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Estimating the cost of interventions to improve water, sanitation and hygiene in healthcare facilities across India

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ABSTRACT

Introduction Despite increasing utilisation of institutional healthcare in India, many healthcare facilities (HCFs) lack access to basic water, sanitation and hygiene (WASH) services. WASH services protect patients by improving infection prevention and control (IPC), which in turn can reduce the burden of healthcare-associated infections (HAIs). However, data on the cost of implementing WASH interventions in Indian HCFs are limited.

Methods We surveyed 32 HCFs across India, varying in size, type and setting to obtain the direct costs of providing improved water supply, sanitation and IPC-supporting infrastructure. We calculated the average costs of WASH interventions and the number of HCFs nationwide requiring investments in WASH to estimate the financial cost of improving WASH across India's public healthcare system over 1 year.

Results Improving WASH across India's public healthcare sector and sustaining services among upgraded facilities for 1 year would cost US$354 million in capital costs and US$289 million in recurrent costs from the provider perspective. The most costly interventions were those on water (US$238 million), linen reprocessing (US$112 million) and sanitation (US$104 million), while the least costly were interventions on hand hygiene (US$52 million), medical device reprocessing (US$56 million) and environmental surface cleaning (US$80 million). Overall, investments in rural HCFs would account for 64.4% of total costs, of which 52.3% would go towards primary health centres.

Conclusion Improving IPC in Indian public HCFs can aid in the prevention of HAIs to reduce the spread of antimicrobial resistance. Although WASH is a necessary component of IPC, coverage remains low in HCFs in India. Using ex-post costs, our results estimate the investment levels needed to improve WASH across the Indian public healthcare system and provide a basis for policymakers to support IPC-related National Action Plan activities for antimicrobial resistance through investments in WASH.

Key questions

What is already known?

- The burden of healthcare-associated infections (HAIs) worldwide is substantial but poses the greatest risk to patients in low/middle-income countries (LMICs), where common lapses in infection prevention and control (IPC), such as poor hand hygiene, can lead to the spread of HAI-causing pathogens.
- Although adequate provision of water, sanitation and hygiene (WASH) is crucial to the appropriate practice of IPC, gaps in WASH infrastructure remain a significant problem in healthcare facilities (HCFs) of LMICs, and knowledge of the cost to implement WASH interventions in LMIC HCFs is lacking.

What are the new findings?

- Improving WASH coverage across the Indian public healthcare system over a 1-year period would require an estimated US$354 million in capital costs and US$289 million in recurrent costs.
- The most costly intervention would be on water service (US$238 million), followed by linen reprocessing (US$112 million), sanitation (US$104 million), surface cleaning (US$80 million), medical device reprocessing (US$56 million) and hand hygiene (US$52 million).
- Investments in primary health centres would account for the majority (US$336 million) of total costs, followed by district hospitals and medical colleges (US$178 million), and community health centres (US$129 million).

What do the new findings imply?

- The need for greater WASH investments in primary care facilities serving rural populations in India is an opportunity to address inequities in public healthcare financing through improvements in WASH.
- However, the immediate and long-term costs of these interventions would be substantial and would require a coordinated effort from all national and subnational levels of government willing to provide long-term political and financial commitments.
- Findings from this study can aid health policy planners allocate resources for future financing of WASH programs in HCFs and make informed decisions that improve the efficiency of healthcare delivery.

INTRODUCTION

Though essential to patient safety and universal health coverage, access to water, sanitation and hygiene (WASH) in healthcare facilities (HCFs) is poor in developing countries, especially in rural, public and primary healthcare.[1] WASH infrastructure provides the enabling

environment for healthcare workers to practice infection prevention and control (IPC), particularly basic practices, which require access to water, such as hand washing, medical device reprocessing and environmental surface cleaning. Inadequate WASH services and subsequent gaps in IPC increase patient risk for healthcare-associated infections (HAIs) and contribute to the growing problem of antimicrobial resistance (AMR).[1–5] Higher rates of HAIs can lead to more frequent use of antibiotics and an overdependence on antibiotic prophylaxis, thereby accelerating AMR.[6] Failures in WASH and IPC can also reduce institutional care-seeking, lower patient confidence in the healthcare system, and adversely impact individual and public health outcomes.[7 8] With healthcare utilisation on the rise in low/middle-income countries (LMICs), improving WASH services in HCFs is critical to reducing the burden of HAIs and ensuring patient safety.[9 10]

In India, more than one in four HCFs lack basic water service (ie, a water source within 500 m of the facility).[11] Sanitation coverage is especially low with only 55% of facilities having access to improved sanitation compared with the global average of 79% across LMICs.[12] Even in facilities where WASH infrastructure is available, the accessibility, quality and functionality of services are often inadequate and/or inappropriate (eg, lack of potable water or safe water storage).[13] Large discrepancies in WASH exist throughout the country with poorer WASH provision generally observed in rural as opposed to urban areas.[14–16] The need for water infrastructure and WASH-related IPC resources also depends on the scope of services provided at different levels of the healthcare system.[13] Compared with subcentres and primary health centres (PHCs), which deliver routine outpatient care to patients, secondary care and tertiary care facilities provide both inpatient and surgical care, which generally require more water-intensive IPC measures due to more invasive services offered.

The healthcare landscape in India has also changed in recent decades with the growth of the private sector in both outpatient and inpatient care.[17 18] Although the increasing trend towards utilisation of the private sector is pronounced across all wealth quintiles, it is the poor that still rely most heavily on the public healthcare system and government-funded insurance schemes.[17 18] However, public facilities are often overburdened, understaffed, and lacking in basic infrastructure and/or resources to deliver quality services; these bottlenecks in accessing quality healthcare force even the poorest populations to seek care in the private sector, which has some of the highest out-of-pocket expenditures in the world.[18 19] Thus, investing in WASH provision in the public sector needs to remain a government priority in order to ensure access and availability of quality, public healthcare services for all populations, especially those most vulnerable. At present, the only national iniative for WASH in HCFs is the Kayakalp programme launched in 2015 as an extension of Swachh Bharat Abhiyan (SBA), the nationwide campaign for universal sanitation coverage.

The unit costs of improving WASH in HCFs are largely unknown in LMICs at a facility, system and country level. While numerous cost studies in India exist for different tiers of healthcare services, healthcare providers and diseases,[20–26] little to no literature exists on the cost of improving WASH services in Indian HCFs. Rather, the majority of WASH-related cost studies in the Indian context are specific to the community setting,[27–30] and/or address only a component of WASH improvement.[28 31 32] Knowledge of the unit costs for various WASH interventions is important for budgeting and decision-making and can help policymakers in resource-limited settings strengthen health infrastructure for quality improvements in service and improve the efficiency of healthcare service delivery. Therefore, the purpose of this study was to estimate the financial cost of implementing WASH services across the Indian public healthcare system to inform allocation strategies of central and state governments responsible for the organisation and delivery of healthcare services.

METHODS

Study setting and aim

The Indian public healthcare system is organised into three principal levels of care: (1) PHCs, which are often the first point of contact for many patients, (2) community health centres (CHCs), which act as referral units for five or six PHCs, and (3) subdistrict/district hospitals (DHs) and tertiary care facilities (eg, medical colleges (MCs)), which provide specialised care to patients typically referred from primary or secondary health centres.[33] Though less regulated, the private sector is as equally extensive and commonly overburdened, with various forms of management from corporate networks and standalone hospitals to non-governmental/charitable HCFs.[19]

The aim of this study was to use ex-post, real-world costs to estimate the national financial cost (in 2018 prices) of implementing basic WASH interventions across the Indian public healthcare system for 1 year from the provider perspective. We emphasised interventions generally recognised as primary mediators in HAI incidence due to inadequate WASH. These include interventions on water—upgrading HCFs with below basic water service (eg, unimproved or limited service) to basic (ie, an improved water source on-site) and from basic water service to advanced (ie, an improved water source piped into the facility with additional collection points); interventions on sanitation—upgrading HCFs with below basic sanitation service to basic (ie, improved toilets present and separated for men/women and patients/staff); and interventions to improve access to hand hygiene infrastructure and the environmental decontamination of hospital surfaces, linens and medical equipment. Where applicable, we attempted to map interventions on water and sanitation to the WHO and UNICEF Joint Monitoring Programme (JMP) service ladder for WASH in

HCFs (table 1),[34] such that improvements to water and sanitation service levels would reflect 2030 Sustainable Development Goals (SDGs).[35]

Study HCFs

A total of 32 HCFs were selected by convenience sampling, although not all sampled HCFs were able to provide cost data for all interventions as detailed in online supplemental table 1. For analysis of facility-level cost data, specialised and tertiary facilities in the public and private sector were grouped with PHCs, CHCs, DHs or MCs based on their facility size and number of beds, which ranged from specialised facilities with 20–290 beds to large multispecialty and tertiary facilities with 500–3800 beds. HCFs were geographically dispersed throughout 11 cities within the northern states/territories of Uttar Pradesh, Haryana, Chandigarh and Delhi, four cities within the central eastern state of Chhattisgarh, and one city within the southern state of Telangana. Among the surveyed government-run facilities, PHCs and CHCs were located in rural areas, while DHs and MCs were predominantly located in urban areas. Privately run specialty and tertiary hospitals served both urban and semiurban areas.

Data collection

Using a survey questionnaire (appendix), we obtained ex-post cost data from March 2018 to September 2019 through interviews with hospital administrators and department officials (eg, stores, procurement, accounts, expenditure, hospital engineering and so on). We searched 2017–2018 expenditure reports and stock registers for cost information on consumables and other recurrent hospital supplies (eg, utility fees). For capital expenditures, including equipment and other non-consumables expected to last for more than 1 year, we searched expenditure reports and stock registers from previous years dating as far back as 1998. Data on outsourced services were obtained from contracts for the year 2018–2019. We also acquired information regarding facility size, hospital bed numbers and admission rates from hospital census records.

Costing method

Using the ingredients costing method,[36] we estimated the direct unit costs and 95% CIs of each WASH improvement based on the average price of each service unit, as described in online supplemental table 2, and the quantity expected at each facility type. Unit cost refers to the total expenditure incurred by the healthcare service provider for one unit of a particular service related to a WASH intervention. For each unit of service, we calculated both capital and recurrent costs. The total annual cost of consumables was extrapolated from the monthly or weekly unit costs reported at the facility level. The 95% CIs for each service unit were calculated from the SD of the sample mean only among facilities reporting cost data.

Facility cost of improving water

For interventions to improve access and availability of water, we estimated the costs of upgrading HCFs with below basic water service to basic defined as an improved water source on-site (eg, an on-premise tube well, borehole, piped water system and/or vended water), and calculated costs at the facility level as opposed to estimating increases in per-unit changes in the water supply. Because surveyed facilities each reported using combinations of different improved water supply, treatment, storage and removal systems, the average costs could not be calculated for all individual inputs. Therefore, all cost inputs for basic water service were combined at the facility level and then averaged across facilities to obtain the mean cost across surveyed facilities. This included the capital costs of materials, equipment, labour and installation, and the recurrent costs of operating and maintaining water quality/safety and utility fees. We assumed sanitation waste was collected in the same water sewage system prior to wastewater removal.

Table 1 WHO/UNICEF Joint Monitoring Programme service ladders for WASH in healthcare facilities

Service ladder	Water	Sanitation
No service	Water source is absent; or water is sourced from an unprotected dug well, spring or surface water	Unimproved or no latrines
Limited	An improved water source is present off-premise or within 500 m of the facility, but does not meet basic needs (eg, off-premise borehole)	Improved toilets or latrines are present but are not separate for men/women and patient/staff
Basic*	An improved water source on premise that meets basic needs (eg, piped water, borehole or vended water)	Improved toilets or latrines are present and separated for men/women and patients/staff
Advanced†	To be defined at national level	To be defined at national level

*Basic sanitation service was further defined as a minimum of four toilets per 20 patients (according to WHO standards) and staff to adjust for facility size.
†Advanced water service was defined in our study as an improved (potable) water source present on premise and piped into the facility with additional water collection points at points of care.
WASH, water, sanitation and hygiene.

Additionally, we calculated the average cost of further upgrading HCFs from basic water service level to advanced (ie, piped water distribution system) for all types of HCFs, as this would be necessary for implementation of water-intensive IPC interventions on hand hygiene and environmental decontamination. Service unit costs for installing a piped water distribution system were calculated at the facility level and included the combined capital costs of labour, equipment and materials, and the recurrent cost for maintenance staff, which were then averaged across facilities to obtain the mean costs of advanced water service.

Facility cost of improving sanitation

For interventions on sanitation, we evaluated the costs of upgrading HCFs with below basic sanitation service to basic (ie, improved toilets are separated for men/women and patients/staff), which we further define as a minimum of 4 toilets per outpatient department and 1 toilet per 20 inpatients according to WHO standards. Service unit costs were calculated for a single toilet and included the capital costs for equipment, labour and installation (eg, plumbing connection), as well as the recurrent costs for custodial services and repairs. To obtain facility-wide costs, we multiplied the unit cost per toilet by the quantity of toilets expected at each facility type to meet the minimum requirement for basic sanitation service.

Facility cost of improving hand hygiene

For interventions on hand hygiene, we assumed improved access to and availability of handwashing stations to meet WHO standards of 1 sink for every 10 inpatient beds, with an additional sink for every 4 toilets and 1 sink per outpatient department. We evaluated the cost per service unit of installing and maintaining a single handwashing station, including the capital costs of installation and equipment (eg, sinks and soap dispensers), and the recurrent costs of materials (eg, soap) and maintenance and repair staff. We then estimated the quantity of stations required to meet the minimum standard of 1 station per 10 patient beds and 1 additional station per department to calculate facility-wide costs.

Facility cost of improving environmental hygiene

For interventions on environmental decontamination, we evaluated the costs of interventions on three primary reservoirs: hospital surfaces, linens and medical devices. All costs associated with increasing access to and availability of detergents, low-level disinfectants, brooms, cloth and mops, as well as maintaining housekeeping staff to clean environmental surfaces periodically (ie, a minimum of at least once daily), were reported by hospitals as a combined monthly recurrent cost at the facility level. Similarly, recurrent costs associated with in-house linen reprocessing (eg, laundry staff, detergent and electrical fees) were reported as a monthly aggregate, while capital costs were calculated by summing the costs of machinery. For interventions on medical equipment reprocessing, recurrent costs included the combined monthly expense reported by HCFs for autoclave solution and high-level disinfectants for semicritical and critical devices. Capital costs included the median costs of an autoclave(s) or ethylene oxide steriliser(s). These costs were applied to all types of HCFs based on the essential medical equipment list provided by the Indian Public Health Standards for PHCs, CHCs and DHs.[37]

Facility cost estimates and adjustments

Where data were not available for a specific facility level, we scaled the cost of interventions using estimates of facility size and/or capacity, including the number of departments/wards, beds, toilets and hand hygiene stations (online supplemental table 3).[37] To calculate the number of toilets required at each facility level for the provision of basic sanitation services, we estimated the number of inpatient beds (as a proxy for patients), the number of staff, as well as the number of outpatient departments in each facility type requiring designated toilets for women and staff. For the development of hand hygiene cost estimates, the number of handwashing stations was adjusted based on the approximate number of beds reported by each facility type and the number of department or wards at each facility. Because we could not find data on the average number of department and wards in MCs, we used the average number of toilets and handwashing stations reported by surveyed MCs to generate these statistics. Finally, recurrent costs obtained from 2017 to 2018 expenditure reports were adjusted for inflation using India's Consumer Price Index to reflect 2018 prices (assuming an inflation rate of 4.86% in 2018).[38] Capital costs, however, could not be adjusted to 2018 prices because we did not collect the years in which capital expenditures were incurred. Conversion from Indian rupees (INR) to US$ used the exchange rate for the base year 2018 (US$1=68.389 INR).[39]

National cost of improving WASH

The cost of improving WASH for the entire Indian public healthcare system was calculated by multiplying the average cost of each intervention by the proportion of facilities requiring intervention (online supplemental table 4), which was estimated using India-specific data from current literature and reports of WASH in HCFs.[1 3 4 8 11–13 40–43] Because water-intensive IPC interventions require an advanced water service level, we included the cost of improving the water source in facilities with below basic service to basic and then to advanced when calculating national-level estimates. We then multiplied these values by the number of facilities reported nationally for each urban and rural facility type (online supplemental table 3) based on the most recently available data obtained from the Open Government Data Platform India and the Ministry of Health and Family Welfare (MoHFW).[44 45] Although only an aggregate value of the total number of urban health centres was available, we

applied the ratio of PHCs to CHCs in rural areas to urban centres and estimated the number of urban PHCs and CHCs to be 3547 and 778, respectively. We also assumed that all 1894 DHs (including subdistrict hospitals) were located in a metropolitan (urban) centre of the district headquarters. Twenty-nine government MCs located in predominantly rural states (eg, Assam, Bihar, Himachal Pradesh and Orissa) were assumed to serve rural populations, while the remaining 206 government MCs were assumed to be in urban settings.[46–48]

Sensitivity analysis

The main source of uncertainty in calculating national costs for improving WASH interventions across the Indian public healthcare system is in the lack of reliable estimates for the proportion of public HCFs in India requiring each WASH intervention type. Therefore, to test the sensitivity of our results, we conducted additional analyses varying the proportion of public HCFs requiring intervention based on the upper and lower uncertainty ranges as listed in online supplemental table 4.

Patient and public involvement

There were no funds or time allocated for patient and public involvement. Thus, we were unable to involve patients or the public in our research.

RESULTS

Water service intervention costs by facility type

Based on ex-post costs obtained from surveyed facilities, the estimated financial costs of improving facility-wide water services from unimproved or limited to basic and advanced are presented in table 2. Overall, DHs and MCs had the highest unit costs for implementation of an improved water source constructed on premise. Though DHs and MCs required far greater capital investments in water infrastructure (US$71 183 per DH; US$138 328 per MC) than PHCs and CHCs (US$5816 per PHC; US$8803 per CHC), the costs of annual recurrent expenses relative to capital investments were greater for PHCs and CHCs. Assuming all facilities have basic water service, the additional cost of upgrading PHCs, CHCs, DHs and MCs with basic water service to advanced required a capital investment of US$2742, US$3491, US$35 491 and US$23 123, respectively, and an annual expense of US$434, US$981, US$11 244 and US$5520, respectively.

Service unit and facility-level costs of sanitation and water-intensive IPC interventions by facility type and/or setting

The service unit costs of interventions on sanitation and water-intensive IPC interventions, used to estimate facility-wide costs, are shown in table 3. Notably, we observed wide CIs for the cost of each service unit. The capital cost of a single flush toilet ranged from US$303 in rural facilities to US$626 in urban facilities, while the capital cost of a single sink with soap ranged from an average of US$393 in rural facilities to US$432 in urban. In general, facility-level costs were greatest for MCs and DHs, followed by

Table 2 Costs of improving water services from unimproved or limited to basic or advanced

Facility	Service-level intervention*	Capital cost (95% CI)		Recurrent cost (95% CI)	
		Thousand INR	Thousand US$	Thousand INR	Thousand US$
PHC	Unimproved or limited to basic	398 (166 to 630)	5.82 (2.42 to 9.21)	122 (86 to 157)	1.78 (1.26 to 2.29)
	Basic to advanced	188 (151 to 224)	2.74 (2.20 to 3.28)	30 (28 to 32)	0.43 (0.41 to 0.46)
CHC	Unimproved or limited to basic	602 (473 to 731)	8.80 (6.92 to 10.68)	239 (180 to 298)	3.49 (2.63 to 4.35)
	Basic to advanced	239 (180 to 298)	3.49 (2.63 to 4.35)	67 (36 to 99)	0.98 (0.52 to 1.44)
DH	Unimproved or limited to basic	4868 (3689 to 6048)	71.18 (53.94 to 88.43)	720 (549 to 891)	10.53 (8.03 to 13.03)
	Basic to advanced	2427 (1135 to 3719)	35.49 (16.60 to 54.38)	769 (205 to 1333)	11.24 (2.99 to 19.49)
MC	Unimproved or limited to basic	9460 (8498 to 10 422)	138.33 (124.26 to 152.40)	1185 (1031 to 1338)	17.32 (15.08 to 19.56)
	Basic to advanced	1581 (1304 to 1859)	23.12 (19.07 to 27.18)	377 (327 to 428)	5.52 (4.78 to 6.26)

*Basic service includes piped potable water, water from a tube well/borehole or vended water on premise; advanced service includes a water distribution system piped into the facility. All cost inputs for basic water service and for advanced water service were combined at the facility level and then averaged across facilities to obtain the mean cost across surveyed facilities.
CHC, community health centre; DH, district hospital; INR, Indian rupee; MC, medical college; PHC, primary health centre.

Table 3 Service unit costs of interventions on sanitation and hospital hygiene

Intervention	Service unit	Facility	Capital cost* (95% CI)		Recurrent cost† (95% CI)	
			Thousand INR	Thousand US$	Thousand INR	Thousand US$
Sanitation	Flush toilet	Urban	43 (35 to 50)	0.63 (0.52 to 0.73)	17 (13 to 20)	0.25 (0.20 to 0.30)
		Rural	21 (8 to 34)	0.30 (0.11 to 0.49)	13 (7 to 19)	0.19 (0.10 to 0.28)
Hand hygiene	Handwashing station	Urban	30 (26 to 33)	0.43 (0.38 to 0.49)	4 (4 to 5)	0.07 (0.06 to 0.07)
		Rural	27 (19 to 35)	0.39 (0.27 to 0.51)	9 (6 to 11)	0.13 (0.09 to 0.16)
Linen reprocessing	In-house laundry machines	PHC	217 (140 to 295)	3.18 (2.05 to 4.31)	231 (83 to 379)	3.38 (1.21 to 5.54)
		CHC	303 (224 to 383)	4.44 (3.27 to 5.60)	628 (357 to 898)	9.18 (5.22 to 13.14)
		DH	1351 (946 to 1756)	19.76 (13.83 to 25.68)	3506 (2135 to 4877)	51.26 (31.21 to 71.31)
		MC	2604 (2337 to 2870)	38.07 (34.18 to 41.97)	3534 (2795 to 4272)	51.67 (40.87 to 62.47)
Medical device reprocessing	Sterilisation equipment	PHC	9 (6 to 12)	0.13 (0.09 to 0.17)	109 (35 to 184)	1.60 (0.51 to 2.69)
		CHC	102 (65 to 138)	1.49 (0.96 to 2.02)	287 (122 to 453)	4.20 (1.79 to 6.62)
		DH	800 (563 to 1037)	11.70 (8.23 to 15.16)	2692 (1130 to 4253)	39.36 (16.53 to 62.19)
		MC	1606 (1297 to 1915)	23.49 (18.97 to 28.00)	1866 (1573 to 2160)	27.29 (23.00 to 31.58)
Surface cleaning	Surface cleaning supplies	PHC	0	0	70 (10 to 129)	1.02 (0.15 to 1.89)
		CHC	0	0	313 (233 to 393)	4.58 (3.41 to 5.75)
		DH	0	0	1569 (1295 to 1842)	22.94 (18.93 to 26.94)
		MC	0	0	6369 (4650 to 8088)	93.13 (67.99 to 118.27)

*Capital costs, shown in 2018 prices, include the costs of equipment (toilet, sink, soap dispensers, washer/dryer/tumbler, autoclave/ethylene oxide steriliser) and installation.
†Recurrent costs, shown in 2018 prices, include the material costs of consumables (eg, soap, detergent, disinfectants), maintenance (eg, laundry and cleaning staff) and utilities.
CHC, community health centre; DH, district hospital; INR, Indian rupee; MC, medical college; PHC, primary health centre.

CHCs and then PHCs. Costs for linen reprocessing were greater than costs for medical device reprocessing across all facility levels, and both interventions required greater investment in recurrent costs relative to capital costs. The highest annual recurrent cost, however, was associated with enhanced surface cleaning in MCs, which required an average annual expense of US$93 130 per MC.

National costs of WASH interventions across India's public health sector

Extrapolating service unit and facility-level costs across urban and rural settings, we estimated the national cost of improving all WASH interventions (including advanced water service provision) for the first year would be US$643 (396–890) million (table 4 and figure 1), of which US$354 (229–478) million would be capital investment and US$289 (166–412) million would be recurrent costs. Rural facilities would compose the majority (64.4%) of total costs, with the greatest national level investments needed for PHCs (52.3%) as opposed to DHs/MCs (27.6%) and CHCs (20.1%). Advanced water service provision was the most costly intervention (US$238 million) followed by interventions on linen reprocessing (US$112 million), sanitation (US$104 million), surface cleaning (US$80 million), medical device reprocessing (US$56 million) and hand hygiene (US$52 million). However, national level costs would also differ widely by facility type (figure 1 and online supplemental table 5-7), with enhanced surface cleaning composing 23.9% of all national level costs for DHs/MCs, but only 6.1% for PHCs.

In sensitivity analysis, we varied the proportion of facilities that would require WASH intervention using the high and low uncertainty ranges. Our results found that the national cost of improving all WASH interventions would be US$958 (592–1324) million assuming upper limit estimates, and US$392 (244–539) million assuming lower limit estimates (online supplemental tables 8 and 9). In both scenarios, the majority of national costs would still be attributed to rural facilities and PHCs; interventions on water would remain the costliest, while interventions on hand hygiene and medical device reprocessing would remain the least costly. In contrast to our original results, sensitivity analysis using lower limit estimates found that the second most costly intervention would be sanitation, followed by surface cleaning and linen reprocessing. No other qualitative differences were found at the national cost level.

DISCUSSION

A 2016 report on the status of WASH in HCFs in India found common gaps in WASH provision across 12 districts including: inadequate access, quality and functionality of WASH infrastructure; shortages of cleaning staff, tools and supplies; poorly equipped handwashing stations; and less provisioning of WASH infrastructure and services in PHCs and CHCs compared with DHs.[13]

Table 4 National costs* in millions of implementing WASH interventions across the Indian public healthcare system

Intervention	Urban cost (95% CI)		Rural cost (95% CI)		Total cost (95% CI)	
	Million INR	Million US$	Million INR	Million US$	Million INR	Million US$
Water—basic†	1910 (1323 to 2498)	27.93 (19.35 to 36.52)	7133 (3938 to 10 328)	104.30 (57.58 to 151.02)	9044 (5261 to 12 826)	132.24 (76.93 to 187.55)
Water—advanced‡	1815 (1007 to 2623)	26.54 (14.73 to 38.35)	5441 (4256 to 6626)	79.55 (62.23 to 96.88)	7256 (5263 to 9248)	106.10 (76.96 to 135.23)
Sanitation	3518 (2874 to 4161)	51.44 (42.03 to 60.85)	3619 (1566 to 5673)	52.92 (22.89 to 82.95)	7137 (4440 to 9834)	104.36 (64.92 to 143.80)
Hand hygiene	1257 (1101 to 1414)	18.39 (16.10 to 20.68)	2303 (1629 to 2978)	33.68 (23.82 to 43.54)	3561 (2730 to 4392)	52.07 (39.91 to 64.22)
Linen reprocessing	3033 (1919 to 4146)	44.34 (28.07 to 60.62)	4637 (2488 to 6787)	67.81 (36.38 to 99.23)	7670 (4407 to 10 932)	112.15 (64.45 to 159.85)
Medical device reprocessing	959 (449 to 1468)	14.02 (6.57 to 21.47)	2842 (1130 to 4554)	41.56 (16.52 to 66.59)	3801 (1579 to 6023)	55.58 (23.09 to 88.06)
Surface cleaning	3157 (2377 to 3936)	46.16 (34.76 to 57.55)	2344 (1023 to 3666)	34.28 (14.96 to 53.60)	5501 (3400 to 7602)	80.44 (49.72 to 111.15)
Total	15649 (11 052 to 20 245)	228.82 (161.61 to 296.03)	28 320 (16 029 to 40 612)	414.10 (234.37 to 593.83)	43 969 (27 081 to 60 857)	642.92 (395.98 to 889.86)

*This includes capital and recurrent costs shown in 2018 prices and evaluated over a 1-year period.
†Water-basic intervention upgrades any HCFs with below basic water service (ie, unimproved or limited service) to basic (ie, an improved water source on-site).
‡Water-advanced intervention further upgrades HCFs from basic water service level to advanced (ie, an improved water source piped into the facility with additional collection points).
INR, Indian rupee; WASH, water, sanitation and hygiene.

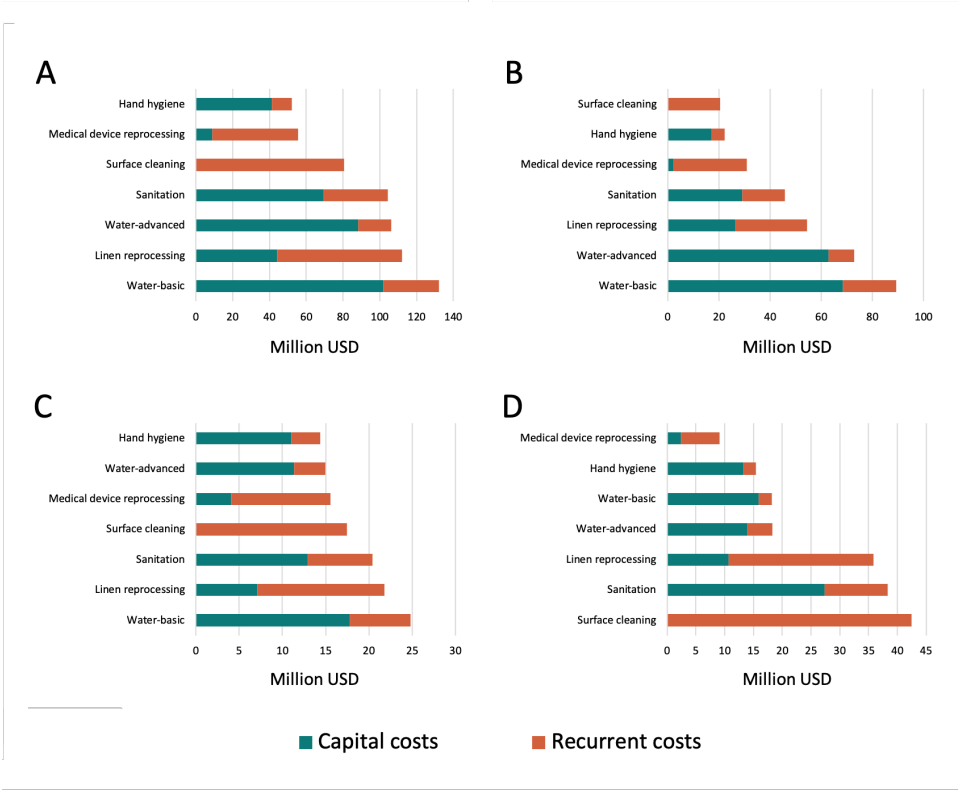

Figure 1 National costs of implementing water, sanitation and hygiene (WASH) interventions across the Indian public healthcare system for 1 year for (A) all healthcare facilities, (B) primary health centers only, (C) community health centers only, and (D) district hospital and medical colleges only. Each bar is the estimated financial capital and recurrent costs of implementing and sustaining interventions in WASH for a period of 1 year. Costs were estimated from ex-post, real-world costs obtained from a survey of 32 Indian heatlthcare facilities, and reported in US dollars (USD) based on 2018 prices.

Gaps in WASH provision do not only reflect the need for improvements but also the inequities in healthcare financing.[49 50] Adequate WASH infrastructure is required to ensure effective IPC programmes in healthcare settings, which have been demonstrated to reduce HAI rates and hospital costs[51] ; however, the cost of building WASH infrastructure and maintaining services nationwide is largely unknown.

We estimated the national financial costs of implementing and maintaining improvements in WASH services for the Indian public healthcare system over 1 year. Although DHs and MCs would require larger cost investments in WASH at the facility level, due to their relative size and complexity of services, the majority of investment at the national level would be needed to improve WASH in PHCs owing to the greater number of facilities lacking adequate services. Larger gaps in WASH provision in PHCs and CHCs would translate to greater investments for rural healthcare.[13] Although one-time capital costs would be substantial, particularly for improvements in water and sanitation, recurrent costs would compose roughly 44.9% of overall costs indicating the need for long-term WASH investments to achieve sustainable improvements nationwide.

The costs of upgrading HCFs to basic and advanced water service would be substantial but are necessary for implementing water-requiring IPC interventions, which can help prevent the spread of HAIs and potentially reduce transmission of drug-resistant pathogens. As non-communicable diseases become more common and device use increases, large improvements in IPC are possible through investments in hand hygiene and medical devices cleaning.[52–54] Costing studies of these interventions in LMICs, however, are few in number.[55] Our study found that increasing access and availability of handwashing stations and sterilisation equipment would be the two least costly interventions to implement (figure 1A). In comparison, improving water service to advanced service levels would be the costliest intervention but a necessary one for implementation of all other studied interventions. Improving access to sanitation facilities would also require large capital investments with high annual maintenance costs but could potentially reduce the burden of diarrhoeal diseases and HAIs,[4 56] preserve patient dignity, promote care-seeking behaviour among patients and restore faith in the healthcare system.[8 57–60] Overall, these results can be used to improve understanding of the cost-effectiveness of WASH interventions given their differences in implementation costs and their impact on IPC. However, estimates from this study only include the financial cost of improving access and availability to WASH infrastructure. They do not include the cost of increasing adherence to IPC guidelines like hand hygiene compliance, which would require

additional costs to promote behaviour change among staff.

Policy implications and strategies for implementation

Findings from our study highlight the urgent need to invest in WASH, particularly at the primary care level, which required the greatest proportion of WASH investment. Substandard WASH has impacts not only in PHCs, but also across the healthcare system as HAI pathogens can rapidly spread as patients move between facilities and communities. Moreover, because of the dichotomy between preventative services (provided by PHCs) and curative services (provided by some CHCs and most DHs), substandard WASH provision in PHCs can harm public perception of the value of preventative healthcare. In India, Panchayat Raj Institutions, a three-tiered system of local, self-governing bodies funded by state grants and local taxes, are responsible for the establishment of PHCs and the provision of essential services (eg, drinking water). To direct more funding towards WASH in PHCs, engaging Panchayat Raj Institutions is critical as they can help generate funds at the village level to support upkeep of WASH facilities in primary healthcare.

Improving budget allocation for WASH in HCFs alone is not enough. Lessons learnt from SBA demonstrate the need for major transformations in social-behavioural norms around cleanliness and hygiene alongside delivery of sanitation services.[61] Behavioural challenges such as the custom of open defecation, which has been observed in HCFs across India,[13] are especially common in rural areas, where investments in sanitation are most needed. Village Health Sanitation and Nutrition Committees can serve as a key resource in challenging these norms and optimising WASH uptake in HCFs through community action and participation.

The estimated first year cost to implement WASH improvements across the Indian public health sector would be roughly US$354 million and US$289 million in capital and recurrent costs, respectively. These costs are comparable to other national health schemes like Pradhan Mantri Jan Arogya Yojana (PMJAY), which seeks to provide free healthcare coverage for 40% of India's population. PMJAY was budgeted roughly US$936 million for 2019–2020,[62] suggesting that improving WASH in HCFs could be affordable if prioritised by the MoHFW. However, these improvements would need to be a coordinated effort for investments to be sustainable. While the construction of WASH facilities in HCFs is supported by the MoHFW's National Health Mission and fully funded by the central government, ongoing maintenance of health services (including WASH) is the responsibility of the state government. Thus, long-term political and financial commitment must come from all levels of government. At the facility level too, establishing and maintaining WASH provision require interfacility cooperation and support from top management, especially in large, multidepartment facilities. Despite these challenges to implementation, the consequences of poor WASH provision and compromised IPC on AMR pose a unique opportunity for policymakers to strategically address the need for WASH and IPC investment within the framework of India's National Action Plan on AMR in an effort to gain greater support from high-level officials. In particular, as LMICs like India scale up their AMR-National Action Plans, AMR sensitive interventions, which indirectly help contain AMR but are primarily for other objectives like improving WASH in HCFs,[63] will be critical to addressing the burden of resistance.

Limitations

We estimated financial costs, which unlike economic costs, do not include the opportunity costs of government-subsidised services not captured in this study. We also evaluated costs over 1 year only, which is useful for understanding where the greatest initial investments are needed, but is not realistic for actual financial planning or comparing life cycle costs of assets with different useful lives. Additionally, we included the cost of capital and recurrent inputs, but did not include the costs of management time to deliver capital infrastructure.

There were also limitations related to study design and challenges to data acquisition including the small sample size of surveyed facilities, which limited the generalisability of our data and led, in part, to wide CIs for each calculated service unit cost. We also used proxy measures to extrapolate the cost of interventions for specific facility levels where data were unreliable or unobtainable. Data were also scattered across HCFs in different departments and were not readily available in some HCFs like small private hospitals. Public sector engagement was also more difficult to obtain as HCF participation was voluntary, resulting in the use of both private and public sector data. This may have led to increased variability in the cost data as we expected more public facilities to have greater access to government-subsidised utilities, wholesale supply sources and purchasing cooperatives. For instance, the average cost per unit for toilets and sinks was lower for public than for private facilities, and only public tertiary hospitals reported free sewage disposal services. Furthermore, cost data reported by HCFs for surface cleaning and medical device reprocessing combined capital or aggregated monthly costs, limiting more granular cost analysis.

There were also a number of challenges in calculating national costs. First, the number of HCFs present in urban and rural settings was obtained from 2016 urban and 2017 rural health statistics and may be underestimated. Second, there were limited data on the proportion of HCFs requiring WASH interventions in existing literature, although our sensitivity analysis found that despite varying these proportions, the greatest national costs were still attributed to PHCs and rural HCFs. However, qualitative differences in the percentage of national costs attributed to sanitation, surface cleaning and linen reprocessing were noted, suggesting that more research on the current status of WASH service levels in HCFs could

improve national cost estimates for policy planning. Finally, we assumed that prices were rigid throughout our 1-year cost evaluation; and due to limitations in data collection, we were unable to apply 2018 market costs to capital expenditures, resulting in an underestimation of these costs.

CONCLUSION

This study is the first that we are aware of to estimate the national costs of implementing WASH interventions in HCFs across the Indian public health sector. Understanding the cost of interventions in relation to other competing needs is a necessary step in determining the cost-effectiveness of WASH interventions to reduce transmission of HAIs. These data can serve as grounds for policymakers to support IPC-related AMR National Action Plan activities through investments in WASH. By mapping interventions to the JMP service ladder for WASH in HCFs where possible, health policy planners and programme managers can use hospital cost information from this study to understand the efficiency of different WASH services across various settings in India, inform the allocation of resources for future financing of WASH programmes in HCFs and guide health interventions on a national level towards the targets set by the SDGs.

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Supplementary Materials for

Estimating the cost of interventions to improve water, sanitation, and hygiene in healthcare facilities across India

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Supplementary Tables

Supplementary Table 1. The number of surveyed public and private healthcare facilities with available cost data

		Public (n = 19)						Private (n = 13)		
Intervention	All (N = 32)	PHC (n = 3)	CHC (n = 3)	DH (n = 4)	MC (n = 3)	Specialty (n = 3)	Tertiary (n = 3)	MC (n = 2)	Specialty (n = 6)	Tertiary (n = 5)
Water-basic	31	3	3	3	3	3	3	2	6	5
Water-advanced	25	3	2	2	2	3	2	2	5	4
Sanitation (toilets)	13	1	0	1	0	0	3	1	3	4
Hand hygiene (sinks)	29	3	3	4	3	2	2	2	6	4
Hand hygiene (non-water-based materials)	30	3	2	4	3	3	3	2	5	5
Linen reprocessing (on-site)	25	2	3	2	3	3	2	2	5	3
Linen reprocessing (off-site/outsourced)	16	2	1	3	2	1	2	0	3	2
Medical device reprocessing	31	3	3	4	3	3	3	1	6	5
Disposable equipment	19	2	2	2	3	3	1	1	3	2
Surface cleaning	31	3	3	4	3	3	3	2	6	4
HAIs	11	0	0	1	0	0	2	1	2	5

Note: CHC = community health center, DH = district hospital, HCF = healthcare facility, MC = medical college, PHC = primary health centers.
[†] Basic service includes piped potable water, water from a tube well/borehole, or vended water on premise; advanced service includes a water distribution system piped into the facility.

Supplementary Table 2. Capital and recurrent inputs for estimating the cost of WASH interventions and service units

		Capital expenditures			Recurrent expenditures	
Intervention unit	Service unit	Inputs	Data source[a]	Expected life years [Reference]	Inputs	Data source[a]
Basic water service	Improved water source (tubewell/borehole or piped water) on premise	NA	NA	NA	Vended water service and delivery fee	2018-2019 contract
		Drilling rig, fuel, casing, piping, platform, pump, labor, and single maintenace charge for tubewell/borehole	1998-2018 expenditure reports (precise year unknown)	20 [1]	Staff salary for maintenance of tubewell/borehole	2017-2018 expenditure report and stock registers
		Connection to municipal water system for piped water	1998-2018 expenditure reports (precise year unknown)	40 [1]	Municipal or private water service/supply fee for piped water	2017-2018 expenditure report and stock registers
		Pipes, valves, fixtures, installation, and labor for water treatment system	1998-2018 expenditure reports (precise year unknown)	20-50 [2]	Water treatment and testing supplies; staff salary for maintenance, quality monitoring, safety, and protection of water treatment system	2017-2018 expenditure report and stock registers
		Water storage tank(s) and pump(s)	1998-2018 expenditure reports (precise year unknown)	20 [3]	NA	NA
		Septic tank and/or soak pits	1998-2018 expenditure reports (precise year unknown)	30 [1]	Staff salary for maintenance, quality monitoring, safety, and protection of sewage system	2017-2018 expenditure report and stock registers
		Connection to municipal sewage system	1998-2018 expenditure reports (precise year unknown)	40 [1]	Sewage disposal fee	2017-2018 expenditure report and stock registers

Advanced water service	Water distribution system (piped into the facility)	Pipes, valves, fixtures, installation, and labor	1998-2018 expenditure reports (precise year unknown)	50 [4]	Staff salary for maintenance	2017-2018 expenditure report and stock registers
Basic sanitation service	Flush toilet	Flush toilet, installation, plumbing connection, and labor	1998-2018 expenditure reports (precise year unknown)	20 [5]	Staff salary for toilet maintenance/repairs and sewage line maintenance	2017-2018 expenditure report and stock registers
Improved access to hand hygiene services	Handwashing station	Sink, installation, plumbing connection, labor, and 500 mL soap dispenser	1998-2018 expenditure reports (precise year unknown)	20 [Author's estimate]	Antiseptic hand-wash solution/soap (bar, liquid or foam), and staff salary for sink maintenance/repairs	2017-2018 expenditure report and stock registers
Improved access to linen reprocessing services	In-house laundry machines	Washer, hydro-extractor, tumbler, dryer, installation, and labor	1998-2018 expenditure reports (precise year unknown)	12 [6]	Laundry detergent, staff salary for laundry and maintenance, electrical fee	2017-2018 expenditure report and stock registers
Improved access to medical device reprocessing services	Sterilization equipment	Steam autoclave or ethylene oxide (EtO) sterilizer	1998-2018 expenditure reports (precise year unknown)	10 [7]	EtO kit, autoclave kit, high-level disinfectant, and staff salary for reprocessing	2017-2018 expenditure report and stock registers
Improved access to surface cleaning services	Surface cleaning supplies	NA	NA	NA	Detergent, low-level disinfectant, and custodial or other designated staff salary for cleaning environmental surfaces and spills	2017-2018 expenditure report and stock registers

Note: NA = not applicable, WASH = water, sanitation and hygiene.

[a] To adjust for inflation, recurrent costs incurred in different years were converted to the base year 2018 using India's consumer price index (CPI) obtained from the World Bank; capital costs could not be adjusted for inflation as data on the year costs were incurred were not collected.

Supplementary Table 3. Healthcare facility characteristics for the Indian public healthcare system

Estimated number	PHC	CHC	DH	MC
Urban HCFs	3,550	775	1,894	206
Rural HCFs	22,193	4,849	0	29
Outpatient departments	1	2	4	12
Licensed beds	5 (4-6)	30 (21-39)	300 (100-500)	800 (150-4,700)
Toilets	6	13	45	124
Handwashing stations	4	13	46	175

Note: CHC = community health center, DH = district hospital, HCF = healthcare facility, MC = medical college, PHC = primary health centers.

Supplementary Table 4. The proportion of healthcare facilities requiring improvements in WASH

	Urban cost (95% CI)				Rural cost (95% CI)			
	PHC	CHC	DH	MC	PHC	CHC	DH	MC
Water-basic	0.31 (0.11-0.49)	0.29 (0.09-0.48)	0.09 (0.02-0.29)	0.09 (0.02-0.29)	0.48 (0.31-0.65)	0.37 (0.20-0.54)	0.30 (0.13-0.47)	0.30 (0.13-0.47)
Water-advanced	0.52 (0.36-0.66)	0.79 (0.52-0.92)	0.19 (0.08-0.31)	0.19 (0.08-0.31)	0.95 (0.87-0.98)	0.64 (0.35-0.85)	0.43 (0.27-0.61)	0.43 (0.27-0.61)
Sanitation (unimproved to basic)	0.26 (0.17-0.33)	0.23 (0.15-0.29)	0.20 (0.13-0.25)	0.20 (0.13-0.25)	0.30 (0.22-0.41)	0.27 (0.20-0.37)	0.26 (0.17-0.33)	0.26 (0.17-0.33)
Sanitation (limited to basic)	0.53 (0.43-0.63)	0.47 (0.32-0.63)	0.37 (0.17-0.57)	0.37 (0.17-0.57)	0.49 (0.40-0.58)	0.46 (0.30-0.62)	0.39 (0.19-0.59)	0.39 (0.19-0.59)
Hand hygiene (unimproved to basic)	0.21 (0.10-0.37)	0.15 (0.05-0.28)	0.10 (0.01-0.19)	0.10 (0.01-0.19)	0.31 (0.21-0.56)	0.26 (0.16-0.51)	0.19 (0.09-0.44)	0.19 (0.09-0.44)
Hand hygiene (limited to basic)	0.22 (0.10-0.42)	0.26 (0.13-0.46)	0.30 (0.16-0.51)	0.30 (0.16-0.51)	0.25 (0.19-0.35)	0.25 (0.19-0.35)	0.25 (0.19-0.35)	0.25 (0.19-0.35)
Linen reprocessing	0.28 (0.13-0.53)	0.25 (0.10-0.50)	0.23 (0.08-0.50)	0.23 (0.08-0.50)	0.33 (0.18-0.58)	0.29 (0.14-0.54)	0.25 (0.10-0.50)	0.25 (0.10-0.50)
Medical device reprocessing	0.60 (0.39-0.78)	0.40 (0.22-0.61)	0.08 (0.01-0.33)	0.08 (0.01-0.33)	0.71 (0.45-0.88)	0.50 (0.27-0.73)	0.35 (0.18-0.57)	0.35 (0.18-0.57)
Surface cleaning	0.79 (0.63-0.91)	0.73 (0.56-0.86)	0.65 (0.52-0.80)	0.65 (0.52-0.80)	0.78 (0.45-0.94)	0.67 (0.35-0.88)	0.65 (0.45-0.85)	0.65 (0.45-0.85)

Note: CHC = community health center, DH = district hospital, PHCs = primary health centers, MC = medical colleges, WASH = water, sanitation and hygiene.

Supplementary Table 5. National costs[a] of implementing WASH interventions in primary health centers in India

	Urban cost (95% CI)		Rural cost (95% CI)		Total cost (95% CI)	
Intervention	Million INR	Million USD	Million INR	Million USD	Million INR	Million USD
Water-basic	572 (277-866)	8.36 (4.05-12.66)	5,532 (2,683-8,381)	80.89 (39.23-122.55)	6,104 (2,960-9,247)	89.25 (43.28-135.21)
Water-advanced	401 (329-472)	5.86 (4.82-6.91)	4,580 (3,763-5,396)	66.96 (55.02-78.90)	4,980 (4,093-5,868)	72.83 (59.84-85.81)
Sanitation	666 (544-788)	9.74 (7.96-11.52)	2,458 (1,063-3,853)	35.95 (15.55-56.35)	3,125 (1,608-4,641)	45.69 (23.51-67.87)
Hand hygiene	155 (135-174)	2.26 (1.98-2.54)	1,371 (970-1,773)	20.05 (14.18-25.92)	1,526 (1,105-1,947)	22.31 (16.16-28.46)
Linen reprocessing	446 (222-669)	6.52 (3.24-9.79)	3,283 (1,634-4,933)	48.01 (23.89-72.13)	3,729 (1,855-5,602)	54.52 (27.13-81.92)
Medical device reprocessing	252 (87-416)	3.68 (1.28-6.09)	1,863 (646-3,081)	27.24 (9.44-45.05)	2,115 (733-3,497)	30.93 (10.72-51.14)
Surface cleaning	195 (29-362)	2.86 (0.42-5.30)	1,207 (177-2,236)	17.64 (2.59-32.70)	1,402 (206-2,598)	20.50 (3.01-37.99)
Total	2,686 (1,624-3,748)	39.28 (23.75-54.81)	20,294 (10,936-29,653)	296.75 (159.91-433.59)	22,981 (12,560-33,401)	336.03 (183.65-488.40)

Note: INR = Indian Rupee, USD = United States dollar, WASH = water, sanitation and hygiene.
[a] This includes capital and recurrent costs evaluated over a one-year period.

Supplementary Table 6. National costs[a] of implementing WASH interventions in community health centers in India

	Urban cost (95% CI)		Rural cost (95% CI)		Total cost (95% CI)	
Intervention	Million INR	Million USD	Million INR	Million USD	Million INR	Million USD
Water-basic	189 (147-231)	2.76 (2.15-3.38)	1,508 (1,172-1,845)	22.06 (17.14-26.97)	1,697 (1,319-2,076)	24.82 (19.29-30.35)
Water-advanced	187 (132-243)	2.74 (1.93-3.55)	837 (472-1,201)	12.23 (6.91-17.56)	1,024 (604-1,444)	14.97 (8.83-21.11)
Sanitation	290 (237-343)	4.24 (3.46-5.02)	1,106 (478-1,733)	16.17 (6.99-25.34)	1,395 (715-2,076)	20.40 (10.46-30.35)
Hand hygiene	99 (87-112)	1.45 (1.27-1.63)	883 (625-1,142)	12.92 (9.13-16.70)	983 (712-1,254)	14.37 (10.41-18.33)
Linen reprocessing	180 (113-248)	2.64 (1.65-3.63)	1,310 (817-1,802)	19.15 (11.95-26.35)	1,490 (930-2,050)	21.79 (13.59-29.98)
Medical device reprocessing	121 (58-183)	1.76 (0.85-2.68)	943 (455-1,432)	13.80 (6.65-20.94)	1,064 (513-1,615)	15.56 (7.50-23.62)
Surface cleaning	177 (132-222)	2.59 (1.93-3.25)	1,018 (758-1,277)	14.88 (11.08-18.68)	1,195 (890-1,500)	17.47 (13.01-21.93)
Total	1,244 (905-1,582)	18.19 (13.24-23.14)	7,605 (4,777-10,432)	111.20 (69.85-152.54)	8,849 (5,683-12,015)	129.39 (83.09-175.68)

Note: INR = Indian Rupee, USD = United States dollar, WASH = water, sanitation and hygiene.
[a] This includes capital and recurrent costs evaluated over a one-year period.

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Supplementary Table 7. National costs[a] of implementing WASH interventions in district hospitals and medical colleges in India

	Urban cost (95% CI)		Rural cost (95% CI)		Total cost (95% CI)	
Intervention	Million INR	Million USD	Million INR	Million USD	Million INR	Million USD
Water-basic	1,150 (899-1,401)	16.82 (13.15-20.48)	93 (83-102)	1.35 (1.21-1.50)	1,243 (982-1,503)	18.17 (14.36-21.98)
Water-advanced	1,227 (546-1,908)	17.94 (7.99-27.89)	24 (20-29)	0.36 (0.30-0.42)	1,251 (566-1,936)	18.30 (8.28-28.31)
Sanitation	2,562 (2,093-3,030)	37.46 (30.61-44.31)	55 (24-87)	0.81 (0.35-1.27)	2,617 (2,117-3,117)	38.27 (30.96-45.58)
Hand hygiene	1,004 (879-1,128)	14.67 (12.85-16.50)	49 (34-63)	0.71 (0.50-0.92)	1,052 (913-1,191)	15.39 (13.35-17.42)
Linen reprocessing	2,407 (1,585-3,228)	35.19 (23.18-47.20)	44 (37-52)	0.65 (0.54-0.76)	2,451 (1,622-3,280)	35.84 (23.72-47.96)
Medical device reprocessing	586 (304-869)	8.57 (4.44-12.70)	35 (29-41)	0.52 (0.43-0.60)	622 (333-910)	9.09 (4.87-13.31)
Surface cleaning	2,784 (2,217-3,351)	40.71 (32.41-49.00)	120 (88-152)	1.76 (1.28-2.23)	2,904 (2,304-3,504)	42.46 (33.70-51.23)
Total	11,719 (8,523-14,915)	171.35 (124.62-218.09)	421 (316-526)	6.15 (4.62-7.69)	12,140 (8,838-15,441)	177.51 (129.24-225.78)

Note: INR = Indian Rupee, MC = medical college, USD = United States dollar, WASH = water, sanitation and hygiene.
[a] This includes capital and recurrent costs evaluated over a one-year period.

Supplementary Table 8. National costs[a] of implementing WASH interventions across the Indian public healthcare system assuming lower limit estimates of the proportion of HCFs requiring WASH intervention

	Urban cost (95% CI)		Rural cost (95% CI)		Total cost (95% CI)	
Intervention	Million INR	Million USD	Million INR	Million USD	Million INR	Million USD
Water-basic	517 (344-690)	7.56 (5.03-10.09)	4,416 (2,393-6,439)	64.57 (34.99-94.16)	4,933 (2,736-7,130)	72.13 (40.01-104.25)
Water-advanced	917 (545-1,290)	13.41 (7.97-18.86)	4,667 (3,717-5,616)	68.24 (54.35-82.12)	5,584 (4,262-6,906)	81.65 (62.32-100.99)
Sanitation	2,110 (1,724-2,496)	30.86 (25.22-36.50)	2,699 (1,168-4,230)	39.46 (17.07-61.86)	4,809 (2,892-6,727)	70.32 (42.29-98.36)
Hand hygiene	475 (416-534)	6.94 (6.08-7.81)	1,577 (1,115-2,039)	23.06 (16.31-29.82)	2,052 (1,531-2,573)	30.01 (22.39-37.62)
Linen reprocessing	1,116 (699-1,533)	16.32 (10.23-22.41)	2,441 (1,300-3,581)	35.69 (19.02-52.37)	3,557 (2,000-5,114)	52.01 (29.24-74.78)
Medical device reprocessing	303 (127-480)	4.44 (1.85-7.02)	1,709 (670-2,747)	24.98 (9.79-40.17)	2,012 (797-3,227)	29.42 (11.65-47.19)
Surface cleaning	2,519 (1,898-3,140)	36.83 (27.75-45.92)	1,311 (559-2,063)	19.17 (8.17-30.16)	3,830 (2,456-5,203)	56.00 (35.92-76.08)
Total	7,958 (5,752-10,164)	116.37 (84.11-148.62)	18,819 (10,922-26,717)	275.18 (159.70-390.66)	26,777 (16,674-36,880)	391.55 (243.82-539.28)

Note: CI = confidence interval, HCF = healthcare facility, INR = Indian Rupee, USD = United States dollar, WASH = water, sanitation and hygiene.
[a] This includes capital and recurrent costs evaluated over a one-year period.

Supplementary Table 9. National costs[a] of implementing WASH interventions across the Indian public healthcare system assuming upper limit estimates of the proportion of HCFs requiring WASH intervention

	Urban cost (95% CI)		Rural cost (95% CI)		Total cost (95% CI)	
Intervention	Million INR	Million USD	Million INR	Million USD	Million INR	Million USD
Water-basic	4,922 (3,578-6,265)	71.96 (52.32-91.61)	9,838 (5,474-14,202)	143.85 (80.04-207.67)	14,760 (9,052-20,467)	215.82 (132.36-299.27)
Water-advanced	2,729 (1,463-3,995)	39.90 (21.39-58.41)	5,870 (4,538-7,202)	85.83 (66.35-105.31)	8,599 (6,001-11,197)	125.73 (87.74-163.72)
Sanitation	4,759 (3,889-5,629)	69.59 (56.86-82.31)	3,962 (1,714-6,210)	57.93 (25.06-90.81)	8,721 (5,603-11,839)	127.52 (81.92-173.12)
Hand hygiene	2,247 (1,967-2,527)	32.86 (28.77-36.95)	2,999 (2,121-3,877)	43.85 (31.01-56.70)	5,246 (4,088-6,404)	76.71 (59.78-93.65)
Linen reprocessing	6,436 (4,091-8,781)	94.11 (59.82-128.40)	8,298 (4,467-12,129)	121.33 (65.32-177.35)	14,734 (8,558-20,910)	215.44 (125.14-305.75)
Medical device reprocessing	2,930 (1,456-4,404)	42.84 (21.28-64.40)	3,744 (1,512-5,977)	54.75 (22.11-87.39)	6,674 (2,967-10,381)	97.59 (43.39-151.79)
Surface cleaning	3,860 (2,917-4,804)	56.45 (42.65-70.24)	2,948 (1,324-4,572)	43.10 (19.36-66.85)	6,808 (4,241-9,376)	99.55 (62.01-137.09)
Total	27,883 (19,360-36,405)	407.70 (283.09-532.32)	37,659 (21,149-54,169)	550.66 (309.25-792.07)	65,542 (40,510-90,574)	958.37 (592.34-1,324.39)

Note: CI = confidence interval, HCF = healthcare facility, INR = Indian Rupee, USD = United States dollar, WASH = water, sanitation and hygiene

[a] This includes capital and recurrent costs evaluated over a one-year period.

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Appendix B

Cost-effectiveness questionnaire for water, sanitation, and hygiene interventions in the Indian public healthcare system.

Part I. General overview

The following questions are about the facility's general infrastructure, the population it serves, and the services provided.

No.	Question	Answer	Remarks/Notes
G1.1	What type of facility is this? • Sub-center • Primary health center • Community health center • Sub-district or district hospital • Tertiary hospital • Other (specify)		
G1.2	Is the facility in a rural or urban setting?		
G1.3	Is the facility a public or private institution?		
G2.1	What population does the facility serve (e.g., pregnant women, newborns, community)?		
G2.2	What is the size of the population, which this facility serves?		

No.	Question	Answer	Remarks/Notes
G2.3	This facility has ___ number of…	_____ Beds _____ Doctors _____ Nurses _____ Other:_____	
G3.1	Does the facility have multiple departments (e.g., OPD, IPD)?		
G3.2	Does the facility have an operation theatre?		
G3.3	Does the facility have specific facilities for deliveries (e.g., delivery suite, labour/delivery room, neonatal room, etc.)? If so, please describe.		
G3.4	Does the facility have specific care units for neonatal care (e.g., NICU, SNCU, nursery)? *NICU = neonatal intensive care unit *SNCU = sick newborn care unit		
G4.1	The facility offers the following outpatient department services (check all that apply): □ Maternity o Antenatal o Delivery including high risk pregnancy? Circle: Yes/No o Postnatal □ Neonatal □ Nursery □ General Medicine □ Obstetrics □ Gynaecology		

No.	Question	Answer	Remarks/Notes
	☐ Other: _____		
G4.2	The facility has the following inpatient department wards/rooms (check all that apply and provide the number of beds): ☐ Male medical: ___ beds ☐ Male surgical: ___ beds ☐ Female medical: ___ beds ☐ Female surgical: ___ beds ☐ Maternity ward: ___ beds ☐ Labour room: ___ beds ☐ Neonatal ward: ___ beds ☐ Neonatal intensive care ward: ___ beds ☐ Children ward: ___ beds ☐ Other: _____		
G4.3	The following procedures are available at the facility (check all that apply): <u>OPD/IPD procedures:</u> ☐ Bronchoscopy ☐ Endoscopy ☐ Dressing (small, medium and large) ☐ Injection (intramuscular and intravenous) ☐ Catheterization ☐ Nebulization ☐ Douche ☐ Blood Transfusion ☐ Hydrotherapy <u>Pediatric procedures specifically relating to newborn care:</u> ☐ Incubator		

No.	Question	Answer	Remarks/Notes
	□ Gases (oxygen) □ Intubation (endotracheal tube) □ Pulse oximeter □ Lumbar puncture □ Exchange transfusion □ Cut down (venouos) □ Plural/ascites tap □ Ventilator □ Live biopsy □ Neonatal resuscitation □ Care of sick new born □ Management of complications through SNCU (Sick Newborn Care Unit) <u>Obstetric & Gynecology specialist services:</u> □ Forceps delivery □ Craniotomy-dead fetus/hydrocephalus □ Caesarean section □ Suturing perineal tears □ Caesarian hysterectomy □ Ectopic pregnancy ruptured & unruptured □ Retained placenta □ Suturing cervical tear □ Colposcopy		
G4.4	If a labor ward, neonatal or special newborn care unit exists, which of the following equipment is present in the facility? □ Baby incubators □ Neonatal resuscitation kit		

No.	Question	Answer	Remarks/Notes
	☐ Neonatal laryngoscope ☐ Newborn care equipment ☐ Delivery kit ☐ Episiotomy kit ☐ Forceps delivery kit ☐ Nebulizer baby ☐ CPAP machine ☐ Weighting machine infant ☐ BP apparatus & stethoscope ☐ Infusion pump or syring pump ☐ Suction machine ☐ Digital thermometer ☐ Other:_____ *>> Proceed to "Part II. Water Source"*		

Part II. Water source

The purpose of the following questions is to determine the main source of water for the healthcare facility, the cost of water provision and infrastructure, and the quality and availability of water.

No.	Question	Remarks/Notes
W1	What is the primary source of water for the facility? Please circle one of the following: Piped water into facility[a] >> *Go to W2.1* Piped water to plot/yard[b] >> *Go to W2.1* Tubewell or borehole[d] >> *Go to W3.1* Cart with small tank/drum[e] >> *Go to W4.1* Tanker-truck[f] >> *Go to W4.1* Dug well >> *Go to W5.1* Public tap or standpipe[c] >> *Go to W6.1* Other: _____ >> *Go to W6.1* Definitions*:* [a] **Piped water into facility**: a water service pipe connected with in-facility plumbing to one or more taps [b] **Piped water to yard/plot**: a piped water connection to a tap placed in the yard or plot outside the facility [c] **Public tap or standpipe**: a public water point from which people can collect water (e.g., a public fountain)	

	[d] **Tubewell or borehole**: a deep hole that has been driven, bored or drilled, to reach groundwater supplies. These are constructed with casing or pipes, which prevent the hole from caving in and protects the water source from run-off water. Water is delivered from a tubewell/borehole through a pump and is protected by a platform around the well to divert spilled water and to protect the well head from runoff water. [e] **Cart with small tank/drum**: water sold by a provider who transports water to the community or facility site [f] **Tanker-truck**: water is trucked into a community or facility site and sold from the water truck.		
W2.1	Is the water service pipe connected to the municipal water system or a private water system? *If neither, please describe how the water service pipe is connected to the water source.*		
W2.2	What is the cost of connecting the water service pipe to the water system?		
W2.3	What is the monthly or annual utility fee for water service?		
W2.4	What are the costs associated with installing the water service pipe, water distribution pipes, and pipe fixtures? This includes the cost of labor and materials – e.g., tubing, valves, pressure bladder tank, pressure switch, pipes/fittings, etc. For water piped into the facility, include the cost of any additional equipment and labor needed to connect to the facility's plumbing.		
W2.5	If an operating theatre exists, does it have a piped water supply directly into the department? If so, is there a provision of both cold and hot water?		

	Does this water undergo further treatment? If so, please describe.		
W2.6	If an operating theatre exists, what are the additional costs for supplying water to the operation theatre, treating the water, and providing hot water? *>> Go to W7.1*		
W3.1	Is the borehole/tubewell located on the facility's premises?		
W3.2	Is the borehole/tubewell in working condition?		
W3.3	What are the costs associated with installing the borehole or tubewell? This includes the following: • Cost of renting a drilling rig and purchasing fuel for the rig • Cost of casing/piping (e.g., concrete lining) and platform around the well head • Cost of pump (e.g., hand, electric, etc.) • Cost of labor *>> Go to W7.1*		
W4.1	Is water sold by a public or private provider?		
W4.2	How does the provider transport the water (e.g., cart with small tank/drum, tanker truck, or other)?		
W4.3	Does the provider transport the water directly to the facility's premises or to a community site?		

W4.4	If transported to a community site, how is the water then transported to the facility, and what are the associated costs including equipment and labor/staff?		
W4.5	How often does the facility purchase water from the provider (e.g., daily, weekly, etc.)?		
W4.6	On average, what is the amount of water the facility purchases from the provider (e.g., daily, weekly, etc.) and what is the cost of purchasing and delivering water? *>> Go to W7.1*		
W5.1	Is the dugwell located on the premises/in the plot or yard? (Yes/No) *>> If no, go to W7.1*		
W5.2	What is the cost of constructing the dugwell? This includes the cost of materials (e.g., shovels) and labor.		
W5.3	Is the dugwell protected with a well lining/casing raised above ground level, a platform to divert spilled water, AND a cover to protect the well head from run-off water? *>> If no (unprotected), go to W7.1*		
W5.4	What is the cost of protecting the dugwell? This includes the cost of materials and labor.		
W6.1	Please describe how water is sourced and transported to the facility.		
W6.2	What is the cost of obtaining and/or transporting water (e.g. materials, labor, etc.)?		

W7.1	Does an overhead water storage tank(s) exist on the premises? (Yes/No) If so, specify the **type**, **size** and **number** of storage units. Examples of storage units include: • Jerry cans • Plastic water tank 500-5,000 L • Steel water tank 5,000-10,000 L • Small storage tanks less than 55 (specify size) • Large temporary storage tanks (e.g., bladder tank, onion tank, etc.) *>> If no, go to W8.1*		
W7.2	Is the overhead tank's capacity sufficient? (Yes/No)		
W7.3	What is the cost per unit for the overhead tank?		
W7.4	Does a pump for the overhead tank exist? (Yes/No) *>> If no, go to W8.1*		
W7.5	Is the pump in working condition? (Yes/No)		
W7.6	What is the cost per unit for the pump?		
W8.1	Is water supplied to the facility from a safe source free from fecal/faecal contamination?		
W8.2	Is water supplied to the facility considered low-quality/non-potable or high-quality/potable (e.g., low turbidity and low organic matter)?		

W8.3	Is the quality of the water supplied to the facility monitored regularly, and is there adequate maintenance of water storage and distribution to avoid contamination?		
W8.4	If so, what is the cost of maintaining water safety and protection from decontamination?		
W8.5	If necessary, can water be treated at the facility? *>> If no, go to W8.10*		
W8.6	If water is treated at the facility, please describe the water treatment process (e.g., sedimentation and/or filtration of turbid water, disinfection with chlorine, etc.).		
W8.7	What are the costs of the treatment process including materials/equipment and installation?		
W8.8	Is the treatment process operated effectively? (Yes/No) Are there sufficient supplies and adequately trained staff? (Yes/No) Is there regular and adequate monitoring of the treatment process and the quality of treated water? (Yes/No)		
W8.9	What are the cost of training/staffing for maintaining operations and monitoring water treatment and quality?		
W8.10	Does water meet WHO guidelines or national standards for safe drinking/potable use? (Yes/No)		
W8.11	If not, is there a safe alternative supply of drinking-water? (Yes/No)		

	If so, please describe. What are the costs of a safe alternative supply of drinking water?		
W8.12	Is the water supply designed and built so that low-quality (non-potable) water used for cleaning, laundry, etc. cannot enter the potable/drinking water supply?		
W9.1	Is there sufficient and reliable potable/drinking water available at all times (round-the-clock) for all needs (e.g., drinking, food preparation, personal hygiene, medical use)? *If no, please explain.*		
W9.2	Is there sufficient and reliable water available for non-potable use? (Yes/No) *If no, please explain.*		
W9.3	Are there 24 hrs of uninterrupted running water supply? *If no, approximately how many hours of the day is water supply available?*		
W10.1	Is there a drainage/sewage system in place for waste water, surface water, and/or subsoil water? (Yes/No) *If no, describe how wastewater is disposed or managed if at all.* *>> then proceed to "Part III. Sanitation facilities"*		
W10.2	If a drainage system exists, is wastewater removed to an off-site sewer? (Yes/No)		

	>> If no, go to *W10.7*		
W10.3	Is the drainage/sewage pipe connected to the municipal sewage system or a private sewage system? *If neither, please describe.*		
W10.4	What is the cost of connecting the drainage/sewage pipe to the sewage system?		
W10.5	What is the monthly or annual utility fee for sewage disposal service, if any?		
W10.6	Are there additional costs associated with installing the drainage/sewage pipes? This includes the cost of labor, maintenance, and equipment – e.g., tubing, valves and fixtures.		
W10.7	For on-site wastewater disposal, what type of drainage system is used (e.g., soak-pit)? What are the costs associated with construction and maintenance of the drainage system? *>> Proceed to "Part III. Sanitation facilities"*		

Part III. Sanitation facilities

The purpose of the following questions is to determine the type of sanitation facilities used by patients and staff at the healthcare facility, and the costs of constructing and maintaining these sanitation facilities.

No.	Question	Remarks/Notes
S1	What type of toilet facility do patients and staff in the facility use? Please circle one of the following: Flush/pour-flush *>> Go to S2.1* Ventilated improved pit latrine (VIP) *>> Go to S3.1* Pit latrine with slab *>> Go to S3.1* Pit latrine without slab/open pit *>> Go to S3.1* Hanging toilet/hanging latrine *>> Go to S3.1* Other: _____ *>> Go to S3.1* No facilities *>> If no sanitation facilities exist, proceed to "Part IV. Hand Hygiene"*	

No.	Question	Answer	Remarks/Notes
S2.1	What type of flush/pour-flush toilet is used in the facility?		
S2.2	How many toilets exist in the facility?		
S2.3	Are toilets in working condition? (Yes/No)		
S2.4	Are toilets separated for men and women AND for patient and staff? (Yes/No)		
S2.5	What is the ratio of toilets to persons in the facility? Does this ratio meet WHO standards of 1 toilet per 20 people? (Yes/No)		
S2.6	What is the cost of installing a single toilet facility including equipment costs and costs of labor?		
S2.7	Where does the flush/pour-flush toilet facility flush to? • Piped sewer system (plumbing) • Septic tank • Pit latrine • Other (describe)		
S2.8	What is the cost of installing the aforementioned sanitary sewer system? This includes cost of labor and equipment for installation.		
S2.9	What are the costs of maintaining working conditions and cleanliness of sanitation facilities? *>> Proceed to "Part IV. Hand Hygiene"*		
S3.1	Describe the type of toilet facility that is used, and the number of facilities available on the premises.		

S3.2	What are the costs of constructing this type of toilet facility on the premises? This includes the cost of labor and materials.		
S3.3	Is there a sewage disposal system in place? (Yes/No) If so, please describe.		
S3.4	If a sewage disposal system exists, what are the costs of constructing and maintaining this system? *>> Proceed to "Part IV. Hand Hygiene"*		

Part IV. Hand hygiene

The purpose of the following questions is to determine the type and availability of hand hygiene stations used by patients and staff at the healthcare facility, and the costs of constructing and maintaining hand hygiene stations.

No.	Question	Answer	Remarks/Notes
H1.1	A hand hygiene stations is defined as a basin with water AND soap available. Do hand hygiene stations exist at the facility? (Yes/No) *>> If no hand hygiene stations exist, proceed to "Part V. Environmental Cleaning"*		
H2.1	Are hand hygiene stations located in the facility or outside the facility?		
H2.2	How are hand hygiene stations constructed? Examples of basins include: • Sink/basin with faucet and drain • Bucket with lid, spigot, metal frame, and basin • Other (describe)		
H2.3	Are the hand hygiene station(s) connected to the facility's plumbing/drainage system? (Yes/No)		
H2.4	Are hand hygiene stations in working condition? (Yes/No)		
H2.5	In what form is soap/handwashing detergent available (e.g., bar, liquid or foam)?		
H2.6	If a soap bottle dispenser or wall dispenser exists, provide the size/volume and number of dispensers available.		

No.	Question	Answer	Remarks/Notes
H3.1	What are the costs of constructing a single hand hygiene station? This should include the cost of: • Installation (labor and equipment) • Sink/basin • Connecting to the drainage/plumbing system if applicable • Soap • Soap dispensers if applicable		
H3.2	Is there a hand hygiene station available within 5 meters of each toilet facility?		
H3.3	Point of care is defined as any location where care or treatment is delivered to a patient from a health care worker. Is there a hand hygiene station available at all points of care? (Yes/No)		
H3.4	If inpatient wards exist, what is the ratio of hand hygiene stations to beds?		
H3.5	If inpatient wards exist, are there at least 2 hand hygiene stations in wards with 20 or more beds?		
H3.6	Are there additional hand hygiene materials available at points of care or toilet facilities? If so, please describe the materials and where they are located in the facility (e.g., high-traffic areas, bedside, personal carriage, etc.). Examples of additional materials are:		

No.	Question	Answer	Remarks/Notes
	• Antiseptic/Alcohol-based hand-rub (ABHR) • Personal protective equipment gloves • Surgical hand-rub solution • Other (please specify)		
H3.7	If alcohol-based hand-rub exists, is it purchased from a vender or produced in-house?		
H4.1	If additional hand hygiene materials exist, what are the costs of providing these materials? This should include the itemized cost of: • In-house production of ABHR (e.g., supplies and production staff) if applicable • Commercially purchased ABHR • Surgical hand-rub solution • Dispensers for hand-rub solution including type, size/volume, and the number of dispensers • Personal protective equipment gloves *>> Proceed to "Part V. Environmental Cleaning"*		

Part V. Environmental cleaning

The purpose of the following questions is to determine the methods and levels of environmental cleaning practiced in the healthcare facility, and the costs of maintaining environmental cleanliness.

No.	Question	Answer	Remarks/Notes
E1.1	Are floors dry swept daily? (Yes/No) If so, what is the cost of this activity including equipment (e.g., broom and dustbin) and custodial staff?		
E1.2	Are floors wet mopped daily with detergent? (Yes/No) If so, what is the cost of this activity including equipment (e.g., mop and detergent) and custodial staff?		
E1.3	Are environmental surfaces (e.g., counters, chairs, tables, etc.) cleaned daily? (Yes/No) If so, what is the cost of this activity including equipment (e.g., cloths, surface wipes, disposable napkins, detergent, etc.) and custodial staff?		
E1.4	Are high-touch surfaces and non-critical medical devises (e.g., stethoscope, blood pressure cuff, etc.) cleaned daily with a low-level disinfectant? (Yes/No) If so, what is the cost per unit of low-level disinfectant?		
E2.1	Is laundry outsourced or washed on-site?		

No.	Question	Answer	Remarks/Notes
E2.2	If outsourced, what is the cost per kilogram of laundry services? And are there additional fees for laundry pick-up and delivery?		
E2.3	On average, how many kilograms of laundry are washed (daily, weekly, etc.)?		
E2.4	If washed on-site by hand, what is the cost of equipment (e.g., laundry detergent, wash basins) and laundry staff to perform these functions?		
E2.5	If washed on-site with laundry washer and dryer: • What is the cost of laundry detergent? • What is the cost of laundry staff to perform these functions? • What is the cost of a washer, hydroextractor, tumbler, and calendar dryer • What is the cost of installation? • What are the electrical fees for running the equipment?		
E3.1	How are semi-critical medical devices disinfected (e.g., high-level disinfectant)?		
E3.2	If high-level disinfectant is used, what is the cost of high-level disinfectant solution?		
	How are critical medical devices sterilized? Examples include: • Cleaning with soap and water only • Boiling in pot of water		

No.	Question	Answer	Remarks/Notes
	• Soaking in high-level disinfectant • Sterilizing with pressure cooker • Sterilizing with steam-pressure autoclave • Other (describe)		
E3.3	What is the cost of sterilization including equipment (e.g., pressure cooker, fuel if non-electric, autoclave, etc.) and staffing?		

E4.2 Are the following disposable medical devices/equipment available?

Check all that apply and provide the cost of each unit item:

Item	Cost	Unit	Quantity
☐ Sterile gloves			
☐ Latex surgical gloves			
☐ Drapes			
☐ Gowns			
☐ Masks			
☐ Forceps			
☐ Blades			
☐ Cord clamp			
☐ Dee Lee's mucus trap			
☐ Intravenous catheters (e.g., 24G)			
☐ Tubing			
☐ IV sets			
☐ Clean birth kits			
☐ Micro drip set with/without burette			
☐ Blood transfusion set			
☐ 3-way stop cock			
☐ Suction catheter size # 10, 12 Fr			
☐ Endotracheal tube size # 2.5, 3, 3.5 mm			
☐ Feeding tube size # 5, 6, 7 Fr			
☐ Tuberculin syringes 1, 2, 5, 10, 50 cc with 22, 24, 26 G needle			
☐ Glucostic and multistix strips			
☐ Capillary tubes for microhaematocrit			

No.	Question	Answer	Remarks/Notes
	☐ Cotton, surgical gauze ☐ Normal saline, 10% dextrose infusion bottle ☐ Other _____		

Part VI. Healthcare costs

The purpose of the following questions is to determine the costs of treatment for hospital-acquired infections in the healthcare facility among mothers and neonates. Costs can be reported per case or per inpatient day (should the respondent provide the average hospital length of stay) and when possible, should include the cost of (1) hospitalization, (2) diagnostic tests, and (3) treatment (e.g., drug doses) among other direct medical costs.

No.	Question	Answer	Remarks/Notes
T1.1	What is the average cost per case of treating intrapartum chorioamnionitis after caesarean delivery?		
T1.2	What is the average cost per case of treating postpartum endometritis after caesarean delivery?		
T1.3	What is the average cost per case of treating a surgical site infection resulting from an episiotomy?		
T1.4	What is the average cost per case of treating a surgical site infection resulting from a caesarean section?		

No.	Question	Answer	Remarks/Notes
T1.5	What is the average cost per case of treating a skin and soft tissue infection resulting from a caesarean section?		
T1.6	What is the average cost per case of treating postpartum (or puerperal) sepsis in mothers?		
T2.1	What is the average cost per case of treating neonatal early-onset septicemia?		
T2.2	What is the average cost per case of treating neonatal late-onset septicemia?		
T2.3	What is the average cost per case of treating a bacterial catheter-associated urinary tract infection (CAUTI) in a newborn?		

No.	Question	Answer	Remarks/Notes
T2.4	What is the average cost per case of treating a bacterial bloodstream infection (BSI) in a newborn?		
T2.5	What is the average cost per case of treating ventilator-associated pneumonia (VAP)?		
T2.6	What is the average cost per case of treating hospital-acquired pneumonia (HAP)?		

>> End of questionnaire.