WSUP | Water & Sanitation for the Urban Poor

Quality Check

How can we ensure sanitation achieves health and quality of life outcomes in low-income areas?

Urban Sanitation Research Initiative

Discussion Paper | February 2021

Executive summary

Background

This publication explores how *high-quality* sanitation can be achieved in low-income urban areas in developing contexts. It is based on findings from four research projects conducted under, or in association with, WSUP's Urban Sanitation Research Initiative 2016–2020 (USRI), funded by DFID. An analogous parallel publication, drawing upon findings of other USRI projects, looks at how high-quality sanitation for low-income areas can be *financed*.

The four research projects considered here are:

– *The **Faecal Pathogen Flows** study in Dhaka (Bangladesh) — aiming to track and model how faecal pathogens move through urban low-income communities (LICs), as a tool to support sanitation intervention planning in developing contexts.* The research was led by the University of Technology Sydney, Emory University, and The Institute for Diarrheal Disease Research, Bangladesh (icddr,b).

– *The **MapSan** study carried out in Maputo (Mozambique) — one of the largest and most rigorous studies ever conducted of the health impacts of an urban sanitation intervention.* The study was led by the London School of Hygiene & Tropical Medicine (LSHTM) and the Georgia Institute of Technology.

– *The **QUISS** study — based on large-scale surveys in Bangladesh, Ghana and Kenya, aiming to identify minimum standards for high-quality shared sanitation in urban contexts, and workable indicators of shared sanitation quality.* The research was led by Eawag-Sandec with researchers from ETH Zürich (Switzerland), icddr,b (Bangladesh), the African Population and Health Research Center (Kenya), the University of Energy and Natural Resources, Kwame Nkrumah University of Science and Technology (KNUST), and the University of Education (Ghana);

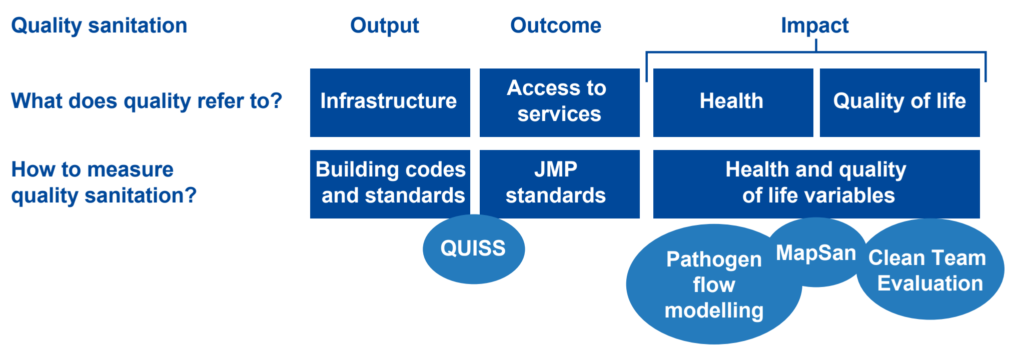
Image: Unimproved shared toilet in Maputo, Mozambique.

– *The **Clean Team evaluation** — assessing customer experience among customers of Clean Team Ghana, a container-based sanitation enterprise.* The study was led by i-San with researchers from Harvard, LSHTM and KNUST.

Full details of the four studies are given in the main text; we note that MapSan was not an USRI-funded project, but WSUP was the implementing partner (delivering the sanitation intervention that was evaluated). All four studies have published, or will soon publish, their detailed findings in peer-reviewed journals: here we present summaries of key findings and implications for policy and practice. In general, and for readability, we do not extensively reference these publications in the text: however, we list all published and submitted publications in acknowledgements and at the end of this report.

The overarching aim of this paper is to provide policy-makers, city sanitation planners and others involved in sanitation programming (including development banks and NGOs) with recommendations to support decision-making around achieving citywide high-quality sanitation. This responds to evidence suggesting that many current slum sanitation intervention strategies (including donor-supported interventions widely

Figure E1: The different dimensions of "quality" of a sanitation service or intervention.



Source: Authors

viewed as "model" interventions) are *not* achieving high-quality outcomes, notably in terms of disease reduction (Cumming et al. 2019; Knee et al. submitted).

Defining quality

"Quality" can be defined in different ways, depending on exactly what aspects of a sanitation service or intervention are under analysis: its *outputs* (e.g. infrastructure); its *outcomes* (what service levels households are benefiting from); or its *impacts* (on health or other aspects of well-being) (Figure E1). These three levels (outputs, outcomes, impact) can be seen as different *dimensions* of sanitation quality.

What does "high-quality" mean in practice?

This report summarises research projects aiming to understand what constitutes "high-quality" sanitation in low-income urban communities (LICs); and this is essentially a research response to recent evidence strongly suggesting that current interventions are not achieving hoped-for health benefits. This report will explore minimum requirements for sanitation that is of high quality in terms of health and other aspects of well-being. But this must be interpreted in a context of cost-effectiveness considerations and political-economic realism: even under best-case scenarios, slumdwellers are not going to receive sanitation of the same quality as is enjoyed by most readers of this report (pour-flush toilets served by well-functioning sewer systems). Rather, this report argues for more focused critical thinking about sanitation quality, from the grounding belief that it is entirely possible to achieve much better sanitation quality than at present, within the cost constraints that apply in low-income contexts. The report also suggests that the necessary improvements are not centrally dependent on the development of new technologies: rather, they are dependent on a change in attitudes that puts greater emphasis on minimum standards for sanitation quality.

Health impacts: a key driver of sanitation investments, yet little understood

Health impact, and resulting economic return, are key drivers of sanitation investments. Safe sanitation is associated with improvements in health, including positive impacts on infectious disease burden, nutrition and well-being, all potentially generating major return on investments (WHO 2018).

Yet, as the World Health Organisation (WHO) recognises, there is little understanding of the potential impacts of specific sanitation interventions on priority pathogens and other health outcomes. Indeed, the quality of the evidence on how specific sanitation interventions lead to improved health is low (WHO 2018). There is limited empirical evidence on how best to design interventions and direct available resources to maximise health gains. As a result, although safe sanitation is acknowledged to result in health benefits, there is limited evidence as to *which specific sanitation improvements can optimally reduce health burden in any given context*. In practice, sanitation investment decision-making is rarely informed by detailed consideration of which options will best reduce the public health risk. Two of the research projects considered here (the Faecal Pathogen Flows study and the MapSan trial) attempt to better understand context-specific health impacts.

High-quality sanitation infrastructure in LICs may not be sufficient, on its own, for significant health improvements

MapSan was the first controlled health impact trial of a non-sewered sanitation intervention, and the first such trial of urban shared sanitation facilities. The WSUP intervention that was evaluated provided communal sanitation blocks and shared toilets, all with septic tanks, in low-income compounds of Maputo. It measured the health outcomes of the intervention among children in approximately 380 compounds with the new infrastructure, compared with 380 matched control compounds with existing shared latrines in poor sanitary conditions.

The intervention did *not* have an impact on the prevalence of enteric infections. However, it had some positive impacts, including a specific effect on two pathogens among very young children, and some impact on faecal contamination in the immediate household surroundings. It also significantly reduced stress levels among users.

The MapSan findings strongly suggest that slum sanitation improvements as currently delivered are *not on their own sufficient* for combating faecal-oral disease; though certainly sanitation improvements are *necessary* to reduce faecal pathogen transmission. [It is important to stress that the trial was *not* a comparison of shared and non-shared sanitation, and in fact it seems likely that an analogous non-shared sanitation intervention would similarly have shown no significant effect on enteric infections.]

So what else *is* necessary? This is complex and context-dependent, and is discussed in detail in the main text. But very briefly: MapSan, the Faecal Pathogen Flows study and other evidence suggest that the following are likely to be important for breaking faecal-oral disease transmission pathways: **1)** more critical analysis of existing sanitation technologies and intervention approaches, some of which may be inadequate; **2)** a greater focus on achieving full community coverage in sanitation interventions, not scattered coverage; and **3)** a greater focus on other parallel improvements (alongside sanitation) that are likely to be necessary for breaking faecal-oral disease transmission pathways.

Maximising the health impact of sanitation interventions requires better understanding of the link between sanitation and pathogen flows

Sanitation is often conceived as a "health" intervention, with better services assumed to lead to health benefits. However, there is limited empirical evidence on how best to design interventions and direct available resources to maximise the health gains of sanitation improvements.

In response to this gap, the Faecal Pathogen Flow study developed a system modelling approach to track and assess the transmission of pathogens originating from sanitation systems. Models of this type can potentially support decision-making, by allowing comparative assessment (in terms of health risk reduction) of different candidate sanitation solutions in any given context.

The modelling approach was developed and tested in an assessment of the relative performance of eight sanitation options in a low-income area in Dhaka (Bangladesh). The model consisted of two connected sub-models: **i)** a pathogen-fate-and-transport sub-model to estimate the levels of different pathogens at specific locations, and **ii)** an exposure-and-risk sub-model which includes the predicted ingestion dose via different environmental routes, and probability of infection. Five target pathogens with high prevalence were selected as indicators of the relative health impact of sanitation options. As part of environmental sampling, undertaken to support validation of the model, the study found a high frequency of all pathogens studied in almost all locations and sample types. The diarrhoeal pathogen Shigella and the disease-causing strain of V. cholerae were the most commonly detected pathogens in drain samples (100% of samples).

Despite variability and uncertainties in input parameters, the model generated plausible estimates of the relative health impact of different sanitation options. For example, the results suggested that full coverage with septic tanks – *if* well-managed – would be associated with a 72% reduction in disability-adjusted life years (DALYs). In comparison, anaerobic baffled reactors (particularly when paired with constructed wetlands for effluent treatment) attained a higher reduction in DALYs. Pathogen removal from unmanaged sanitation systems that are overloaded, blocked or clogged was assumed to be lower than well-managed systems, and showed reduced health improvements. Hence "quality" in terms of achieving health impact relies on appropriate infrastructure choices as well as good management. The study highlighted that long-term health impacts can only be achieved where proper maintenance is carried out. Crucially, the quality of the *containment infrastructure* is a key determinant of pathogen transmission, and should be carefully considered from the outset.

Shared latrines can provide high-quality sanitation

The current UNICEF-WHO JMP classification of sanitation levels recognises shared sanitation as only "limited", below the "basic" level. This is problematic in urban contexts: for many LIC residents, shared sanitation is the only available option for space reasons, and the "below basic" categorisation may disincentivise appropriate efforts to support

Image: Communal Toilet in Nakuru, Kenya. **Credit**: Brian Otieno.

shared sanitation. Furthermore, there is emerging evidence to suggest that shared sanitation can be of high quality in terms of public health and user experience. But conversely, shared sanitation is certainly often of poor quality, so that it is very important to identify minimum standards for high-quality shared sanitation.

The QUISS study, which collected data from shared and non-shared toilet users in Ghana, Bangladesh and Kenya, indicated that shared sanitation can and often does provide acceptable high-quality sanitation. In fact, the clearest discriminant between low- and high-quality sanitation was not number of households sharing (1, 2 or more), but rather technology: flush/pour-flush toilets showed much better quality than non-flush latrines, independently of number of households sharing.

In order to encourage governments and donors to increase investment in high-quality shared sanitation (as required in many urban LICs), there are strong arguments for a modification of the JMP classification in relation to urban contexts. This needs to be counterbalanced by strong adherence to minimum standards for shared sanitation. The results of the QUISS study can be the starting point for the discussions to establish minimum standards which can inform development of a revised JMP framework which categorises high-quality shared sanitation facilities as “basic sanitation”.

Quality of life indicators: a standard metric to compare sanitation systems and services

Few metrics exist to objectively compare different types of sanitation systems. Sanitation-related Quality of Life (SanQoL) can provide a metric of quality-of-life dimensions, to be used alongside health impact assessments (as might be obtained by faecal pathogen flow modelling). SanQoL metrics measure user perceptions of sanitation quality, such as feelings of safety, privacy and disgust: these are important demand-side drivers of sanitation improvement. SanQoL indicators were used to measure the user-perceived impact of interventions in both the MapSan trial and the Clean Team evaluation.

From a public investment perspective, user-centred approaches like SanQoL may be helpful (alongside health impact projections) for identifying which types of sanitation investment can be effective. Different sanitation solutions, providing apparently similar levels of services, may in fact result in very different user experiences. For example, in MapSan, the SanQoL analysis revealed that user experience of shared toilets was better than user experience of the more expensive option of communal sanitation blocks. SanQoL can therefore provide decision-makers with a method for projecting the quality-of-life impacts of different sanitation solutions, which

Image: Toilet entrance in Beira, Mozambique. **Credit**: Stand Up Media.

can be used – alongside health impact projections and cost data – to inform policy and investment decisions.

SanQoL indicators are particularly relevant for “non-traditional” sanitation systems, such as container-based sanitation solutions (CBS). The user-experience evaluation of Clean Team (a CBS social enterprise that serves more than 1,500 people in Kumasi) revealed that customers experienced substantial quality-of-life gains after adopting CBS, by comparison with their previous use of existing public toilets. If properly managed, the CBS model can ensure full containment of faecal waste, by contrast with on-site infiltration systems such as latrines and septic tanks, which discharge contaminated effluent locally, and which may therefore be inappropriate in at least some slum contexts. Notwithstanding these apparent advantages, CBS has yet to be embraced and scaled up by policy-makers in Ghana, or indeed elsewhere. This evaluation adds weight to advocacy for stronger consideration of CBS models; though certainly the report does not suggest that CBS is universally applicable.

Image: Open drain in Rangpur, Bangladesh.
Credit: Green Ink.

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Most of this paper is based on reports and publications produced by the research teams. Key relevant citations for research protocols and papers published or in process are provided below:

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Tidwell B, Nyarko KB, Ross I, Dwumfour-Asare, B, Scott P (submitted) Evaluation of user experiences for the Clean Team Ghana container-based sanitation service in Kumasi, Ghana. Pre-print doi: 10.1101/2020.10.23.20218578

About the Urban Sanitation Research Initiative

This publication is a synthesis of the findings of four research projects carried out under, or in association with, the 2016 – 2020 Urban Sanitation Research Initiative (USRI). USRI was a research programme led by Water & Sanitation for the Urban Poor (WSUP) and funded by UK Aid from the British People. The Initiative aimed to drive pro-poor sector change in urban sanitation in the three focus countries — Bangladesh, Ghana and Kenya – and globally. The present publication is one of two final synthesis publications commissioned under USRI: the other publication looks at sanitation financing (forthcoming, April 2021).

WSUP would like to thank the in-country partners of the Urban Sanitation Research Initiative for their sustained engagement and support:

Bangladesh: Centre for Water Supply and Waste Management (ITN – BUET); International Centre for Diarrhoeal Disease Research (icddr,b)

Ghana: Environmental Health & Sanitation Directorate, Ministry of Sanitation and Water Resources (EHSD); Kwame Nkrumah University of Science and Technology (KNUST); Institute of Local Government Studies (ILGS)

Kenya: Water Services Regulatory Board (WASREB); Ministry of Health (Division of Environmental Health)

Introduction

1.1 Background

Globally, more than 600 million people living in urban areas lack basic sanitation. The challenge of urban sanitation is intensified by strong population growth, especially in low- and middle-income countries. In Africa alone, the urban population is expected to double by 2050 (United Nations 2018). The consensus is growing that the traditional approach to urban sanitation – premised on extending sewerage networks and associated treatment plants – is not sufficient to deliver sanitation services for all by 2030 (BMGF 2016). Such sanitation systems are difficult to implement in many low-income areas, which are often unplanned, densely populated, and lack access to piped water. Furthermore, conventional onsite solutions (including latrines and septic tanks) may be inappropriate for some dense urban communities, in view of inadequate containment of faecal waste (WHO 2018).

As alternative approaches are emerging to address the sanitation needs of low-income areas, a key question for city planners and decision-makers is how to maximise the benefits provided by different types of sanitation services. Among those benefits, health impacts and the associated economic benefits are often cited as a key driver for improving access to sanitation services. According to the World Health Organisation (WHO), the health benefits of sanitation are achieved where sanitation facilities are hygienically and technically safe to use and where good hygiene, as well as access to water for cleansing and handwashing at critical times, are in place (WHO 2018). It should be stressed that "hygienic" is not just about the toilet itself: it's about what happens to the faecal pathogens from that point on.

To achieve these benefits, city planners must understand what sanitation solutions will be most effective in any particular context. However, whilst it is clear that faecal-oral diseases are due to faecal pathogens ingested orally, there is little understanding around the transmission routes of faecal pathogens in slums.

Image: Open drain in Chittagong, Bangladesh. **Credit**: Green Ink.

Decisions around funding allocation are made *assuming* that sanitation interventions (such as sewers, or on-site septic tank systems, or pit-emptying) will yield health benefits. But these assumptions are weak, and we need a better understanding of what types of sanitation improvement (and other associated improvements) are necessary to break faecal pathogen transmission pathways in any particular location.

The custodians for tracking progress to the Sustainable Development Goals for sanitation (SDG 6.2) are UNICEF and the WHO, through the Joint Monitoring Programme (JMP), which has defined the service level standards for which government and city planners should be aiming. For SDG 6.2, JMP has set the aspirational target of "safely managed services for all", which entails the safe separation of human excreta from human contact, not only at the point of containment but also at all points in the sanitation service chain. Crucially, JMP specifies that "safely managed" sanitation is only achieved where sanitation facilities meet certain criteria, including that they are not shared by multiple households. Below "safely managed", facilities which meet certain

Box 1: Terminology and definitions.

- **Safely managed sanitation (JMP):** Use of improved facilities which are not shared with other households and where excreta are safely disposed in situ or transported and treated off-site
- **Basic sanitation (JMP):** Use of improved facilities which are not shared with other households
- **Limited sanitation (JMP):** Use of improved facilities shared between two or more households
- **Unimproved (JMP):** Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
- **Open defecation (JMP):** Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or with solid waste
- **Improved sanitation facilities (JMP):** Facilities designed to hygienically separate excreta from human contact, including: flush/pour flush to the piped sewer system, septic tanks or pit latrines; ventilated improved pit latrines; composting toilets; or pit latrines with slabs
- **Anaerobic baffled reactor:** An improved septic tank with a series of baffles under which the wastewater is forced to flow; the increased contact time with the active biomass (sludge) results in improved treatment
- **Container-based sanitation:** A sanitation model in which excreta is captured in sealable containers that are then transported to treatment facilities
- **Conveyance:** The transport of wastewater or faecal sludge from a containment technology to off-site treatment, and/or end-use/disposal; conveyance systems can be sewers, or based on manual or motorised emptying and transport

criteria are considered “basic sanitation”; and facilities which otherwise meet the criteria for “basic” sanitation but are *shared* are classified at a lower level termed “limited sanitation” (see Box 1 for definitions).

However, due to space and other constraints in dense urban settlements, private household sanitation facilities may not be feasible. An important question is therefore whether shared sanitation could provide the benefits of private household sanitation. Whilst JMP acknowledges that shared facilities may be the only realistic solution in the short- to medium-term, it also recognises that indicators are missing for differentiating between shared facilities that are poorly designed and managed, and shared facilities that are hygienic, accessible and safe (Evans et al. 2017).

Under the human right to sanitation, WHO defines sanitation quality in terms of availability, accessibility and acceptability (See Box 2, P.12).

To date, the global indicator framework of access to “quality” sanitation is solely based on considerations of sanitation facilities’ capacity to reduce faecal-oral disease transmission. Access to “quality” sanitation, a key criterion of the realisation of the human right to sanitation, is measured, according to the JMP, based on whether sanitation facilities are technically and hygienically safe to use, with access to water for cleansing. As such, quality of sanitation does not strongly take into account broader benefits experienced by sanitation users, which is an important consideration in addition to infectious disease implications, and also the main driver from the demand side (Ross 2019a). WHO does recognise, however, the need for a more detailed investigation to comprehensively characterise the sanitation needs of the target population and desired level of service quality (including sex-related differences in needs and preferences) (WHO 2018).

Further, emerging alternative approaches to traditional latrines (prevalent in low-income areas) call for a widening in the understanding of “sanitation quality” beyond the quality of the infrastructure. In recent years, social enterprises and NGOs have begun piloting Container-Based Sanitation (CBS) as one solution for providing safely managed sanitation in low-income areas. CBS refers to a sanitation service in which excreta is captured in sealable containers that are then transported to treatment facilities. As of 2019, CBS systems have been piloted in Haiti, Ghana, Kenya, Madagascar, Peru and the Philippines (Mikhael et al. 2019). Although they can meet all JMP criteria for safely managed sanitation (including *full* containment of

Box 2: Determinants of sanitation quality as per (WHO, 2018).

- **Availability:** There should be sufficient facilities that limit waiting to an acceptable length of time that does not discourage use or cause inconvenience, including in households, health facilities, schools, workplaces and public places.
- **Accessibility:** The facility should be accessible at all times for all intended users, taking into consideration the age, gender and disabilities of users. Where toilets are sex-separated, users should be able to access the toilet matching their gender identity.
- **Acceptability:** The superstructure should provide privacy and safety for the user, for example through the provision of light and a door lockable from the inside; this is particularly important where the toilet is shared or public or in a school, healthcare facility or workplace. Facilities for safe menstrual hygiene management should be provided, such as a covered container for disposal of menstrual hygiene products. Where the toilet is shared or public, the container should be sized according to the expected usage, with an emptying and safe disposal arrangement and schedule. Used menstrual hygiene products should not be flushed down or disposed into the toilet.

faecal pathogens, by contrast with conventional solutions like septic tanks, which discharge a contaminated liquid outflow even if regularly emptied), CBS systems have been slow to gain traction. A common perception of city planners and policy-makers is that CBS represents a step back to "bucket sanitation" (as widely used in the colonial period); and indeed, an estimated 90% of bucket latrine waste in Ghana was not adequately disposed of (Ayee & Crook 2003). In order to overcome this perception (that CBS is just "bucket latrines"), a critical research gap is to understand whether CBS can be perceived as "high-quality sanitation" by users.

As utilities and municipal service authorities gradually take on responsibility for sanitation across their cities, correctly identifying high-quality sanitation solutions becomes crucial. Several underlying questions emerge, including: What types of sanitation improvement are necessary to stop faecal-oral disease transmission? Can high-quality *shared* sanitation stop faecal-oral disease transmission? If so, what are the objective criteria that must be met to classify shared sanitation as high-quality sanitation? Can CBS be a solution which satisfies customers? Does gender influence technology preference between types of sanitation? Such questions are particularly relevant in contexts of poverty and government budget constraints.

1.2 Purpose and rationale

This synthesis report aims to fill some of the evidence gaps on "high-quality sanitation". It takes the view that "quality" can be defined and measured differently, depending on *what* is being measured in a sanitation intervention: its outputs (e.g. infrastructure); its outcomes (what service levels households are benefiting from); or its impacts (health and other determinants of well-being).

This report explores these different dimensions of "sanitation quality" drawing upon a set of research projects delivered under the Urban Sanitation Research Initiative (USRI). It aims to provide policy-makers, city sanitation planners and others involved in sanitation programming with recommendations to support the planning process for citywide high-quality sanitation, focusing in particular on the following questions: What parameters need to be considered to define sanitation quality in slum communities? How can we optimise sanitation interventions to generate the best health impacts? Can high-quality shared facilities be an acceptable solution for urban low-income urban communities? How can quality-of-life indicators help inform sanitation investment decisions?

1.3 Scope

This synthesis paper draws responses to these questions from four selected research projects conducted under or in association with USRI in Bangladesh, Ghana, Kenya and Mozambique:

The Faecal Pathogen Flows study *(Faecal pathogen flows modelling in urban environments: a proposed approach to inform sanitation planning in developing contexts):* This research (Foster et al. 2021; Nuhu et al. 2020) was carried out by the Institute of Sustainable Futures (ISF) at the University of Technology Sydney (UTS), Emory University, and the Institute for Diarrheal Disease Research in Bangladesh (icddr,b). It aimed to develop a modelling approach, building on previous work (Mills et al. 2018), that can inform sanitation infrastructure and service decision-making in terms of optimisation of public health impact. The model was developed and used to investigate the relative performance of eight sanitation options in reducing disease burden in a low-income community in Dhaka (Bangladesh).

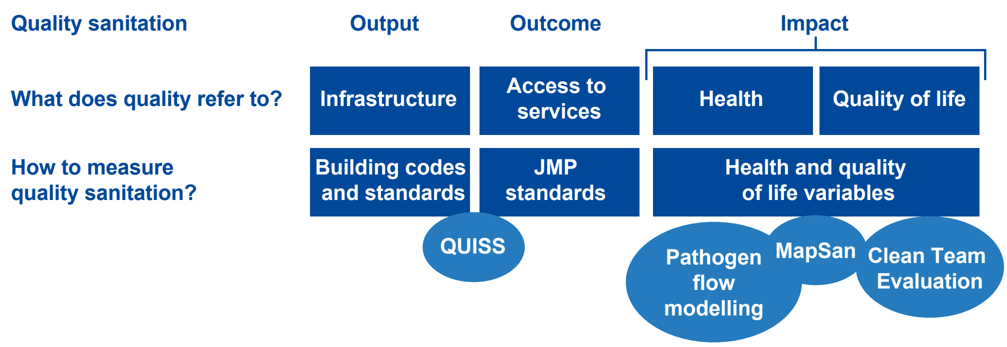
The MapSan trial: This four-year controlled before-and-after trial – led by the London School of Hygiene & Tropical Medicine (LSHTM) and the Georgia Institute of Technology – aimed to evaluate the health impacts of a shared sanitation intervention delivered by WSUP in the low-income communities of Maputo (Mozambique) (for study protocol, see Brown et al. 2015; for overview of health impact findings, see http://mapsan.gatech.edu/Results.pdf; for full listing of study publications to date, see http://mapsan.gatech.edu). This research was *not* part of USRI, but its findings are closely relevant to the questions considered here.

The QUISS study *(Quality Indicators of Shared Sanitation: identification of indicator criteria for the definition of high-quality shared sanitation in urban contexts)*: This research (Schelbert et al. 2020) was led by Eawag-Sandec with researchers from ETH Zürich (Switzerland), icddr,b (Bangladesh), the African Population and Health Research Center (Kenya), the University of Energy and Natural Resources (Ghana), Kwame Nkrumah University of Science and Technology (Ghana), and the University of Education (Ghana). QUISS was a mixed-methods cross-sectional study aiming to identify key criteria for what constitutes high-quality shared sanitation in urban low-income contexts, based on extensive qualitative and quantitative surveys of shared and non-shared sanitation users, and observations of shared sanitation facilities, across cities in Bangladesh, Ghana and Kenya.

Image: Payment record book for Clean Team Customers, Kumasi, Ghana.

The Clean Team evaluation *(Evaluation of user experience outcomes of Clean Team service use)*: This panel survey (Tidwell et al. submitted) was commissioned by WSUP and carried out by i-San with researchers from Harvard Kennedy School, London School of Hygiene & Tropical Medicine, and Kwame Nkrumah University of Science and Technology. It was a longitudinal prospective cohort study that evaluated customer satisfaction with Clean Team, a CBS service provider serving about 3000 customers in Kumasi and the surrounding metropolitan areas in Ghana.

Figure 1: The different dimensions of "quality" in a sanitation intervention.



Source: Authors.

Figure 1 illustrates how these research projects address the different elements of sanitation quality.

Whilst these research projects are limited in their geographical scope, they provide valuable lessons for policy-makers and city planners in other countries with similar features. First, these countries are low- and lower-middle-income economies facing similar challenges with regards to sanitation provision: large disparities at the city level in access to sanitation, sanitation agencies grappling with setting-up or incentivising service models, and very low income levels in certain areas. These countries also face serious budget constraints: this means that "sewers for all" is not realistic in the short- to medium-term, which in turn means that non-sewered systems have to be considered. One major question, however, is whether and how these non-sewered systems can provide high-quality sanitation to densely populated low-income areas. The experiences in these cities can help inform sanitation interventions to deliver health and wider user benefits in urban low-income communities in other settings.

However, we stress that some recommendations or research findings may not be relevant to all contexts. For example, given how much CBS service offerings differ, findings on Clean Team customer satisfaction can only be taken as illustrative of the potential of CBS, not as a globally valid conclusion. The paper highlights where recommendations and findings are limited in scope (or relate to very specific contexts).

1.4 Paper structure

The rest of this synthesis paper is structured as follows:

- **Section 2** presents findings on measuring and increasing health outcomes when designing sanitation interventions;
- **Section 3** presents findings on criteria for planning and assessing the quality of shared sanitation;
- **Section 4** presents the well-being impacts of shared and container-based sanitation services in different contexts; and
- **Section 5** brings together findings and policy implications, and identifies possible areas for future research.

References cited are listed in the bibliography. Readers are encouraged to consult the published journal articles.

2. Considering health impacts when designing sanitation interventions

2.1 Health impact: a key driver of sanitation investments, yet little understood

Health impact, and resulting economic return, are key drivers of sanitation investments. And this makes sense: faecal-oral diseases cause major health burden, and they are (incontrovertibly) caused by pathogens in faeces. Safe sanitation is certainly associated with improvements in health, including positive impacts on infectious diseases, nutrition and well-being (WHO 2018). In 2012, WHO estimated that the global economic return on sanitation spending was US$ 5.5 for every one dollar invested. These economic benefits primarily relate to health improvements linked to better sanitation, as households spend less on health care, have more productive time and spend less time seeking sanitation facilities. Sanitation is also linked to reducing premature mortality (WHO 2012) and is increasingly recognised as playing an important role in improving broader aspects of well-being, including security, quality of life and overall well-being (Sclar et al. 2018).

Yet, as WHO recognises, there is little understanding of the potential impacts of specific sanitation interventions on faecal pathogen transmission. The quality of the evidence on whether and how specific sanitation interventions lead to improved health is low (WHO 2018). There is limited empirical evidence on how best to design interventions and direct available resources to maximise health gains. As a result, although safe sanitation is acknowledged to result in health benefits (and must surely be necessary, in view of the biological nature of faecal-oral disease), there is limited evidence as to which specific sanitation improvements can optimally reduce health burden in any given context. In practice, sanitation investment decision-making is rarely informed by detailed consideration of which options will best reduce the public health risk (Mills et al. 2018).

Image: Open drain in Rangpur, Bangladesh. **Credit:** Green Ink.

Two of the research projects considered here (the MapSan trial and Faecal Pathogen Flows study) aimed to better understand health impacts. Key findings from these projects are presented below.

2.2 Health impact of shared sanitation facilities

2.2.1 MapSan: research design

MapSan is the first controlled health impact trial of a non-sewered urban sanitation intervention, and the first such trial of urban

shared sanitation facilities (Knee et al. submitted). The intervention consisted in the provision of shared pour-flush-to-septic-tank toilets to multiple households in compounds or household clusters: either shared toilets for smaller compounds, or larger "communal sanitation blocks" for larger ones. WSUP commissioned the construction of about 50 communal sanitation blocks and about 250 shared toilets, all with septic tanks, in low-income compounds across various districts of Maputo. The researchers measured health outcomes in approximately 1000 children before the intervention and at 12 and 24 months after the intervention (about 450 children with household access to interventions, about 550 matched controls using existing shared latrines with poor sanitary conditions).

Previous studies of urban sanitation health impact have been observational rather than experimental, which allows for confounding by unobserved variables and unclear causality (WHO 2018). By contrast, the MapSan trial was a controlled before-and-after trial: not as powerful for demonstrating causality as a randomised controlled trial (which would have been difficult or impossible for an intervention of this type), but nonetheless a highly rigorous quasi-experimental design. Previous studies have mainly used self-report of diarrhoea as outcome variable, with significant risk of bias. The MapSan trial used a direct measure of enteric infection as primary outcome measure (prevalence of enteric infections among children under 5). Specifically, the researchers assessed the prevalence of 15 enteric pathogens in child faeces samples: *Campylobacter*; *Clostridium difficile*, Toxin A/B; Enterotoxigenic *Escherichia coli* (ETEC) LT/ST; Shiga-like toxin producing *E. coli* (STEC) stx1/ stx2; *E. coli* O157, a serotype of STEC; *Shigella*; *Vibrio cholerae*; *Yersinia enterocolitica*; adenovirus 40/41; norovirus GI/GII; rotavirus A; *Giardia*; *Cryptosporidium*; and *Entamoeba histolytica*.

For the main analysis, *presence* of non-viral enteric infection in child faeces was defined as a positive result for one or more of these

Image: Communal Sanitation Block in Chamanculo, Maputo.

pathogens: *prevalence* is the proportion of children in the sample with *presence* of enteric infection.

The secondary and tertiary outcome measures included child height and weight; diarrhoeal prevalence (carer-reported diarrhoeal disease); prevalence of helminth parasites in child faeces following baseline deworming (*A. lumbricoides*, *T. trichura*, hookworm, *En. vermicularis*, *Taenia* spp., *Hymenolepis* spp., and *Strongyloides stercoralis*); and other infection markers.

Analogously to the Faecal Pathogen Flows study, MapSan also used exposure assessment, faecal source tracking, and microbial transmission modelling to examine whether and how routes of exposure for diarrhoea-causing pathogens and soil-transmitted helminths changed following the sanitation intervention. Environmental exposure indicators were collected from a subset of compounds as matched pre- and post-intervention samples, as well as from control compounds (also pre- and post-intervention).

The relationship between compound-level faecal contamination and compound density was investigated in relation to three domains of transmission: the household, the compound, and the immediate area around the compound. The compounds were stratified by neighbourhood population density, and compound sanitation exposure was defined by three metrics: 1) microbiological quality of household drinking water in the household, as a proxy of household hygiene; 2) presence of helminth parasites in soil samples from key locations near latrines; and 3) fly prevalence in key household and compound locations.

Parallel studies tracked diverse other metrics, including metrics of sanitation-related stress and sanitation-related quality of life (SanQoL) among adult users.

2.2.2 Key findings

The research found that this shared sanitation intervention did not have an impact on the prevalence of enteric infections, but did have a specific effect on two pathogens among very young children. In other words, the prevalence of enteric infections (i.e. the presence of one or more of the enteric pathogens in child faeces) did not decline as a result of providing communal sanitation blocks or shared toilets. There was no effect on the secondary outcomes, including other infection markers, diarrhoea prevalence, and child height and weight. However, in analyses considering only children born in an intervention compound after the intervention, significant declines were detected in the prevalence in child faeces of the pathogenic bacterium *Shigella* and the helminth *Trichuris*.

The intervention appears to have had some impact on faecal contamination in the immediate household environment, though significant contamination remained. Environmental sampling indicated some reduction in pathogen concentrations in soil at the toilet entrance. There was also a significant reduction in the prevalence of flies around latrines. The findings therefore provide evidence of some impacts on faecal-oral disease transmission, but no impact on the primary measures of health considered within the lifespan of the study.

The provision of improved well-managed and maintained shared facilities can impact positively on the mental health of users. Four sources of sanitation-related stress were reported by users: lack of safety; lack of privacy; feelings of disgust or shame about the condition of the latrine; and collective action failure in terms of managing the latrine, often leading to conflict among users, or unhygienic sanitation conditions. Participants in the intervention were divided between users of shared sanitation used by more than 20 residents (communal sanitation blocks) and shared sanitation used by less than 20 residents (shared toilets). Participants in the intervention group reported experiencing fewer sanitation-related stressors than participants in the control group, and the majority of intervention respondents (89%) reported that the higher-quality latrine lessened their stress level. Stress reduction was attributable primarily to decreased disgust, followed by increased privacy and safety. Results indicate that factors including latrine location and neighbourhood violence were important determinants of safety perceptions and corresponding psychosocial stress, and that improved shared facilities can reduce stress when proper maintenance and management systems are in place. However, shared sanitation only had limited impact on users' perceptions of safety, particularly at night, suggesting that in this context safety concerns depend on other factors, not only on latrine location and its characteristics. The data comparing compound blocks (20+ users) and shared toilets (less than 20 users) suggest that facilities with less than 20 users are preferable in terms of psychosocial stress.

2.2.3 Policy implications

The MapSan trial indicates that this slum sanitation intervention was not by itself sufficient for combating faecal-oral disease. In fact, rigorous evaluation by the researchers confirmed that this was an effective intervention in terms of infrastructure quality and use: the new facilities were constructed to high quality, and were used as intended by the beneficiary population. It was therefore a "good intervention" by sector standards: but nonetheless no clear health impact was seen. This raises two main possibilities: **a)** that intervention coverage density was insufficient (the intervention improved sanitation in some compounds, but did not provide blanket improvement across the community); and/or **b)** that there may be a need for parallel improvements in other areas, potentially including better water treatment, education around food hygiene and handwashing, infant nutrition, animal waste management, flood control and/or compound paving (so that children are playing on washable concrete surfaces, not soil).

These findings align with WHO recommendations for transformative WASH interventions: interventions should address multiple exposure pathways, leading to a comprehensively clean environment (WHO 2019). In short, the MapSan trial suggests that **1)** sanitation interventions may need to aim for full community coverage, not scattered coverage, and **2)** sanitation improvements may need to take place in parallel with other improvements likely to be necessary for breaking faecal-oral disease transmission pathways. This ties to the Faecal Pathogen Flows study (see Section 2.3), which offers a framework for better understanding faecal-oral disease transmission pathways in any particular location.

These observations may be particularly relevant for low-income unplanned communities in urban areas. Provision of sanitation services without improving other aspects of the environment may not be sufficient to interrupt all pathways for contamination, and therefore may be insufficient to prevent human exposure to faecal pathogens. This is certainly *not* an argument against improving sanitation: it's an argument for improving sanitation AND other basic services and environmental quality aspects. Multiple pathways need to be taken into account to sufficiently reduce faecal pathogen transmission. Interventions to address all pathways may be delivered together or separately, but ultimately all pathways will need to be addressed to achieve significant health gains (WHO 2018).

2.3 Faecal pathogen flow modelling: an approach to model the health impacts of different sanitation systems

2.3.1 A model to fill a critical gap in sanitation decision-making

Sanitation is often conceived as a "health" intervention, as access to services is assumed to lead to health benefits. Yet, there is limited empirical evidence on how best to design interventions and direct available resources to maximise health gains of sanitation systems. This is particularly the case for non-sewered sanitation, which relies on multiple and often fragmented services. Maximising health benefits implies that policy-makers need to better understand how different faecal pathogens are transmitted, from release into the environment, through the environment, to eventual exposure (Foster et al. 2021).

To date, existing tools and approaches are insufficient to guide sanitation investments based on health outcomes. Shit Flow Diagrams (SFDs) have been enormously influential in highlighting the scale of potential exposure risks at the city level. However, the approach does not in itself improve understanding of pathogen transmission: whether and how pathogens in the environment are likely to decrease or increase as a result of changes to sanitation systems and services. Furthermore, rigorous health impact evaluations are very powerful for assessing retrospectively whether a particular intervention had an impact, but are not in isolation sufficient for understanding what type/s of intervention might be most effective in any given context. This relates to the fact that "sanitation improvement" (unlike, say "treatment with aspirin") is not a readily generalisable intervention, but rather has strong context dependence.

In response, this research proposes a system modelling approach to track and assess the transmission of faecal pathogens originating from sanitation systems. System modelling offers an approach to examine and predict the context-specific health impacts of sanitation interventions. Systems modelling is widely used to analyse and understand a range of complex cause-effect systems, including in fields of environmental health, public health and water management. Therefore, applying a system modelling approach to sanitation interventions has the potential to link understanding of pathogen release into the environment with potential for exposure and likelihood of illness, which in turn can better inform sanitation investments. A consortium led by Juliet Willetts from the Institute for Sustainable Futures, University of Technology Sydney developed the pathogen flow modelling to link microbiological theory with applied sanitation options assessment to inform decision-making based on public health risks (Mills et al. 2018; Foster et al. 2021).

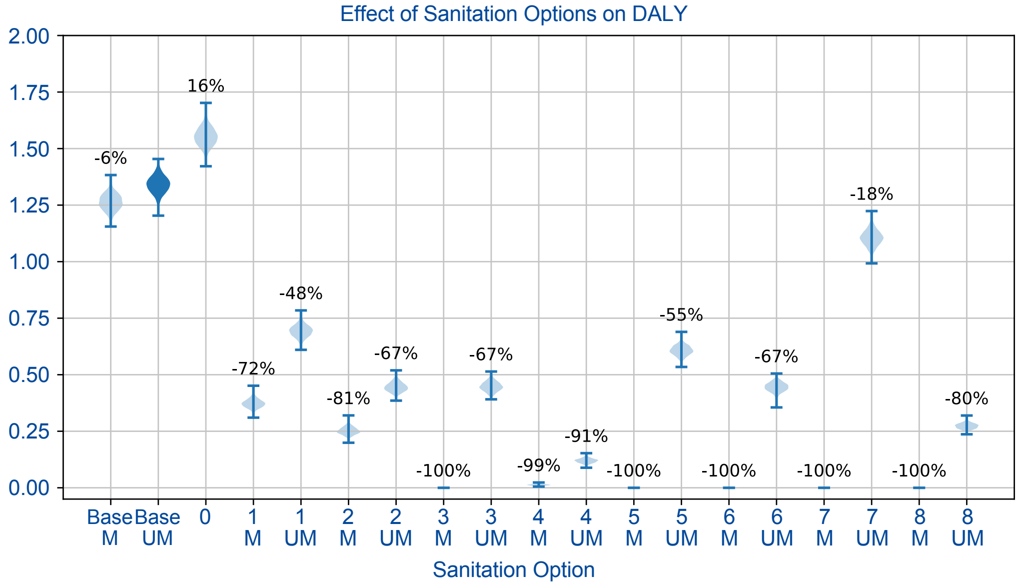
Modelling health outcomes of different sanitation systems is envisaged to support decision-making based predicted health risk reduction, which could be easily combined with cost analyses for different options. For example, it can address questions such as "what happens if 10,000 people are moved from septic tanks to sewer"? Or if sludge removal rate increases by 25%? Or if groundwater use is reduced by half? The model provides a flexible method which can be applied to different contexts (infrastructure, exposure behaviours, epidemiology and climate), as long as the assumptions and inputs are tailored accordingly. It allows identifying which points along the sanitation service chain are the most significant sources/causes of exposure risk to pathogens, while taking into account the different patterns of removal or inactivation of different pathogens in different circumstances. It compares how different sanitation improvements in a city are

Table 1: Sanitation options examined by the model.

Option	Description
Base case	Represents the sanitation infrastructure in the study site (a combination of septic tanks, holding tanks and toilets discharging directly to drains)
0	**No containment:** Hypothetically remove all sanitation systems (so all toilets discharge to drains) (included as a reference point)
1	**Septic tanks:** Full septic tank coverage for all household compounds (two-chamber tank only without soak-away infiltration), septic tank effluent flows direct to drains
2	**Communal primary treatment:** Toilets discharge to closed sewer and piped to decentralised primary treatment in anaerobic baffled reactors (ABRs) (three ABR per road, approximately 400hh per ABR) which then discharge to the drain
3	**Septic tanks with secondary treatment:** Full septic tanks coverage for all household compounds. All septic effluent collected and piped to decentralised secondary treatment (constructed wetland) at the end of each road (for approx. 1200hh) discharging into the adjacent canal
4	**Communal primary and secondary treatment:** Toilets discharge to closed sewer and piped to a decentralised primary and secondary treatment (three ABR and constructed wetlands per road, approximately 400hh per system), which then discharge to drain
5	**Deepen and cover drains:** Sanitation systems remain as per base case but the open drains are all deepened and covered
6	**Septic tanks with small-bore pipe to centralised tertiary treatment:** Full septic tank coverage with effluent piped through a shallow small-bore sewer to centralised secondary and tertiary treatment (beyond the study boundary)
7	**Fully sealed vaults:** Toilets discharge to fully sealed vaults or containers (with contents tankered to centralised faecal sludge treatment)
8	**Sewer system to centralised tertiary treatment:** Toilets discharge to a closed sewer and conveyed to centralised secondary and tertiary treatment (beyond the study boundary)

Source: Foster et al. 2021.

Figure 2: Modelled effect of sanitation options on annual DALYs, relative to base case unmanaged (Base UM) and base case managed (Base M)



Source: Foster et al. 2021.

Note: Numbers above violin plots refer to percentage change in DALYs relative to the unmanaged base case. Base = sanitation status quo in study site; Option 0 = no containment (direct to drain); Option 1 = septic tanks; Option 2 = communal treatment in ABRs; Option 3 = septic tanks with effluent treated in constructed wetlands; Option 4 = communal ABRs and constructed wetlands; Option 5 = deepen and cover drains; Option 6 = septic tanks with centralised tertiary treatment offsite; Option 7 = fully sealed vaults (contents regularly removed by tanker and treated offsite); Option 8 = sewerage to centralised treatment offsite.

likely to change the relative health risks compared with the current situation (including understanding whether different sanitation options may simply 'shift' the pathogen problem to a different location, rather than genuinely mitigating it). However, it should be stressed that modelling approaches of this type provide broad predictions, and can only distinguish between different *orders of magnitude* in risk associated with different sanitation improvement options: they cannot provide exact predictions. This is particularly the case since our knowledge of pathogen removal in different types of sanitation systems is very limited, and hence the assumptions underpinning the modelling include both uncertainties and variability.

2.3.2 Testing and applying the model in a slum in Dhaka

The faecal pathogen flow modelling method was developed and used to assess the relative performance of eight sanitation options in reducing disease burden in a low-income area in Dhaka, Bangladesh (Foster et al. 2021). The model consists of two connected sub-models: i) a pathogen-fate-and-transport sub-model to estimate pathogen concentrations at specific locations, and ii) an exposure-and-risk sub-model which includes the predicted ingestion dose from different environmental exposure sources (e.g. open drains), and associated probability of infection. Five target pathogens with high prevalence were selected, and their pathways of release-transport-exposure examined. A total of 150 environmental samples were tested for a longer list of pathogens using quantitative polymerase chain reaction (qPCR) methods, including virus (norovirus), bacteria (the cholera-causing strain of Vibrio cholerae, Salmonella Typhi, Shigella, and protozoa (Giardia and Cryptosporidium)) and the faecal indicator E. coli, using IDEXX methods. By modelling the pathway of pathogens through sanitation systems and local drains and canals, and subsequent expected human exposure, it was possible to examine the relative health impact of potential sanitation options. "Managed" and "unmanaged" variants of each option were analysed, based on the level of faecal sludge management and other common management issues such as blockages and overflows that occur in practice for each specific option. "Managed" should be understood to mean optimally managed.

An important finding from the study is the high frequency of all pathogens studied in almost all locations and sample types. Environmental sampling was undertaken to inform the modelling, and revealed high levels of pathogens throughout the urban slum environment. For example, *Shigella* and *V. cholerae* were the most commonly detected pathogens in drain samples (100% of samples), followed by norovirus (67%), *Giardia* (50%) and *S. Typhi* (27%). This has major implications in terms of health risks for the population living in the area.

Despite variability and uncertainties in input parameters, the model proved to be a useful approach to examine the relative health impact of different sanitation options. The results suggested that, relative to the base case of sanitation in the study site (24% septic tanks, 5% holding tanks and 71% toilets discharging directly to drain), full coverage of septic tanks would be associated with a 72% reduction in disability-adjusted life years (DALYs)[1] if well-managed, and a 48% reduction if poorly managed. Complete coverage of communal scale anaerobic baffled reactors was predicted to have a higher impact (81% reduction) if well-managed. Other options considered, including connection to a fully-centralised sewer treatment system, showed further reductions in projected health risk. However, several options were also predicted to export pathogens into neighbouring areas. The results for each option are presented in Figure 2.

Despite its potential, this pathogen flow modelling approach is not yet in a format which could be directly used by city planners. The approach requires further development in slums and city areas in other contexts (including other countries) to provide replicable results, tools and conclusions which can be used by policy-makers and regulators when designing interventions. For example, if applied in multiple contexts and combined with empirical research on pathogen presence, the approach could generate a "body of knowledge" linking sanitation systems and health outcomes (under certain conditions), which can then form a basis for identifying appropriate systems. Certainly, there are multiple challenges in achieving reliable system modelling (including lack of data upon which to base input parameters; context-specific data collection requirements; and the complexity of model expansions to larger geographical areas and/or to wider consideration of other relevant system components, including groundwater contamination where groundwater is used for drinking). Notwithstanding these challenges, WSUP considers that this approach shows enormous potential for maximising the impact of sanitation interventions.

Image: Mirpur LIC in Dhaka, Bangladesh.

[1] One disability-adjusted life year (DALY) can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost due to premature mortality in the population and (severity-weighted) Years Lost due to Disability for people living with the health condition or its consequences (WHO, 2020).

2.3.3 Policy implications

The Faecal Pathogen Flow study again highlights the very significant health risks faced by LIC slum populations. Households living in these areas remain exposed to pathogens, even when nominally "improved" sanitation facilities are in place, as a result of poor infrastructure choice, design and mismanagement in the sanitation service chain. The study population in Dhaka (low-income urban) lives in an environment with active sources of pathogen exposure, such as open drains with high levels of faecal contamination.

The choice of sanitation system in any given location has implications for health that are dependent on many location-specific factors: as a result, that choice needs to be very carefully considered. Indeed, the study found that several non-sewered system options had significant residual health risk, particularly when poorly managed, with major implications for sanitation investment and decision-making. This type of finding suggests the limitations of "piece-meal" sanitation interventions in a densely populated low-income urban environment. Improving toilet quality or containment systems alone will not protect LIC residents. Interventions need not only to consider the appropriate sanitation technologies (depending, for example, on density, drainage, groundwater situation, etc.), but also the chain of services that can effectively prevent the transmission of pathogens through the environment.

System management is an important determinant of health outcomes. Regardless of the technology selected, poor management of facilities undermines health outcomes. Under poor management – such as inadequate cleaning, containment and sludge emptying, or sludge dumping – any sanitation option will fail to provide adequate pathogen removal to protect public health.

In addition, sanitation interventions should increase their focus on the containment of excreta, through higher-quality sub-structures and adequate effluent treatment. These studies highlight the importance of well-designed and constructed containment systems to eliminate pathogen exposure. Sanitation facilities connected to open drains were found to be major health risks. This situation is particularly frequent in Dhaka and other south Asian urban contexts, but is also widely seen elsewhere. The local disease burden associated with poor sanitation could be eliminated by well-managed closed drains if they have appropriate hydraulic capacity (carrying wastewater to an appropriate treatment/disposal location, not simply discharging to another neighbourhood nearby) and by ensuring that well-managed, fully-sealed containment systems are in place, noting that the latter requires significant, frequent safe emptying.

The pathogen flow modelling approach, though promising, still requires further development before it can be readily integrated into real decision-making processes by planners. First, the approach must be further developed to be usable at the city scale, which is the most useful scale for urban sanitation policy-making and decision-making. In addition, further empirical data is needed to establish a strengthened evidence base on the fate of different key pathogens in sanitation systems, including in both effluent and faecal sludge. The scope of the model should be expanded to include aspects such as wastewater export and import between neighbouring areas, and relationships to the water supply. However, by selecting a larger system such as a large city, the complexity of the model will necessarily increase, requiring more assumptions and more inputs, and consequently, more resources to implement it. Certainly, reliable modelling raises many methodological challenges. However, this approach is well placed to contribute to sector knowledge, supporting consideration of causal pathways that are difficult and costly to measure, as well as enabling the identification of key inter-relationships and evidence gaps, and ultimately providing evidence that can support sanitation decision-making.

3. What is a high-quality shared sanitation facility?

3.1 The debate around shared sanitation

The JMP ladder classifies improved facilities which are shared by more than one household as a limited service regardless of their condition. This is in part because, in large-scale national and global monitoring processes, it is difficult to differentiate between shared facilities that are poorly designed and managed, and shared facilities that are hygienic, accessible, and safe. In addition, there is little evidence on the relationship between the number of households sharing facilities and their hygiene, accessibility and safety, making it difficult to find an adequate proxy indicator (Evans et al. 2017). There is some evidence that shared sanitation may be of higher structural quality (Jenkins et al. 2014), but those shared by more households may (Gunter et al. 2012) or may not (Exley et al. 2015) be less clean, and they may have poorer health outcomes (Baker et al. 2016).

Furthermore, most studies have not disaggregated based on a typology of shared sanitation. WHO has recently recognised that shared facilities may be the only realistic option as a first step up the sanitation ladder from open defecation in densely populated low-income urban areas, and thus recommends shared facilities when relevant: “Shared and public toilet facilities that safely contain excreta can be promoted for households as an incremental step when individual household facilities are not feasible” (WHO 2018).

Currently, the WHO Sanitation and Health Guidelines (Chapter 3.2.2) indicate minimum conditions for shared sanitation (WHO, 2018): “shared facilities are only acceptable when they meet the standards for accessibility, safety, hygiene, maintenance and affordability” (see Box 3 for more details). While this definition provides general guidelines for designing shared sanitation facilities, it does not provide enough detail for planning services and developing quantitative standards for regulators and policy-makers (for example, maximum number of people per toilet). Besides, limited data exist on users’ acceptability criteria for shared sanitation.

Image: Shared Toilet in Mirpur, Dhaka.

The following section, based on the findings of the QUISS study, presents user-centred criteria for defining high-quality shared sanitation services. It focuses on the criteria to define a high-quality shared sanitation facility superstructure, not the sub-structure.

Box 3: Minimum criteria for shared sanitation.

All shared or public toilets should have:

- A safe location and access route;
- Doors that can be locked from the inside, and lights;
- Handwashing facilities with a water supply and soap;
- Menstrual hygiene management facilities (MHM);
- Separate cubicles for men and women, or gender-neutral cubicles that include: handwashing and menstrual hygiene management facilities
- Suitable modifications for all users e.g. an access ramp and handrails for people with disabilities;
- A management system in place to operate and maintain all the facilities provided.

Source: (WHO 2018)

3.2 The QUISS study: identifying indicators of shared sanitation quality

3.2.1 QUISS: study design and methodology

The Quality Indicators of Shared Sanitation Facilities (QUISS) project was designed to provide policy-makers with a set of objective criteria for evaluating the acceptability of shared household and compound toilets (Schelbert et al. 2020; Meili et al. submitted). Across Kumasi (Ghana), Kisumu (Kenya) and Dhaka (Bangladesh), the study evaluated how shared sanitation users themselves define the quality of shared sanitation facilities, and which aspects they consider as essential priorities for good quality. The study then aimed to identify reliable metrics by which policy-makers can define high-quality shared sanitation.

The QUISS study collected data from users using a mixed-methods approach. In a first qualitative phase, to explore general user challenges and concerns, an extensive literature review was performed, and participatory community meetings with users of shared sanitation facilities were conducted. This provided the basis to design evidence-based focus group discussion (FGD) guidelines. The FGDs aimed to evaluate how users of shared sanitation facilities themselves define sanitation quality, and which aspects are essential to them. These findings provided the basis for the second phase: to design an evidence-based household survey and an observation protocol, which enumerators used for a rapid quality assessment of each sanitation facility. The questionnaire was then used in an extensive quantitative survey of shared and non-shared facilities[2] and their users in the three countries: sample size per country was at least 600 facilities (of which at least 80% were shared), with on average two different questionnaire respondents per facility. Non-shared toilets were included for comparative purposes. The questionnaire included questions on toilet properties, cleaning responsibilities and arrangements, MHM arrangements and privacy, user satisfaction and preferences, and demographic and household information.

Alongside the questionnaire, a structured rating process was used to assess the cleanliness of the toilet as observed by the survey enumerator. In the data analysis phase, the research team used an approach based on Multiple Correspondence Analysis to develop a "Sanitation Quality Index" (SQI) for scoring each facility, based on three user-perception dimensions identified as key in the qualitative phase: cleanliness, privacy and safety (Box 4).

Then, to identify indicators of shared sanitation quality, a regression-based approach was used, with outcome variables SQI and enumerator-rated cleanliness. This approach allowed assessment of whether "number of users per toilet" (for example) is a reliable indicator of sanitation quality.

3.2.2 Key findings: what aspects of quality are priorities for users?

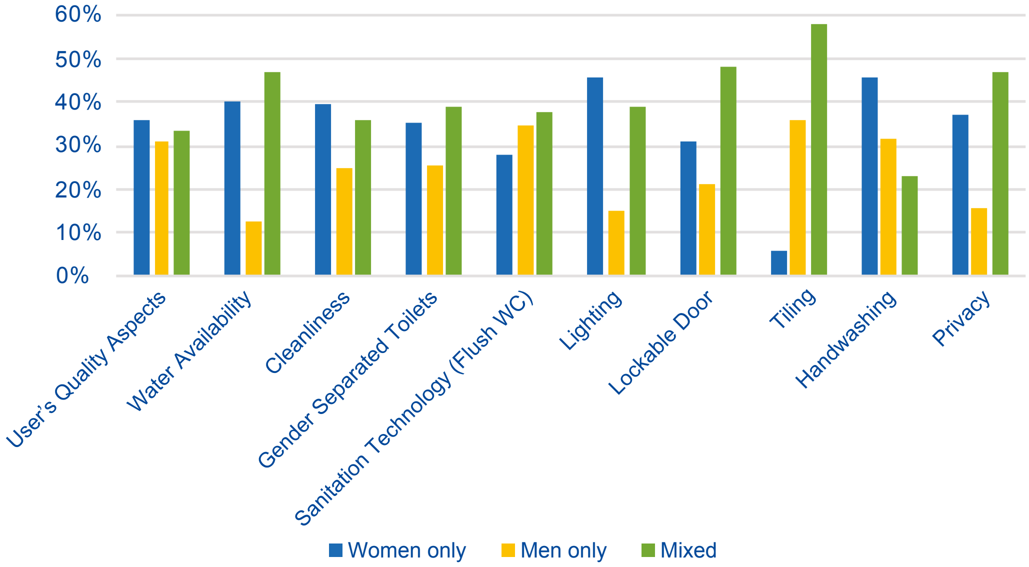
Detailed findings of quality criteria from a user perspective are presented in Table 2. Considering data from all three countries together, QUISS determined nine user quality priorities. In descending order beginning with highest priority first, these were: *immediate water access, cleanliness, gender-separated toilets, flush toilets, lighting for use at night, lockable/functional doors, tiling, handwashing stations and privacy.* Figure 3 indicates gender differences concerning the particular quality priorities. Women expressed a higher concern for almost all quality priorities; only two quality priorities were more important to men than women (sanitation technology and tiling).

[2] Within shared sanitation facilities, the following categories were not included in the study: community toilets and public toilets. Shared household toilet is defined as a toilet in one household also used by other households. Compound toilet is defined as a toilet used only by the people living in a particular compound. Community toilets are defined as non-household toilets used by a restricted group. Public toilets are defined as toilets open to anybody (Evans et al. 2017).

Table 2: Quality criteria from a user perspective (ticks indicate high priority, crosses indicate low priority: the binary categorisation is detailed in Meili et al. submitted).

User Quality Criteria	Ghana			Kenya			Bangladesh		
	Women-only	Men-only	Mixed	Women-only	Men-only	Mixed	Women-only	Men-only	Mixed
Water Availability	✓	x	✓	✓	✓	✓	✓	✓	✓
Cleanliness	✓	✓	✓	✓	✓	x	✓	✓	✓
Gender Separated Toilets	✓	✓	✓	✓	✓	x	✓	✓	✓
Sanitation Technology (Flush WC)	✓	✓	✓	✓	✓	✓	✓	x	✓
Lighting	✓	x	✓	✓	✓	✓	✓	x	✓
Lockable door	✓	x	✓	✓	✓	✓	✓	✓	✓
Tiling	✓	✓	✓	x	✓	✓	✓	x	✓
Handwashing	✓	x	✓	x	✓	✓	✓	✓	✓
Privacy	✓	x	✓	✓	✓	✓	✓	x	✓
Odour / Smell	✓	✓	✓	✓	x	✓	x	x	✓
Cleaning Arrangement	✓	✓	✓	✓	x	x	✓	✓	✓
Space Availability (inside)	x	✓	x	✓	x	✓	✓	✓	✓
Safety / Security	✓	x	✓	✓	✓	x	✓	x	x
Toilet-User-Ratio	✓	x	x	✓	✓	✓	✓	✓	x
Detergent	✓	x	✓	x	x	x	✓	✓	✓
Vermin	✓	x	x	✓	✓	x	✓	x	x
Queuing / Waiting Time	✓	x	x	✓	✓	x	✓	✓	✓
Tissue / Toilet Paper	✓	x	x	✓	✓	x	✓	✓	✓

Figure 3: User Quality Priorities by gender (distribution normalised; Schelbert et al. 2020).



For analysis, the researchers considered two of these user-quality priorities, cleanliness and privacy, as dependent or outcome variables. This means that they are expected to be dependent on diverse inter-related factors, including (but not limited to) the remaining seven user-quality priorities. Additionally, the researchers defined a third outcome variable, safety/security. Taking into account the three outcome variables, the remaining seven user-quality priorities can be subordinated as follows:

Outcome variable: Cleanliness

- Water availability in close proximity
- Flush WC
- Lighting
- Tiling
- Handwashing stations

Outcome variable: Privacy

- Gender-separated toilet
- Lockable/functional door

Outcome variable: Safety/Security

- Lighting
- Lockable/functional door
- Handwashing stations

Overall, the qualitative results confirm previous findings on important user-quality concerns determining acceptable sanitation, but provide more nuanced information than past research on user priorities for shared sanitation. The list can assist in defining investment priorities to improve shared facilities and increase user satisfaction, while also acting as input to future sanitation guidelines, local building codes and the establishment of minimum standards, for example in national sanitation policies. Establishing minimum criteria could then inform the development of a revised JMP framework that categorises shared facilities meeting these criteria as "basic sanitation": shared facilities that meet these minimal criteria can then be promoted as an incremental step when individual household facilities are not feasible.

Box 4: The sanitation quality index (SQI).

The sanitation quality index (SQI) used in data analysis was obtained from the statistical analysis described in Meili et al. (submitted), with the following variables, and weightings for each variable determined by Multiple Correspondence Analysis. The table shows overall weightings for all 3 countries together; weightings for each country showed substantial variation from the overall pattern, and are listed in Meili et al. (submitted). Absolute scores were normalised to percentage values (0-100); see Figure 4.

Observation	Weighting
Visible faeces: yes	0.80
Visible faeces: no	3.70
Insects: yes	1.81
Insects: no	3.96
Solid waste: yes	1.58
Solid waste: no	3.74
Floor material: low quality	0.00
Floor material: high quality	3.35
Roof material: low quality	1.12
Roof material: high quality	3.57
Wall material: low quality	0.31
Wall material: high quality	3.40
Toilet full/clogged: yes	0.41
Toilet full/clogged: no	3.56
Handwashing station with soap: no	2.90
Handwashing station with soap: yes	4.22

3.2.3 Key findings: what are the best indicators of shared sanitation quality?

QUISS identified technology type as strongly associated with sanitation quality. Regression analysis was used to identify the most reliable indicators of sanitation quality. Separate analyses were carried out with two different metrics of quality: cleanliness rating and the Sanitation Quality Index (SQI). Candidate explanatory variables considered in regression analysis were: toilet technology (flush/pour-flush versus non-flush), number of households using the toilet, location of the toilet, presence of water on the premises, lighting, lockable door, tiled floor, gender-separated cubicles, presence of cleaning rota, the degree of user relationship, toilet age, landlord residing on the same plot, and presence of bin inside the cubicle.

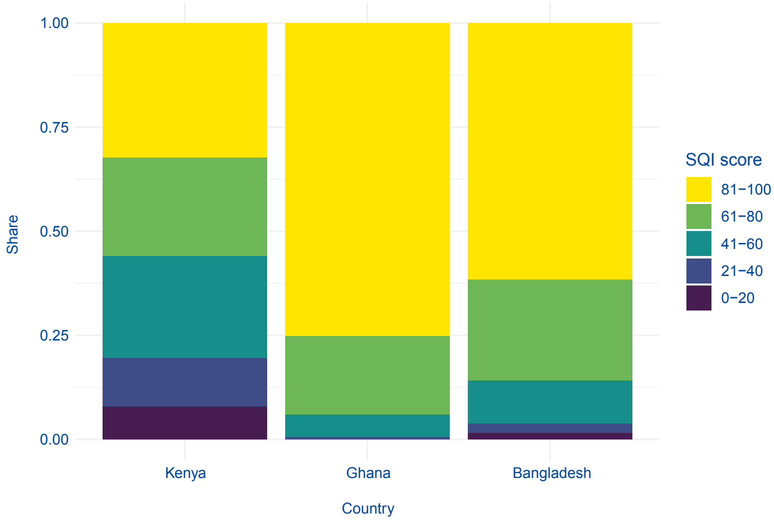
In analyses with enumerator-assessed cleanliness rating as quality metric (i.e. as outcome variable), results strongly suggest that the most reliable indicator of perceived quality is technology (flush/pour-flush versus non-flush). This can be seen from Figures 5 and 6, P 28. Figure 5 shows the effect of different toilet technologies on the probability of the toilet being clean, with reference to the base case “flush toilet to sewer”. Figure 6 shows the effect of number-of-households-sharing on the probability of the toilet being clean, with reference to the base case “single household”. For example, a toilet used by 10 households is about 12.5% less likely to be clean than the reference situation. It is of interest to note that:

a) The impact of toilet technology (flush/pour-flush versus non-flush) is much more marked than the effect of sharing;

b) The effect of sharing is small: only about a 6% reduction in probability of toilet being clean between no-sharing and 2-households -sharing;

c) The incremental effect of number-of-households-sharing is not strong: there is an apparent drop-off in cleanliness after 3 households, but this is not marked. Even more-than-10-households- sharing has less effect on cleanliness than technology.

Figure 4: Distribution of toilet quality (SQI scores) by country; lower score = lower quality.



Source: Schelbert et al. 2020.

Other variables which had a significant effect on cleanliness (though not shown in Figures 5 and 6) were *location of the toilet, lockable door, lighting, and to a lesser extent tiling, and presence of a cleaning rota.*

Closely similar results were obtained when the metric of toilet quality was the Sanitation Quality Index, as opposed to enumerator-observed cleanliness: again, the most reliable indicator was technology (flush/pour-flush versus non-flush), and again the number of households sharing did not have a strong and progressive effect.

These findings are broadly similar across all three countries (Bangladesh, Ghana and Kenya): in other words, the conclusion (that technology is a better predictor of quality than number-of-households-sharing) is maintained across the three countries.

3.2.4 QUISS: policy implications

When shared sanitation facilities are the only short-term solution — notably, for people occupying very small dwellings, with no inside or outside space for a household toilet — they should be supported by policy-makers and funding agencies. But it is critical to ensure adequate quality.

Results from QUISS suggest a set of minimum standards for designing quality shared toilets. This set is as follows:

- The toilet should use pour-flush or flush technology
- The toilet (each seat) should be used by a maximum of 3 households *
- Separate toilets should be provided for each gender **
- The toilet should have water available in close proximity
- The toilet should have functioning internal lighting
- The interior of the toilet superstructure should be tiled
- The toilet should be sited in a location which is safe for users
- The toilet should have a secure and lockable door providing adequate privacy

* This is not directly demonstrated by the results of this study, which showed only a gradual decline in quality with number-of-households-sharing, with no clear drop-off. Nevertheless a gradual decline in quality was observed (Figure 6), and it seems likely that 3 households per cubicle may be an appropriate minimum standard.

** In small compounds this can substantially increase cost, since it requires construction of at least two cubicles; nevertheless, this was clearly identified as a quality requirement by male and female users.

Figure 5: Effect of different toilet technologies on the probability of the toilet being clean, with reference to the base case "flush toilet to sewer".

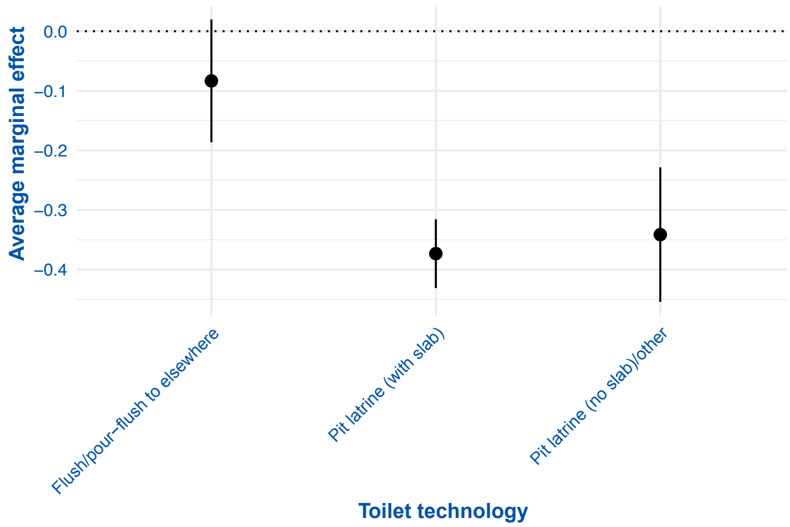
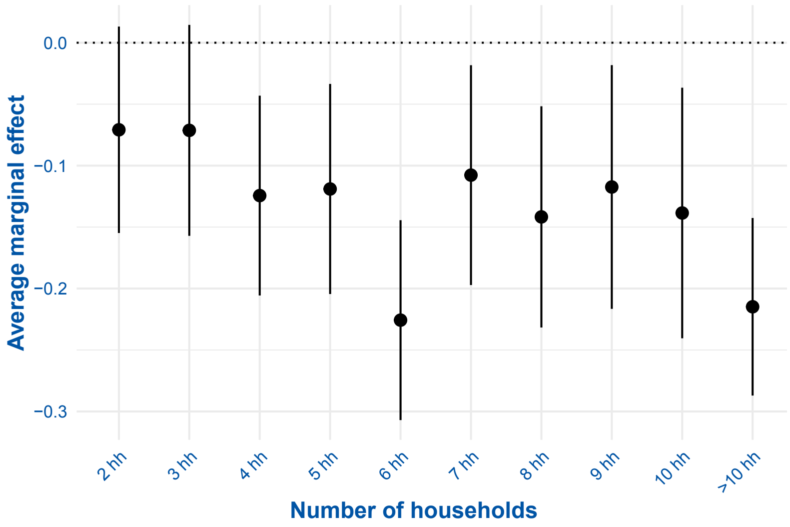


Figure 6: Effect of number-of-households-sharing on the probability of the toilet being clean, with reference to the base case "single household".



Source: Meili et al (submitted).

Clearly, in addition to this set, policy-makers must consider management models of toilet facilities. Most experience with shared toilet facilities suggests they fail due to lack of an enduring management model to support maintenance. There tends to be weak or absent planning for long-term service provision, weak accountability between users and service providers, and missing, or at best inconsistent, revenue streams to ensure continued operations (World Bank 2018). Therefore, the criteria related to maintenance such as “the toilet is kept clean at all times” and “the septic tank will be emptied when full” will require future in-depth user-centred research aiming to provide guidelines for regulators.

Further, QUISS strongly indicates that toilet technology type (flush/pour-flush versus non-flush) is a more reliable indicator of shared sanitation quality than number of users per toilet. In the urban context, and at least in the three cities included in this research, classifying flush/pour-flush toilets as “basic” and pit latrines (with or without slab) as “unimproved” would discriminate more effectively between clean “high-quality” toilets and dirty “low-quality” toilets than the existing JMP definitions. [Though not included in this paper, detailed analysis on this point is included in the QUISS final report to WSUP.]

QUISS findings suggest it could be of value to reconsider how shared toilets are treated in the JMP ladder, and perhaps argue for a stronger focus on technology type than on sharing status. In addition, these findings suggest that the current approach (treating non-shared latrines with slab as “basic”) may be misleading in the urban context, since (at least in the three cities included in this research) such facilities would probably be more usefully classified as “unimproved” where they do not provide user-centered quality outcomes.

Image: Shared toilet and water point, Dhaka.

4. Understanding user experiences of different types of sanitation

Few metrics exist to compare different types of sanitation systems in terms of user experience. Alongside the challenges of assessing the health impacts of different types of sanitation, there is a lack of a "common currency" by which to evaluate the user-experience benefits of different sanitation options (Tidwell et al. 2018). This kind of evaluation is essential for policy-makers tasked with deciding between different candidate sanitation interventions, whether on defined cost-effectiveness grounds, or on the basis of cost-benefit analysis requiring attempts to comprehensively monetise all types of cost and benefit.

This section outlines an approach for assessing user-experienced quality-of-life benefits: the Sanitation-related Quality of Life (SanQoL) measure, developed by Ian Ross (LSHTM), as applied in both the MapSan trial and the Clean Team evaluation.

4.1 SanQoL impacts of moving from low-quality to high-quality shared sanitation

For the MapSan trial (see Section 2.2), both shared toilets (ST) and communal sanitation blocks (CSB) were constructed for residents of Maputo and compared to lower-quality shared toilets. Shared toilets designed for a minimum of 15 users had concrete floors and walls, a tin roof, and high-quality containment systems. CSBs were larger, designed for a minimum of 21 people; included laundry and washing facilities; were accessible to those with physical disabilities; and had handwashing stations and rainwater harvesting capabilities. Economic costs over 15 year lifespans were 15 times higher for CSBs than existing low-quality toilets, while STs were 7 times more expensive: the study aimed to assess whether investing in CSBs or STs is more cost-effective.

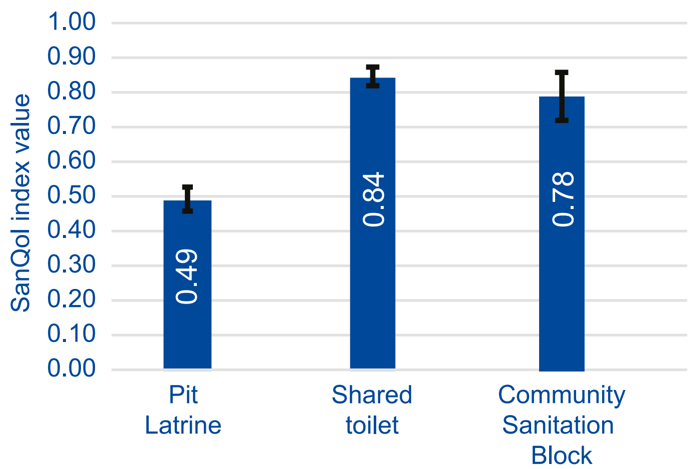
Significantly better user experiences were seen for both types of improved latrines, but STs were seen as the more cost-effective investment in quality-of-life terms. Following on from 19 in-depth interviews and 8 focus group discussions to develop a conceptual model for sanitation-related quality of life, a cross-sectional survey (n=424) was performed that collected data across five SanQoL attributes: disgust, health, privacy, shame, and safety, with each being assessed on a 4-point scale (Table 3). For example, for disgust, respondents were asked, "Can you use the bathroom without feeling disgusted?" with possible responses being Always, Sometimes, Rarely, or Never. The

Table 3: SanQoL psychometric items and response options.

Attribute	Psychometric item	Responses
Disgust	Can you use the toilet without feeling disgusted?	3 - Always 2 - Sometimes 1 - Rarely 0 - Never
Health	Can you use the toilet without worrying that it spreads diseases?	
Privacy	Can you use the toilet in private, without being seen?	
Shame	Can you use the toilet without feeling ashamed for any reason?	
Safety	Are you able to feel safe while using the toilet?	

Source: Ross (2019b).

Figure 7: Mean SanQoL values for different types of sanitation in Maputo (MapSan).



Source: Ross (2019b).

SanQoL index applies user-derived weights to combine each of these five categories into an index value ranging from 0 to 1, where 0 represents no sanitation capability and 1 represents full sanitation capability.

For basic pit latrines, the average SanQoL index value was 0.49, versus 0.84 for STs and 0.79 for CSBs. This demonstrates that there were significantly better user experiences for these higher-quality pour-flush latrines than pit latrines. However, given the much higher cost of CSBs, these results also suggest that STs should be prioritised by policy-makers in this setting. It should be stressed that SanQoL only captures user-perceived quality-of-life gains: it does not provide a complete assessment of economic benefits to users or society at large, which might include the value of averted morbidity, mortality, and time savings, among other things.

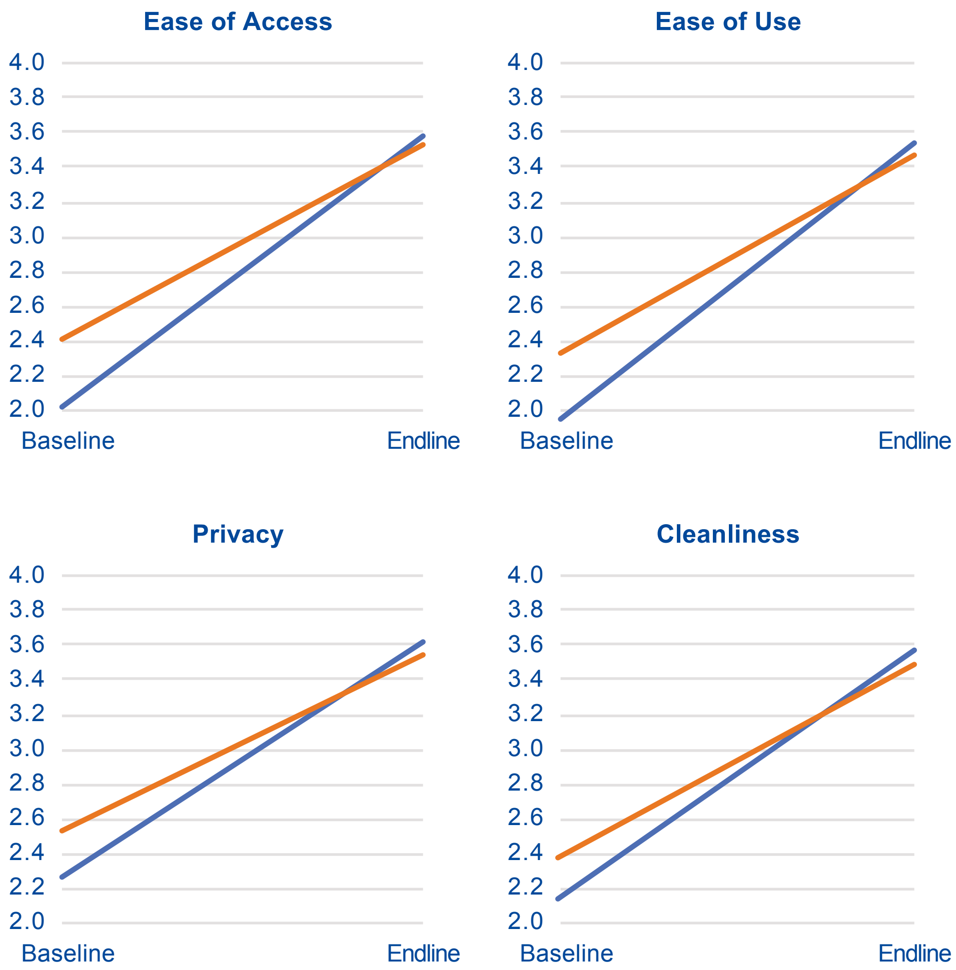
4.2 SanQoL impacts of moving from public toilets to container-based sanitation

Container-Based Sanitation (CBS) has emerged during the last decade as a potential solution to provide safely managed sanitation services to low-income households in high-density urban settlements, due to the lack of permanent infrastructure required. CBS consists of an end-to-end service that collects excreta hygienically from toilets designed with sealable, removable containers and strives to ensure that the excreta is safely treated, disposed of, and reused. Container-based sanitation, if properly managed, ensures full containment of faecal waste, by contrast with onsite-infiltration systems (latrines, septic tanks) which discharge contaminated liquid effluent locally. It is an alternative for those living in rented accommodation, especially in high-density areas without secure tenure, since it can offer a direct service to tenants without bearing the full cost of investment in improving a home they do not own or for any resident where there may be no space for improvements outside of living units (WHO 2018). However, the policy and regulatory framework for CBS services are not yet fully developed. CBS has yet to be recognised as a viable sanitation option by most policy-makers and regulators, as it is still a relatively new approach, and no CBS company has yet reached the scale required to attain financial viability (World Bank 2019). Therefore, understanding user experiences may help policy-makers to assess the potential for CBS in their settings, help to assess service quality and define standards for regulating the services, and lead to improved marketing approaches in high-density urban areas to help companies reach scale.

Clean Team is a social enterprise that serves more than 5,000 people in Kumasi, Ghana with Container-Based Sanitation. The toilet, which includes a cartridge for solid waste and diverts urine to an external location, was designed jointly by IDEO, WSUP, and Unilever in 2012. The service costs US$ 7.56 per month, which compares favourably with the common alternative of public toilets, which costs US$ 0.09 per use, or about US$ 14 for a family of four per month. Cartridges are replaced twice a week, and the toilet is self-contained and easily fits within interior spaces. Clean Team customers were surveyed immediately before and 10 weeks after the installation of the Clean Team toilet. Measures of objective sanitation quality and service quality were obtained, along with satisfaction and SanQoL measures before and during Clean Team toilet use. Objective quality was measured along dimensions such as use, hygiene, desirability, accessibility, and sustainability. Data was collected using a longitudinal prospective cohort study of 292 Clean Team customers, 24 cognitive interviews and 20 in-depth interviews with customers and those who had discontinued the service before the evaluation. Data was collected and analysed by an independent team that worked in coordination with WSUP and Clean Team at the beginning of the study to ensure that data collection could proceed without impacting Clean Team operations; measures were put in place to ensure that the study was critically independent and not influenced by WSUP or Clean Team reputational considerations.

Figure 8: Differences in satisfaction scores by gender before and during Clean Team toilet use.

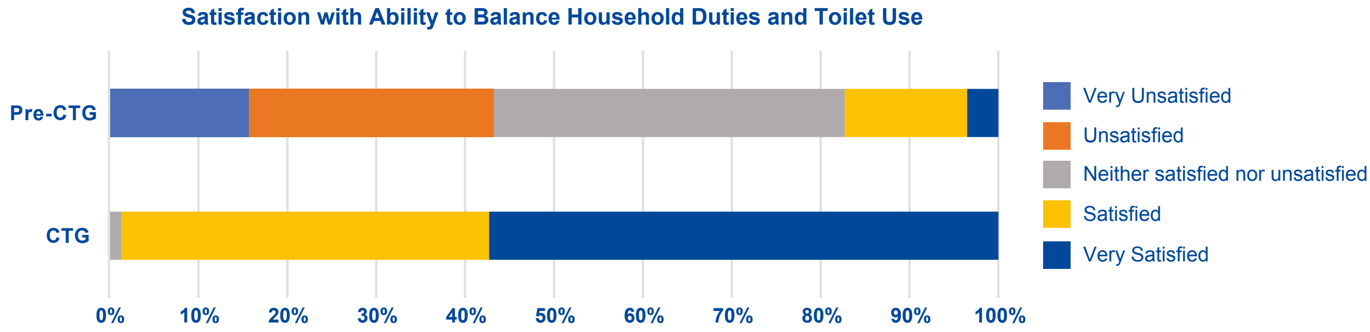
Note: Women are represented in blue, men in orange



Source: Tidwell et al. (submitted).

Clean Team customers experienced significant Quality of Life gains from using CBS over public toilets. The infrastructure quality of the public toilets previously used by most customers was high, and the Clean Team toilet and service was delivered with few issues faced by customers: therefore, the comparison was informative as a good example of how satisfaction differs across sanitation types even when both are delivered well. Customers' satisfaction with Clean Team's sanitation service was high and increased compared to public toilet services in almost every domain measured. For Clean Team toilets, there were few reported issues with leaking (0%), filling up (1%), smell (2%), or not being replaced as scheduled (4%). Satisfaction with the toilet and service characteristics was high. On a four-point scale, the largest increases (between previous situation and Clean Team toilet) were observed for satisfaction with smell (Difference: +1.78 points, $p<.001$), comfort (1.55 points, $p<.001$), ease of use (+1.49 points, $p<.001$), and ease of access

Figure 9: Comparison of women's satisfaction with ability to manage menstruation, before and after signing up to Clean Team.



Source: Tidwell et al. (submitted).

(+1.45 points, p<.001). For SanQoL, substantial increases were seen across all five attributes (Figure 10).

Women were less satisfied than men with public toilets, but Container-Based Sanitation closed these gender gaps and met female-specific needs, and also the needs of those excluded from existing sanitation options. Overall across all QoL domains measured, women were less satisfied than men with the previous public sanitation service. However, women scored higher in the sample at endline for ease of access, ease of use, privacy, and cleanliness (see Figure 8), P.32. Considering explicitly gendered behaviours, women were satisfied or very satisfied with both their ability to manage their menstrual hygiene (97%) and to balance household duties and toilet use (98%) (Figure 9). Use of the service also benefitted those who had been unable to use a toilet for physical or social reasons beforehand (5.2% before vs 0.4% afterwards, p<.001).

Customers are satisfied with the price. Satisfaction with sanitation costs increased from 44% when using public toilets to 86% when using the Clean Team service. The average cost of using the Clean Team service was 3.6 USD per household per month lower than previous public toilet use. The Clean Team service does not require any upfront cost to the user and currently does not benefit from any subsidy.

Figure 10: Comparison of SanQoL attributes before and after use of CTG toilet.

4.3 Policy implications

These examples show that some types of urban sanitation systems not fully embraced by policy-makers may still be very appealing to users. Both *high-quality close-to-dwelling shared toilets* and *private household container toilets* were well-liked by consumers, representing a substantive increase in sanitation-related quality-of-life and high scores relative to the best possible sanitation solutions from the users' perspective. Beyond the quality-of-life impacts, it is worth noting that CBS can be expected to be a highly favourable option from the public health perspective, because of full containment of faecal waste (assuming that the toilet itself is of high quality, and that waste is collected and treated hygienically).

However, experiences and service levels may vary substantially across contexts. Types of shared sanitation vary widely, and understanding how different types are perceived by users in different settings is crucial. The quality of CBS may vary widely depending on who provides the service. Therefore, minimum requirement criteria should be established for CBS before policy-makers and regulators can endorse it as a solution, including criteria like minimum collection frequency depending on the number of users, and minimum technological specifications.

Image: Staff member displays Clean Team toilet. **Credit:** Clean Team.

5. Conclusion

5.1 Overarching policy conclusions

This paper set out to explore how high-quality sanitation can be achieved in low-income areas, based centrally on research findings under USRI. This section brings together some of the main policy conclusions relevant to in-country decision-makers, but also to NGOs and development funding agencies.

What are the determinants of high-quality sanitation for low-income urban locations?

Sanitation quality has multiple dimensions: when designing sanitation interventions, policy-makers, city planners and donors need to critically assess whether the sanitation solutions they are supporting are of high-quality. Interventions need to assess whether a candidate infrastructure or system can provide the expected health benefits, within that particular urban context: for example, pour-flush toilets may be of little value if linked to dysfunctional septic tanks which discharge to the local environment. In addition, well-being considerations (as measured by SanQoL) can also be useful for identifying cost-effective solutions. Providing improved sanitation services alone may not be sufficient to achieve health benefits, as demonstrated by MapSan and the Faecal Pathogen Flows study: households in slums are surrounded by multiple sources of faecal contamination, even if they themselves have a high-quality toilet and containment unit.

As they seek to increase access to sanitation services, city planners (and other organisations involved in sanitation services development) need to better consider the ultimate outcomes for health and quality of life, and how specific sanitation systems will generate expected impacts. Pathogen flow modelling provides a methodology for the sanitation sector to better link systems (infrastructure and services) with outcomes; however, further development of the approach is required to develop a body of knowledge of sanitation systems and its potential use in different contexts.

Image: Compound in low-income area of Kisumu, Kenya.

How can a sanitation intervention generate significant health impacts?

It seems likely slum sanitation interventions will only achieve substantive health impact if they a) ensure high percentage coverage and b) are delivered as part of a holistic approach, which also improves other basic services and basic environmental conditions. This aligns with WHO's recommendation that multiple barriers need to be lifted to address all pathways of faecal pathogen transmission. The design of sanitation interventions should, therefore, be context-specific, taking into account the socio-economic and geographic context, as well as the development of other basic services.
As indicated above, sanitation should be addressed as part of a broader range of services and wider slum upgrading that includes water and hygiene measures, and other improvements, potentially including built structure improvement (e.g. compound paving). Formalising tenancy contracts could also significantly improve access to high-quality sanitation. Policy-makers (including development agencies) need to carry out in-depth context-specific analysis to understand what is required in any given context.

For any sanitation system, long-term health impacts can only be achieved where proper maintenance (cleaning, containing and emptying) is carried out. In relation to health risks, non-sewered systems put a higher responsibility on individuals than sewer systems. Service authorities should therefore increase their efforts to address maintenance challenges in LICs. High-quality sanitation ceases to be high-quality if it is poorly managed!

Sanitation interventions should increase focus on the quality of containment systems. The USRI studies highlight the importance of containment systems in reducing pathogen exposure from sanitation facilities. In Dhaka, as illustrated by the Faecal Pathogen Flow study, most toilets discharge directly onto drains, without containment. Even when the containment structures provide some primary treatment, and solids are removed by faecal sludge management services, the on-site liquid discharge remains high in pathogens, representing a major health risk (unless it is feasible to have soil infiltration, in sites where groundwater is not shallow or used). The quality of containment systems is more difficult to inspect (and upgrade) than superstructures, and should therefore be prioritised from the outset, with the effluent pathway also given consideration.

CBS systems can provide solutions to challenges related to maintenance and to the quality of containment and emptying. In private-sector-delivered CBS models, maintenance of the CBS system is integrated within the scope of services provided by the private operator (though certainly, CBS could be delivered by public or quasi-public agencies). Containers (fully containing the faecal waste) are *removed* from the household, so the model also facilitates processes of inspection and regulatory enforcement, which can occur at service provider facilities rather than on-site at the household.

Can high-quality shared toilets be considered an acceptable form of sanitation in low-income urban communities?

Yes, shared sanitation can be considered acceptable and of high-quality when constructed and managed by specific quantitative criteria. The QUISS study provides a list of specific indicators that can help prioritise investment strategies to improve shared sanitation facilities to quality levels acceptable to users.

However, for governments to increase investments in high-quality shared sanitation, a modification of the JMP classification would be of value. The results of the QUISS study can be a starting point for discussion on establishing minimum standards to inform the development of a revised JMP framework, which categorises high-quality shared sanitation facilities as “basic sanitation” (or which makes a *technology*-based distinction in urban contexts, as outlined above). With “basic sanitation” being the minimum JMP target, shared sanitation facilities that meet these criteria can then be promoted as an incremental step when individual household facilities are not feasible.

There is a role for regulators in developing high-quality shared sanitation services. Regulators should provide standards for maintenance arrangements and provide support to improve their financial management. Specific regulations and maintenance models will vary across cities, but high-quality shared sanitation requires that the roles and responsibilities for maintenance and funding are clear from the outset. Financial arrangements should be in place to address any affordability issue related to emptying services.

How can quality of life indicators help inform investment decisions?

User-centred approaches to measuring impact, such as the SanQoL score, can be

used (alongside health impact projections) to prioritise investments, maximise the uptake of services, and ensure equitable provision of services across populations. Different sanitation systems, providing similar types of services, may result in different user experiences. SanQoL can provide city planners with a method for estimating the quality-of-life improvements of different systems, which can be used together with health impact projections and cost data to inform decisions. SanQoL or other user-centred indicators are particularly relevant for "non-traditional" sanitation systems such as shared toilets and container-based sanitation. SanQoL can also ensure that equity of user experience is considered, even when the deployment of different technologies in different areas is necessary.

Focusing particularly on the user experience of CBS and high-quality shared sanitation, USRI research highlighted that both systems can provide quality-of-life improvements. The shared toilets evaluated by the MapSan study demonstrate that substantial gains in quality-of-life can be achieved with relatively modest investments. Similarly, Clean Team CBS users are highly satisfied with the services, especially compared with public toilet services that are often more expensive for users. These substantial improvements are particularly felt by women and girls and those with disabilities.

5.2 Future research needs

The research outlined in this report provides clear pointers to further research required to improve the sector's understanding of high-quality sanitation, and to provide policy-makers and development actors with effective tools and approaches to better plan services. WSUP considers that key research priorities are as follows:

Image: Communal toilet in Mirpur LIC, Dhaka.

A. **Further development of pathogen flow modelling approaches in different contexts.** There are two possible avenues here: development aimed at generating wide understanding as a basis for generalised judgements about how to break faecal pathogen transmission pathways; and development aimed at supporting decision-making in specific contexts. But in fact, the two are closely linked at this still-early stage, because efforts to develop the modelling approach and generate wider understanding must necessarily be based on an adequately representative set of specific contexts. In an ideal world, we would see a) application of the University of Technology Sydney approach (or an analogous approach) at city scale in Dhaka and at least two other cities, in all cases with sufficient funding to support extensive local data collection; and b) expansion of model scope to incorporate other clearly relevant systems components (including groundwater contamination and drinking water supply), and to facilitate exploration of research areas B and C below. Such future research would certainly require strong attention to model validation.

B. **Research to identify which types of parallel intervention can enhance the benefits of sanitation, and which types of combined intervention can break faecal-oral disease transmission pathways.** An effective way to approach these critical questions is likely to be pathogen flow tracking/modelling approaches, expanded to consider wider aspects of environmental quality (including for example groundwater contamination and drinking water quality, or built structure improvements). Pathogen flow tracking/modelling can be used to develop hypotheses which can be tested with impact trials, and impact trials can be designed to include assessment of intermediary effects on environmental pathogen levels. Ideally, we would see large-budget long-duration research+intervention programmes which use extensive and sophisticated pathogen tracking/modelling (and other inputs including expert opinion) to develop a combined-intervention strategy, then roll out that intervention strategy in a manner designed to allow rigorous but nuanced impact evaluation. A key priority here must be to identify minimum requirements where full slum upgrading is not practically possible.

C. **Research to better understand the importance of urban sanitation coverage density for achieving health impact.** Again, development of pathogen tracking/modelling offers a useful approach for understanding this question, alone or in structured combination with impact trials. Researchers and practitioners have been cognisant of the likely importance of coverage density for decades, but it is methodologically challenging to explore, and to date there has been no impact trial which has approached this as primary research question. In fact, there is a case that research areas B and C may perhaps be best approached in an integrated fashion, not as independent questions.

D. **Research to support acceptance of high-quality shared sanitation (and rejection of low-quality shared sanitation).** In WSUP's view, the QUISS study provides strong evidence to suggest that the current JMP framing of sanitation quality is unhelpful in urban contexts: shared facilities can be of high quality in terms of health and user experience, and may be of higher quality than some non-shared facilities recognised as "basic" under JMP criteria. The QUISS research was done in only 3 cities: stronger evidence might be obtained by delivering analogous research across a wider range of contexts. WSUP considers that the evidence is already strong for JMP "up-grading" of shared sanitation in urban contexts, associated with messaging to ensure that a) shared sanitation is only considered acceptable where it is necessary for reasons of space, and b) strong minimum standards are in place to ensure that shared sanitation is of high quality in terms of health and user experience.

E **What are the broader benefits of sanitation improvements from a user perspective and how can these be integrated into decision making processes by policy-makers?** Innovative methodologies to quantify impacts of sanitation interventions beyond infectious disease exposures are emerging, such as SanQoL, two of the studies featured in this paper. However, these methodologies are yet to be broadly applied and standardised across different types of sanitation and contexts, to better understand the immediate impacts of sanitation interventions and perceptions of quality from the beneficiary perspective.

F. **What is the most cost-effective way to improve sanitation quality?** This report has focused on quality; but evidently, financing considerations are equally critical to prioritise investments and inform policy-makers [see accompanying USRI synthesis paper on sanitation financing, forthcoming: April 2021]. USRI findings suggest that insufficient attention is currently paid to defining high-quality sanitation, and so the correct balance has to be found between quality and cost, keeping in mind both equity concerns and realistic understanding of political constraints.

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Image: Shared toilet in Rangpur, Bangladesh.
Credit: Green Ink.

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Font Cover Image: LIC resident using a newly constructed shared toilet, Maputo, Mozambique.