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Environmental conditions in health care facilities in low- and middle-income countries: Coverage and inequalities

Ryan Cronk, Jamie Bartram*

The Water Institute, University of North Carolina, Chapel Hill, NC, United States

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ABSTRACT

Safe environmental conditions and the availability of standard precaution items are important to prevent and treat infection in health care facilities (HCFs) and to achieve Sustainable Development Goal (SDG) targets for health and water, sanitation, and hygiene. Baseline coverage estimates for HCFs have yet to be formed for the SDGs; and there is little evidence describing inequalities in coverage. To address this, we produced the first coverage estimates of environmental conditions and standard precaution items in HCFs in low- and middle-income countries (LMICs); and explored factors associated with low coverage. Data from monitoring reports and peer-reviewed literature were systematically compiled; and information on conditions, service levels, and inequalities tabulated. We used logistic regression to identify factors associated with low coverage. Data for 21 indicators of environmental conditions and standard precaution items were compiled from 78 LMICs which were representative of 129,557 HCFs. 50% of HCFs lack piped water, 33% lack improved sanitation, 39% lack handwashing soap, 39% lack adequate infectious waste disposal, 73% lack sterilization equipment, and 59% lack reliable energy services. Using nationally representative data from six countries, 2% of HCFs provide all four of water, sanitation, hygiene, and waste management services. Statistically significant inequalities in coverage exist between HCFs by: urban-rural setting, managing authority, facility type, and sub-national administrative unit. We identified important, previously undocumented inequalities and environmental health challenges faced by HCFs in LMICs. The information and analyses provide evidence for those engaged in improving HCF conditions to develop evidence-based policies and efficient programs, enhance service delivery systems, and make better use of available resources.

1. Introduction

Safe and adequate environmental conditions in health care facilities (HCFs) – including the availability of water, sanitation, hygiene, energy, and waste management – and the availability of standard precaution items (e.g. disposable gloves) are essential to protect and improve the health of patients, staff, visitors, and the wider community.

In low-income countries, the prevalence of health care acquired infection (HCAI) is estimated to be 16% (Allegranzi et al., 2011). Many HCAIs are attributable to inadequate environmental conditions and insufficient availability of standard precaution items (Anaissie et al., 2002; Borg, 2009; Galadanci et al., 2011; Leslie et al., 2016; Li et al., 2017; Moffa et al., 2017). Inadequate environmental conditions and insufficient availability of standard precaution items in HCFs contribute to infection through contaminated water, hands, fomites, food, medical equipment, inadequate sharps and infectious waste disposal, and unsafe blood transfusions. Associated adverse health outcomes include gastrointestinal, respiratory, surgical site, burn wound, and sharps-related infections (World Health Organization, 2008).

Adequate hand hygiene, such as handwashing with soap, is a cost-effective practice for preventing infection in health care settings (World Health Organization, 2008). However, several hundred million patients annually acquire infections arising from poor handwashing practices – in part to the lack of available handwashing materials and facilities (World Health Organization, 2009). Compliance with handwashing standards among health care providers is often low and health care providers often transmit infection (Erasmus et al., 2010). Because of these deficiencies, HCFs serve as foci for infection and patients seeking treatment fall ill, and potentially die, for the lack of basic elements of a safe and clean environment (Bartram et al., 2015).

Establishing and maintaining a safe health care environment is a fundamental consequence of the Hippocratic oath: *primum non nocere* (first do no harm). It is recognized in international development policy through the Sustainable Development Goals (SDGs). The WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) is responsible for monitoring the SDG targets for water,

* Corresponding author at: The Water Institute, University of North Carolina at Chapel Hill, 144 Rosenau Hall, CB #7431, 135 Dauer Drive, Chapel Hill, NC 27599-7431, United States.
E-mail addresses: jbartram@email.unc.edu, jbartram@unc.edu (J. Bartram).

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Table 1
Guideline topics and definitions in the essential environmental health standards in health care settings and the core indicators for water, sanitation, hygiene, and waste management in HCF, adapted from (WHO/UNICEF, 2016a; World Health Organization, 2008).

Guideline topic and definitions from the essential environmental health standards in health care settings, adapted from (World Health Organization, 2008)	
Guideline topic	**Definition in the guideline**
Water quality	Water for drinking, cooking, personal hygiene, medical activities, cleaning and laundry is safe for the purpose intended.
Water quantity	Sufficient water is available at all times for drinking, food preparation, personal hygiene, medical activities, cleaning and laundry.
Water facilities and access to water	Sufficient water-collection points and water-use facilities are available in the health-care setting to allow convenient access to, and use of, water for medical activities, drinking, personal hygiene, food preparation, laundry and cleaning.
Excreta Disposal	Adequate, accessible and appropriate toilets are provided for patients, staff and carers.
Wastewater disposal	Wastewater is disposed of rapidly and safely.
Health care waste disposal	Health-care waste is segregated, collected, transported, treated and disposed of safely.
Cleaning and laundry	Laundry and surfaces in the health-care environment are kept clean.
Food storage and preparation	Food for patients, staff and carers is stored and prepared in a way that minimizes the risk of disease transmission.
Building design, construction and management	Buildings are designed, constructed and managed to provide a healthy and comfortable environment for patients, staff and carers.
Control of vector-borne disease	Patients, staff and carers are protected from disease vectors.
Information and hygiene promotion	Correct use of water, sanitation and waste facilities is encouraged by hygiene promotion and by management of staff, patients and carers.
SDG Related water, sanitation, hygiene, and waste management in HCF indicators, adapted from (WHO/UNICEF, 2016b)	
Core indicators for water, sanitation, hygiene, and waste management in HCF for the SDGs	Normative definitions of core indicators for basic water, sanitation, hygiene, and waste management services in health care facilities
The proportion of health care facilities with basic water supply	Facilities where the main source of water is an improved source, located on premises, from which water is available at the time of the survey, or if not, water is available from an alternative improved source.
The proportion of health care facilities with basic sanitation	Facilities with improved toilets or latrines for patients located on premises, that are functional at the time of visit, with at least one toilet designated for women/girls with facilities to manage menstrual hygiene needs, at least one separated for staff, and at least one meeting the needs of people with limited mobility.
The proportion of health care facilities with basic hand hygiene	Facilities with hand hygiene stations including a basin with water and soap, or alcohol-based hand rubs, present at critical points of care and within 5 m of toilets.
The proportion of health care facilities practicing basic healthcare waste management	Facilities where waste is safely segregated in the consultation area and infectious and sharps wastes are treated and disposed of safely.

sanitation, and hygiene. These targets include both household and non-household settings including schools, workplaces, and health care facilities (Cronk et al., 2015; United Nations General Assembly, 2015; WHO/UNICEF, 2016a). Sanitation, water, and hygiene in HCFs are recognized through dedicated targets of SDG 6. SDG 6 calls for the "availability and sustainable management of water and sanitation for all" (United Nations General Assembly, 2015). SDG target 3.8 calls for "access to quality essential health-care services" for all (United Nations General Assembly, 2015). Stratifying data by important factors (e.g. rural-urban; facility type) and using these data to identify opportunities to progressively reduce inequalities are important components of every SDG and human rights (Meier et al., 2016; United Nations General Assembly, 2015).

The JMP developed a set of harmonized survey questions and indicators for water, sanitation, hygiene and waste management in HCFs (WHO/UNICEF, 2016b). These correspond to service levels of basic, limited, and no service. Service levels are used to describe the proportion of HCFs receiving different services and to report progressive improvements.

Baseline estimates of the status of environmental conditions and the availability of standard precaution items in HCFs have yet to be made for the SDGs. Few studies explore inequalities in coverage of environmental conditions and the availability of standard precaution items in HCFs by factors such as facility type, managing authority, and sub-national administrative area. Baseline estimates and inequality analyses are needed to benchmark progress and identify sub-national administrative areas, countries, and world regions in need of financial, technical, management, and human resources to make improvements to service delivery systems and facilities. Available studies examine maternity settings in a few countries of sub-Saharan Africa; a limited set of indicators of environmental conditions and standard precaution items; a limited set of HCF data; and/or a specific facility type (e.g. hospitals) (Benova et al., 2014b; Chawla et al., 2016; Gon et al., 2016; World Health Organization and UNICEF, 2015).

We produced the first coverage estimates of environmental conditions and standard precaution items in HCFs – including the availability of piped water in the facility premises, availability of sterilization equipment, safe storage and disposal of infectious and sharps waste, and the availability of guidelines for standard precautions. We present the most comprehensive estimates compiled to-date for sanitation, handwashing soap, and energy availability in HCFs. Using available nationally representative survey data, we approximate the SDG service levels for water, sanitation, hygiene, and waste management – and document sub-national inequalities in coverage with these services. We identify gaps in monitoring to measure and report the SDG service levels and environmental health standards in health care settings. We identify opportunities for harmonizing and improving HCF monitoring initiatives so that actors supporting HCFs can use these data to document service challenges and develop policies and strategies to improve service delivery systems.

2. Methods

2.1. Search strategy

Eighteen data repositories including the Global Health Data Exchange, the International Household Survey Network, the World Bank Data exchange, and the International Health Facility Assessment Network were reviewed for publications, reports, and datasets relevant to environmental conditions and the availability of standard precaution

items in health care facilities.

Using a list of LMICs as defined by the World Bank, the following searches were conducted in English using PubMed and Google Scholar: "[country name]" AND "health facility assessment" and "[country name]" AND "health facility survey." Systematic reviews that documented health care facility surveys were reviewed for relevant data (Adair-Rohani et al., 2013; Chawla et al., 2016; Nickerson et al., 2015).

Further publications, reports, and datasets were obtained from members of the World Health Organization task team on water, sanitation, hygiene, and waste management in health care facilities.

Websites of the Ministry of Health and the National Bureau of Statistics (or equivalent ministries and government agencies) for low- and middle-income countries were searched for relevant reports and datasets.

2.2. Data assessment

All identified publications, reports, and datasets were reviewed for data that related to the WHO Essential Environmental Health Standards in Health Care, the WHO standard precautions in health care and/or the SDG-related water, sanitation, hygiene, and waste management in HCF indicators (Table 1) (WHO, 2007b; WHO/UNICEF, 2016a; World Health Organization, 2008). The status of standard precaution items, rather than practices, were tabulated as monitoring instruments are used to collect data on the availability of items in HCFs. Standard precaution items comprise materials for hand hygiene, gloves, facial protection (eyes, nose, and mouth), gowns, sharps boxes, items for environmental cleaning, clean linens, waste disposal, and patient care equipment (WHO, 2007b).

2.3. Data extraction and analysis

2.3.1. Estimating coverage

Data were extracted from publications and reports or from datasets if the datasets were publicly available.

In some instances, more than one publication, report, and/or dataset was available for a single country. One was selected for each country for coverage estimation based on the following criteria: the most representative country-level data (e.g. selecting a nationally representative dataset when available; in the absence of nationally representative data, a sub-nationally representative dataset with the broadest national coverage was selected); the most comprehensive dataset in terms of indicators reported (e.g. reporting on all or most environmental conditions and standard precautions items); and the most recent dataset (by year). Comparable data from more than five countries were used to develop multi-country coverage estimates. Each country estimate was weighted by facility type and each facility type (e.g. hospital, clinic) was weighted equally.

Data related to the essential environmental health standards, standard precautions items, and/or SDG indicator guidance with comparable data available from less than five countries were extracted and reported separately.

2.3.2. Descriptive analysis of water, sanitation, hygiene, and waste management service levels

Approximations of the SDG service levels (Table 2) for water, sanitation, hygiene, and waste management were compared between countries using publicly-available datasets from the Service Provision Assessment (SPA) surveys available from the DHS Program (The DHS Program, 2011). The SPA datasets that were comparable and could be used to approximate the SDG service levels were available from six countries: Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania.

Stata/SE 13.1 was used to perform statistical analysis. The *Svyset* command was used to account for complex survey design. The unit of analysis was the health care facility. Water sources and sanitation facilities were categorized using the JMP improved water source and improved sanitation facility criteria (WHO/UNICEF, 2014). Missing responses, and responses of "other" or "don't know" were categorized as unimproved.

2.3.3. Country-level analyses

The six SPA country datasets were used to explore factors associated with the availability of basic water services in those countries. The availability of a basic water service was used as the dependent variable in the analysis; where the outcome is binary (where each HCF either had, or did not have a basic water service). Independent variables depended on the country and included rural-urban setting, facility type, and management authority. Facility types included clinics, hospitals, and dispensaries (where a dispensary is a small outpatient facility providing basic primary health care services). Management authorities included government, private for-profit, and private not-for-profit (e.g. NGO, faith-based management authority). Univariable logistic regression and multivariable logistic regression were used to analyze associations between the dependent and independent variables.

3. Results

Data on environmental conditions and the availability of standard precautions items in HCFs were identified from 78 of 170 LMICs and territories (Table 3). These 78 countries represent 58% of the total population of LMICs. Most data were from sub-Saharan Africa (36 countries). According to the World Bank income classification, 27 (35%) were low-income countries, 32 (41%) were lower middle-income countries, and 20 (24%) were upper middle-income countries. Publicly available datasets were available for 14 of 78 countries (18%) in the analysis. For all others, data were extracted from reports. Data from 37 of 78 countries (47%) were nationally representative and 41 were sub-nationally representative (53%).

3.1. Environmental conditions and standard precaution items in health care facilities in low- and middle-income countries

Coverage of environmental conditions and the availability of standard precaution items in HCFs is presented in Table 4. Data availability varied by indicator. The most data were available for the indicator "use of an improved water source within 500 m of the facility" which was representative of 128,155 HCFs. On average, data for 6.8 indicators were available for each country with a median of 5.5. Data are available by country in the supplementary materials.

An estimated 50% of HCFs in LMICs lack a piped water source on premises, 33% lack improved sanitation facilities on premise, 39% lack soap for handwashing, 39% lack adequate infectious waste disposal, 73% lack sterilization equipment, 74% lack guidelines for standard precautions, and 59% lack reliable electricity.

3.2. Infrequently used questions related to environmental conditions and standard precaution items in HCFs

Indicators for which data were available in less than five countries but are of importance to environmental conditions, standard precaution items, and the SDGs are presented in Table 5. For example, in Nepal, nearly all (93%) HCFs did not have disability-accessible toilets. In Nigeria, three in four staff in health care settings have not received training on health care waste management.

3.3. Service levels for water, sanitation, hygiene, and waste management

Service levels for water, sanitation, hygiene, and waste management were calculated using SPA survey data from Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania (Fig. 1). The service levels approximate the SDG service levels developed by the JMP for monitoring of SDG 6 (Table 2). There are differences between the reported service levels and

Table 2
Comparing the SDG service levels with data available in the SPA surveys. Adapted from (WHO/UNICEF, 2016a)[a].

	Service level	W1	W2	W3	W4	AW1	AW2	AW3	AW4
Water service (W)	Basic Service	Improved source	On premises	Available from main source at time of survey (W3) or water is available from an alternative improved source (W4)		Same as W	Same as W	Year-round availability	Not available
	Limited service	Improved water source	A “No” response for ANY (W2, W3, W4)			Same as W	A "No response for AW2 or AW3		Not available
	Unimproved / No facility	An unimproved or no water source (W1) OR An improved water source (W1) that is more than 500m from the facility (W2)				Same as W			

	Service level	S1	S2	S3	S4	AS1	AS2	AS3	AS4
Sanitation service (S)	Basic Service	Improved facilities located on premises and usable at time of visit	Sex-separated and have facilities to manage menstrual needs	At least one toilet designated for staff	At least one toilet meets the needs of people with limited mobility	Sanitation piped to sewer	Not available	Not available	Not available
	Limited service	Improved facilities but not usable	A “No” response for ANY (S2, S3, S4)			Other improved facility	Not available	Not available	Not available
	Unimproved / No facility	Unimproved or no facilities	Not applicable (N/A)	N/A	N/A	Unimproved or no facilities	N/A	N/A	N/A

	Service level	H1	H2	AH1	AH2
Hygiene service level (H)	Basic Service	Hand hygiene stations (water and soap or alcohol based hand rub) at points of care	Hand hygiene (water and soap) available within 5m of toilets	Same as H	Not available
	Limited service	Hand hygiene stations at either points of care (H1) or toilets (H2), but not both		Not available	
	Unimproved / No facility	No hand hygiene stations available or available but with no soap or water or alcohol based hand rub		No running water and soap NOR alcohol based hand rub	

	Service level	M1	M2	M3	AM1	AM2	AM3	AM4
Waste management service (M)	Basic Service	Waste safely segregated in consultation room	Infectious waste treated and disposed of safely	Sharps waste treated and disposed of safely	Infectious waste safely stored	Infectious waste safely disposed[b]	Sharps waste safely stored	Sharps waste safely disposed[c]
	Limited service	Bins are in place but not used effectively.	Waste is segregated but either infectious or sharps waste (or both) are not disposed of safely		A 'No' response for one to three of ANY of AM1, AM2, AM3, AM4			
	Unimproved / No facility	There are no bins for sharps and infectious waste	Waste is not safely treated and disposed	Waste is not safely treated and disposed	Infectious and sharps waste are neither safely stored nor safely disposed			

[a] W1, W2, S1, etc. correspond to survey questions used to measure each service level. Those with ‘A’ (‘alternative’) represent the survey questions available in SPA surveys.
[b] The process of infectious waste disposal is incineration, and the facility has a functioning incinerator with fuel on the day of the assessment, or else the facility disposes of infectious waste by means of open burning in a protected area, dumping without burning in a protected area, or removal offsite with storage in a protected area prior to removal offsite” Ministry of Health [Malawi] and ICF International, 2014. Malawi Service Provision Assessment 2013–2014, Lilongwe, Malawi.
[c] The process of sharps waste disposal is incineration and the facility has a functioning incinerator with fuel on the day of the assessment, or else the facility disposes of sharps waste by means of open burning in a protected area, dumping without burning in a protected area, or removal offsite with storage in a protected area prior to removal offsite” ibid.

those developed by the JMP (the differences are described in Table 2). For example, there is insufficient data in the SPA to report a basic sanitation service. Therefore, the service levels in this article should not be interpreted as SDG reporting but rather approximations of the SDG service levels using best-available data. Of these six countries, Senegal had the highest proportion of HCFs with basic water services (61%) while Tanzania had the lowest (32%). Bangladesh had the highest proportion of facilities with sanitation piped to sewer (17%) and Nepal had the lowest (6%). Senegal had the highest availability of handwashing materials (86%) while Nepal had the lowest (55%). In a facility-weighted average of the six countries, 2% of facilities provided all four of water, sanitation, hygiene and waste management services (based on the service levels developed for this article that approximate the SDG service levels).

3.4. Differences in availability of basic water services in Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania

Using the six SPA country datasets, inequalities in the availability of basic water services at HCFs were tabulated (Table 6). Differences between urban and rural settings were largest in Bangladesh, Senegal, and Tanzania (31 percentage point difference) and smallest in Malawi (18 percentage points). Differences between administrative units (e.g. districts, regions) were largest in Senegal (67 percentage points) and smallest in Malawi (eight percentage points). Differences between managing authorities (e.g. private-for-profit, private not-for-profit, government) were largest in Bangladesh (44 percentage points) and smallest in Senegal (10 percentage points). In all six countries, government-managed HCFs had the lowest coverage. Differences between facility types were largest in Malawi (71 percentage points) and smallest in Tanzania (31 percentage points). Hospitals had the highest coverage in five of the six countries (Tanzania was the exception where clinics had the highest coverage, 60%). Differences between facilities with inpatient services and those with outpatient services only were largest in Haiti (25 percentage points) and smallest in Bangladesh (no difference).

In univariable regression analysis, there was a significant association between the availability of a basic water service and urban-rural setting (except for Nepal, which did not distinguish facilities between urban-rural setting); in the other five countries, HCFs in rural settings

Table 3
Countries included in a study of environmental conditions and availability of standard precaution items in health care facilities in low- and middle-income countries.

World Region	Countries	Number of countries included in this study (percent of this study)	Total countries and territories in each region (percent of countries represented in this study)	Percent of world region population represented by countries and territories included in this study
Caucasus and Central Asia (CCC)	Azerbaijan (Bradley and Mursagulova, 2006), Kyrgyzstan (Domashov et al., 2011), Tajikistan (WHO, 2010), Uzbekistan (WHO, 2009)	4 (5%)	8 (50%)	54%
Eastern Asia (EA)	Mongolia (Spiegel et al., 2011)	1 (1%)	6 (17%)	< 1%
Latin America and the Caribbean (LAC)	Barbados (MEASURE Evaluation, 2006a), Belize (IHME, 2014a), Bolivia (Goldberg et al., 2006), Dominica (MEASURE Evaluation, 2006b), Ecuador (Sullivan and Bertrand, 2000), El Salvador (IHME, 2011), Grenada (MEASURE Evaluation, 2007a), Guatemala (IHME, 2014b), Guyana (Ministry of Health (MOH) (Guyana), 2005), Haiti (Institut Haïtien de l'Enfance (IHE) et ICF International, 2014), Honduras (IHME, 2013), Mexico (Aquil et al., 2010), Nicaragua (MEASURE Evaluation., 2001), Panama (IHME, 2014c), Paraguay (Angeles et al., 1999), Peru (Macro International, 2009), Saint Lucia (MEASURE Evaluation, 2006c), Saint Vincent and Grenadines (MEASURE Evaluation, 2006d), Suriname (MEASURE Evaluation, 2007b)	19 (24%)	46 (41%)	39%
Northern Africa (NA)	Egypt (Ministry of Health and Population, 2005), Libya (El-Zanaty and Associates, 2012), Morocco (WHO, 2007a)	3 (4%)	6 (50%)	70%
Oceania (O)	Papua New Guinea (National Department of Health and Environmental Health Branch (EHB), 2015), Solomon Islands (WaterAid and UNICEF, 2016), Vanuatu (Zurovac et al., 2015)	3 (4%)	20 (15%)	78%
Southern Asia (SA)	Afghanistan (Ministry of Public Health (Islamic Republic of Afghanistan), 2009), Bangladesh (National Institute of Population Research and Training (NIPORT) et al., 2016), Bhutan (Ministry of Health, 2009), India (National Rural Health Mission (NHRM) India, 2009), Nepal (Ministry of Health/Nepal et al., 2017), Pakistan (Majrooh et al., 2015), Sri Lanka (Taira et al., 2010)	7 (9%)	9 (78%)	18%
South-East Asia (SEA)	Cambodia (National Center for HIV/AIDS Dermatology and STD (NCHADS), 2009), Indonesia (National Population and Family Planning Board of Indonesia (BKKBN) et al., 2015), Myanmar (The Republic of the Union of Myanmar and UNICEF, 2014), Timor Leste (Environmental Health Department, 2011)	4 (5%)	11 (36%)	52%
Sub-Saharan Africa (SSA)	Angola (Frøystad et al., 2011), Benin (Ministère de la Santé, 2015), Burkina Faso (Santé, 2014), Cameroon (Cameroon Ministry of Public Health et al., 2013), Chad (Gauthier, 2004), Cote d'Ivoire (Gilbert et al., 2008), Democratic Republic of the Congo (Ministère de la Santé Publique (MSP), 2014), Eritrea (Ghebrehiwe et al., 2008), Ethiopia (Ethiopian Public Health Institute (EPHI) et al., 2014), Gambia (Ministry of Health and Social Welfare et al., 2012), Ghana (Institute for Health Metrics and Evaluation (IHME), 2015), Kenya (National Coordinating Agency for Population and Development (NCAPD) (Kenya), 2011), Liberia (Knowlton et al., 2013), Madagascar (Republic of Madagascar Vice Prime Ministry in Charge of Public Health et al., 2010), Malawi (Ministry of Health (Malawi) and ICF International, 2014), Mali (Pays, 2013), Mauritania (Republique Islamique de Mauritanie, 2016), Mozambique (Molina and Martin, 2016), Namibia (Macro, 2010), Niger (Institut National de la Statistique et al., 2016), Nigeria (World Bank, 2013), Republic of the Congo (Ministere de la sante et de la population et al., 2014), Rwanda (National Institute of Statistics (NIS) (Rwanda), 2008), Senegal (Agence Nationale de la Statistique et de la Démographie (ANSD) (Sénégal), ICF International, 2012), Sierra Leone (Sanitation, 2012), Somalia (Elkheir et al., 2014), South Africa (Health Systems Trust, 2004), South Sudan (Berendes et al., 2014), Sudan (Abdelgader et al., 2012), Swaziland (Ministry of Health and Social Welfare (Kingdom of Swaziland) et al., 2008), Togo (WHO, 2012a), Uganda (WHO, 2012b), United Republic of Tanzania (Ministry of Health and Social Welfare (MoHSW) (Tanzania Mainland) et al., 2015), Zambia (Ministry of Health, 2010), Zimbabwe (The Ministry of Health and Child Welfare (Zimbabwe), 2012)	36 (46%)	51 (71%)	97%
Western Asia (WA)	Iraq (USAID, 2011)	1 (1%)	13 (8%)	16%
Total		78	170 (45%)	–

had significantly lower odds of having a basic water service as compared to HCFs in urban settings (Table 7). The relationship was significant in the multivariable models of Haiti, Malawi, Senegal, and Tanzania.

The significance of managing authority (i.e. authority operating the facility) differed by country. In univariable regression in Bangladesh, Haiti, Malawi, and Nepal, NGO-managed HCFs had significantly higher odds of having a basic water service as compared to government-managed facilities (no NGO facility categorization was used in the Senegal and Tanzania datasets). In Malawi and Tanzania, mission and faith-based managed HCFs had significantly higher odds of having a basic water service as compared to government managed HCFs in both univariable and multivariable models, whereas there was no difference in Haiti (there was no faith-based management categorization provided in the Bangladesh, Nepal, and Senegal datasets). In univariable and multivariable analyses of Haiti, Nepal, and Tanzania, private-for-profit facilities had significantly higher odds of having a basic water service as compared to government-managed facilities.

Across all six countries, facility types other than hospitals (e.g. clinics, dispensaries) either had no significant difference from hospitals or had significantly lower odds of having a basic water service. In univariable and multivariable analyses of Bangladesh, health and family welfare centers and clinics had significantly lower odds of having a basic water service as compared to hospitals. In univariable and multivariable analyses of Haiti, dispensaries were significantly less likely to have a basic water service as compared to hospitals. In univariable analysis in Malawi, health centers and dispensaries had significantly lower odds of having a basic water service as compared to hospitals. In univariable and multivariable analyses in Senegal, health centers, health posts, and health houses had significantly lower odds of having a basic water service as compared to hospitals. In univariable and multivariable analyses in Tanzania, dispensaries had significantly lower odds of having a basic water service as compared to hospitals.

4. Discussion

This study is the most comprehensive assessment of environmental conditions (including water sanitation, hygiene and waste management) and availability of standard precaution items in HCFs in LMICs conducted to-date; with 21 different indicators documented, many for the first time.

Data on environmental conditions and the availability of standard precaution items in HCFs were available from as many as 78 LMICs and were representative of 129,557 facilities. The data are from countries that represent nearly 60% of the population of all LMICs. Most HCFs in LMICs have inadequate environmental conditions and insufficient availability of standard precaution items. An estimated 50% of HCFs lack piped water on-premise, 33% lack improved sanitation facilities on the facility premises, 39% lack soap for handwashing, 39% lack adequate infectious waste disposal, 73% lack sterilization equipment, 74% lack guidelines for standard precautions, and 59% lack reliable electricity. Facility-weighted averages of comparable nationally representative facility surveys from Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania suggest that 2% of health care facilities provide all four of water, sanitation, hygiene, and waste management services.

Significant differences in availability of basic water services exist between health care facilities in urban and rural settings, sub-nationally, by managing authority, and by facility type. We found that HCFs in rural settings had lower service levels than those in urban settings. Unsurprisingly, hospitals had consistently higher coverage of basic water services as compared to all other facility types. More resources are likely invested in hospitals as they serve a greater number of patients than smaller facility types (Campbell et al., 2016). In regression analysis, privately-managed facilities consistently had higher levels of basic water service than government managed facilities. Facilities managed by NGO and faith-based organizations may receive more external support (e.g. financial, human resources, supplies) than public facilities which may explain why coverage is higher; though better understanding the policy context and resource limitations in government-managed HCFs is needed (Olivier et al., 2015).

There are many data gaps. Most HCF data concern sub-Saharan Africa and few were available for Latin America and the Caribbean, Western Asia, South East Asia, and Oceania. Data from these regions are needed to understand the extent and distribution of inadequate coverage − especially in western and southeast Asia where a substantial proportion of the LMIC population lives.

4.1. Study limitations

Because not all LMICs were represented in this study, our estimates may be inaccurate. Inaccuracy is likely to occur due to countries not included in the estimates (due to data unavailability), some large population countries that are excluded (e.g. China); data included in the estimates that are only sub-nationally representative (e.g. India); and data included in the estimates that are only representative of specific facility types in a country (e.g. facilities that provide services for HIV/AIDS patients). The estimates may also be inaccurate because data from some countries were older than others (e.g. Peru data are from 2008). However, our estimates are in broad agreement with previous estimates. For example, as compared to a WHO/UNICEF report on water, sanitation, and hygiene in health care facilities which represented 66,101 facilities in 54 LMICs, our estimate for “access to an improved source within 500m” is higher compared to the WHO/UNICEF report (62% in the WHO/UNICEF report; 71% in our estimate); sanitation is lower (81% in the WHO/UNICEF report; 67% in our estimate); and soap for handwashing is slightly lower (65% in the WHO/UNICEF report; 61% in our estimate) (World Health Organization and UNICEF, 2015). Our findings are also comparable with a study reporting 66% of hospitals in LMICs as having water available in the facility (Chawla et al., 2016).

Some countries and world regions may be under-represented because the search was conducted in English. Some data from peer-reviewed studies may have been missed. Government monitoring data are not always publicly available and may have been omitted when this was the case.

The questions used in survey instruments had some differences. The design and implementation of the Service Provision Assessment (SPA) and Service Availability and Readiness Assessment (SARA) instruments (two nationally-representative facility surveys implemented by the DHS Program and the World Health Organization, respectively) were coordinated and harmonized to increase data comparability. However, assessing environmental conditions and the availability of standard precaution items were not the primary purpose of other assessments such as the WHO Tool for Situational Analysis to Assess Emergency and Essential Surgical Care. In this, questions such as “was running water available” was used instead of the more commonly used water source survey question on “use of an improved water source” (MEASURE Evaluation, 2016; World Health Organization, 2010). At present, the SPA and survey questions do not directly match with the JMP core indicators for the SDGs, therefore our service level estimates should be interpreted with caution.

Few datasets were publicly available, so many of the data used to generate the coverage estimates were extracted from reports. This meant that much of the data could not be disaggregated beyond that provided in the reports, limiting our reporting of coverage by facility type, managing authority, and other factors. This also meant that we had to weight facility types equally in the coverage estimates, despite differences in size and patient volume served.

Fewer data were available for some indicators as compared to others (e.g. data on the availability of alcohol-based hand disinfectant were available from 66,257 facilities versus 85,664 facilities for handwashing soap), which may affect the accuracy of coverage estimates.

Table 4
Coverage of environmental conditions and availability of standard precaution items in health care facilities based on data from 78 low- and middle-income countries.

Indicator	Estimated coverage	Number of countries in the estimate	Number of facilities in the estimate	Coverage in low-income countries	Number of low income countries	Coverage in lower middle-income countries	Number of lower middle-income countries	Coverage in upper middle-income countries	Number of upper middle income countries
Improved water source within 500 m	70.7%	71	129,557	65.2%	33	70.4%	26	81.0%	29
Piped water source on premises	50.3%	26	52,689	45.7%	11	48.3%	7	100.0%	13
Reliable electricity	41.2%	46	121,381	39.9%	27	40.4%	21	41.6%	17
Client toilet	67.4%	49	123,695	64.6%	27	67.9%	20	75.6%	19
Soap	60.8%	34	85,742	54.1%	14	60.9%	12	74.6%	14
Running water	54.3%	11	69,746	57.4%	7	54.3%	5	57.6%	6
Soap and running water	44.1%	10	66,355	43.2%	6	44.1%	5	50.6%	5
Alcohol-based hand disinfectant	29.5%	9	66,257	28.1%	6	29.5%	5	–	4
Soap and running water or alcohol-based hand disinfectant	62.2%	17	94,676	60.3%	13	62.2%	12	70.2%	5
Sterilization equipment	26.8%	25	71,048	27.7%	11	26.4%	9	22.7%	7
Equipment for high level disinfection	46.1%	6	54,349	–	4	–	4	–	2
Appropriate storage of infectious waste	39.3%	15	85,116	43.2%	12	39.6%	11	–	3
Appropriate disposal of infectious waste	60.9%	14	82,915	54.3%	12	63.7%	11	–	3
Disinfectant (e.g. chlorine solution for decontamination)	63.6%	35	108,022	63.1%	18	63.7%	16	66.4%	11
Latex gloves	76.5%	41	114,086	81.1%	22	76.7%	16	70.2%	15
Appropriate storage of sharps waste (e.g. sharps boxes)	74.7%	39	113,628	76.3%	22	74.7%	16	73.3%	16
Safe disposal of sharps	63.6%	17	91,382	58.7%	14	68.4%	11	80.2%	6
Disposable syringe	85.2%	30	96,218	86.9%	16	85.1%	12	80.6%	9
Guidelines for standard precautions	26.2%	19	95,708	28.6%	16	26.3%	12	22.5%	6
Gowns	43.7%	19	57,989	52.8%	6	44.2%	5	–	3
Eye protection	6.7%	9	55,613	5.3%	5	6.7%	5	–	2

Table 5
Infrequently used questions related to environmental conditions and standard precaution items in health care facilities.

Country	Question topic	Findings
Bangladesh (National Institute of Population Research and Training (NIPORT) et al., 2016)	Separate toilets for men and women	The Bangladesh SPA reported 72% of facilities had access to toilets for clients; however, 26% of facilities had separate toilets for female clients.
El Salvador (IHME, 2011)	Availability of single use towels	11% of facilities had single use towels for hand drying after handwashing.
El Salvador (IHME, 2011)	Water availability	69% of facilities reported having a water source. 41% of facilities with a water source reported a severe shortage or lack of water occurring last year.
Ethiopia (Ethiopian Public Health Institute (EPHI) et al., 2014)	Health care facilities connected to the power grid	5% of health posts were connected to the power grid and 67% of other facility types (e.g. hospitals) were connected to the grid.
Indonesia (National Population and Family Planning Board of Indonesia (BKKBN) et al., 2015)	Handwashing area is near a sanitation facility	13% of facilities had no handwashing facilities. 57% had handwashing facilities but they were not near the sanitation facilities and 30% had handwashing facilities that were near sanitation facilities.
Nepal (Ministry of Health/Nepal et al., 2017)	Is the toilet disability accessible	93% of facilities did not have a disability accessible toilet.
Nigeria (World Bank, 2013)	Staff received training in health care waste management	Staff at 28% of facilities have received training in health care waste management; 72% have not.
Pakistan (Majrooh et al., 2015)	Separate toilets for men and women	88% of HCFs had a toilet available; however, only 20% had separate toilets for men and women.
Solomon Islands (WaterAid and UNICEF, 2016)	Some or all of the toilet facilities are accessible to people with disabilities	43% had at least one toilet, which was accessible to persons with limited mobility, and 57% of facilities did not.

4.2. Implications for monitoring

We reveal important new insights on the situation in HCFs and previously undocumented inequalities. There are several opportunities to increase value from HCF monitoring. Administrators of HCF monitoring initiatives should consider reviewing their monitoring instruments and refining questions to maximize value and include questions on essential environmental health standards, the SDG indicators, indicators of service quality, important stratifying factors, and questions that reflect adequacy for infection control. To prevent monitoring instruments from becoming more burdensome, these questions could either replace lower value questions in monitoring instruments or questions on different HCF topics could similarly be refined to reduce the total number of questions. Poor environmental conditions and insufficient availability of standard precaution items represent a substantial health risk in HCFs and more information on these would inform better decision-making and health protection.

Present HCF monitoring instruments do not consider all essential environmental health standards, the SDG indicators, indicators of service quality, and/or important stratifying indicators (WHO, 2007b; WHO/UNICEF, 2016a; World Health Organization, 2008). For example, safely managed water and sanitation are important components of SDG 6 and questions to measure safely managed water and sanitation are recommended in JMP guidelines (Bain et al., 2014; WHO/UNICEF, 2015a, 2017). However, none of the nationally representative survey instruments such as the SPA or SARA measured water quality or safe disposal of feces. Quality health care services are an important component of SDG 3 yet no HCF-specific monitoring initiatives include questions on wastewater disposal, cleaning, laundry, or vector control (World Health Organization, 2008).

Disaggregating HCF data by factors such as facility type, accessibility of services by gender, and disability status is important for SDG monitoring yet few instruments include these. Data from those that did include these factors suggest substantial inequalities exist. For example, in Pakistan and Bangladesh, many HCFs had toilets available, but few had separate toilets for women (Majrooh et al., 2015; National Institute of Population Research and Training (NIPORT) et al., 2016). In the Solomon Islands, few HCFs had toilets accessible by disabled persons (WaterAid and UNICEF, 2016). Inadequate services disproportionately affect certain types of people, for example, people who receive health care in rural areas, patients who are disabled, and patients with limited mobility (e.g. elderly and pregnant women) (Cronk et al., 2015). Medical waste and wastewater management is important to prevent the spread of infection in the wider community. These are also important stratifying factors for human rights and SDG reporting.

Monitoring instruments should go beyond the SDGs and include questions that provide useful information that reflects adequacy for infection and outbreak prevention – especially for facilities providing specialized care. For example, a health care facility that has gender-separated, disability-accessible, 'improved' toilets for patients and visitors and a separate dedicated facility for staff would meet the SDG criteria for basic sanitation. "Improved" sanitation facilities are not necessarily sufficient for managing infectious fecal wastes. Transmission of infection through waste leakage into the surrounding environment may contribute to larger outbreaks (Cairncross et al., 1996; Levine et al., 1976). Safe water management is important to prevent nosocomial infection by pathogens such as *Pseudomonas aeruginosa* and nontuberculous mycobacteria in piped water in facilities (Anaissie et al., 2002; Li et al., 2016). To mitigate infection, standards should be more stringent for facility types providing intensive patient care with a higher risk of infection (e.g. intensive care unit). For example, a hospital with a burn wound unit should have risk management plans in place such as building-level water safety plans (World Health Organization, 2011). Questions in monitoring instruments and service level benchmarks should reflect this.

Aggregating HCFs for coverage estimates is challenging. Facilities are different sizes, serve different types of patients, and serve different patient volumes. Equal weighting of HCFs in coverage estimates – which was the approach used in every facility survey and in the calculations for this study – distort estimates of human exposure to low service levels. Use of facility weights (different from survey sample weights) may better represent the situation. For example, facilities might be weighted by the volume of deliveries (Gon et al., 2016), average daily or weekly patient volume, or number of patient beds available. Data to support such weighting are available in few survey instruments.

Facilities are classified differently (e.g. clinic, health center, health post) depending on the country and/or survey instrument. There is no internationally-accepted typology for HCFs (WHO/UNICEF, 2016a). A typology and the ability to assign facilities (e.g. health house; health and family welfare center) to a type would facilitate data pooling, sharing, comparison and benchmarking.

Improvements to monitoring would increase the quality and comparability of data over space and time; inform burden of disease estimates at the sub-national, national, and international levels; enable identification of conditions represent the greatest disease burden; and provide information that can be used to improve to environmental conditions and the availability of standard precaution items in HCFs.

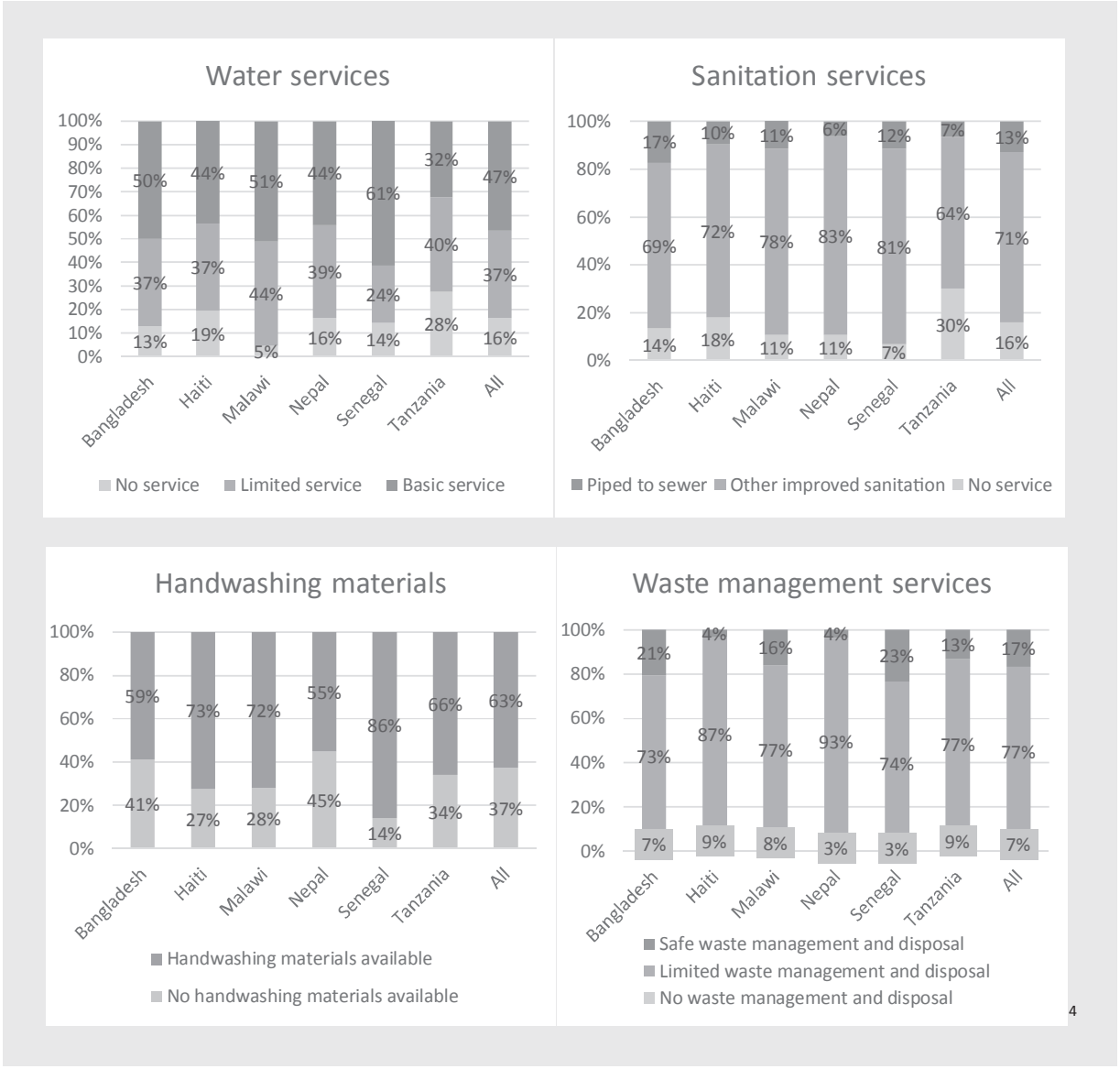

Fig. 1. Service levels for water, sanitation, hygiene, and waste management in Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania.
[1]A basic water service is an improved source, on the facility premises, and available year-round. A limited water service is an improved source that is either not available year-round or not on the facility premises. No water service is either an unimproved source or no water source; or an improved source beyond 500m of the facility. A limited sanitation service is an 'other improved' sanitation facility. No sanitation service is either an unimproved sanitation facility or no facility available at the HCF. Handwashing materials available is water and soap or alcohol based hand rub. Safe waste management is infectious waste safely stored and disposed (as defined in the SPA survey); and sharps waste safely stored and disposed (as defined in the SPA survey). A limited service is at least one of four (but less than four) of the safe service items available. No waste management and disposal service is none of the four items.

4.3. Implications for public health practice and policy

The health consequences of inadequate environmental conditions and insufficient availability of standard precaution items and the preventable illness and cost savings that could be achieved suggest urgent attention and prioritization of resources are needed in many LMICs. Our estimates suggest that half of HCFs lack piped water on the facility premises. Insufficient piped water on the facility premises limits handwashing, performing safe surgeries, performing safe deliveries, and cleaning (Benova et al., 2014a; Benova et al., 2014b; Velleman et al., 2014; World Health Organization, 2010; World Health Organization and UNICEF, 2015).

Nearly three in five facilities have unreliable electricity supplies. Reliable energy in HCFs is essential for functional HCFs. Intermittent electricity can create facility hazards and limit patient care: sterilization equipment cannot be operated, lighting is inadequate to perform procedures at night and in under-illuminated rooms, and electrically-powered tools for procedures cannot be used (Adair-Rohani et al., 2013). Unreliable electricity impedes the use of information technology and communications to inform decision-making.

Inadequate conditions were not exclusive to low-income countries – many lower-middle and upper-middle income countries had comparatively low coverage or less than universal coverage for many indicators. For example, 70% of HCFs in lower-middle income countries and 64% of HCFs in upper-middle income countries had disposable gloves available. This suggests that basic surveys, such as the DHS Program's Service Provision Assessment (SPA), may be relevant in higher income countries, especially in rural areas where health care service delivery is a challenge.

Government agencies and external support actors could make better use of monitoring data to properly benchmark services, increase accountability by facility management, make better use of available resources, and progressively improve services to achieve universal coverage of basic services. In some instances, HCF censuses were conducted

Table 6
Differences in availability of water services in Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania.

Unit of comparison	Difference in coverage	Bangladesh	Haiti	Malawi	Nepal	Senegal	Tanzania
Urban and rural settings	Urban	78%	58%	63%	–	81%	55%
	Rural	47%	34%	45%	–	50%	24%
	Difference	31 percentage points (p.p.)	24 p.p.	18 p.p.	–	31 p.p.	31 p.p.
Sub-national administrative area (e.g. district, region)	With highest coverage	73% (Rangpur)	58% (Ouest)	55% (South)	47% (Eastern)	82% (Louga)	–
	With lowest coverage	36% (Barisal)	23% (Nord-Ouest)	47% (Central)	33% (mid-west)	16% (Kédougou)	–
	Difference	37 p.p.	35 p.p.	8 p.p.	13 p.p.	67 p.p.	–
Managing authorities	With highest coverage	92% (Local government)	56% (NGO/private not for profit)	80% (Company)	81% (NGO/private)	70% (Private)	61% (private for-profit)
	With lowest coverage	48% (Government)	34% (Government)	44% (Government)	41% (Government)	60% (Government)	20% (Parastatal)
	Difference	44 p.p.	22 p.p.	36 p.p.	40 p.p.	10 p.p.	41 p.p.
Facility types	With highest coverage	83% (NGO hospital)	74% (Hospital)	100% (Central Hospital)	76% (Hospital)	95% (Hospitals)	60% (clinics)
	With lowest coverage	46% (Community clinic)	24% (Dispensary)	29% (Health post)	32% (sub-health post)	28% (Health clinic, Case de santé)	29% (dispensary)
	Difference	37 p.p.	50 p.p.	71 p.p.	44 p.p.	67 p.p.	31 p.p.
Inpatient versus outpatient	Inpatient service provided	50%	67%	55%	–	89%	29%
	Outpatient service only	50%	42%	51%	–	67%	32%
	Difference	0 p.p.	25 p.p.	4 p.p.	–	22 p.p.	3 p.p.

which provide resource targeting opportunities as compared to sample surveys. For example, using censuses conducted in Haiti and Malawi, it is possible to identify the specific facilities that have inadequate conditions and services (Institut Haïtien de l'Enfance (IHE) et ICF International, 2013; Ministry of Health (Malawi) and ICF International, 2014).

Many sub-national and specialized monitoring instruments provide more detail at the facility-level as compared to more general national monitoring instruments such as the SPA and SARA. For example, the Emergency Obstetric and Neonatal Care (EmONC) assessment and the WHO Tool for Situational Analysis to Assess Emergency and Essential Surgical Care provide data on conditions in units within HCFs (e.g. labor and delivery wards; surgical suites) (MEASURE Evaluation, 2016; World Health Organization, 2010). These can be used to identify improvement opportunities in settings within HCFs as this information is rarely available in nationally representative monitoring instruments.

Poor data accessibility is a challenge – most data on environmental conditions and standard precaution items are only available in reports. The datasets used to create the reports are often not publicly available yet could be analyzed beyond their original use. Data accessibility and public data repositories are beneficial for transparency and accountability. Open access data enables sharing for pooling of data, comparison, and learning.

Monitoring data can be used to inform facility-level improvements. Once low coverage facilities are identified, facility managers, infection prevention and control practitioners, and program managers might collaborate to identify simple technology and low-cost solutions to improve the situation progressively. For example, Bennett et al. (2015) found in Kenya that 15 months after installing low-cost, portable handwashing stations and simple drinking water stations with drinking water treatment, coupled with health care provider training, there was successful adoption and sustained use of the stations, despite the absence of piped water(Bennett et al., 2015).

Government actors may adopt standards higher than those sought under the SDGs. Higher levels of service are necessary for safe patient care and to protect health care workers, visitors, and the wider community. For example, this study shows that many HCFs rely on water sources that are not safe, on-site or available year-round. Governments and external support agencies should upgrade services to ensure that *all* HCFs have sufficient, continuously-available, safe piped water in the facility. Sanitation facilities that safely manage patient fecal wastes are imperative to prevent infection in the HCF and nearby communities (World Health Organization and UNICEF, 2015).

Bartram et al. (2015) note that hardware interventions and the availability of standard precaution items are necessary but not sufficient. Improvements must also include strengthening of the enabling environment and the systems that support environmental health in health care facilities. Governments should establish national standards and policies, invest in human resources, and improve coordination of related health initiatives, such as universal health coverage, infection prevention, and maternal and child health programming. To assist with such efforts, in 2015 the World Health Organization launched an action plan for environmental health in health care facilities – aimed at supporting good practice and improving advocacy and leadership; monitoring and evaluation; evidence and operational research; and policy, standards, and facility improvements (WHO/UNICEF, 2015b).

4.4. Implications and priorities for research

There are several low-cost opportunities for exploratory research using available data to gain further insight on the status of HCFs and factors associated with low service levels. They include geospatial analysis of inequalities in coverage (and linking these data to other geospatial data to enable more explanatory power); detailed analyses of sub-national regions to better target resources; use of the data to model regional estimates of coverage (e.g. sub-Saharan Africa; South East

Table 7
Unadjusted and adjusted logistic regression results for factors associated with the availability of basic water services in health care facilities in six countries.

Country	Urban vs. rural (reference: urban)			Managing authority (reference: public facility)								
Bangladesh	Urban vs. rural			NGO			Local government			Private for profit		
(N = 1165)	OR	CI	P	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.3	(0.2, 0.4)	< **0.001**	2.9	(1.8, 4.6)	< **0.001**	12.6	(2.4, 64.9)	**0.002**	6	(3.0, 12.1)	< **0.001**
Adjusted	0.7	(0.4, 1.2)	0.157	2.3	(1.2, 4.5)	**0.015**	8.7	(1.5, 50.1)	**0.016**	2	(0.9, 4.4)	0.082
Haiti	Urban vs. rural			NGO			Mission/faith-based			Private for profit		
(N = 907)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.4	(0.3, 0.5)	< **0.001**	2.5	(1.7, 3.7)	< **0.001**	1.2	(0.8, 1.8)	0.286	2.3	(1.6, 3.3)	< **0.001**
Adjusted	0.7	(0.2, 0.4)	**0.022**	2.2	(1.5, 3.3)	< **0.001**	1.2	(0.8, 1.8)	0.379	1.9	(1.3, 2.7)	**0.001**
Malawi	Urban vs. rural			NGO			Faith based			Private for profit		
(N = 977)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.5	(0.4, 0.6)	< **0.001**	2.2	(1.2, 3.8)	**0.007**	1.7	(1.2, 2.4)	**0.005**	1.7	(1.2, 2.3)	**0.001**
Adjusted	0.5	(0.4, 0.7)	< **0.001**	1.7	(0.9, 3.4)	0.121	1.6	(1.1, 2.3)	**0.013**	1.4	(0.9, 2.3)	0.216
Nepal (N = 992)	Urban vs. rural			NGO/private for-profit			–			Private for profit		
	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	–	–	–	4.2	(2.3, 7.6)	< **0.001**	–	–	–	6.0	(3.3, 11.1)	< **0.001**
Adjusted	–	–	–	2.4	(1.3, 5.1)	**0.008**	–	–	–	2.6	(1.3, 5.1)	**0.008**
Senegal	Urban vs. rural			Private			–			–		
(N = 438)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.2	(0.1, 0.4)	< **0.001**	1.6	(0.8, 3.0)	0.182	–	–	–	–	–	–
Adjusted	0.3	(0.2, 0.6)	< **0.001**	0.7	(0.3, 1.5)	0.337	–	–	–	–	–	–
Tanzania	Urban vs. rural			Parastatal			Mission/faith-based			Private for profit		
(N = 1200)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.3	(0.2, 0.4)	< **0.001**	0.8	(0.2, 2.5)	0.672	2.9	(1.7, 4.8)	< **0.001**	4.8	(2.8, 8.3)	< **0.001**
Adjusted	0.4	(0.2, 0.6)	< **0.001**	0.5	(0.2, 2)	0.354	2.4	(1.4, 4.2)	**0.002**	2.6	(1.3, 5.4)	**0.007**

Country	Facility type (reference: hospital)									Inpatient vs. no inpatient (reference: inpatient service provided)		
Bangladesh	Health and family welfare center			Clinic			Dispensary			Inpatient		
(N = 1165)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.3	(0.2, 0.5)	< **0.001**	0.3	(0.2, 0.4)	< **0.001**	0.3	(0.2, 0.5)	< **0.001**	1	(0.6, 1.6)	0.972
Adjusted	0.5	(0.3, 0.9)	**0.032**	0.5	(0.3, 0.8)	**0.004**	0.5	(0.3, 1.0)	0.043	1.1	(0.7, 1.9)	0.617
Haiti	Health center with beds			Health center without beds			Dispensary			Inpatient		
(N = 907)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.7	(0.4, 1.2)	0.252	0.6	(0.4, 0.9)	**0.026**	0.2	(0.1, 0.3)	< **0.001**	0.4	(0.2, 0.7)	0.001
Adjusted	0.9	(0.5, 1.5)	0.689	0.7	(0.4, 1.1)	0.078	0.3	(0.1, 0.4)	< **0.001**	0.6	(0.3, 1.2)	0.188
Malawi	Health center			Clinic			Dispensary			Inpatient		
(N = 977)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.6	(0.4, 0.9)	**0.009**	0.8	(0.5, 1.3)	0.443	0.4	(0.2, 0.8)	**0.007**	0.8	(0.4, 2)	0.707
Adjusted	0.9	(0.6, 1.4)	0.573	0.7	(0.4, 1.3)	0.286	0.6	(0.3, 1.3)	0.199	0.8	(0.3, 1.9)	0.640
Nepal (N = 992)	Primary health care center			Health post			Sub-health post			Inpatient		
	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.4	(0.3, 0.6)	**0.001**	0.2	(0.2, 0.4)	< **0.001**	0.1	(0.1, 0.3)	< **0.001**	–	–	–
Adjusted	0.7	(0.4, 1.1)	**0.093**	0.5	(0.3, 0.7)	**0.002**	0.3	(0.2, 0.5)	< **0.001**	–	–	–
Senegal	Health center			Health post			Health house			Inpatient*		
(N = 438)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.1	(0, 0.5)	**0.006**	0.1	(0, 0.5)	**0.005**	0	(0, 0.1)	< **0.001**	0.2	0.1, 0.9)	**0.042**
Adjusted	0.1	(0, 0.5)	**0.008**	0.2	(0, 0.9)	**0.034**	0	(0, 0.3)	**0.001**	–	–	–
Tanzania	Health center			Clinic			Dispensary			Inpatient		
(N = 1200)	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Crude	0.6	(0.4, 0.9)	**0.023**	1.2	(0.7, 2.3)	0.519	0.3	(0.2, 0.5)	< **0.001**	1.2	(0.5, 2.9)	0.748
Adjusted	0.9	(0.6, 1.4)	0.624	0.5	(0.2, 1.2)	0.107	0.5	(0.3, 0.8)	**0.007**	1.5	(0.6, 3.8)	0.441

Asia); and using the data for exposure estimates for burden of disease modeling.

While we demonstrate that there are extensive data available describing the status of conditions and precautions, evidence on effectiveness of approaches and programs for improving environmental health in health care settings in LMICs is urgently needed. At the facility level, there are opportunities for researchers to collaborate with HCF practitioners to conduct qualitative research, operational research, and continuous quality improvement to identify and implement improvement opportunities. Qualitative research would provide insight into enablers and barriers of a safe health care environment and contribute to understanding the motivations influencing health care workers and facility staff to improve services. Operational research could be used to identify which approaches and programs are most effective in reducing infection and means to enhance beneficial impact. Continuous quality improvement projects help identify and overcome bottlenecks that prevent adequate environmental conditions and sufficient availability of standard precaution items and deliver improvement solutions.

5. Conclusion

Sufficient environmental conditions and the availability of standard precaution items in HCFs are critical for safe patient care and to protect health care workers, visitors and the wider community. Using publicly available data, our findings reveal an under-appreciated but fixable crisis – many HCFs in LMICs lack adequate environmental conditions and the most basic standard precaution items to prevent infection. We identified important, previously undocumented inequalities in coverage of services. The analyses in this study are important for those involved in improving HCF conditions to benchmark services, increase accountability, and develop evidence-based policies and efficient programs to make better use of available resources to target facilities with inadequate services. With leadership from health care workers, health facility administrators, local and national governments and external support actors, HCFs can become models of dignified, safe and people-centered care. The maxim *primum non nocere* (first do no harm) – could not be more apposite.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ijheh.2018.01.004.

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