

Review Paper

Towards sustained sanitation services: a review of existing frameworks and an alternative framework combining ecological and sanitation life stage approaches

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ABSTRACT

Despite increased promotion, sanitation programmes have varying degrees of success partly because of limited consideration of the wider context beyond individual factors in programme design. Although a recent model, Integrated Behaviour Model for Water Sanitation and Hygiene (IBM-WASH) comprehensively addresses this gap, the model focuses on the initial adoption factors and lacks emphasis on the functioning of the entire sanitation system from toilet usage to the safe disposal of the waste. Hence application of the model is limited, to some degree, in achieving the Sustainable Development Goals for sanitation which have broadened the scope for sustainable sanitation service. Based on a review of available frameworks, this paper proposes an alternative comprehensive framework using an ecological public health approach to health determinants but does so through application across the spectrum of sanitation stages. A systematic literature review on sanitation adoption factors and comparative analysis of the proposed framework and the IBM-WASH framework was conducted to analyse the benefits of the framework. The findings show that different factors operate differently for each sanitation service stage, requiring a different set of actions for each stage. Our alternative framework can better address factors across sanitation stages and encourage collaboration among stakeholders with different disciplinary backgrounds.

Key words | comprehensive framework, ecological approach, factors, sanitation adoption, sanitation system, sustainability

INTRODUCTION

A current global challenge is the 2.4 billion people without access to 'improved sanitation', a term that refers to sanitation facilities that ensure privacy and hygienic use (WHO/UNICEF 2004; UN 2015). A lack of sanitation causes a high burden of faecal related diseases, particularly among children (WHO 2004; UN-WATER 2008). Drinking water, sanitation and hygiene (WASH) programmes have been developed over the last four decades, designed to address health issues, especially in children. Despite some global progress, the Millennium Development Goal of

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halving the proportion of people without access to sanitation has not universally been met and a new target for universal sanitation access by 2030 has been set in the Sustainable Development Goals (SDGs) (UN 2015; WHO/UNICEF 2015). The SDGs have an additional focus on sustainable sanitation services and resource management. Previous experience in India suggests that sanitation facilities are often not maintained in working order, reducing both health gains and environmental benefits of sanitation (Jenkins *et al.* 2014b). Many other challenges threaten the

sustainability of sanitation practice and services, including technical and financial support for maintenance and final waste disposal, environmental protection and stakeholder partnerships (Rosemarin *et al.* 2008; Coussens 2009; Jenkins *et al.* 2014a).

Some recent approaches used in sanitation, such as the household-centred environmental sanitation approach, community health clubs, community-led total sanitation and sanitation marketing, have been successful in increasing sanitation coverage (Waterkeyn & Cairncross 2005; Sah & Negussie 2009; Cameron *et al.* 2013; Devine 2013). However, there remains high variability in sustainability of practice and system functions (UNICEF 2013; Jenkins *et al.* 2014b) and there is little robust evidence on the health impacts of such interventions (Fewtrell *et al.* 2005; Clasen *et al.* 2014; Luby 2014). Results of these approaches vary widely, for two reasons. First, the different physical, social or political contexts where interventions are implemented lead to varying results for similar interventions (Tiberghien *et al.* 2011; O'Reilly & Louis 2014). Second, interventions tend to be dominated by a single discipline perspective (e.g., engineering, which mostly focus on hardware), which leads to ignoring benefits derived from other discipline perspectives (Figueroa & Kincaid 2010; Aboud & Singla 2012; Okurut *et al.* 2015).

Despite the number of models and frameworks available in the WASH sector, very few interventions or evaluation studies in the sector have used these models and frameworks (Aboud & Singla 2012; Dreibelbis *et al.* 2013). This is perhaps because information on the available frameworks might not reach many sanitation practitioners in developing countries where significant sanitation challenges remain. Another concern is that local professionals need systematic and comprehensive tools to identify factors to guide the design of actions within the local context (WSSCC 2015). Identifying factors is an important initial step before implementing strategies, although this step needs to be followed by more detailed planning for implementation and political support so that sanitation programmes can be successful.

A recently developed operational framework, the Integrated Behavioural Model for Water, Sanitation and Hygiene (IBM-WASH) (Dreibelbis *et al.* 2013) has provided comprehensive guidance to examine the factors of sustained WASH adoption using an ecological public health approach. However, despite including a technological

domain, the model does not explicitly address the need for proper functioning of the complete sanitation system, which Kvarnstrom *et al.* (2011) and Verhagen & Carrasco (2013) have argued is an important issue.

This research proposes an alternative framework that comprehensively identifies factors of sanitation uptake and sustainability across the sanitation system. We first review the general literature on existing frameworks and propose an alternative framework that comprehensively addresses sanitation factors. We then conduct a systematic literature review to identify factors of sanitation uptake and sustainability that can be viewed within our proposed framework. Finally, we compare our framework to the IBM-WASH framework.

METHODS

The study was conducted in two main stages: (1) review of existing frameworks and (2) demonstration of the applicability and the utility of the alternative framework.

Stage 1: review of existing frameworks

A list of WASH-related frameworks including the IBM-WASH framework was identified through a manual search of review papers, bibliographies and databases. Studies and guideline documents from both peer-reviewed and grey literature that focus on analysing factors of sanitation uptake and sustainability were included. These frameworks assisted us to propose an alternative framework that builds on the IBM-WASH framework.

Stage 2: demonstrating the utility of the proposed framework

We did a systematic review and identified factors of sanitation adoption and sustainability across the literature to fill the proposed framework. A systematic search of peer-reviewed articles up to August 2015 from Web of Sciences, PubMed, Science Direct, Scopus and manual scanning of bibliographies from identified articles was conducted to capture a wide range of empirical studies, both quantitative and qualitative, on adoption, intervention, usage and maintenance of sanitation using various combinations of search

terms (Table 1). In this paper, sanitation refers to facilities for human excreta containment and disposal.

The inclusion criteria were that studies were designed to analyse and discuss factors of sanitation adoption, usage and/or maintenance either in intervention studies or non-intervention studies in the general population. Thus it excluded studies covering water and hygiene without sanitation factors, studies focusing on specific settings such as hospitals, schools or other institutions, and studies focusing on specific target populations such as infants or people with disability. Technical studies that analysed sanitation technology and the planning process of sanitation improvement were excluded because they focus more on technology efficiency and the decision-making process than on the factors of sanitation uptake. Further, based on full text review, studies were also excluded if they focused on health factors and effectiveness of sanitation intervention or health, environment or economy impact of sanitation, or described sanitation conditions or proposed monitoring tools and indicators, because they did not provide factors affecting sanitation uptake and maintenance.

There was no limitation on the date of publication, but the review included only articles in English and studies that had been conducted in middle and low income countries, as classified by the World Bank (2015). The aim of this review was to gain ‘theoretical saturation’ (Booth *et al.* 2012, p. 136) of factors relating to sanitation uptake and sustainability. Grey literature was excluded as generally it includes factors similar to those considered in the reviewed articles. Moreover, the normal issue of potential publication bias regarding positive results of peer-reviewed

articles (Booth *et al.* 2012) is not relevant for this review as it is not the intention of this review to assess the effectiveness of sanitation interventions. Figure 1 presents the screening process for this review.

For each study, information on study methods, sampling characteristics, geographical setting (urban, peri-urban and rural), study focus (adoption, sustainability behaviour and sustainability facility), background concept/frameworks, sanitation facilities investigated, and whether facilities were individual or communal were abstracted. The extraction of sanitation factors was based on the categorisation in our proposed alternative framework. In each intersection of category and sanitation stage, the listed factors were then sub-grouped based on the findings of the reviewed literature. The extraction, using NVivo 10 software, assisted in grouping and counting the articles reporting particular factors or any combination of factors (vote counting) (Kitchenham & Charters 2007). A descriptive analysis of patterns was conducted based on the number of studies in each cell, row and column.

Finally, the systematic review assists us to compare the proposed alternative framework to the IBM-WASH framework to identify the advantages. The comparative analysis first queried how the different multi-level ecological models perform in both frameworks (the columns in both tables), followed by an assessment of the categorisation of factors based on the rows in both tables. Factors found in both frameworks were also compared. Finally, the comparison examines how the two frameworks assist in translating factors into action strategies.

Table 1 | Search terms included in the systematic review (Stage 2)

Sanitation keywords (OR)	sanitation; hygiene; toilet; excreta; latrine; domestic wastewater; black water; night soil
AND	
Adoption keywords (OR)	adoption; adopter; uptake; operation; maintenance; behaviour; decision making; demand; attitude; norm; cultural values; beliefs; perceived risk; preferences; perception
OR	
Intervention keywords (OR)	improvement; intervention; program; marketing; promotion; health education

FINDINGS

Stage 1 findings: literature review of sanitation frameworks

The frameworks and approaches used in sanitation studies are grouped into three main categories, namely, frameworks that are based on behaviour change models ($n = 12$), those based on sustainability concepts ($n = 14$) and those based on an anthropological approach ($n = 2$) (a full list of frameworks and associated factors is provided in Appendix A which is available in the online version of this paper). Public health ecological models were also examined as a

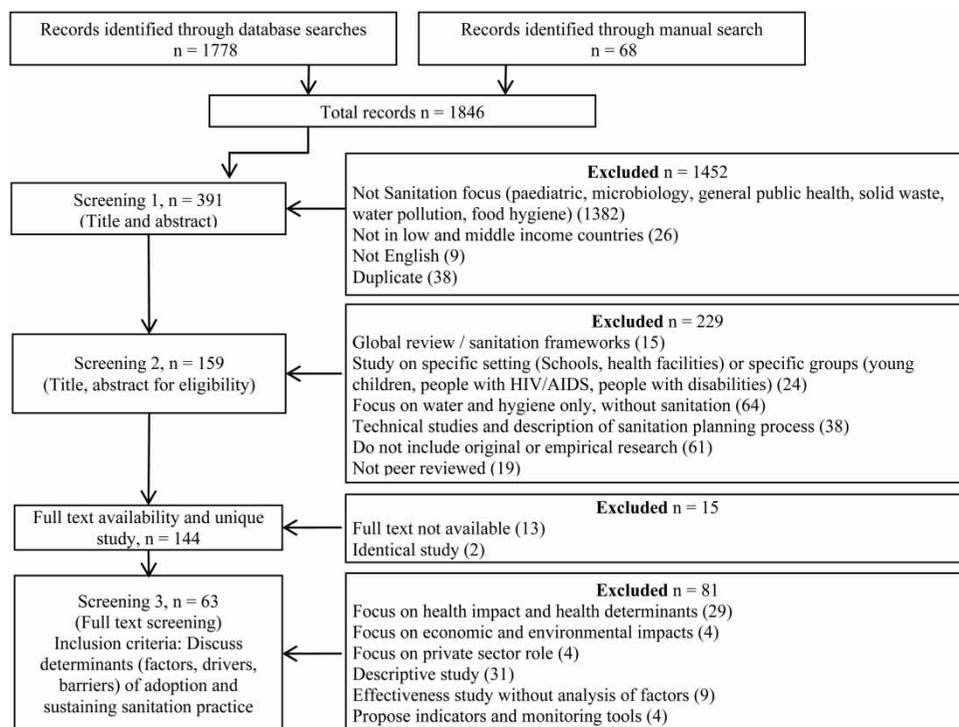


Figure 1 | Screening process in the systematic literature review in Stage 2.

category (Appendix B (available in the online version of this paper)) because although they are not necessarily used in sanitation studies, they have been widely used to understand complex determinants of health.

In the first category, frameworks focus on individual behavioural factors that affect the initial sanitation uptake. These factors are based on behavioural theories which, in turn, are based on psychological and social factors. However, many of these models provide limited consideration of the wider policy, structural and technological factors that also affect the adoption and sustainability of sanitation, as also pointed out by Dreibelbis *et al.* (2013). Examples of missing factors include water availability, geographical conditions and government policies that are beyond community control but significantly influence the adoption and sustainability of sanitation practices. The need to consider maintenance and waste treatment in the sanitation system is also not fully acknowledged by behavioural frameworks.

The frameworks based on the concept of sustainability examine the technological challenges to achieving sustainability. These frameworks focus on the life stages of sanitation technologies, and assess the factors based on sustainability

indicators, which include economic, technology, environment, health and social factors (Brikké & Bredero 2003; McConville & Mihelcic 2007). Frameworks using this concept provide complete assessment to ensure the whole system is functioning properly and maintained over time; however, some lack an assessment of behavioural and cultural factors in the early adoption stages that have led to facilities that do not match with user preferences (Palaniappan *et al.* 2008; O'Reilly 2010; Tiberghien *et al.* 2011). Moreover, structural factors such as policy and regulations, political will or institutional capacity are sometimes overlooked (Hawkins *et al.* 2013).

From the behavioural and sustainability perspectives, two important aspects that need to be considered are the factors at the initial stage of sanitation uptake and the factors for sustaining sanitation service. Eight frameworks from both perspectives (summarised in Table 3) show the stages from adoption to maintenance of sanitation function. They fall into five stages (acceptance, construction, utilisation, maintenance and safe disposal) that are experienced by users in adopting and maintaining sanitation facilities. All these stages should be considered in addressing issues of both coverage and function.

Finally, the anthropological approach emphasises the role of social norms and cultural values in shaping sanitation practice in communities (Jarvela & Rinne-Koistinen 2005; Avvannavar & Mani 2008). These values also need to be recognised in understanding the complex factors underpinning sanitation practice in a community. The approaches in this category are rarely specifically examining stages in sanitation adoption and sustainability; hence, this category was not included in Table 3.

These three approaches address important aspects of sanitation practice. However, Hadwen *et al.* (2015) (integration of water resource management in WASH assessment) and Okurut *et al.* (2015) (multidisciplinary sanitation assessment teams) highlight the need for a comprehensive approach for sanitation that includes all of these three perspectives.

The discipline of public health offers a different way of addressing these complex issues, the public health ecological approach. This approach systematically identifies determinants of complex public health issues (Glanz & Bishop 2010; Golden & Earp 2012). It suggests that an individual's health outcome results from the interactions of many other factors beyond the individual system, including

both biophysical and socio-economic environments (Van-Leeuwen *et al.* 1999).

The IBM-WASH framework adopts an ecological health promotion approach which was adapted from a model proposed by McLeroy *et al.* (1988). The use of an ecological approach enables us to comprehensively assess WASH issues. The IBM-WASH framework (Table 2) identifies factors at habitual, individual, inter-personal, community and societal/structural levels (Dreibelbis *et al.* 2013). The model also categorises factors in each level into a psychosocial dimension (e.g., values, social norms, attitudes), a contextual dimension (e.g., socio-economic and physical environment) and a technological dimension (e.g., supply and attributes of physical facilities) (Dreibelbis *et al.* 2013). (See Table 2 for the matrix arrangement of the IBM-WASH framework.) The IBM-WASH framework has been used in the design and evaluation of hygiene interventions (Hulland *et al.* 2013; McMichael & Robinson 2016) and in a systematic literature review of factors that determine sustained adoption of WASH behaviour, which includes safe water use, hand hygiene and sanitation (Hulland *et al.* 2015) (A summary of the review results of Hulland *et al.* are presented in Table 2.) It should be noted that the IBM-WASH

Table 2 | Summary of factors affecting sustained sanitation adoption using the IBM-WASH framework, adapted from Hulland *et al.* (2015)

Dimensions	Levels			
	Habitual	Individual	Interpersonal/Household Community	Societal/Structural
Contextual factors		Income generation/work patterns Age Religion Ethnicity	Household income Level of education Household structure	Seasonality Infrastructure
Psychosocial factors	Ease of use Existing habits (e.g., open defecation)	Perceived benefits (privacy, safety, cleanliness) Perceived barriers Knowledge of disease transmission Aspirations Disgust factor	Social norms Stigma surrounding defecation Shared values	
Technological factors	Appropriate design Durability	Cost Installation mechanisms Ownership/Responsibility Status of using/owning the technology	Local manufacturing and maintenance	Procurement and distribution of sanitation supplies

Note: The summary of factors in this table was sourced from a systematic review conducted by Hulland *et al.* (2015) of factors affecting sustained sanitation adoption. This summary will be used to compare the IBM-WASH framework to the proposed OCSS framework.

Table 3 | Selected frameworks mapped across stages of sanitation uptake and sustainability

References	Indicators/issues addressed	Sanitation stages ^a				
		Acceptance	Construction	Utilisation	Maintenance	Safe Disposal
WHO in Franceys <i>et al.</i> (1992); Sanitation evaluation	Ownership; Utilisation; Functioning (Hygienic function and reliability)		✓	✓	✓	✓
Carter <i>et al.</i> (1999); Sustainability components	Motivation; Maintenance; Cost recovery; Continuing support	✓		✓	✓	
Jenkins & Curtis (2005); Sanitation adoption stage	Preferences stage; Intention stage; Choice stage	✓	✓			
McConville & Mihelcic (2007); Sanitation LCA (project stages)	Needs assessment; Conceptual design and feasibility; Design and action planning; Implementation; Operation and Maintenance	✓	✓	✓	✓	
Von Munch (2008) in Potter <i>et al.</i> (2011); Sustainable sanitation criteria	Sustainability (Robust construction; Easy to use; Maintenance) Health (No contact with excreta; Easy to clean; Controlled downstream effect) Environment (Controlled sludge disposal; Provision against flooding; Low risk of groundwater pollution)		✓	✓	✓	✓
Kvarnstrom <i>et al.</i> (2011); Sanitation function	User functions (Excreta containment; Access; Greywater management) Environmental functions (Pathogen elimination; Nutrient use; Nutrient containment; Integrated Resource Management)		✓	✓	✓	✓
Potter <i>et al.</i> (2011) and Verhagen & Carrasco (2013); Sanitation Service Parameter	Accessibility: easily accessed to toilet in the compound by all members Use: used by all family members Reliability: regular and routine operation and maintenance, evidence of care and cleaning Environmental protection: non-problematic environmental impact/safe disposal and reuse of safe by-products		✓	✓	✓	✓
Jenkins <i>et al.</i> (2014a); Safe and Sustainable Facility	Improve design (facility design) Functional condition (functioning superstructure and pit) Safe and sustainable (pit quality, reliable waste disposal service)		✓		✓	✓

Notes: This table is developed based on literature review in Stage 1.

Please refer to Appendix A (available in the online version of this paper) for descriptions of WASH-related frameworks reviewed in this study.

^aThe following stages are stages in sanitation uptake and sustainability experienced by users:

- (1) Acceptance (preferences and intention to have a sanitation facility).
- (2) Construction (stage for constructing the facility in order to have access to proper excreta containment).
- (3) Utilisation (continuous use by all family member supported by sufficient hygiene facility such as water and soap).
- (4) Maintenance (routine care and cleaning, regular maintenance and appropriate improvement, and durability for daily functioning).
- (5) Safe disposal (reliable waste disposal service for environmental protection and/or hygienic reuse of waste).

framework's interpersonal and community levels were merged into one level in their review.

Although the IBM-WASH framework includes technological dimensions and assesses factors across the ecological levels, it does not explicitly address the environmental functions of the sanitation system aside from the health functions. Thus, the IBM-WASH framework does not fully meet the requirement for the SDGs for sanitation, which go beyond universal access to a toilet (UN 2015). The environmental functions are important for not only understanding the factors at initial adoption but also for continuous use and service improvement (Verhagen & Carrasco 2013). This is perhaps because the IBM-WASH framework was mainly developed from studies of adoption of hand washing practice and safe water treatment, with limited input from sanitation studies. Sanitation issues, to some extent, differ from other WASH behaviours such as safe water treatment and hand washing behaviour, particularly when the use of facilities requires further responsible practice such as preventing environmental pollution from the collected waste.

In order to incorporate the need to consider factors at initial adoption and sanitation functions (summarised in Table 3 as sanitation stages) into an ecological approach, a review of other ecological public health models suggests that the Ottawa Charter is an alternative fit for a focus on sanitation promotion. The Ottawa Charter considers not only individual to structural level factors but also includes environmental and service factors in the model.

The Charter was developed by the World Health Organization in the first International Conference on Health Promotion in 1986 to address inequities in health status (WHO 1986). Although the Charter is almost 30 years old, the key features of public health addressed in the Charter remain relevant today and have been widely used in addressing complex public health issues (Hancock 2011; Talbot & Verrinder 2014). The five main strategies for health promotion in the Charter are: (1) building healthy public policy, (2) creating supportive environments, (3) strengthening community actions, (4) developing personal skills and (5) reorienting health services (WHO 1986). Although the five main strategies of the Ottawa Charter were designed for health issues, they are also effective for addressing environmental sustainability issues resulting in a set of

systematic strategies of change corresponding to the actions in sustainable development (Brown 1994).

Corresponding with the five strategies of the Ottawa Charter are five factor categories relevant to sanitation: structural, environmental, cultural, individual and service categories (Chu & Yongying 2005). The structural category includes policy and social structures which operate at the wider society level. The environmental category comprises the conditions of the natural physical environment, the built environment and the individual facilities to facilitate continuous sanitation practice. The cultural category relates to social norms and cultural values that may hinder or support sanitation practice. The individual category includes knowledge, skill, attitudes and habitual factors at the individual level.

The service category is an important contribution of this proposed model. If service factors are categorised separately from physical availability of infrastructure (hardware), the management aspect of service (software) can be assessed and a complete picture can be shown of how the service has been provided, and what mechanism has been set up to ensure its sustainability. The service category incorporate factors that relate to access to and acceptability of information services, access, affordability and functionality of maintenance services and other services provided to communities by government, organisations or the private sector to support sanitation uptake and sustainability. These services include the management aspects of a sanitation programme and sanitation service that make it sustainable over time. Financial factors are also included in service category in order to make the service financially viable for the service provider and affordable for the customer.

Thus, the five categories derived from the action strategies of the Ottawa Charter can assess factors more tangibly at each sanitation service stage. This proposed alternative framework is a combination of an ecological model and sanitation service stages and is referred to as the Ottawa Charter for Sanitation Services (OCSS) framework, as presented in Table 4.

Stage 2 findings: utility of the proposed framework

Systematic literature review findings

The literature screening process resulted in the inclusion of 63 articles (Table 5). Of these, 61.9% were conducted in rural

Table 4 | An alternative framework for identifying determinants of sanitation uptake and sustainability: The Ottawa Charter for Sanitation Service (OCSS)

Sanitation stages ^a	Categories ^b				
	Individual	Culture	Environment	Structure	Service
Acceptance	Education, habitual problems. Knowledge on disease, perceived risk and benefit	Norms related to open defecation, social pressure, beliefs related to diseases, taboo, values about purity and pollution	Surrounding environment, geographic location, village infrastructure	Policy and regulations affecting sanitation, leadership and political will	Accessibility and acceptability of information, intensity of facilitation and promotion
Construction	Competing priorities, awareness on sanitation options, residential plan, perceived cost	Values and norms about toilet siting	Space availability, supporting infrastructure for construction, complexity of construction, geographical condition	Poverty, tenancy (type of residency), financing, institutional arrangement	Product information and distribution, access to materials, access to skill labour, financial mechanism for consumers and service providers
Utilisation	Perceived risk and benefit of utilisation, sense of ownership, satisfaction with current facility	Cultural values and norms about gender accessibility, taboo related to utilisation, social bond and conflict	Toilet design and performance, water availability (supporting facilities), location, climate	Poverty, tenancy, social class	Management for ensuring continues use, follow-up hygiene promotion and monitoring
Maintenance	Knowledge about maintenance, sense of ownership	Cultural values about cleanliness, vandalism, maintenance responsibility	Material and construction quality, pit capacity, disasters (landslides, flooding), cleaning tools	Poverty, tenancy, maintenance financing support	Access to maintenance labour, management of public facilities, financing mechanism for maintenance
Safe Disposal	Perceive treats and benefit of safe disposal of faecal waste, perceived cost, awareness of waste disposal options	Values and local taboos related to handling human waste	Availability, location and quality of waste transport and treatment facility for safe disposal, pit design for sludge disposal, dwelling location	Policy and permit for sludge disposal, legality of residency, institutional arrangement for waste disposal	Availability, reliability, functionality, acceptability and affordability of services for safe disposal (promotion and actual service), human resource capacity, financial mechanism for sustainable management of services

^aSanitation stages based on non-systematic literature review of existing frameworks in Stage 1 (see Table 3).

^bCategories of factors based on the five action strategies in the Ottawa Charter.

settings, 47.6% focused on initial adoption, 68.3% assessed individual toilets rather than shared or public toilets, and 34.9% assessed pit latrines rather than other types of technology. Of the included studies, 63.5% did not explicitly use any specific frameworks or concepts in assessing the factors. Among studies that did utilise well-defined/recognised

concepts, 15.9% used psychological concepts (e.g., SaniFOAM, consumer behaviour models) while 7.9% used sustainability (sustainable technology) and 4.8% used sociological (e.g., social networks, societal approach to sanitation) concepts. Other concepts used by other studies (7.9%) included organisational theories, political ecology and the receptivity concept.

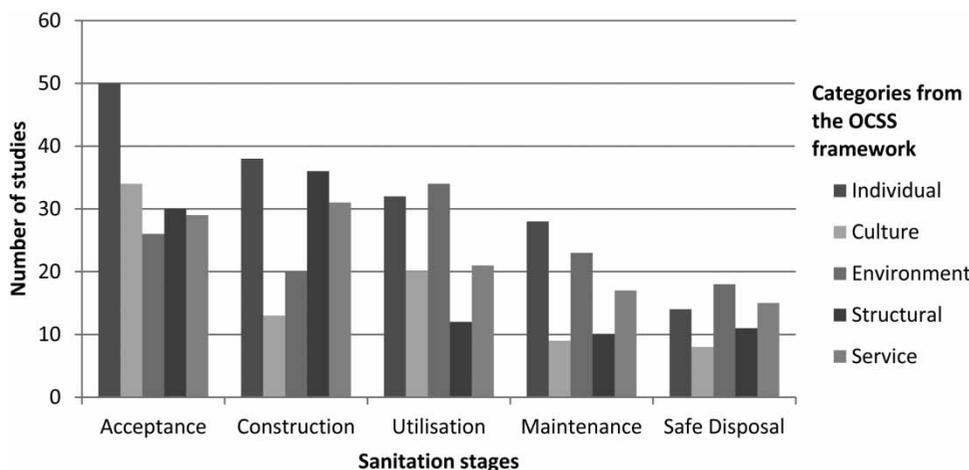
Table 5 | Characteristics of the reviewed studies (Stage 2)

Characteristics	n	%
Methods		
Quantitative	18	28.6
Qualitative	29	46.0
Mixed methods	16	25.4
Study setting		
Urban	18	28.6
Rural	39	61.9
Peri-urban and rural	3	4.8
Mix	3	4.8
Toilet use		
Individual toilet	43	68.3
Shared or communal toilet	8	12.7
Any	12	19.0
Concept used		
Psychological	10	15.9
Sociological	3	4.8
Ecological model	0	0.0
Sustainability concept	5	7.9
Others	5	7.9
None	40	63.5
Study focus		
Adoption	30	47.6
Sustainability of behaviour	6	9.5
Sustainability of facility	8	12.7
Adoption and sustainability	17	27.0
Other	2	3.2

None of them explicitly used an ecological model in analysing sanitation issues. One explanation for this, as described by Dreibelbis *et al.* (2013), is that many sanitation interventions or studies are small in size, so that wider structural factors would be beyond their capacity. Another possible reason is that studies on sanitation are mainly based on theory from disciplines of psychology, epidemiology or engineering with more operational constructs, which may be difficult to use in measuring changes at upper ecological levels such as environment, structural and service levels (Golden & Earp 2012). Moreover, in implementation, professionals in these disciplines may also be unfamiliar with a social ecological approach with a public health perspective (Golden & Earp 2012).

We counted the studies that mentioned each of the five sanitation stages and mapped them against five categories of the proposed OCSS framework (Figure 2 and Appendix C). In the *acceptance stage*, individual and cultural factors ($n = 50$ and 34 , respectively) were reported more than other factors, suggesting that factors such as individual attitudes, knowledge, social norms and traditional beliefs are most commonly identified as influencing whether sanitation technology will be accepted in communities.

For the *construction stage*, individual factors such as economic status and structural factors such as poverty, which may influence the affordability of a technology, were the most cited factors ($n = 38$ and 31 , respectively). Service factors such as access to resources and workforce were also cited commonly in many of the articles ($n = 31$),

**Figure 2** | Number of studies cited in each cell of the proposed OCSS framework on the basis of the systematic review ($n = 63$) (Stage 2).

while cultural factors were seldom cited. Interestingly, environmental factors such as geographical condition and infrastructure availability, which may hinder toilet construction, were cited in only 20 of the reviewed studies.

For the *utilisation stage*, 34 studies cited environment factors such as the facility performance and design, while individual factors such as individual characteristics, perceived risk of use, habitual problems, and knowledge were cited almost as frequently ($n = 32$). Service factors such as tariff and queuing, which are more related to shared toilets in urban areas, and cultural level factors such as beliefs on sharing toilets, as well as gender values on access to space were also cited in relation to the use of sanitation facilities ($n = 21$ and 20, respectively). Structural factors such as tenancy status or poverty were less frequently cited ($n = 12$) in relation to the utilisation stage.

For the *maintenance stage*, the largest numbers of studies ($n = 28$) cite individual factors such as knowledge on maintenance, sense of ownership and financial capacity, followed by 23 studies that discussed environmental factors such as construction quality, climate condition, pit capacity (which influences durability of toilet), as well as service factors ($n = 17$) such as access to maintenance service and follow-up monitoring programmes. Structural factors such

as residential status, government maintenance support, and socio-cultural factors such as maintenance responsibility in the case of shared facilities are only cited by a few studies ($n = 10$ and 9, respectively). For the *safe disposal stage*, environmental factors such as toilet pit design, availability and location of a disposal facility, and service factors such as affordability of pit emptying service were the most frequently cited factors ($n = 13$).

Overall, regardless of the stages, individual factors were the most reported factors among all categories (96.8%) (Figure 3, left). Similarly, when distinguishing urban and rural studies, individual factors are also more cited compared to other factors (100% and 94.9%, respectively). Other factors in the ecological categories also cited by a significant number of studies (>50%) and the distribution of these factors show that the combination of factors are different at each sanitation stage.

In addition to examining the factors within each stage, we also examined factors within each category of the OCSS framework (Figure 2 and columns of Appendix C), *individual factors* are more frequently reported in acceptance stages than in other sanitation stages ($n = 50$). Similarly, *cultural factors* are also reported more in the acceptance stage ($n = 34$) than among other sanitation

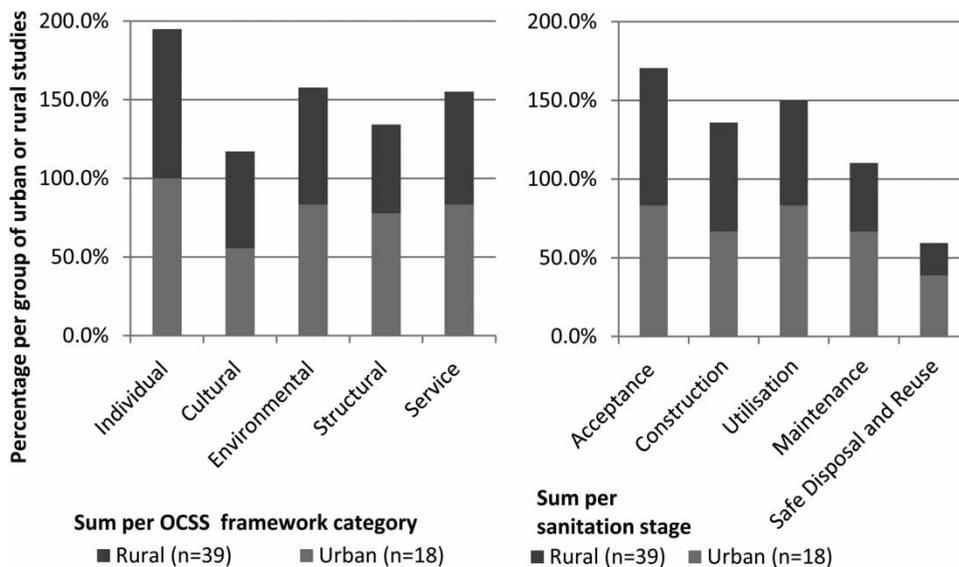


Figure 3 | Percentage of urban and rural studies cited for each sanitation stage and each category of the OCSS framework on the basis of the systematic review (Stage 2). Note: The 'Sum per OCSS framework category' represents the percentage of studies in each urban or rural group that report factors of all sanitation stages in each category of the OCSS framework. The 'Sum per sanitation stage' represents the percentage of studies in each urban or rural group that report factors of all categories of the OCSS framework in each service stage.

service stages. *Environment factors* are reported mostly in utilisation stages ($n = 34$) while both *structural* and *service factors* are the most reported in the construction stage ($n = 36$ and 31 , respectively).

Overall, regardless of the categories of the OCSS framework, factors related to safe disposal stage were the least cited in studies included in the review (27%), while the majority of studies reported factors in the acceptance stage (87.3%) (Figure 3, right). Particularly for studies in urban settings, 83.3% of studies also report factors in the utilisation stage which mainly includes factors related to utilisation of public toilets.

In Figure 2, it can be seen that different combinations and interactions of factors of the ecological categories exist for different sanitation stages. This different combination of factors indicates that different sanitation stages require different sets of strategies, thus warranting separate assessment in the framework. As also suggested by Jenkins & Scott (2007) and Okurut & Charles (2014), a set of different factors would operate at different stages of adoption.

Based on this descriptive analysis, it cannot be concluded that any particular group of factors is more important than others within each sanitation service stage and among different settings (which is not the purpose of the review), because studies included in this review were conducted for different purposes and in different contexts. Certainly, factors identified in each cell would also depend on settings; type of sanitation technology and other contextual background. For example, urban studies report more factors in utilisation and maintenance stages (83.3% and 66.7%, respectively) which relate to shared toilets and factors in the safe disposal stage such as accessibility to waste disposal service, while those factors are currently less of an issue in rural areas (66.7% and 43.6%, respectively). Urban studies also report more (77.8%) structural factors such as government policy, government responsibility and legality of residency than rural studies (56.4%). These setting and socio-political differences lead to a requirement for different strategies and involvement by different stakeholders in addressing sanitation issues.

However, for any particular community or context, the diversity of users generally experiences all of the sanitation stages, although with differing levels of constraints and different needs at each stage. Thus, it is important to have

a complete awareness of any possible combination of ecological factors at each sanitation stage for any community (which can be facilitated by using the proposed framework) before designing an intervention programme. This will assist local professionals to prepare strategies and the needed diverse range of stakeholders not only for the short-term objectives of a sanitation programme, but also for the long-term benefits of sanitation.

Comparative analysis

Multi-level ecological model

The OCSS and the IBM-WASH frameworks use a multi-level ecological approach, but they use different ecological models. Both frameworks are similar in that they both consider how behaviour is affected by the natural, built and household environment (see Table 6 for a list of comparison). The IBM-WASH framework adds a habitual level nested under the individual level to support habit formation, which includes factors such as 'ease of use' and 'appropriate design' of facility (Dreibelbis *et al.* 2013, p. 6; Hulland *et al.* 2015, p. 57). However, the OCSS framework groups those factors under the environmental category. Unlike the IBM-WASH framework, the OCSS framework specifically categorises sanitation service factors, which include external support services related to sanitation programmes and systems such as services for emptying, transport and treatment of faecal waste. A service category is also considered in Bronfenbrenner's ecological model of human development (McLaren & Hawe 2005) and the Butterfly model (VanLeeuwen *et al.* 1999), but it is seldom explicitly presented in the application of ecological models.

Organisation of factors within the ecological model

Both frameworks organise factors in each category of the ecological model into several domains or issues, in a matrix form, but with a different grouping approach. In the IBM-WASH framework, each category of the ecological model is divided into three main dimensions which are actually based on the perspectives of different disciplines. The psychosocial dimension is frequently the concern of psychology researchers and practitioners, and the technology

Table 6 | Comparison between the OCSS framework and the IBM framework**Similarities and differences**

	SIMILARITIES
Use of ecological model:	<ul style="list-style-type: none"> • Acknowledge environment influences on behaviour
Organise factors under ecological levels:	<ul style="list-style-type: none"> • Use a matrix to organise factors • List similar factors in overall assessment? Not sure what you mean
	DIFFERENCES
The IBM-WASH Framework	The OCSS Framework
Use of ecological model:	
<ul style="list-style-type: none"> • Adds habitual level under the individual level that focuses on the supporting environment for habit formation 	<ul style="list-style-type: none"> • The environmental category includes not only factors related to household environment but also natural and built environment • Assigns service factors that include support services for community to access and use adequate sanitation services (including waste disposal)
Organise factors under ecological levels:	
<ul style="list-style-type: none"> • Uses three dimensions that are based on fragmented discipline (Contextual, Psychosocial and Technological) • Overlapping group of factors that lead to difficulties identifying specific needs and strategies • Less detail on factors to address needs across the different stages of sanitation 	<ul style="list-style-type: none"> • Incorporates technological, psychosocial and contextual dimensions into the ecological model • Thus can expand the assessment to include sanitation stages and more appropriately address SDGs • Within each stage, issues can be detailed further when necessary to meet local needs/priority (e.g., urban setting to include transport service for safe disposal stage) • More detailed description of factors to consider across each sanitation stage
Implication for translating factors into strategies:	
<ul style="list-style-type: none"> • May lead to fragmented actions by different stakeholders 	<ul style="list-style-type: none"> • Encourages collaboration for identifying factors and designing strategies • When used as an advocacy tool, the framework shows an interrelatedness of factors at each sanitation stage, thus it assists with potential argument to convince relevant stakeholders to adopt more integrated strategies • Identification of service factors helps to improve current services that are needed for any particular setting/case at each sanitation stage • Assists in identifying stakeholders related to each category and each sanitation stage

dimension is mainly the concern of sanitary engineering professionals. The limitation of these three dimensions is that they may lead professionals from different backgrounds to continue to view the problem through a fragmented set of factors and address them separately. This issue has been identified as a shortcoming in the Millennium Development Goals, and has been addressed in the SDGs, by emphasising the holistic and interdependent nature of the targets and goals (Witoelar 2015), stressing the need for collaboration between agencies for each issue.

Another limitation of the IBM-WASH framework is that the contextual dimension groups a wide range of factors,

which may lead to difficulties in designing further actions. For example, the contextual dimension groups environmental factors, which include the natural environment and the built environment, with factors related to policy and access to resources. This does not assist stakeholders to clearly see how they could address each of those factors. Hence, it is better to have a group of structural factors related to policy and socio-political conditions, and a separate group of environmental factors which include natural and built environment and supporting facilities, so that the strategy can be focused on anticipating or modifying each type of factor. The technology dimension in the IBM-WASH

framework also overlaps with the psychosocial dimension. For example, the technology dimension includes perceived values and perceived cost of a technology (Dreibelbis *et al.* 2013), which are also a psychosocial aspect of the behaviour related to perceived benefit and perceived barriers.

The five categories of the OCSS framework incorporate the three dimensions (contextual, psychosocial and technological) as well as the ecological levels in the IBM-WASH framework. Therefore, using these ecological categories in the OCSS framework enables us to expand the assessment to include sanitation stages and more appropriately address the sanitation targets of the SDGs which have the additional focus on increasing the safe treatment of waste.

The safe disposal stage in the OCSS framework encourages stakeholders and professionals to examine factors that influence the safety of the waste disposal, which includes safe removal and safe treatment. This will not only assess the individual and cultural factors related to the awareness and acceptance of any safe disposal options, but also other environment, service and structural factors for safe disposal of the waste. The environment factors include the availability, reliability and accessibility of infrastructure for removing, transporting (if needed) and treating the waste before it is disposed of. The service factors include the accessibility and affordability of services such as pit emptying, waste transport and treatment, and factors affecting the operation of those services such as human resource capacity and financing mechanism. The structural factors include policy and regulation to support those services and any institutional arrangements to assure clear responsibility for safe management of faecal waste.

In reality, different communities can be at different stages of sanitation service and hence have different priority issues. The factors and needs in each sanitation service stage are also different among individual and publically shared facilities (Nelson *et al.* 2014). As mentioned above, different combinations of factors and strategies apply to each sanitation service stage. Basing the categorisation of factors on the sanitation stages assists sanitation stakeholders (practitioners, decision-makers and donors) in the process of prioritising the issues at any sanitation stage for a particular community without compromising the need to consider the whole sanitation system to address long-term needs. This flexibility in prioritising issues of sanitation stages and the

comprehensiveness in considering the whole system (socioecological system and sanitation system) make the framework applicable for any settings (rural or urban) and for different types of sanitation facilities. Once issues are identified for a specific setting, the focus in any sanitation stage can be expanded further to specify the particular services needed for that particular setting (for example, transporting or further reusing the waste at the safe disposal stage for urban areas).

A comparison of the list of factors identified in each cell in the matrix of both frameworks reveals that both frameworks list similar factors, but that the OCSS framework provides a more detailed description of factors that correspond to issues at each sanitation stage. For example, in the IBM-WASH framework, the knowledge factors are described as knowledge of disease, while in the OCSS framework, knowledge is presented as several different fields such as knowledge of disease, knowledge of technology options, knowledge of how to use, knowledge of construction techniques and knowledge of safe disposal options, which are identified within each sanitation stage. Overall, application of the OCSS framework can guide local stakeholders to unpack more in depth the factors that affect not only adoption, but also the sustained use and functioning sanitation system.

Implications for translating factors into actions

The importance of having a comprehensive framework is that it not only clarifies the types of factors which assist in designing strategies, but also encourages collaborative actions. The categories in the OCSS framework can be translated into actions that, in general, resemble the five groups of action strategies of the Ottawa Charter (see strategies identified for the utilisation stage in Table 7 as an example). In addition, the challenge in the ecological approach is not on how to understand the interconnectedness of the factors but to encourage practitioners from a single discipline programme perspective to move out and integrate with the wider social and policy domains (Chu 1994). This is where the constraint of the traditional disciplinary barriers among different institutions needs to be addressed.

Although application of the IBM-WASH framework provides for a comprehensive assessment of factors, the

Table 7 | Examples of possible action strategies for the utilisation stage from the OCSS framework

Ecological categories	Factors affecting utilisation of sanitation facility	Possible actions	Supporting discipline
Individual	Perceived benefit and threats Knowledge of use	Provide information session and promotion of benefits, how to build, use and maintain and linking with local values (improve skill)	Public health, anthropology, engineering and rural development
Cultural	Traditional beliefs related to toilet use Cultural values about women's access to public space Strength of social bonds	Work with community to build community commitment to improve sanitation, and participatory process for design of sanitation facility and action planning (community action)	Engineering, anthropology and public health
Environmental	Superstructure design Toilet performance Toilet location Water availability	Accommodate values about utilisation and reduce threats through toilet design and location (create supportive environment)	Health promotion, anthropology and engineering

actions derived from the dimensions of factors would still be based on the separate domains, which could lead to fragmented actions. In contrast, the OCSS framework accommodates perspectives of behaviour change, public health and sanitary engineering into the framework for assessing each sanitation stage. This should encourage stakeholders from the key different disciplines to appreciate the perspectives of other disciplines while also knowing that their own perspective is equally considered in the framework. Using sanitation stages as the basis of the description of the issues is more likely to encourage all local stakeholders to contribute to the identification of the factors at each sanitation stage then to collaborate in designing the corresponding strategies. It is also particularly important for the local practitioners as the use of a visual matrix tool may serve as a useful advocacy tool and assist in convincing decision-makers regarding the relative importance and interrelatedness of different factors within a holistic framework.

The OCSS framework explicitly categorises the service factors that can provide valuable information about the currently available services, particularly about their current performance, potential strengths and possible improvement. This enables local practitioners to learn from the existing resources and services of the targeted communities and identify the support needed by different service providers. Moreover, more detailed description of the factors in the OCSS framework would also assist local stakeholders in

designing more locally specific strategies such as providing content material needed for promotion, improving services, creating a supportive environment and other needs relevant to a particular community.

The five categories of the Ottawa Charter that are used in the OCSS framework are also useful for mapping the related stakeholders (Brown 1994). For example, when considering the cultural category, stakeholders such as traditional healers or religious organisations should be involved if there are identified factors related to them, and in the service category, local municipal sanitation institutions would be identified as stakeholders related to the service factors. Similar mapping can also be applied for each sanitation stage. This process could also be used to identify support needed by each stakeholder for making necessary changes or improvements.

Applying a comprehensive framework would not guarantee successful sanitation development, but it would indicate where internal and external support is required for sanitation planning and implementation.

Limitations

There are some limitations of this study that may affect the validity of the findings. Due to the non-systematic process of the Stage 1 review, there is a possibility that other frameworks were missed from the review. Although we aimed to extensively capture relevant studies in the screening process

via the systematic review in Stage 2, the studies identified in the review are limited by the search keywords used in the review. This can affect the proportion of studies reporting factors and also types of factors listed in each category and sanitation stage in the OCSS framework. This could be improved by including more keywords reflecting a complete sanitation system, such as sanitation services related to transport and treatment of faecal waste.

It is possible that the review missed factors from other studies that were excluded, such as studies that are not reported in the English language as well as studies that were not published in peer-reviewed journals. Thus, the finding of this systematic review is limited to what was reported in peer-reviewed papers.

The proposed framework has also not been tested in a real context in order to validate the operability and implications of its use. Further, the utility of a framework may not only be limited by its theoretical construct and scope, but also by the users' awareness of its benefits and scope. Hence, dissemination and explanation of comprehensive and somewhat complex frameworks such as this are critical for their ongoing utility and successful application.

CONCLUSION

This literature review and comparative paper has identified areas for improvement in the frameworks for assessing factors currently used in the sanitation sector. It identifies the WASH framework as a useful benchmark, identifying its strengths and weaknesses in addressing the range of sanitation stages important for sustainable sanitation access. The study proposes an alternative framework, the OCSS framework, that incorporates a sanitation system approach and an ecological public health approach to appropriately address the sanitation target of the SDGs.

Combining this sanitary engineering perspective with the ecological approach of public health has several advantages. First, the way the OCSS framework incorporates ecological categories and sanitation service stages allows for a more detailed description of the factors influencing each stage; where categories in an ecological model operate differently in each sanitation service stage. This can assist sanitation stakeholders and policy-makers to ensure

comprehensive design of their action strategies to meet the current and future community needs in adopting and sustaining sanitation practice.

Secondly, a focus on the sanitation service stages also encourages more collaboration among various stakeholders in designing the most appropriate set of actions. The next step is to test this operational framework in various settings to provide valuable information on strengths and weaknesses of the proposed OCSS framework in order to enhance its applicability and operability and then promote its application so its benefits can be realised in practice.

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