npj | clean water

Article

Published in partnership with King Fahd University of Petroleum & Minerals

https://doi.org/10.1038/s41545-024-00386-7

Indicators for evaluating shared sanitation quality: a systematic review and recommendations for sanitation monitoring

Sarah Lebu[1], Lauren Sprouse[1], John Apambilla Akudago[2], Carrie Baldwin-SoRelle[3], Chimdi C. Muoghalu[1], Carmen Anthonj[4], Barbara Evans[5], Joe Brown[1], Jamie Bartram[1,5] & Musa Manga[1]

Shared sanitation facilities have replaced open defecation in many areas, improving sanitation access. Although a broad body of literature has been published regarding the importance of shared sanitation services, it is still unclear how to assess their quality. The objective of this review was to synthesize evidence on the use of shared sanitation facilities in informal settlements and identify indicators for assessing their quality. We conducted a systematic review of relevant studies and a total of 248 studies were included in the final analysis. Findings include a proposed list of indicators for evaluating the quality of shared sanitation such as the number of people sharing facilities, cleanliness, privacy, facility location, accessibility, and safety, and a tool for distinguishing between sanitation facilities that are improved shared, basic shared and unimproved shared. We recommend incorporating the proposed indicators in primary data collection, and routine national and global sanitation monitoring.

Access to sanitation remains a challenge in many parts of the world. An estimated 30% of the world's population lives in informal settlements (or slums, as defined by the United Nations[1]), and their population continues to grow. These settlements present unique challenges to the provision of sustainable and hygienic sanitation, particularly in sub-Saharan Africa and in Central and Southern Asia where 762 million and 482 million from the general population, respectively, lack access to basic sanitation services[2]. Poor sanitation access in informal settlements is caused by several factors, including inadequate infrastructure and lack of proper planning[3,4,5]. In the absence of accessible sanitation infrastructure and waste disposal mechanisms, open defecation and improper waste disposal become common practices, resulting in contamination of drinking water sources and the spread of diseases[6,7,8]. Furthermore, the inadequate number of sanitation facilities, lack of maintenance, and limited access to clean water further exacerbate the sanitation challenges in these settlements[9,10,11,12,13]. These communities are also often transient[14] and lack formal legal recognition, making it difficult to invest in and implement long-term solutions for sanitation[15,16]. Yet it is projected that the number of people living in informal settlements will increase to 2 billion by 2030 and 3 billion by 2050[17], despite efforts by governments, local authorities, and international institutions to curb their expansion[18].

In many places shared sanitation facilities have been effective in improving sanitation access, replacing open defecation[19,20], which is much more detrimental to public and environmental health[21]. Provision of individual household toilets can be challenging and unfeasible in places with high population density, insufficient space, high capital costs, and the quantity of water required to operate most sanitation systems efficiently[4,22,23]. In such conditions, high-quality shared toilets may be the most viable option for extending sanitation services to residents[15,24,25]. Where land tenure status is murky, many residents live on rented or squatted land, which makes it impossible for them to make any decisions regarding the development or use of the land[26,27]. As of 2022, it is estimated that 570 million people shared sanitation facilities with other households[2]. Considering that sharing of sanitation facilities is likely to be higher in urban slums and other high-density informal settlements with inadequate services[28], households in informal settlements likely make up a large

[1]Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA. [2]Habitat for Humanity International, Americus, GA, USA. [3]UNC Health Sciences Library, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA. [4]Faculty of Geo-Information Science and Earth Observation, ITC, University of Twente, Enschede, The Netherlands. [5]School of Civil Engineering, University of Leeds, Leeds, UK.
e-mail: mmanga@email.unc.edu

proportion of this estimate. It is also common for multiple households to share sanitation facilities in planned residential areas[29]. It has been reported that communal living is prevalent in many urban areas in low- and middle-income countries (LMICs), where up to 80 families live together in a compound and share sanitation, cooking, and other facilities[30]. Research indicates that nearly one in five people in Sub-Saharan Africa (18%) and Eastern Asia (19%) use shared sanitation; it is especially common in Ghana (59%), Congo, and Gabon (both 34%)[29,31,32]. It may be necessary to provide shared sanitation as an interim step in these contexts due to the challenges associated with implementing household toilets[3,33].

Studies investigating shared sanitation services in informal settlements have focused on their prevalence[29], contribution to improving sanitation access in informal settlements[15,25], perceptions of users[34–37], and associated health outcomes[38–40]. It has been reported that users of shared sanitation facilities seek qualities such as affordability, cleanliness, access 24 h a day, accessibility for everyone (irrespective of gender, age, ability, or condition), privacy, access to handwashing facilities, good lighting, and responsiveness to their menstrual health needs[3,19,34]. The majority of studies examining the health impacts of shared sanitation facilities compare them to individual household toilets[21,39]. Many report that poorly maintained shared sanitation facilities can serve as environmental reservoirs for pathogens that cause diarrhea, increasing the risk of diarrheal disease[41,42]. Despite the negative health outcomes associated with shared sanitation when compared to household toilets, shared sanitation offers health improvements when open defecation is the only alternative, and maintaining cleanliness and high hygiene standards can help minimize this risk[21,34,36]. There are some studies that link some characteristics of shared sanitation with health outcomes, but there is no comprehensive framework that can be used to assess which dimensions of shared sanitation are most critical.

Despite growing interest in shared sanitation, the measurement of different aspects of shared sanitation remains challenging[25]. Currently, national and global monitoring systems have difficulty distinguishing between high-quality shared sanitation facilities and unacceptable ones[15]. Additionally, it is uncommon for censuses and national household surveys to ask whether households share sanitation facilities: only 85 countries reported that information to the Joint Monitoring Programme (JMP) in 2015[15]. Furthermore, important elements of shared sanitation such as the number of households or people sharing, safety, privacy, accessibility, and cleanliness are seldom measured in routine data collection processes. For example, in the Demographic Health Survey (DHS) and the Multiple Indicator Cluster Surveys (MICS), data on shared sanitation use were derived from two core questions – "Do you share this facility with other households?" and, if yes, "How many households use this facility?". In more recent versions of the MICS, an additional question is asked on whether the facility is shared with persons known to the respondent, such as neighbors, (i.e., shared private) or if shared with the general public (i.e., shared public)[28]. Given these limitations in monitoring, the JMP classifies shared sanitation as a 'limited' sanitation service[2], and research is needed to build the evidence on a set of indicators that can be considered for distinguishing high-quality shared sanitation from unacceptable ones.

This systematic review aimed to collect evidence on indicators for evaluating the quality of shared sanitation and to recommend a set of priority indicators linked to positive health outcomes. Having clear criteria for distinguishing between high-quality shared facilities and unacceptable ones will enable higher accuracy during monitoring. Governments, development partners, and sanitation actors can adapt the proposed criteria to improve and incentivize further investment in sanitation programs in informal settlements.

Methods

Systematic review protocol and reporting guidelines

This review was conducted according to the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines[43]. A review protocol for the study was registered prospectively on PROSPERO, the international prospective register of systematic reviews for human and animal studies [ID CRD42023431460].

Search strategy

Seven databases (PubMed, Scopus, Embase, Cochrane Central, Global Health, Environment Complete, and Virtual Health Library (VHL) Regional Portal) were searched for studies published up to June 30, 2023. Grey literature databases were also searched. We searched grey literature databases through Google Scholar as well as government and non-government websites and databases. In total, 19 websites were searched for grey literature. A detailed search strategy containing terms for shared sanitation and informal settlements, including alternative spellings and synonyms, was developed for PubMed, and revised appropriately for each database used. The search strategy documentation is provided in the Supplementary information. The electronic search was followed by a manual search of the reference lists of all potentially eligible studies obtained as full reports to identify any further studies not retrieved by the electronic search.

Inclusion and exclusion criteria

Studies were included in the final analysis if they met the following inclusion criteria: (1) Study reported on sanitation facilities that are shared by more than one household; (2) Study reported the use of public or communal toilets; (3) Study focused on informal settlements; (4) Study was published in the English language, and (5) Study was published before June 30, 2023. Studies were excluded if they focused on non-household sanitation or institutional sanitation such as in schools, markets, transport hubs and healthcare facilities (all of which exist in informal settlements). No restrictions were applied based on the geographical location of the study (studies from low- and middle-income countries as well as high-income countries were included in the review).

Screening of studies

Screening and management of literature was conducted in Covidence, a web-based software platform that streamlines the production of systematic reviews. Duplicate studies were removed before screening. Two reviewers independently completed the initial screening of titles and abstracts. Where there was uncertainty in rejecting a title or abstract, the full text was obtained for further screening. Two independent reviewers also performed full-text screening. To minimize bias, a third reviewer examined 10% of all screened full texts. Whenever conflicts occurred during the screening process, a third neutral reviewer was consulted for the final decision.

Data extraction and analysis

Data extraction was conducted using a piloted form, extracting general study information (e.g., author, date of publication, study design, study methods, country of study, etc.), the profile of sanitation users (disaggregated by gender and age), perspectives on cleanliness practices, privacy, safety concerns, costs, management of shared facilities, indicators for evaluating shared sanitation, and direct and indirect health outcomes. We chose these parameters based on five normative criteria in the Human Rights to Water and Sanitation framework, namely availability, quality and safety, physical accessibility, affordability, and acceptability. Additionally, existing literature on the topic was used to guide data extraction. The extraction form was piloted using 10 randomly selected studies. Any discrepancies identified during the pilot were jointly discussed and resolved. Data extraction was completed by five reviewers. Data on user perceptions, attitudes and experiences, and health impacts were tagged with author information and exported to a Word processor. Findings were grouped by number of households sharing a sanitation facility and country of study.

Risk of bias assessment

Study quality and risk of bias were assessed using previously established protocols[44,45]. For observational studies, quality was assessed using a tool adapted for water, sanitation, and hygiene (WASH)-related studies[45], and non-observational studies were assessed using the ROBIS tool for evaluating

the risk of bias[44,46]. Where reviewers disagreed during the screening and extraction stages, disputes were resolved by discussion among all reviewers. The quality of papers was assessed based on the quality of reporting, risk of bias, and appropriateness of conclusions. A 10-item checklist was used to assess the quality of evidence and assign an overall rating for each study. The domains considered in the checklist were: well-articulated aims and objectives, sufficient detail provided for context, clarity of study design, data collection procedures, quality of data analysis, rigor of study methods, interpretation of findings, disclosure of study limitations, appropriateness of study conclusions, and strength of evidence. All items in the checklist received a score of 0, 0.5, or 1, corresponding to low, moderate, and good, respectively.

Indicator selection framework

The indicators that were included in this analysis were determined inductively from published studies[25,37,40,47,48]. The quality of the indicators was assessed against a checklist of criteria for selection of high-performing indicators outlined in a prior study[49]. This criteria was selected because of its practical relevance for data collection, WASH policy, and practice[50]. Candidate indicators were selected and prioritized using the following checklist:

- Accepted practice and history of use—Refers to the degree to which an indicator is consistent with current and previous practices. An indicator may be selected based on the advantages identified from its previous use, or the discussion of accepted practice and history of use of an indicator may result in data collection in a different or novel direction.
- Measurable—Indicator is straightforward to measure and quantifiable.
- Availability of data—Data is available and accessible, accurate, comparable over time, complete with historical information and covering sufficient geographic areas. The discussion should include the availability of data at a single point in time (e.g., baseline data) and overtime, as appropriate.
- Applicability in different settings—Refers to the extent to which an indicator is relevant in diverse settings. The ability to collect comparable and consistent data across space and time is an important consideration relevant to the utility of an indicator.
- Burden of data collection—Refers to the degree to which data collection imposes a burden on participants and requires a substantial resource life. It is important that the indicator limits both the human and fiscal burden of data collection.
- Clarity of focus and meaning—Indicator should adequately represent the descriptor or marker being measured without ambiguity. This includes defining the indicator in a way that can be consistently interpreted by all audiences.
- Independence of indicator and value within a set of indicators—Refers to the extent to which a single indicator adds meaning to the set of selected indicators. This criterion aids in identifying duplications or redundancies in data collection and may result in the use of a more manageable, smaller number of high-performing indicators.

Each candidate indicator was scored for its suitability in relation to each criterion. An indicator was assigned "high" if it met more than six criteria, "medium" if it met between 4–5 criteria, and "low" if it met 1–3 criteria. Based on this rating system, a final set of indicators was chosen.

Role of funding sources

The funders of this study had no role in the study's design, conduct, analysis, interpretation of results, or the writing of the report.

Results

Characteristics of included studies

In total, 4741 peer-reviewed studies and 2788 grey publications were identified through the search. The distribution was PubMed (NLM) (844), Scopus (Elsevier) (1221), Embase (Elsevier) (897), Cochrane Central (Wiley) (62), Global Health (Ebscohost) (779), Environment Complete (Ebscohost) (312), and VHL Regional Portal (626). Duplicates were removed and 1953 unique articles were screened against the inclusion criteria. After the screening process was completed, a total of 248 articles were included in the final analysis (Fig. 1).

A total of 23 countries across Africa, Asia, South America, and Europe were included in the studies (Fig. 2). Most of the included studies were conducted in Sub-Saharan Africa ($n = 114$) and Southern Asia ($n = 64$), and 14 were conducted in more than one LMIC. India ($n = 41$), Kenya ($n = 28$), and Uganda ($n = 21$) had the highest number of studies. The focus or the context of all studies was informal settlements. In total, 179 informal settlements were covered in the review. All studies were conducted in urban areas.

Quality assessment results

The result of the study quality assessment showed minimal variation across studies (Fig. 3). The quality of studies was assessed based on the quality of reporting, risk of bias, and appropriateness of conclusions. Evaluated papers were scored on a scale of 1 to 13. The mean quality assessment score was 85% (score of 11/13). Although many studies sufficiently reported details of the study design, data collection and analysis, our assessment obtained an average 72% rating for rigor of methods used. Only 74% of evaluated studies sufficiently described their study limitations. The most frequently identified issues in the quality assessment were inadequate description of data analysis methods, lack of data collection validation (e.g., pilot interviews), and lack of data verification (e.g., use of independent coders).

The long list of indicators

Table 1 presents evidence regarding indicators for monitoring shared sanitation quality. It shows a long list of indicators and their domains and then assesses them according to seven criteria levels: accepted practice and history of use; measurable; data availability; applicability in many different settings; burden of data collection; clarity of focus and meaning; and independence of indicator and value within a set of indicators. It is worth noting that most studies did not report a consistent domain classification (this refers to categorizing indicators according to specific areas of interest or similar themes).

Collectively, the proposed set of indicators provides a hypothesis for the assessment of shared sanitation quality. We submit that this suite of indicators could be tailored to address assessment priorities in a specific place and time. It is important to reassess the list of potential indicators as new information, technologies, and data-collection techniques become available. We selected six indicators that scored over 80% in the evidence quality appraisal and were high or medium in the indicator selection criteria.

The body of research supporting the final six selected indicators

The review identified key aspects of shared sanitation quality: availability, quality/safety, physical accessibility, affordability (or economic accessibility), and acceptability were factored into the analysis. Several studies reported key considerations for improving the quality of shared sanitation facilities and their management[23,31,34,47,48,51–60]. Six commonly reported qualities were identified across the literature as prioritized by users of shared sanitation. A detailed characterization of each quality aspect and supporting evidence is discussed in Table 2.

Number of households sharing a sanitation facility. The number of people sharing a sanitation facility is a critical determinant of shared sanitation quality. Of the studies reviewed, 52 (21%) reported an estimate of the number of households or people who shared a sanitation facility. The average number of households sharing a sanitation facility across these studies was 16 and the average household size across our sample was 5. Heavy sharing (>10 households per facility) was less commonly reported than fewer households sharing a facility (<10 households). There was no consideration of gender ratios, children-to-adult ratios, or livestock ownership when determining the number of people sharing a sanitation facility.

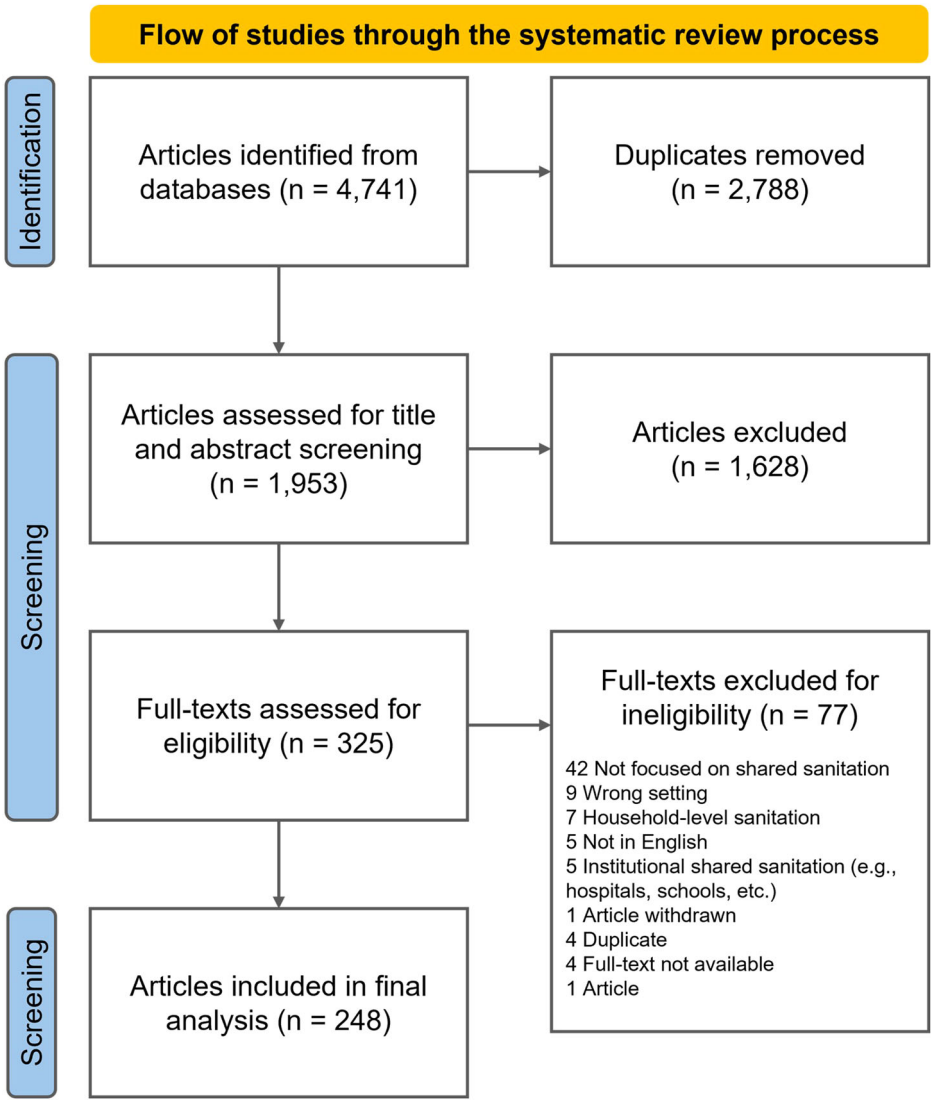

Fig. 1 | PRISMA flow diagram for studies included in the systematic review. The majority of included studies were cross-sectional ($n = 133$) and case studies ($n = 45$). Reports ($n = 15$), reviews ($n = 10$), and expert opinions ($n = 10$) were common ways that evidence was presented in the literature. Few case-control studies ($n = 8$), cohort studies ($n = 8$), and experimental design ($n = 9$) met the inclusion criteria. Policy analysis ($n = 7$) and modeling studies ($n = 3$) were also included. A summary of the reviewed evidence by study design is shown in Table 3.

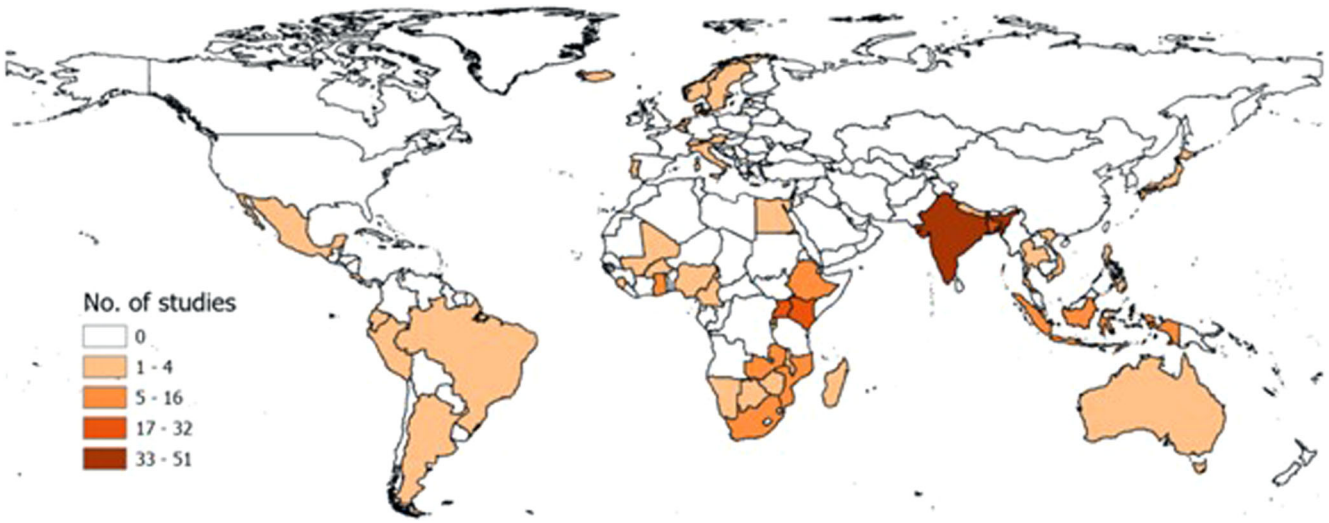

Fig. 2 | Distribution of included studies. Geographical distribution of studies included in the systematic review, representing research conducted across more than 23 countries.

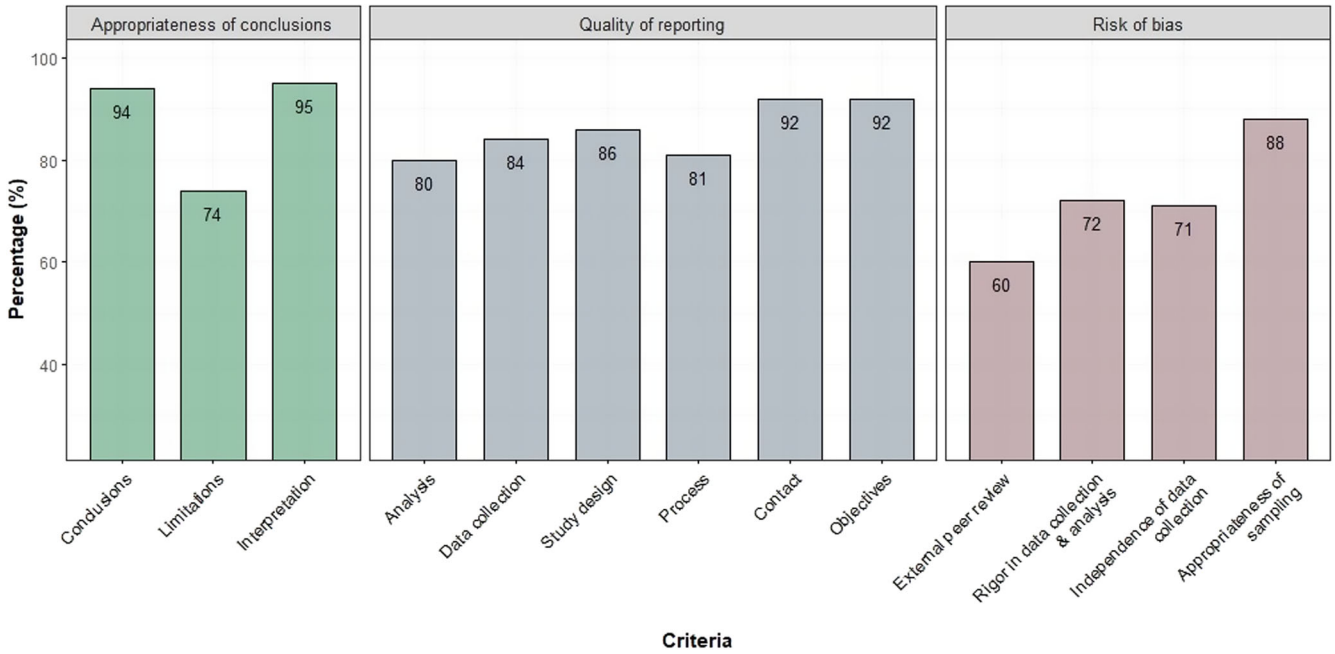

Fig. 3 | Study quality assessment. Study quality was assessed based on quality of reporting, risk of bias and appropriateness of conclusions. A total of 248 studies that were included in the review were assessed.

There was evidence that the number of households sharing sanitation facilities is inversely proportional to the facility's quality[25,61]. More people sharing a facility impacts the level of cleanliness, as well as maintenance patterns[55]. When a compound has many members, even when there is a leader, reaching a consensus may be difficult because of differences in opinion, uncooperative members, or the inability to meet with all members at the same time[37,62,63]. Due to this, maintaining a clean facility can be challenging. Some evidence suggests that outsiders and the public should not use compound sanitation facilities meant for residents[29]. The argument is that the number of users sharing a toilet should be kept small enough to manage collective cleanliness and maintenance. Some studies substantiate this finding, suggesting that sharing toilet facilities between too many households could lead to disagreements and non-use[64].

The threshold number at which toilet sharing is deemed acceptable has been suggested in prior literature[65,66]. Depending on the literature, it is recommended that no more than five households or 30 people are allowed to share a sanitation facility and that those sharing should be related to each other in a way[25]. There is also evidence that a different threshold may be needed in humanitarian settings; the SPHERE guidelines (a set of principles and minimum humanitarian standards) recommend up to 4 households or 20 people use a toilet[65]. The reality is that there is no conclusive scientific evidence to support a cutoff number of people sharing a toilet. Rather, an argument is made that when there is kinship (for example, members of the same family), or familiarity (for example, tenants of the same landlord), this forms a point of mutuality that allows for the establishment of a cleaning system and conflict resolution system. We argue that adopting this criterion risks limiting improvement efforts to extended family settings at the expense of other populations. A better solution would be to develop strategies for better communication, understanding, and resolving conflicts among toilet users.

Where more households share a latrine, it is often necessary to implement management strategies that guide latrine users[67,68]. These include dividing latrine units into male and female, assigning particular latrine units to specific families, organizing monthly compound-wide cleanings, arranging financial contributions for ongoing maintenance, and regulating use with keys[68]. According to a study, shared toilets are more likely to be safe, functional, and well-maintained than non-shared toilets because pooling cash resources makes building, maintaining, and operating a shared facility easier than trying to resolve challenges as a single household[69]. Furthermore, cleaner shared facilities can have a financial incentive for landlords. In one study, landlords who offered better sanitation facilities to their tenants were able to raise their rents[69]. However, it is important to note that this assumes that management decisions need to be taken by the users internally, without external support. In rural water supply there has been a lot of discussion about community management working better if communities can call in external support to help improve decision-making or deal with complicated problems. In the case of shared sanitation, this is never considered because sanitation is considered an internal issue within the household/compound. This can be explored further in research. In conclusion, a low number of users familiar with one another is essential for linking shared sanitation use to positive health outcomes, and it scores a medium score against the selection criteria outlined in Table 3.

Facility location. A total of 29 (12%) studies examined how facility location impacted the quality of sanitation services and user perceptions. Results show that in-compound shared sanitation facilities have advantages over those located outside compounds[21]. Shared sanitation facilities that are located within compounds or yards are more accessible and convenient, save time walking to a public toilet, and provide a sense of safety and security to users compared to using public toilets located outside residential compounds, particularly at nighttime[34,70]. It is important to reflect on how limited evidence exists to support the claim that sharing toilets with known people can reduce the risk of sexual assault (since, often, sexual violence is perpetrated by people who are familiar to the victim)[71].

A common feature of in-compound shared sanitation facilities is that they are typically free at the point of use for tenants, which makes them a cost-saving alternative to public facilities on a day-to-day basis[34]. Installation, maintenance, and repair costs are typically covered by the landlord or collectively by the tenants[25,72]. They also tend to be cleaner than public toilets and can minimize distress that can occur when waiting in line or waiting for a toilet for a long time[34]. Although the distance taken to walk to a sanitation facility was commonly linked to perceptions of safety, especially among women and girls, few studies examined this association empirically. In general, toilet facilities within residential compounds are associated with positive health and well-being outcomes, including perceptions of safety,

Table 1 | Initial long list of indicators for evaluating the quality of shared sanitation

			Criteria								
Factor	**Indicator**	**Source**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**Overall rating on indicator selection criteria**	**Strength of evidence / quality appraisal score**
Cleanliness	Clean and hygiene level is well maintained at all times.	34	✗		✗	✗	✗		✗	Medium	92%
	Having a sealed toilet to reduce smell and contamination.	25,37		✗	✗	✗	✗	✗		Medium	100%, 65%
	Shared responsibility for cleaning and involving all users in cleaning through a rotational system.	25,36	✗	✗	✗	✗	✗	✗	✗	**High**	100%, 65%
	Devoid of poor user behavior such as soiling the facility with feces or urine and spitting on the floor.	35		✗		✗				Low	92%
	No odor.	19	✗	✗	✗	✗	✗			Medium	88%
	Having a designated caretaker or cleanliness system	19									88%
Sharing	Sanitation facility is used by multiple households?	34	✗	✗	✗	✗	✗	✗	✗	**High**	92%
	Number of households sharing a toilet facility	34	✗	✗	✗	✗	✗	✗	✗	**High**	92%
	Sharing among people in the same compound but not accessible to outsiders.	34	✗	✗	✗	✗	✗	✗	✗	**High**	92%
Privacy	Having an outside lock for security.	25	✗	✗	✗	✗	✗	✗	✗	**High**	100%
	Having a solid door on the toilet used by tenants with an inside lock for privacy.	48		✗			✗	✗	✗	Medium	88%
	Solid wall made out of solid material and have no holes that would allow a person to peek through.	48		✗			✗	✗		Low	88%
Safety and security	Safe (protects the user from risks such as falling into the pit).	25	✗	✗		✗		✗	✗	Medium	100%
	Good lighting available, especially at night.	25		✗	✗		✗	✗	✗	Medium	100%
Gender-sensitivity	Separated spaces for women and men.	25		✗		✗	✗	✗	✗	Medium	100%
	Availability of menstrual health facilities (e.g. sanitary disposal bin).	25		✗		✗	✗	✗	✗	Medium	100%
Facility location	Should be located inside the compound.	19	✗	✗	✗		✗			Medium	88%
	Should not be located too far from people's premises.	19	✗	✗	✗		✗	✗		Medium	88%
Accessibility	Accessible to all members of the household, including those with disabilities.	19	✗	✗	✗	✗	✗	✗	✗	**High**	88%
	Accessible at all times (7 days a week, 24 hours a day).	19		✗		✗			✗	Low	88%
Structural quality	No signs of cracking or instability.	37		✗		✗	✗	✗	✗	Medium	65%
	Superstructure is regularly maintained.	37		✗		✗	✗		✗	Medium	65%
Facility management	Communication and problem-solving mechanisms among tenants, and between tenants and landlord.	37				✗			✗	Low	65%
	Timely desludging according to planned schedules or demand.	34	✗	✗	✗	✗		✗		Medium	92%
Technology design	Tiled floors to improve cleanability.	19		✗		✗	✗	✗	✗	Medium	88%
	Flush toilet technology.	19	✗	✗	✗		✗	✗		Medium	88%
	Availability of a functional handwashing facility with soap.	19,48		✗		✗	✗	✗	✗	Medium	88%, 88%
	Water availability.	19	✗		✗	✗		✗	✗	Medium	88%

Criteria:
C1 Accepted practice and history of use
C2 Measurable
C3 Availability of data
C4 Applicability in different settings
C5 Burden of data collection
C6 Clarity of focus and meaning
C7 Independence of indicator and value within a set of indicators
The overall rating on indicator selection criteria is scored as one of three levels:
High—meets 6 criteria and above
Medium—meets 4–5 criteria
Low—meets 1–3 criteria

and should therefore be considered critical indicators of high-quality shared sanitation.

Facility cleanliness. Of the studies reviewed, a total of 90 (36%) reported cleanliness of shared sanitation facilities to be an issue and noted the importance of further strategies for effecting high standards of cleanliness. Across the literature, complaints related to the cleanliness of the facility were commonly reported by shared sanitation users, regardless of the number of households sharing[19,34,36,73]. Conflicts related to cleaning often arose due to a lack of an enforced cleaning schedule, inadequate

https://doi.org/10.1038/s41545-024-00386-7

Table 2 | Summary of evidence in support of the indicators identified for evaluating shared sanitation quality

	Indicator	Rating on indicator selection criteria	Reference	Study design	Evidence	Quality assessment score
1	Number of households sharing a sanitation facility	Medium	40	Analysis of Demographic Health Survey (DHS) data from 51 countries. Examining the impact of sharing on diarrhea prevalence. Stratifying exposure by those that share with <5 HHs vs > 5 HHs.	Each sharing category had an increased prevalence compared with the non-sharing reference group. Little evidence for a dose-response relationship. No support for a threshold of households for which sharing does not present an increased risk of diarrhea.	92%
			89	A cross-sectional study investigating the association between toilet-to-household ratio and health outcomes of shared sanitation	Utilizing a heavily shared toilet (>18 people) was a risk factor for both waterborne illness (OR: 1.18, 95% CI: 1.06–1.31) and diarrhea (OR: 1.33, 95% CI: 1.17–1.53)	96%
			21	Cross-sectional study conducted among 570 households from 30 slums in India	No accurate data were collected on the number of households sharing a facility	81%
			90	Cross-sectional study among children under the age of 5 years Study sample size = 778 children from 707 households	Lower risk of diarrhea among households sharing a facility with >3 other households compared to those with non-sharing facilities	96%
					Noted variation in how shared latrines are managed based on the number of users Collective action failure was more frequent in compounds where more houses shared the latrine	
2	Facility location	Medium	91	Community-led mapping and enumerations for four cities across sub-Saharan Africa	Communal toilets are on average about 150 m from each house, a significant distance for women and children to walk in the dark	85%
			92	Expert opinion examining intra-slum patterns around basic infrastructure use	Women reported having to walk 20 min to community toilets	77%
			93	Qualitative study design—focus group discussions and in-depth interviews—to understand perceptions on menstruation and challenges faced by women in the reproductive age (20–49 years) and adolescent girls (10–19 years)	Community toilets were located on the boundaries of slums, or within a 1–2 km radius. In Seemapuri (Delhi), the community toilet was located nearly 1–1.5 km from households in the last few lanes of the slum	73%
			83	30 in-depth interviews, 12 focus group discussions, and 22 key informant interviews conducted with female slum-dwellers and community members on menstrual health	73.3% of females living without any disability had WASH facilities fewer than 25 feet from their household, compared to 43.8% of females with a disability. Females with a disability listed distance to the toilet as an obstacle to sanitation access	73%
			94	Modeling study to predict the most optimal distance between households and sanitation facilities to guide planning	Results show that the developed sanitation system using a single vehicle is scalable (100–700 users), can provide reliable service, and can be cheap (<1.5 c/p/day)	92%
3	Facility cleanliness	High	95	Applied molecular sequencing to determine the common bacterial communities on key contact surfaces in shared sanitation facilities within a metropolitan area	36 different bacterial phyla were detected on key contact surfaces within CABs (toilet seat, tap on wash hand basin, toilet cistern handle, and door latch on the cubical door), including rare and potentially pathogenic bacteria.	73%
			96	Mixed-methods study drawing on key informant interviews, focus group discussions, field observations, and face-to-face interviews of 400 residents selected from 249 houses to examine open defecation practices	Communities that do not have a fee to use facilities tend to be unclean, have foul odors, and be in a state of disrepair	69%
			97	A quantitative health risk model concerning the annual probability of infection and disease burden (DB) was performed for different exposed populations during their use of the shared toilet after flushing with time	Bioaerosols can stay suspended in the air for an extended period, so the next user of a shared toilet faces health risks due to exposure to suspended particles. The time interval between shared toilet users should be as long as possible	85%
			35	The study used focus group discussions and in-depth interviews with 70 users (landlords and tenants) of shared sanitation in	Participants' description of high-quality shared sanitation was centered on cleanliness, user behavior, smell, and user	100%

https://doi.org/10.1038/s41545-024-00386-7

Table 2 (continued) | Summary of evidence in support of the indicators identified for evaluating shared sanitation quality

	Indicator	Rating on indicator selection criteria	Reference	Study design	Evidence	Quality assessment score
				Kumasi, Ghana to assess barriers and opportunities of "high-quality" shared sanitation	crowding. A good landlord-tenant relationship is often linked to productive management practices by all toilet users, which are also associated with adequate shared sanitation, as well as proper toilet cleanliness and maintenance	
			37	Thirty-nine in-depth interviews and 11 focus group discussions were held with residents—mainly tenants and landlords—of a low-income settlement in Kisumu	Availability of cleaning materials such as water, brooms, and detergent facilitated cleaning. These materials were bought by landlords, or by tenants who contributed money towards their purchase. Compounds that were fenced or had a gate restricted the entry of other users who might soil the toilets, while those without a gate or fence were more likely to have intruders and hence unclean toilets. Tenants in such compounds were less motivated to clean their toilets. Other forms of barriers included the use of padlocks which ensured that users from outside the compound did not gain access to the toilets.	96%
			98	A community-based unmatched case-control study was conducted among 100 cases and 200 control households that shared latrines in a slum district in Addis Ababa	The barriers to cleaning shared latrines were found to be monthly household income of less than $55.60 (AOR = 1.80; 95% CI: 1.20–3.10), users feeling a lack of privacy during latrine use (AOR = 2.95; 95% CI: 1.60–5.43), no locking latch on the latrine door (AOR = 4.60; 95% CI: 2.43–8.79), inadequate ventilation of latrine (AOR: 4.88; 95% CI: 2.44–9.63), lack of regular monitoring of latrine by health extension workers (AOR = 2.86; 95%CI: 1.32–6.21) and a lack of enough water at home for cleaning the latrine (AOR = 4.91; 95% CI: 1.07–9.48)	88%
4	Accessibility	High	68	A cross-sectional design study in a convenience sample of 30 informal settlements	Facilities may not be available at night, or easily used by women and children	100%
			79	A mix of qualitative and quantitative methods was applied in four Accra neighborhoods over six months in 2012 to collect data on the physical conditions of public toilets	Older women can't use public toilets, so they defecate into a bag and dump it into the gutters, so some can't afford to use the toilet in some places	96%
			99	The study conducted involved 41 one-on-one in-depth interviews with users of managed shared sanitation facilities.	Participants noted that having a shared sanitation facility in the community did not always make it accessible. People noted that users may openly defecate if they have to walk long distances to reach a sanitation facility, especially for women after dark. Accessibility is defined in this study by the distance people have to walk to reach the facility, the amount of time they have to wait in line, and the design features of the facility that encourage use.	100%
5	Safety and security	High	100	Cross-sectional study on women living in slums	Women in Jayanagar slum, Karnataka, experienced psychosocial stress from open defecation due to the risk of sexual violence and using shared sanitation facilities far from their homes. Most of the women participants (26 out of 36) stated that they had faced sexual harassment such as teasing, being followed, peeped at, and commented on by men. Challenges are also associated with menstrual health management including walking long distances to toilets; the cost of using toilets several times per day; lack of privacy, safety, and security; lack of cleanliness; and lack of a place to hang their bags or dustbins to dispose of menstrual waste.	77%

Table 2 (continued) | Summary of evidence in support of the indicators identified for evaluating shared sanitation quality

	Indicator	Rating on indicator selection criteria	Reference	Study design	Evidence	Quality assessment score
			94	A qualitative study assessing the challenges associated with menstrual health and sanitation	Fighting and violence were common around community toilets. In Jaipur, one of the girls reported that boys and men congregate near the toilets and pass comments, making it difficult to use the facilities and forcing women and girls to constantly be on guard.	73%
			80	Household survey data to report on self-rated health and sociodemographic, housing, and infrastructure conditions in the Mathare informal settlement in Nairobi, Kenya.	Women expressed feeling vulnerable when using public toilets that are far from their homes and that do not have locks on doors or proper lighting at night. Fear of rape, especially at night, can lead to women not drinking fluids, chronic constipation, and using a bucket in their home as a toilet. The majority of sexual violence in slums occurs in the context of using a toilet, bathing, and/or menstrual hygiene, and in addition to the physical assault, it also leads to increased anxiety, a sense of powerlessness and hopelessness, marginalization, and stigmatization.	73%
6	Privacy	High	68	A cross-sectional design study in a convenience sample of 30 informal settlements	Half of the latrine facilities assessed provided segregated facilities for men and women (n = 104), with the remainder making no distinction. The majority of these (n = 91, 87.5%) were community or Sulabh latrines. None of the facilities in the study catered specifically for children (data not shown). No difference was found in levels of privacy (composite variable) between latrines used by neighbors or those used communally	100%
			101	An account based on field researchers' observations and 1751 householders' opinions in three regions, Tanzania	The likelihood of finding latrines without lockable doors and therefore, limiting users' privacy while using the facility was higher in non-shared latrines than in the shared latrines.	100%
			102	The study involved interviewing 197 adults living in three communities with a survey consisting of 70 psychosocial defecation-related questions	Poor latrine maintenance was noted as both a safety and privacy concern (i.e., a lack of a door or cracks in a wall)	81%

water supply, and expensive supplies[74–76]. In several studies, cleanliness was said to be more influenced by the nature of the community than by user numbers. People who are familiar with each other (e.g., family members or tenants sharing a compound) are more likely to communicate and establish cleanliness norms. There is, however, a knowledge gap concerning the threshold beyond which a common understanding of cleanliness becomes difficult. Research on these tensions, as well the potential for offering external support in making sanitation decisions should be conducted in the future. Promoting effective landlord-tenant relationships, in addition to creating cleaning schedules that involve all users, may be effective in improving latrine cleanliness of private shared sanitation[29,63,77]. Community members can also be made aware of the need for improved cleaning behavior through health and behavior change education. By implementing a dedicated place to dispose of trash and menstrual waste, sanitation facilities can be kept clean, and blockages can be minimized. The main indicators of poor toilet cleanliness included: the presence of visible feces in the toilet pan or the toilet cubicle, the presence of flies or other insects, improper disposal of menstrual hygiene products, odor, poor drainage, or clogged toilets, infrequent or inadequate cleaning, lack of cleaning equipment, and a lack of functional handwashing stations (with soap and clean water). Cleanliness is often easier in sanitation facilities with plastered or tiled floors[31]. A shared sanitation facility should be considered clean if there is a system for collective cleanliness if there is a designated caretaker, if there is water available for cleaning, or if the physical design of the facility promotes cleanliness (e.g., tiled floor).

Table 3 | Reviewed evidence by study design

Study design	Number of studies
Cross-sectional studies	133
Case studies	45
Reports	15
Reviews	10
Expert opinion	10
Experimental designs	9
Case-control studies	8
Cohort studies	8
Policy analysis	7
Modeling studies	3
Total	248

Accessibility. Accessibility refers to the proximity of toilets to households, hours of operation, and time spent waiting in queues, as well as accessibility for disabled persons, the elderly, and children[34,78]. Without the safety offered by accessible sanitation facilities, especially at night, women and girls may be at increased risk of sexual violence, especially if they must openly defecate at night when shared facilities are closed[79–81]. Long wait times[34], slippery conditions during rain[82], and distance to access sanitation facilities were other major accessibility-related barriers. Improvements to shared sanitation should also address overcrowding and long queues, especially where more children are co-users[34]. This may be accomplished by implementing more hygienic sanitation facilities per community to decrease the number of people sharing[41,56,83], as well as installing facilities suitable for children, the elderly, and people with disability. disabled persons[84]. A shared sanitation facility is considered accessible if the following criteria are met toilets are situated near residential premises, and accessibility features are available for people with disabilities, young children, and the elderly.

Privacy. Adequate privacy in shared sanitation facilities includes the presence of well-fitting doors with functional locks, facilities separated by gender, solid walls, and roofs without cracks or holes[85]. Facilities located closer to households also tended to offer more privacy, as they were not in a central location such as a main road where several people pass by ref. 40. Specific indicators of shared sanitation facilities that offer sufficient privacy include the presence of a door, the presence of a door locking latch inside a cubicle, the presence of an outside door lock, especially at night, and a solid superstructure. Studies report that installing gender-separated toilets can improve feelings of privacy, however, it is not well documented whether the inherent net benefit of gender-separated toilets is greater than the benefit of individual household toilets. According to the literature, indicators for maintaining privacy in shared sanitation facilities should include a functional and lockable door and a solid structure without holes or cracks.

Safety and security. In informal settlements, sexual violence is sometimes related to the use of sanitation facilities, which leads to increased anxiety, a sense of powerlessness, and marginalization[79,80,86]. There is evidence of increased sexual violence and harassment faced by women and girls when using sanitation facilities that are located outside their homes[37,47,48]. Having to walk long distances alone at night and long distances to the toilet heightens the risk of sexual violence[79]. Facilities that are located at the periphery of neighborhoods away from busy streets have been reported as hotspots for sanitation-related

Fig. 4 | Proposed reclassification of shared sanitation facilities based on facility quality and user needs. Facilities are categorized into three groups—improved shared sanitation, basic shared sanitation, or unimproved shared sanitation—according to their quality and ability to meet user requirements.

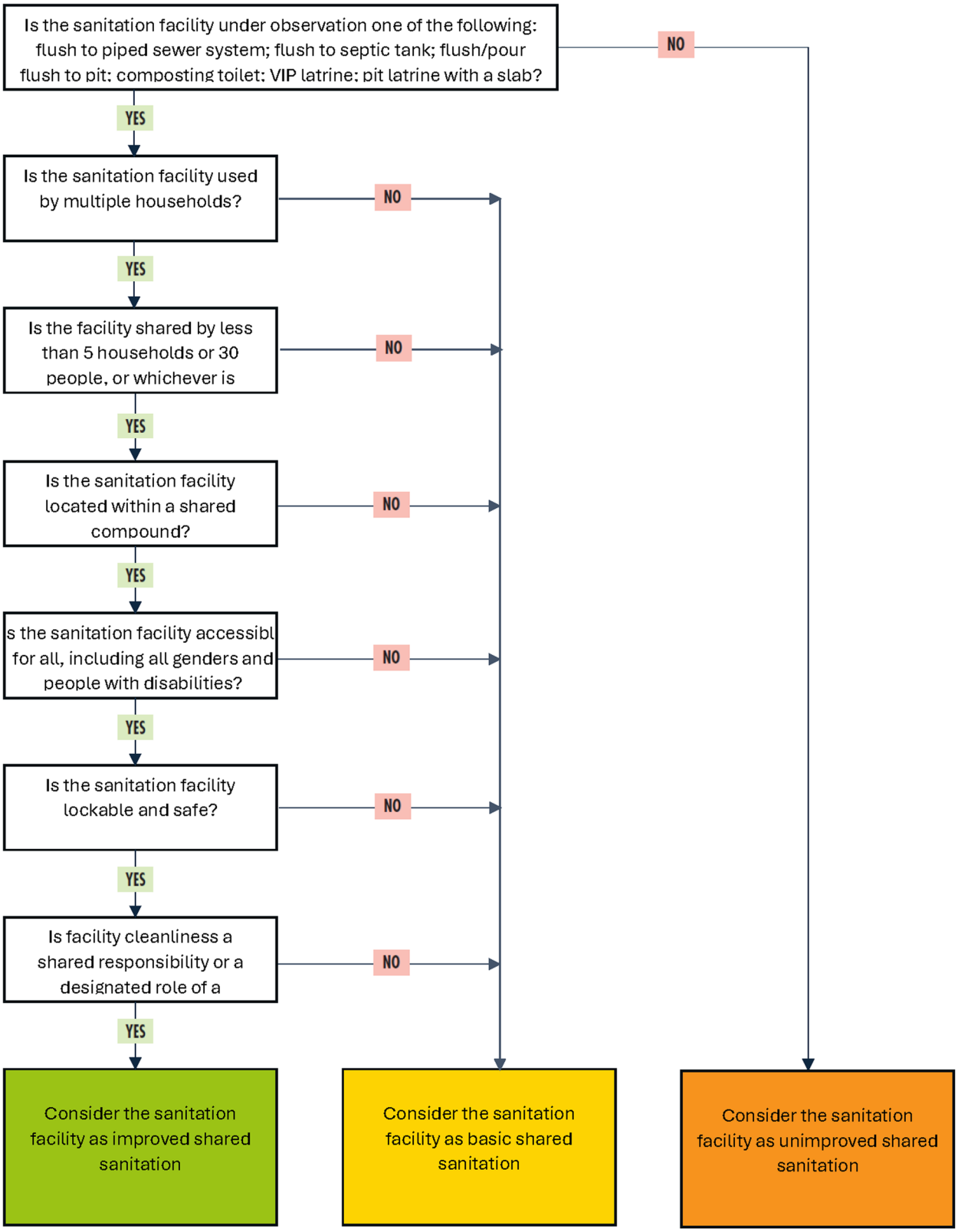

Fig. 5 | Proposed indicator matrix for evaluating the quality of shared sanitation facilities. The matrix outlines key dimensions for evaluating the quality of shared sanitation facilities, including number of users, facility location, accessibility, safety, and cleanliness. The dimensions are presented in a decision-tree format framed as evaluation questions that culminate in one of three sanitation categories: improved shared sanitation, basic shared sanitation, or unimproved shared sanitation.

sexual violence[72,79]. Providing lighting in and around the shared sanitation facility, as well as a 24-h caretaker at the facility, can improve women's perceptions of safety and encourage proper sanitation usage[47]. For shared sanitation facilities to promote feelings of safety especially for women and girls, the following indicators should be considered: proper lighting fixtures both inside and outside toilet cubicles, lockable doors, presence of a 24-h caretaker, and facility located closer to premises.

Discussion

Over the coming years, the population of people living in informal settlements in the world's two poorest regions—South Asia and Sub-Saharan Africa—is expected to double[87], suggesting that the absolute numbers of people relying on shared sanitation will dramatically grow[47]. It is impossible to predict how economic growth, changes in urbanization patterns, and changes in demographics will unfold since urbanization is changing rapidly. However, we can be certain that housing development will outstrip states' ability to provide adequate high-quality private sanitation for long periods of time. A significant proportion of sanitation investment will take place in the private and/or informal sector and shared sanitation is likely to be widely deployed. A failure to recognize this fact, and to provide suitable guidance and indicators for monitoring shared facilities, will lessen the ability to secure the best possible outcomes for those people using shared facilities. One option is to establish the basis on which some shared sanitation facilities currently categorized as "limited" could be re-categorized as "basic" in JMP reporting. The JMP defines basic sanitation as *sanitation facilities designed to hygienically separate excreta from human contact (also referred to as improved sanitation) and are not shared with other households*, and limited sanitation as *improved facilities that are shared with other households*. Although there is no conclusive evidence of a specific safer number of users, multiple studies suggest that toilets shared by less than five households are cleaner, safer, and more private than toilets shared by four or more households[88,61]. This review has shown that the evidence base that links specific aspects of shared sanitation facilities to improved health and/or wellbeing outcomes is incomplete and sometimes conflicting. Any reclassification of shared facilities into differentiated service levels requires confidence that (a) each level can be plausibly linked to differential health/wellbeing outcomes based on existing evidence and (b) each level can be plausibly assessed through a small set of robust, measurable indicators. Our review suggests that on this basis it is plausible to call for a shared household (not institutional) sanitation to be reclassified into three categories (Fig. 4).

In Fig. 5, we describe a framework of questions that can be factored into routine monitoring and data collection processes to generate data on the quality of shared sanitation. This framework was informed by widely tested indicators from previously published literature[19,25,34,47,88]. Paying attention to the number of households or people sharing facilities, cleanliness, privacy, structural quality, shared responsibility, facility location, accessibility, safety, and security is important for understanding shared sanitation quality. Thus, facilities that meet these targets can be considered improved shared sanitation. By making these changes to national sanitation monitoring protocols, the sanitation service ladder could become an even more valuable tool for informing urban sanitation quality, especially in informal settlements. Additionally, the indicators recommended above should be included in local sanitation programs' monitoring systems.

We identify several areas for further research. First, the proposed indicators should be refined and validated using empirical data in future studies to ensure they adequately evaluate all forms of shared sanitation facilities. Secondly, we found some evidence that safety, security, and gender-based violence have been addressed in some studies, but research needs to focus on factors affecting safety and develop strategies for reducing sexual violence. Third, we found conflicting and inconclusive information regarding how user ratio varies with quality and satisfaction, and this can be achieved through quantitative and modeling studies implemented in multiple settings. We identified areas of tension regarding adequate lighting at shared sanitation facilities, with studies suggesting that adequate lighting may improve safety, while others associated it with increased security risks as well-lit facilities may attract unsavory groups of people to gather there. Our findings also indicate that measuring accessibility reliably could be challenging, therefore, there is a need to develop approaches for measuring accessibility in shared sanitation facilities and understand how different accessibility features can affect different user groups. Based on our review of the literature, we did not find sufficient evidence to support the statement about menstrual health indicators within shared sanitation. We recommend that research be conducted to fill this knowledge gap. Additionally, it is important to investigate the health outcomes associated with shared sanitation use, especially when open defecation is an alternative.

Our work has some limitations. First, the JMP uses a sanitation technology type categorization as the basis for its monitoring. This approach can be complicated by quality inconsistencies across sanitation technologies. The indicator framework proposed in this study does not follow the JMP's sanitation technology type categorization but has the advantage of minimizing the risk of overcounting what is considered improved sanitation. Secondly, the indicator selection framework and our approach to assessing strength of evidence may have omitted important indicators that have been recently identified but not yet extensively tested. As a result, our findings may vary with those found by other researchers. Lastly, we found a variation in the definition of what constitutes shared sanitation facilities in the literature, which may have an impact on how the findings are interpreted. Even with these limitations, our recommendations are relevant for all forms of household-level shared sanitation across the world.

Data availability

Authors can confirm that all relevant data are included in the paper and/ or its supplementary information files.

Received: 30 April 2024; Accepted: 5 September 2024;
Published online: 04 October 2024

References

1. UN-Habitat. The Challenge of Slums: Global Report on Human Settlements 200320043. *Manag. Environ. Qual. Int. J.* **15**, 337–338 (2004).
2. UNICEF & WHO. *Progress on Household Drinking Water, Sanitation and Hygiene 2000–2022: Special Focus on Gender*. https://citeas.org/cite/https://data.unicef.org/resources/jmp-report-2023/ (World Health Organization, 2023).
3. Sprouse, L. et al. Shared sanitation in informal settlements: A systematic review and meta-analysis of prevalence, preferences, and quality. *Int J. Hyg. Environ. Health*. **260**, 114392 (2024).
4. Corburn, J. & Sverdlik, A. Informal settlements and human health. in *Integrating Human Health into Urban and Transport Planning: A Framework* (eds. Nieuwenhuijsen, M. & Khreis, H.) 155–171 (Springer International Publishing, Cham, 2019). https://doi.org/10.1007/978-3-319-74983-9_9.
5. Cheng, S. Constructing a toilet standard system for the toilet revolution in China. *J. Water Sanit. Hyg. Dev.* **14**, 291–301 (2024).
6. Mara, D. The elimination of open defecation and its adverse health effects: a moral imperative for governments and development professionals. *J. Water Sanit. Hyg. Dev.* **7**, 1–12 (2017).
7. Prüss-Ustün, A. et al. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. *Int J. Hyg. Environ. Health* **222**, 765–777 (2019).
8. Manga, M. et al. Public health performance of sanitation technologies in Tamil Nadu, India: Initial perspectives based on E. coli release. *Int. J. Hyg. Environ. Health* **243**, 113987 (2022).
9. Dickson-Gomez, J. et al. Water, sanitation, and hygiene challenges in informal settlements in Kampala, Uganda: a qualitative study. *Int. J. Environ. Res. Public Health* **20**, 6181 (2023).
10. Lebu, S., Gyimah, R., Nandoya, E., Brown, J., Salzberg, A. & Manga, M. Assessment of sanitation infrastructure resilience to extreme rainfall and flooding: Evidence from an informal settlement in Kenya. *J. Environ. Manage.* **354**, 120264 (2024).
11. Muanda, C., Goldin, J. & Haldenwang, R. Factors and impacts of informal settlements residents' sanitation practices on access and sustainability of sanitation services in the policy context of Free Basic Sanitation. *J. Water, Sanit. Hyg. Dev.* **10**, 238–248 (2020).
12. Sinharoy, S. S., Pittluck, R. & Clasen, T. Review of drivers and barriers of water and sanitation policies for urban informal

settlements in low-income and middle-income countries. *Util. Policy* **60**, 100957 (2019).
13. Conaway, K., Lebu, S., Heilferty, K., Salzberg, A., On-site sanitation system emptying practices and influential factors in Asian low- and middle-income countries: A systematic review. Hyg Environ Health Adv. https://doi.org/10.1016/j.heha.2023.100050.
14. Okurut, K., Kulabako, R. N., Chenoweth, J. & Charles, K. Assessing demand for improved sustainable sanitation in low-income informal settlements of urban areas: a critical review. *Int. J. Environ. Health Res.* **25**, 81–95 (2015).
15. Evans, B. et al. Limited services? The role of shared sanitation in the 2030 Agenda for Sustainable Development. *J. Water Sanit. Hyg. Dev.* **7**, 349–351 (2017).
16. Manga, M., Evans, B. & Bartram, J. Economic cost analysis of low-cost sanitation technology options in informal settlement areas (case study: Soweto Johannesburg). *Int J. Hyg. Environ. Health* **223**, 289–298 (2019).
17. Mahabir, R., Crooks, A., Croitoru, A. & Agouris, P. The study of slums as social and physical constructs: challenges and emerging research opportunities. *Reg. Stud. Reg. Sci.* **3**, 399–419 (2016).
18. Aboulnaga, M. M., Badran, M. F. & Barakat, M. M. Global Informal Settlements and Urban Slums in Cities and the Coverage. In *Resilience of Informal Areas in Megacities – Magnitude, Challenges, and Policies: Strategic Environmental Assessment and Upgrading Guidelines to Attain Sustainable Development Goals* (eds. Aboulnaga, M. M., Badran, M. F. & Barakat, M. M.) 1–51 (Springer International Publishing, Cham, 2021). https://doi.org/10.1007/978-3-030-87794-1_1.
19. Schelbert, V. et al. Quality determinants of shared sanitation facilities in low-income urban settlements. *Water Science Policy* https://doi.org/10.53014/HZGG5241 (2021).
20. Lebu, S. et al. The case for shared sanitation access in informal settlements: A dialogue on science, policy, and practice integration.*PLOS Water* **3**(5), e0000243 (2024).
21. Heijnen, M. et al. Shared sanitation versus individual household latrines: a systematic review of health outcomes. *PLoS ONE* **9**, e93300 (2014).
22. Satterthwaite, D., Mitlin, D. & Bartlett, S. Is it possible to reach low-income urban dwellers with good-quality sanitation? *Environ. Urban.* **27**, 3–18 (2015).
23. Schouten, M. A. C. & Mathenge, R. W. Communal sanitation alternatives for slums: a case study of Kibera, Kenya. *Phys. Chem. Earth* **35**, 815–822 (2010).
24. Ross, I. et al. Impact of a sanitation intervention on quality of life and mental well-being in low-income urban neighbourhoods of Maputo, Mozambique: an observational study. *BMJ Open* **12**, e062517 (2022).
25. Tidwell, J. B. et al. Where shared sanitation is the only immediate option: A research agenda for shared sanitation in densely populated low-income urban settings. *Am. J. Trop. Med. Hyg.* **104**, 429–432 (2021).
26. Awunyo-Akaba, Y. et al. Sanitation investments in Ghana: An ethnographic investigation of the role of tenure security, land ownership and livelihoods. *BMC Public Health* **16**, 594 (2016).
27. Corburn, J. & Karanja, I. Informal settlements and a relational view of health in Nairobi, Kenya: sanitation, gender and dignity. *Health Promot. Int.* **31**, 258–269 (2016).
28. Heijnen, M., Rosa, G., Fuller, J., Eisenberg, J. N. & Clasen, T. The geographic and demographic scope of shared sanitation: an analysis of national survey data from low- and middle-income countries. *Trop. Med Int Health* **19**, 1334–1345 (2014).
29. Foggitt, E., Cawood, S., Evans, B. & Acheampong, P. Experiences of shared sanitation – towards a better understanding of access, exclusion and 'toilet mobility' in low-income urban areas. *J. Water Sanit. Hyg. Dev.* **9**, 581–590 (2019).
30. Bateganya, N. L. et al. Shifting from traditional infrastructure planning to a collaborative approach: lessons from the Freetown sanitation master plan. *J. Water Sanit. Hyg. Dev.* **13**, 974–985 (2023).
31. Antwi-Agyei, P., Monney, I., Amaning Adjei, K., Kweyu, R. & Simiyu, S. Shared but clean household toilets: what makes this possible? Evidence from Ghana and Kenya. *Int. J. Environ. Res. Public Health* **19**, 4271 (2022).
32. Kabange, R. S., Graham, J. P. & Nkansah, A. Sanitation system solution for Kotoko Community in Suame (Kumasi). *Ghana. Am. Sci. Res.* **16**, 19–54 (2016).
33. World Health Organization. *Guidelines on Sanitation and Health* (World Health Organization, 2018).
34. Antwi-Agyei, P., Dwumfour-Asare, B., Amaning Adjei, K., Kweyu, R. & Simiyu, S. Understanding the Barriers and Opportunities for Effective Management of Shared Sanitation in Low-Income Settlements—The Case of Kumasi, Ghana. *Int. J. Environ. Res. Public Health* **17**, 4528 (2020).
35. Heijnen, M., Routray, P., Torondel, B. & Clasen, T. Shared sanitation versus individual household latrines in urban slums: a cross-sectional study in Orissa, India. *Am. J. Trop. Med Hyg.* **93**, 263–268 (2015).
36. Simiyu, S., Kweyu, R. M., Antwi-Agyei, P. & Adjei, K. A. Barriers and opportunities for cleanliness of shared sanitation facilities in low-income settlements in Kenya. *BMC Public Health* **20**, 1–12 (2020).
37. Simiyu, S., Swilling, M., Cairncross, S. & Rheingans, R. Determinants of quality of shared sanitation facilities in informal settlements: case study of Kisumu, Kenya. *BMC Public Health* **17**, 68 (2017).
38. Caruso, B. A. & Freeman, M. C. Shared sanitation and the spread of COVID-19: risks and next steps. *Lancet Planet. Health* **4**, e173 (2020).
39. Fuller, J. A., Clasen, T., Heijnen, M. & Eisenberg, J. N. S. Shared sanitation and the prevalence of diarrhea in young children: evidence from 51 countries, 2001–2011. *Am. J. Trop. Med. Hyg.* **91**, 173–180 (2014).
40. Schelbert, V. et al. When is shared sanitation acceptable in low-income urban settlements? A user perspective on shared sanitation quality in Kumasi, Kisumu and Dhaka. *J. Water Sanit. Hyg. Dev.* **10**, 959–968 (2020).
41. Capone, D. et al. Impact of an intervention to improve pit latrine emptying practices in low income urban neighborhoods of Maputo, Mozambique. *Int J. Hyg. Environ. Health* **226**, 113480 (2020).
42. Just, M. R. et al. The impact of shared sanitation facilities on diarrheal diseases with and without an environmental reservoir: a modeling study. *Pathog. Glob. Health* **112**, 195–202 (2018).
43. Page, M. J. et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* **372**, n71 (2021).
44. Sterne, J. A. et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* **355**, i4919 (2016).
45. Venkataramanan, V., Crocker, J., Karon, A. & Bartram, J. Community-led total sanitation: a mixed-methods systematic review of evidence and its quality. *Environ. Health Perspect.* **126**, 026001 (2018).
46. Whiting, P. et al. ROBIS: A new tool to assess risk of bias in systematic reviews was developed. *J. Clin. Epidemiol.* **69**, 225–234 (2016).
47. Meili, D. et al. Indicators for sanitation quality in low-income urban settlements: evidence from Kenya, Ghana, and Bangladesh. *Soc. Indic. Res.* **162**, 683–720 (2022).
48. Schelbert, V. et al. Quality determinants of shared sanitation facilities in low-income urban settlements. *wspg* https://doi.org/10.53014/HZGG5241 (Water Science Policy, 2021).
49. MacDonald, G. Criteria for selection of high-performing indicators: a checklist to inform monitoring and evaluation. *Evaluation Checklists Project, The Evaluation Center, Western Michigan University* (2013).

50. Schwemlein, S., Cronk, R. & Bartram, J. Indicators for monitoring water, sanitation, and hygiene: a systematic review of indicator selection methods. *Int. J. Environ. Res. Public Health* **13**, 333 (2016).
51. Alam, M. U. et al. Behaviour change intervention to improve shared toilet maintenance and cleanliness in urban slums of Dhaka: a cluster-randomised controlled trial. *Trop. Med Int Health* **22**, 1000–1011 (2017).
52. Chaudhuri, I. N. Community mobilization for slum upgrading through sanitation in Roma informal settlements in the Paris Region. *Front. Public Health* **5**, 213 (2017).
53. Haque, S. S., Yanez-Pagans, M., Arias-Granada, Y. & Joseph, G. Water and sanitation in Dhaka slums: access, quality, and informality in service provision. *Water Int.* **45**, 791–811 (2020).
54. Jenkins, M. W., Cumming, O., Scott, B. & Cairncross, S. Beyond 'improved' towards 'safe and sustainable' urban sanitation: assessing the design, management and functionality of sanitation in poor communities of Dar es Salaam, Tanzania. *J. Water Sanit. Hyg. Dev.* **4**, 131–141 (2013).
55. Mazeau, A., Tumwebaze, I., Lüthi, C. & Sansom, K. Inclusion of shared sanitation in urban sanitation coverage? Evidence from Ghana and Uganda. *Waterlines* **32**, 334–348 (2013).
56. McGranahan, G. & Mitlin, D. Learning from sustained success: how community-driven initiatives to improve urban sanitation can meet the challenges. *World Dev.* **87**, 307–317 (2016).
57. Mutyambizi, C., Mokhele, T., Ndinda, C. & Hongoro, C. Access to and satisfaction with basic services in informal settlements: results from a baseline assessment survey. *Int. J. Environ. Res. Public Health* **17**, 4400 (2020).
58. Naranjo, A. et al. The MobiSan approach: informal settlements of Cape Town, South Africa. *Water Sci. Technol.* **61**, 3078–3090 (2010).
59. Shermin, N. & Rahaman, S. N. Assessment of sanitation service gap in urban slums for tackling COVID-19. *J. Urban Manag.* **10**, 230–241 (2021).
60. Tumwebaze, I. K., Niwagaba, C. B., Günther, I. & Mosler, H. J. Determinants of households' cleaning intention for shared toilets: Case of 50 slums in Kampala, Uganda. *Habitat Int.* **41**, 108–113 (2014).
61. Günther, I. et al. When is shared sanitation improved sanitation? - The correlation between number of users and toilet hygiene. *MPRA Paper* (2012).
62. Aluko, O. O., Oloruntoba, E. O., Chukwunenye, U. A., Henry, E. U. & Ojogun, E. The dynamics and determinants of household shared sanitation cleanliness in a heterogeneous urban settlement in Southwest Nigeria. *Public Health* **165**, 125–135 (2018).
63. Tidwell, J. B. et al. Effect of a behaviour change intervention on the quality of peri-urban sanitation in Lusaka, Zambia: a randomised controlled trial. *Lancet Planet Health* **3**, e187–e196 (2019).
64. Obeng, P. A. et al. The latrine ownership ladder: a conceptual framework for enhancing sanitation uptake in low-income peri-urban settings. *Manag. Environ. Qual.: Int. J.* **26**, 752–763 (2015).
65. Sphere Association. *Sphere Handbook: Humanitarian Charter and Minimum Standards in Disaster Response, 2011*. www.spherestandards.org/handbook (Practical Action Publishing, 2018).
66. World Health Organization. *Progress on Drinking Water and Sanitation: Joint Monitoring Programme Update 2013*. (World Health Organization, 2013).
67. Heijnen, M., Routray, P., Torondel, B. & Clasen, T. Neighbour-shared versus communal latrines in urban slums: a cross-sectional study in Orissa, India exploring household demographics, accessibility, privacy, use and cleanliness. *Trans. R. Soc. Trop. Med Hyg.* **109**, 690–699 (2015).
68. Shiras, T. et al. Shared sanitation management and the role of social capital: findings from an urban sanitation intervention in Maputo, Mozambique. *Int J. Environ. Res Public Health* **15**, 2222 (2018).
69. Rheinländer, T., Konradsen, F., Keraita, B., Apoya, P. & Gyapong, M. Redefining shared sanitation. *Bull. World Health Organ.* **93**, 509–510 (2015).
70. Ritter, R. L. et al. Within-compound versus public latrine access and child feces disposal practices in low-income neighborhoods of Accra, Ghana. *Am. J. Trop. Med Hyg.* **98**, 1250–1259 (2018).
71. Sodipo, O. O., Adedokun, A., Adejumo, A. O. & Oibamoyo, O. The pattern and characteristics of sexual assault perpetrators and survivors managed at a sexual assault referral centre in Lagos. *Afr. J. Prim. Health Care Fam. Med* **10**, 1727 (2018).
72. Simiyu, S., Swilling, M. & Cairncross, S. Decision-making on shared sanitation in the informal settlements of Kisumu, Kenya. *Int. J. Environ. Health Res.* **27**, 377–393 (2017).
73. Chipungu, J., Tidwell, J. B., Chilengi, R., Curtis, V. & Aunger, R. The social dynamics around shared sanitation in an informal settlement of Lusaka, Zambia. *J. Water Sanit. Hyg. Dev.* **9**, 102–110 (2018).
74. Kwiringira, J., Atekyereza, P., Niwagaba, C. & Günther, I. Gender variations in access, choice to use and cleaning of shared latrines; experiences from Kampala Slums, Uganda. *BMC Public Health* **14**, 1180 (2014).
75. O'Keefe, M., Messmer, U., Lüthi, C. & Tobias, R. Slum inhabitants' perceptions and decision-making processes related to an innovative sanitation service: evaluating the Blue Diversion Toilet in Kampala (Uganda). *Int. J. Environ. Health Res.* **25**, 670–684 (2015).
76. Schoell, A. T. & Scott, R. Stakeholder acceptance of shared toilets to improve sanitation access in low-income urban settings: a case study of Gulu city, Uganda. *J. Water Sanit. Hyg. Dev.* **13**, 11–18 (2023).
77. Winter, S., Barchi, F. & Dzombo, M. N. Not just any toilet–women's solutions to sanitation in informal settlements in Nairobi. *Dev. Pract.* **29**, 15–25 (2019).
78. Peprah, D. et al. Public toilets and their customers in low-income Accra, Ghana. *Environ. Urban.* **27**, 589–604 (2015).
79. Corburn, J. & Hildebrand, C. Slum sanitation and the social determinants of women's health in Nairobi, Kenya. *J. Environ. Public Health* **2015**, 209505 (2015).
80. Kayser, G. L. et al. Household sanitation access and risk for non-marital sexual violence among a nationally representative sample of women in India, 2015-16. *SSM Popul. Health* **13**, 100738 (2021).
81. Sahoo, K. C. et al. Sanitation-related psychosocial stress: a grounded theory study of women across the life-course in Odisha, India. *Soc. Sci. Med.* **139**, 80–89 (2015).
82. Chowdhury, M. A. et al. WASH and MHM experiences of disabled females living in Dhaka slums of Bangladesh. *J. Water Sanit. Hyg. Dev.* **12**, 683–697 (2022).
83. Tomlinson, R. Scalable community-led slum upgrading: The Indian Alliance and community toilet blocks in Pune and Mumbai. *Habitat Int.* **50**, 160–168 (2015).
84. Sunarti, S., Helmi, M., Widjajanti, R. & Purwanto, A. A. Modelling behavioural change from sea-based 'helicopter latrines' to land-based shared improved latrines in the Demaan, Jepara, Indonesia. *J. Water Sanit. Hyg. Dev.* **11**, 10–25 (2021).
85. Winter, S., Dreibelbis, R. & Barchi, F. Women's sanitation practices in informal settlements: a multi-level analysis of factors influencing utilisation in Nairobi, Kenya. *Glob. Public Health* **14**, 663–674 (2019).
86. Sahoo, K. C. et al. A systematic review of water, sanitation, and hygiene for urban poor in low- and middle-income countries during the COVID-19 pandemic through a gendered lens. *Int. J. Environ. Res. Public Health* **19**, 11845 (2022).
87. UN-Habitat. *Habitat III Issue Papers: 22 - Informal Settlements*. (2015).
88. Simiyu, S., Antwi-Agyei, P., Adjei, K. & Kweyu, R. Developing and testing strategies for improving cleanliness of shared sanitation in low-income settlements of Kisumu, Kenya. *Am. J. Trop. Med Hyg.* **105**, 1816–1825 (2021).

89. Hubbard, S. C. et al. Household illness and associated water and sanitation factors in peri-urban Lusaka. *NPJ Clean Water* **3**, 1–7 (2020).
90. Nguyen, T. Y. C. et al. Diarrhoea among children aged under five years and risk factors in informal settlements: a cross-sectional study in Cape Town, South Africa. *Int. J. Environ. Res. Public Health* **18**, 6043 (2021).
91. Banana, E., Chitekwe-Biti, B. & Walnycki, A. Co-producing inclusive city-wide sanitation strategies: lessons from Chinhoyi, Zimbabwe. *Environ. Urban.* **27**, 35–54 (2015).
92. Chidambaram, S. How do institutions and infrastructure affect mobilization around public toilets vs. piped water? Examining intra-slum patterns of collective action in Delhi, India. *World Dev.* **132**, 104984 (2020).
93. Chakravarthy, V., Rajagopal, S. & Joshi, B. Does menstrual hygiene management in urban slums need a different lens? Challenges faced by women and girls in Jaipur and Delhi. *Indian J. Gend. Stud.* **26**, 138–159 (2019).
94. Schmitt, R. J. P., Morgenroth, E. & Larsen, T. A. Robust planning of sanitation services in urban informal settlements: an analytical framework. *Water Res.* **110**, 297–312 (2017).
95. Ramlal, P. S. et al. 16S rRNA-based metagenomic profiling of microbes on contact surfaces within shared sanitation facilities. *Ecol. Genet. Genom.* **21**, 100095 (2021).
96. Monney, I., Baffoe-Kyeremeh, A. & Amissah-Reynolds, P. K. Accelerating rural sanitation coverage in Ghana: what are the speed bumps impeding progress? *J. Water Sanit. Hyg. Dev.* **5**, 531–543 (2015).
97. Ali, W. et al. Comparing bioaerosol emission after flushing in squat and bidet toilets: quantitative microbial risk assessment for defecation and hand washing postures. *Build. Environ.* **221**, 109284 (2022).
98. Hailu, K., Alemu, Z. A. & Adane, M. Barriers to cleaning of shared latrines in slums of Addis Ababa, Ethiopia. *PLoS ONE* **17**, e0263363 (2022).
99. Vu, S., Jain, A., Harrison, C., Ghimire, P. & Graham, J. Someone should be there to take care of it': a case study of users' views of managed shared sanitation facilities in Jharkhand, India. *Am. J. Trop. Med. Hyg.* **106**, 1135–1140 (2022).
100. Biswas, D. & Joshi, S. Sanitation and gendered psychosocial stress in peri-urban Bangalore. *Dev. Pract.* **31**, 548–557 (2021).
101. Massa, K. et al. Contributing to the debate on categorising shared sanitation facilities as 'unimproved': An account based on field researchers' observations and householders' opinions in three regions, Tanzania. *PLoS ONE* **12**, e0185875 (2017).
102. Lopez, V. K. et al. Determinants of latrine use behavior: the psychosocial proxies of individual-level defecation practices in rural coastal Ecuador. *Am. J. Trop. Med Hyg.* **100**, 733–741 (2019).

Acknowledgements

This study was funded by Habitat for Humanity International [grant number A23-1351-001]. The funder played no role in study design, data collection, analysis and interpretation of data, or the writing of this manuscript. We are tremendously grateful for this support, as well as for the time, technical contributions, and administrative assistance provided by David Hughes and the Habitat team. Professor Pete Kolsky has been an invaluable asset to this effort, and we are extremely thankful. Additionally, we would like to express our gratitude to the organizers of the UNC Water and Health Conference. As part of this effort, the team would also like to acknowledge the following key UNC contributors: Jackqueline Tu-uyen Nguyen, Andromede Uwase, and Jiahui (Wendy) Guo.

Author contributions

Sarah Lebu: Conceptualization, Investigation, Formal analysis, Data curation, Methodology, Software, Validation, Visualization, Writing – original draft; Lauren Sprouse: Conceptualization, Investigation, Formal analysis, Data curation, Methodology, Software, Validation, Writing – review & editing; John Apambilla Akudago: Conceptualization; Validation; and Writing - review & editing; Carrie Baldwin-SoRelle: Methodology, Validation; Chimdi C Muoghalu; Methodology, Validation, Writing – Review & Editing; Carmen Anthonj: Conceptualization; Investigation; Methodology; Validation; and Writing - review & editing; Barbara Evans: Investigation; Methodology; Validation; and Writing - review & editing; Joe Brown: Conceptualization; Investigation; Methodology; Validation; and Writing - review & editing; Jamie Bartram: Conceptualization; Investigation; Methodology; Data curation; Formal analysis; Validation; and Writing - review & editing; Musa Manga: Conceptualization, Funding acquisition, Investigation, Methodology, Data curation, Formal analysis, Validation, Project administration, Resources, Supervision, Writing – review & editing.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41545-024-00386-7.

Correspondence and requests for materials should be addressed to Musa Manga.