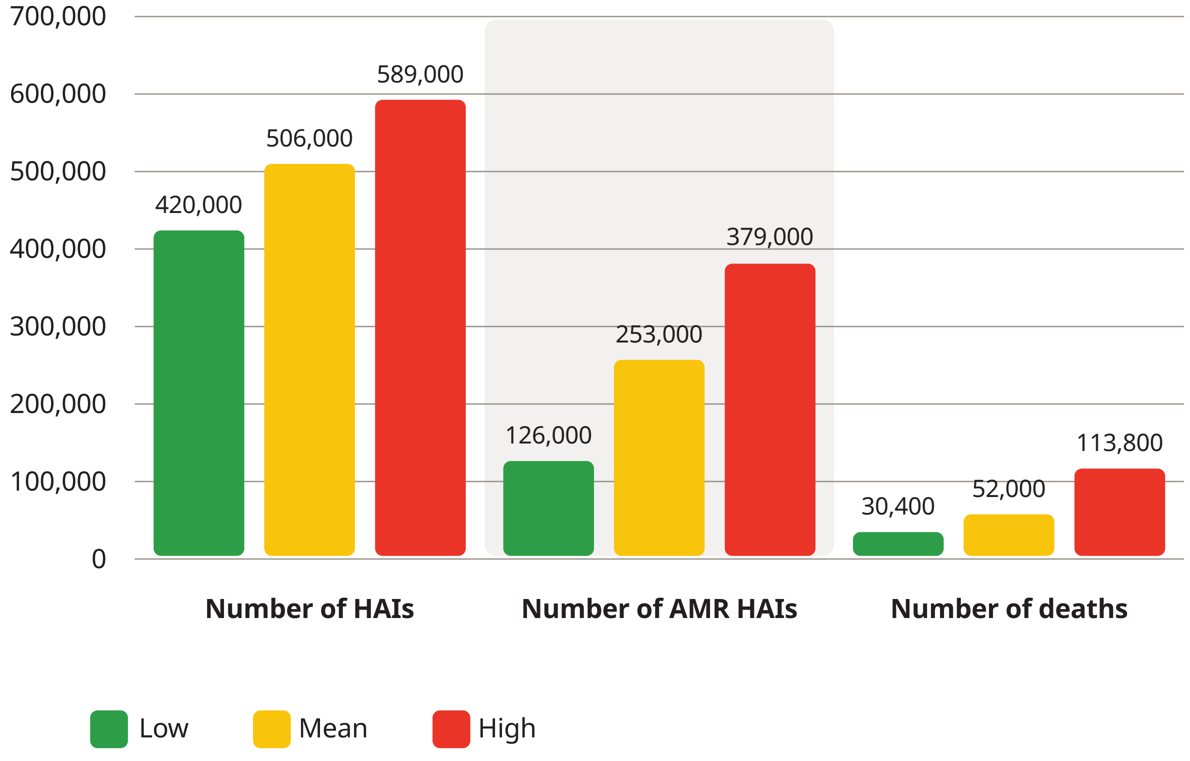
3. No comprehensive study of the economic and financial costs of HAIs has been conducted anywhere in the world, so it is not possible to conclude by how much this current study underestimates the true costs of HAIs.

Results

Disease burden due to healthcare associated infections

In total, the average number of HAIs in Ethiopia is estimated to be 506,000 in 2022 (Figure 2), of which half are predicted to be antimicrobial resistant (Berhe et al. 2021; Murray et al. 2022). The number of fatalities resulting from these HAIs is estimated to be 52,400 deaths.

Figure 2. Estimated number of healthcare associated infections and related deaths in Ethiopia

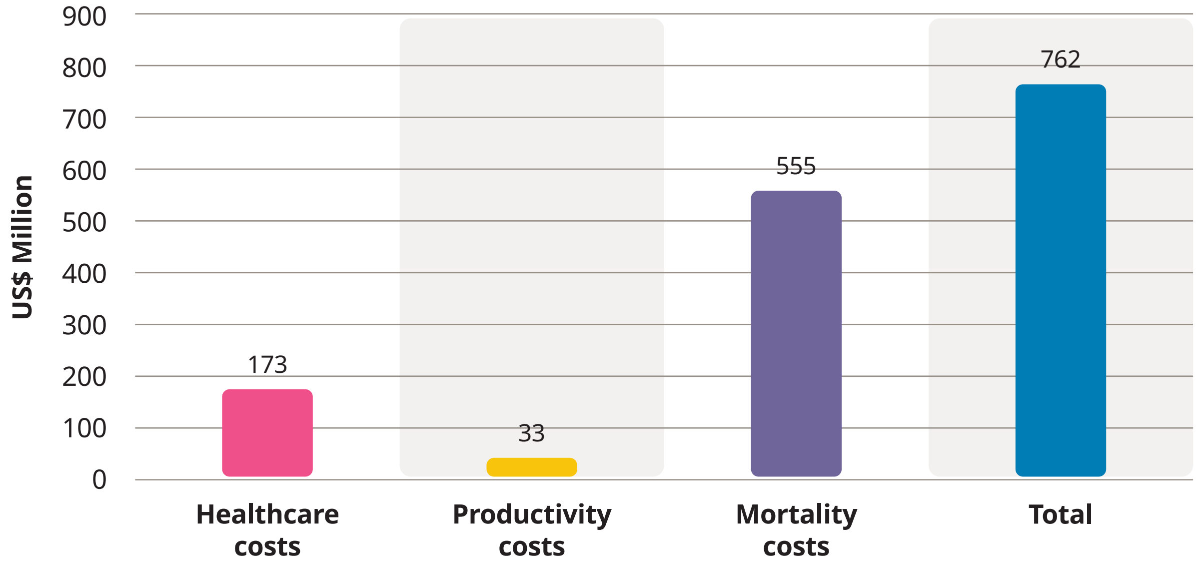


Estimates were made using different data inputs. When varying the baseline HAI rate of 17.0% from 14.1% to 19.8%, the number of HAIs varied from 420,000 to 589,000. When varying the AMR rate (baseline 50%) from 25% to 75%, the number of HAIs that are anti-microbial resistant varies from 126,000 to 379,000. When varying the case fatality rate (baseline 6.9%) from 4% to 15%, the number of deaths varies from 30,400 to 113,800.

Monetary impacts due to HAIs

Costs of HAI are presented in Figure 3. Total costs exceed US$ 762 million per year in Ethiopia.

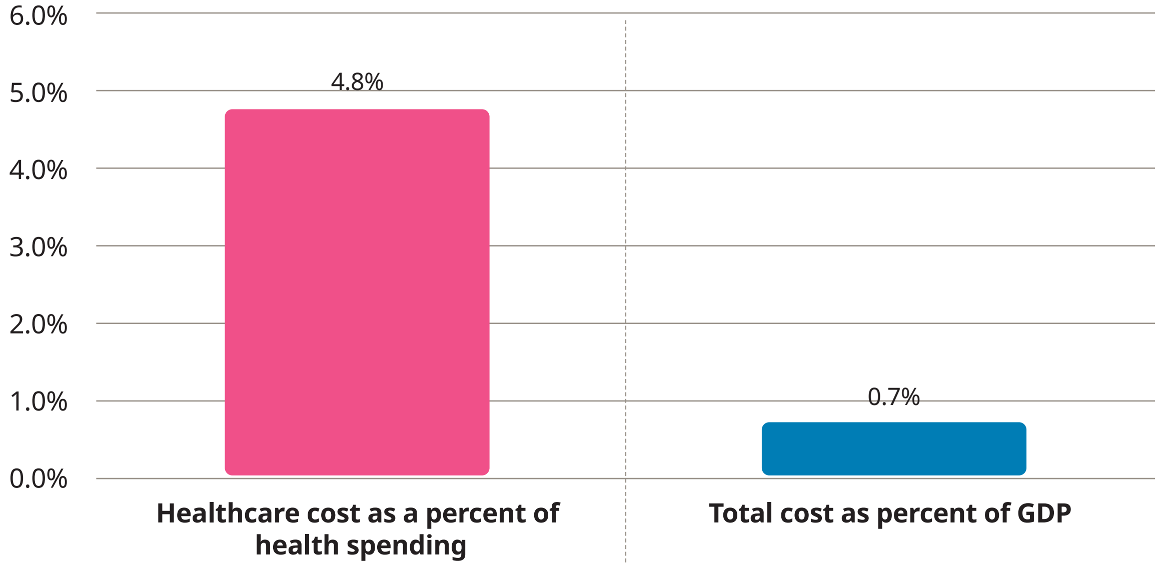
Figure 3. Estimated costs from HAIs in Ethiopia



Healthcare costs amount to US$ 173 million per year, with US$ 33 million in productivity losses and US$ 555 million in lost lives. The costs of premature death accounts for 73% of the total costs, due to the relatively high case fatality rate from HAIs. Total cost per HAI is US$ 1,506. Healthcare cost averaged US$ 343 per HAI episode.

Costs as a proportion of GDP and healthcare spending are shown in Figure 4. In terms of economic cost, HAIs cost an equivalent 0.7% of GDP. The costs of treating HAIs (US$ 173 million per year) reflect 4.8% of overall healthcare spending from all sources.

Figure 4. Costs as a proportion of GDP and healthcare spending



Sensitivity analysis

To better understand the impact of uncertain data inputs on the results, the values of selected variables were altered one at a time to assess what impact would be on the overall results in terms of economic impact. The variables selected include the HAI rate, the AMR rate, the average length of hospital stay, the value of time, the value of death, the case fatality rate. The results are shown in Figure 5. The biggest impact is the value of statistical life (VSL) which when a higher value was used it led to a total economic cost of US$ 2.3 billion in 2022. The results were also sensitive to the case fatality rate and the HAI rate. The resulting impact on costs as a percent of GDP were from 0.5% (low data value for CFR rate) to 2.1% (high value for VSL).

Figure 5. Results of sensitivity analysis

Cost-benefit analysis

The financial cost per capita to the health system due to HAIs across all the Ethiopian population is at least US$ 1.44 each year. Comparing this conservative figure with the cost per capita needed to provide basic WASH, waste management and environmental cleaning in healthcare facilities in low-income countries (US$ 0.3 per capita for capital cost and starting at US$ 0.7 recurrent cost) it is highly feasible that the spending will be covered by the savings in medical costs (Chaitkin et al, 2022).

Patient satisfaction as a key outcome of healthcare

Beyond the HAIs and additional costs to the health system and patients themselves, there will be several other negative consequences of inadequate WASH in healthcare facilities. Patient satisfaction has many determinants. Cleanliness, good housekeeping services and availability of drinking-water and a clean toilet have been reported in the literature as key determinants of patient satisfaction.

Adequate WASH is particularly important to some population groups. For example, women attending antenatal clinic and choosing to have their child in a healthcare facility will consider the cleanliness of the facility and WASH services as essential, especially when they experience prolonged hospitalisations. Hygienic conditions for newborn health are vital and are therefore an important determinant of maternal and paternal satisfaction. A 2019 survey of over 1 million women and girls in 114 countries found that respectful and dignified maternity care was the most cited demand for quality reproductive and maternal healthcare, and this was closely followed by WASH services and facilities (White Ribbon Alliance, 2019).

Studies that assess the rates of HAI typically do not include infections to healthcare workers, which can seriously impact the health system's ability to provide quality healthcare. Healthcare worker job satisfaction influences their future career decisions and, if they do not feel safe in their working environment, they may leave their job. Furthermore, studies that measure HAIs focus on patients *admitted* to hospitals, while excluding the impact on outpatients of the lack of WASH facilities, cleaning, and waste management. Hence, there is a hidden burden of disease of ambulatory patients who pick up – and take home – a healthcare associated infection, with implications for the health of other family members. Furthermore, the lack of cleanliness and WASH facilities causes dissatisfaction of ambulatory patients with the quality of care and inconvenience, which might impact future treatment-seeking behaviour.

Conclusions

HAIs and other impacts of inadequate WASH are key challenges that need to be urgently addressed to achieve progress towards universal healthcare. Hospitals and health centres should be seen as safe environments where people can go to overcome illness and heal fully, and not places to get even sicker and stay for longer than necessary. Several percent – up to 2.4% – of healthcare expenditures could be saved if HAIs were minimised.

As has been found in richer nations, it is difficult to eliminate HAIs altogether, but significant reductions can be achieved through targeted interventions as well as improved general training and healthcare practices. Therefore, WASH and IPC measures should be essential interventions implemented by the health sector in Ethiopia to reduce HAIs and improve the quality of healthcare and patient satisfaction across the country.

References

Aerts C, Leahy S, Mucasse H, et al (2022). Quantifying the Acute Care Costs of Neonatal Bacterial Sepsis and Meningitis in Mozambique and South Africa. *Clin Infect Dis.* 74(Suppl_1): S64-S69.

Alemu AY, Endalamaw A, Bayih WA (2020). The burden of healthcare-associated infection in Ethiopia: a systematic review and meta-analysis. *Trop Med Health* 48(77).

Banzhaf H (2022). The Value of Statistical Life: A Meta-Analysis of Meta-Analyses. *Journal of Benefit-Cost Analysis* 13(2): 182-197.

Berhe DF, Beyene GT, Seyoum B, et al (2021). Prevalence of antimicrobial resistance and its clinical implications in Ethiopia: a systematic review. *Antimicrob Resist Infect Control* 10(168).

Bocoum A, Fané S, Traoré Y, Sanogo S, et al (2019). Bacteriology of Healthcare-Associated Infections in the Gynecology and Obstetrics Department of CHU Gabriel Touré. *Open Journal of Obstetrics and Gynecology* 9: 1336-1346.

Chaitkin M, McCormick S, Alvarez-Sala Torreano J, et al (2022). Estimating the cost of achieving basic water, sanitation, hygiene, and waste management services in public health-care facilities in the 46 UN designated least-developed countries: a modelling study. *Lancet Glob Health* 10(6): e840-e849.

DHIS2 (2022). Ethiopian Health Information Management System.

Escribano-Ferrer B, Cluzeau F, Cutler D, et al (2017). Quality of healthcare in Ethiopia: mapping of interventions and the way forward. *Ethiopia Medical Journal* 50: 238–47.

Ethiopia Public Health Institute (2020). Covid-19 Guidelines. Available at: https://ephi.gov.et/public-health-emergency/covid-19/guidelines/. Accessed 02 April 2024.

Fenny AP, Asante FA, Otieku E, et al (2020). Attributable cost and extra length of stay of surgical site infection at a Ethiopiaian teaching hospital. *Infection Prevention in Practice* 2: 100045.

Gidey K, Gidey MT, Hailu BY, et al (2023). Clinical and economic burden of healthcare-associated infections: A prospective cohort study. *PLoS One* 18(2): e0282141.

Hutton G, Chase C, Kennedy Walker R (2024). Costs of Health Care Associated Infections from Inadequate Water and Sanitation in Health Care Facilities in Eastern and Southern Africa. Policy Research Working Paper 10708. Water Global Practice. Washington, D.C.: World Bank.

Hutton G (2012). Global costs and benefits of drinking-water supply and sanitation interventions to reach the MDG target and universal coverage. Department for Protection of the Human Environment, World Health Organization. WHO/HSE/WSH/12.01.

IHME (2014). Health Service Provision in Uganda: Assessing Facility Capacity and Costs of Care. Seattle, WA: Institute for Health Metrics and Evaluation (IHME).

ILOSTAT (2023). International Labour Organization. Labour Force Statistics database (LFS). ILOSTAT. Available at: ilostat.ilo.org/data. Accessed February 21, 2023.

Kariuki S, Kering K, Wairimu C, et al (2022). Antimicrobial resistance rates and surveillance in Sub-Saharan Africa: Where are we now? *Infect Drug Resist.* 15: 3589-3609.

Labi AK, Obeng-Nkrumah N, Owusu E, et al (2019). Multi-centre point-prevalence survey of hospital-acquired infections in Ethiopia. *J Hosp Infect.* 101(1): 60-68.

Leopold SJ, van Leth F, Tarekegn H, Schultsz C (2014). Antimicrobial drug resistance among clinically relevant bacterial isolates in sub-Saharan Africa: a systematic review. *J Antimicrob Chemother* 69(9): 2337-53.

Ministry of Health, Ethiopia (2019). National infection prevention and control (IPC) reference manual for healthcare service providers and managers. Vol 2. Available at: http://repository.iifphc.org/handle/123456789/667. Accessed 02 April 2024.

Ministry of Health, Ethiopia (2021a). Healthcare facilities WASH Guidelines. Available at: http://repository.iifphc.org/bitstream/handle/123456789/1680/National-HCF-WASH-guideline-ETHIOPIA-May-2021.pdf?sequence=1&isAllowed=y. Accessed 02 April 2024.

Ministry of Health, Ethiopia (2021b). Antimicrobial resistance prevention and containment strategies plan: The One Health approach, 2021-2025. Addis Ababa: WHO.

Ministry of Health, Ethiopia (2022). National WASH and Environmental Health Strategy (2021-2025). Available at: https://www.washinhcf.org/resource/national-wash-and-environmental-health-strategy-2021-2025-ethiopia/. Accessed 02 April 2024.

Ministry of Health, Ethiopia (2022). Health sector annual programme of work. 2021 *Holistic Assessment Report*. April 2022.

Murray, CJ, et al (2022). Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*, 399(10325), pp.629-655.

Newman MJ (2009). Nosocomial and community acquired infections in Korle Bu Teaching Hospital, Accra. *West Afr J Med*. 28(5): 300-303.

Onuzo CN, Sefogah PE, Nuamah MA, et al (2022). Surgical site infections following caesarean sections in the largest teaching hospital in Ethiopia. *Infect Prev Pract*. 4(2): 100203.

Otieku E, Fenny AP, Labi AK, et al (2023). Attributable patient cost of antimicrobial resistance: A prospective parallel cohort study in two public teaching hospitals in Ethiopia. *Pharmacoecon Open*. 7(2): 257-271.

Republic of Ethiopia (2017). National Action Plan for Antimicrobial Use and Resistance 2017-21. Ministry of Health, Ministry of Food and Agriculture, Ministry of Environment, Science, Technology and Innovation, Ministry of Fisheries and Aquaculture Development.

Sahiledengle B, Seyoum F, Abebe D, et al (2020). Incidence and risk factors for hospital-acquired infection among paediatric patients in a teaching hospital: a prospective study in southeast Ethiopia. *BMJ Open* 10: e037997.

Sunkwa-Mills G, Rawal L, Enweronu-Laryea C, et al (2020). Perspectives and practices of healthcare providers and caregivers on healthcare-associated infections in the neonatal intensive care units of two hospitals in Ethiopia. Health Policy Plan 35 (Supplement 1): i38-i50.

Tadesse BT, Ashley EA, Ongarello S, et al (2017). Antimicrobial resistance in Africa: a systematic review. *BMC Infect Dis* 17(616).

White Ribbon Alliance (2019). What Women Want survey: Demands for quality healthcare for women and girls. Washington DC: White Ribbon Alliance. Available at: https://www.whatwomenwant.org/ accessed February 21, 2023.

Annex 1: Notes to table 1

[a] Alemu et al (2020) conducted a meta-analysis of 18 studies in Ethiopia with 13,821 patients participated in the overall prevalence estimation. The pooled prevalence of healthcare-associated infection was 16.96% (95% CI 14.10–19.82). Specifically, surgical site infection (39.7%), urinary tract infection (27.7%), bloodstream infection (19.9%), dual infections (SSI and UTI) (14.0%), and respiratory tract (13.5%) were the commonest types of healthcare-associated infection.

[b] Systematic reviews of antimicrobial drug resistance in sub-Saharan Africa show that antimicrobial resistance varies widely for different first- and second-line drugs and across geographies from 0% to over 80% (Leopold et al, 2014; Tadesse et al, 2017; Kariuki et al, 2021). Berhe et al (2021) conducted a systematic review antimicrobial resistance and its clinical implications in Ethiopia. Antibiotic resistance varied between Gram-positive and Gram-negative bacteria. The highest number of Gram-positive isolates were S. aureus (n = 3470), S. pneumoniae (n = 775), and S. pyogenes (n = 118). For S. aureus, resistance to anti-Staphylococcal penicillins (oxacillin, cloxacillin, methicillin) ranged from 35 to 47% and high minimal inhibitory concentration to vancomycin was reported in 20%. Resistance to doxycycline (38%), tetracycline (52%), and TMP/ SMX (44%) were also alarmingly high. For S. pneumoniae, resistance to penicillin was noted at 25%, ceftriaxone at 10% and azithromycin at 28% (few isolates tested). For S. pyogenes, resistance to penicillin was noted at 24% and ceftriaxone at 26%. S. pyogenes resistance to amoxicillin/ clavulanic acid (32%), TMP/SMX (56%) and tetracycline (42%) were documented. Vancomycin resistance in Gram-positive bacteria varied from 8 to 20%. Over 50% of enterococcus species were resistant to ampicillin but vancomycin resistant enterococci prevalence was 8%. Antibiotic resistance profile of Gram-negative bacteria. Among Gram-negative bacteria, E. coli (n = 3151), P. aeruginosa (n = 857) and K. pneumoniae (n = 480) were the most common isolates with high resistance to the commonly used antimicrobial agents. Over 50% of K. pneumoniae, E. coli, Proteus, Enterobacter species, Citrobacter, Acinetobacter and Pseudomonas isolates were resistant to amoxicillin/clavulanic acid. Ceftazidime resistance was over 50% except for Pseudomonas, Proteus and Citrobacter. Resistance to ceftriaxone ranged between 38–74%. In addition, 14% of K. pneumoniae, 39% of P. aeruginosa and 35% of the Acinetobacter species isolates were carbapenemase resistant. For E. coli, the resistance rate for trimethoprim-sulfamethoxazole was 59%, ceftriaxone 38%, ciprofloxacin 26%, piperacillin-tazobactam 44%, and cefepime 25%. For P. aeruginosa, the resistance rate for ciprofloxacin was 20%, cefepime 56%, gentamicin 27%, piperacillintazobactam 33% (small numbers), and meropenem 39% (small numbers). For K. pneumoniae, the resistance rate for trimethoprim-sulfamethoxazole was 66%, ceftriaxone 56%, piperacillin-tazobactam 52%, cefepime 56%, and meropenem 14% (small numbers).

Murray et al (2022) report a systematic analysis of the global burden of bacterial antimicrobial resistance in 2019 and produce modelled estimates for resistance of several important pathogens to frontline drugs. From Murray et al, 2022, rates of resistance are the following for Ethiopia:

- Meticillin-resistant Staphylococcus aureus is 30-40%.
- Isoniazid and rifampicin co-resistant (excluding XDR) Mycobacterium tuberculosis is <5% f or all of Africa.
- Third-generation cephalosporin-resistant Escherichia coli is 50-60%.
- Carbapenem-resistant Acinetobacter baumannii is 20-30%.
- Fluoroquinolone-resistant Escherichia coli is 50-60%.

- Carbapenem-resistant Klebsiella pneumoniae is 10-20% in Ethiopia.
- Third-generation cephalosporin-resistant Klebsiella pneumoniae is >80% in Ethiopia.

[c] Due to lack of published data available on the total costs of treating HAIs, it is necessary to construct the cost based on the cost per hospital bed day, the additional length of stay due to HAI, and the costs of drugs, procedures and laboratory tests related to the HAI. AMR will also lead to longer length of stay, and additional costs of drugs, procedures and laboratory tests.

[d] The cost per bed day in 2022 is estimated using the 2011 cost in Uganda (IHME, 2014), updating to current prices using the GDP deflator for Uganda for 11 years, and then converting to Ethiopian Birr using the average exchange rate for 2022.

[e] Aerts et al (2022) for Mozambique, Gidey et al (2023) for Ethiopia and Bocoum et al (2019) for Mali, reflecting three ranges for different levels of care. Values in local currency were updated to 2022 costs and converted to Ethiopia Birr using PPP.

[f] Based on Ethiopia data, as follows. Gidey et al (2023) found average length of stay (ALOS) 8.3 days longer among patients with HAI than non-HAI patients (18.85 vs 10.59 days). Sahiledengle et al (2020) found ALOS was 11.5 days for paediatric admissions with HAI compared to 6.5 days for non-HAI, giving an addition ALOS of 5 days.

[g] Otieku et al (2023) found patients in the AMR cohort stayed approximately 5 more days compared with HAI patients and 8 more days compared with uninfected cohorts.

[h] An exploratory literature review with a focus on the nine countries of the Hutton et al (2023) study found seven studies. Two studies presented case fatality of only HAI patients, while five compared HAI and non-HAI patients. Differences in case fatality ranged from 4.2% to 14.6%, with two studies from Ethiopia with a difference of 6.9%.

[i] US$ 8 million value of statistical life (VSL) from the USA (Banzhaf, 2022) converted to Ethiopia based on GDP per capita differential with the USA and using an income elasticity of 1.5.

WaterAid is an international not-for-profit, determined to make clean water, decent toilets and good hygiene normal for everyone, everywhere within a generation. Only by tackling these three essentials in ways that last can people change their lives for good.

WaterAid