

Review Paper

Relationships between shared sanitation facilities and diarrhoeal and soil-transmitted helminth infections: an analytical review

P. S. Ramlal, T. A. Stenström, S. Munien, I. D. Amoah, C. A. Buckley and Sershen

ABSTRACT

Shared sanitation is widely proposed as a means to increase access to improved sanitation. There are few reports of a causal relationship between the use of shared sanitation and community-acquired diarrhoea. This paper presents an analytical review of studies that have investigated the relationship between the use of shared sanitation and the prevalence of (1) diarrhoeal disease and (2) soil-transmitted helminth (STH) infections. Data were extracted from the reviewed literature to calculate odds ratios (ORs) and confidence intervals (CIs). The use of shared sanitation showed a significant increase in diarrhoeal diseases, with an overall OR of 2.39 (85% CI 1.15–8.31). Children under 5 years were slightly less affected with a prevalence ratio of 1.09 (95% CI 1.06–1.12). The number of published reports on STH infections in relation to shared sanitation was limited, but the few that do exist report on 'improved sanitation', showing a positive and protective impact with an overall OR of 0.49 (95% CI 0.28–0.89), which is contrary to the negative impact related to diarrhoea. Despite the limited information on the direct link between shared sanitation and incidence of diarrhoeal/STH infections, this literature review demonstrates that the relationship deserves close attention in future practice and research.

Key words | diarrhoea, odds ratio, private toilets, shared sanitation, soil-transmitted helminths

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INTRODUCTION

Poor or unimproved sanitation is associated with high disease burdens worldwide, which includes diarrhoea and soil-transmitted helminths (Clasen *et al.* 2012). Diarrhoea accounts for the largest burden of disease from poor sanitation, with an estimated 1.4 million deaths per year (Prüss-Üstün *et al.* 2014; Sclar *et al.* 2016). Diarrhoeal disease, in general, is a major cause of morbidity and

mortality, particularly in low- and middle-income countries (Black *et al.* 2010). In addition to being ranked as the fourth leading cause of death for children under 5 years (GBD 2015), child diarrhoea morbidity has not decreased since the 1980s, persisting at 2–3 incidents per child under 5 years per year (GBD 2018).

Poor sanitation has been implicated by several researchers to be the main cause of diarrhoea (Moraes *et al.* 2003; Barreto *et al.* 2007; Cameron *et al.* 2013; Prüss-Üstün *et al.* 2014; Freeman *et al.* 2017). Improvement in sanitation can result in over 32% reduction in diarrhoeal cases (Fewtrell *et al.*

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2005). Sanitation excludes disease-causing microorganisms from the environment, thereby acting as a primary barrier to infection (Freeman *et al.* 2017). Additionally, unhygienic practices could contribute to over 23% of diarrhoeal cases (WHO 2004). Practices including a lack of handwashing in relation to defaecation, food and water handling have been implicated (Curtis & Cairncross 2003). Approximately 54% of diarrhoeal cases can be reduced with an improvement in handwashing behaviour, especially for severe diarrhoea (48%) and Shigellosis (59%) (Fewtrell *et al.* 2005).

Access to clean and adequate water supply supports hygiene and sanitation and could, therefore, be beneficial in preventing diarrhoea and other infections (Bartram & Cairncross 2010). Additionally, safe water at the points of collection, treatment and storage all play important roles in preventing diarrhoea (Benova *et al.* 2014). Accessibility to water is also a major contributory factor in diarrhoeal infections (Esrey *et al.* 1991). The WHO estimates that over 1.1 billion people globally rely on unsafe drinking water (WHO 2003).

Over 88% of the global cases of diarrhoea are attributed to unsafe water, sanitation and hygiene (WHO 2003), which further relates to behaviour that may either lead to an increase or decrease in infection (Dreibelbis *et al.* 2013). This influences the adoption of water, sanitation and hygiene practices or technologies aimed at diarrhoea reduction (Dreibelbis *et al.* 2013).

Infection with STHs is often linked to poverty, poor hygiene and lack of clean water (Brooker 2010; Utzinger *et al.* 2010). Approximately 4.5 billion people are at risk of soil-transmitted helminth (STH) infection worldwide, with over 1.5 billion people infected presently (WHO 2018). Poor sanitation may contribute to the elevated risk of STH

infections by increasing the number of infective eggs in the environment, including in soil, thereby promoting the risks of egg ingestion (King & Bertino 2008; Brooker 2010). Additionally, the infection may occur due to penetration of the skin by hookworm larvae (Bethony *et al.* 2006). Improvements in sanitation can be achieved through both the upgrading of sanitation facilities and the promotion of shared sanitation (Pickering *et al.* 2015; Garn *et al.* 2017). The Joint Monitoring Programme (JMP) of the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) categorises sanitation into five levels: safely managed, basic, limited, unimproved and open defaecation (WHO & UNICEF 2017).

According to the JMP, shared sanitation is either considered 'limited', where improved sanitation is shared between two or more households, or 'unimproved', when this shared facility is a pit latrine without a slab or platform (WHO & UNICEF 2017). Based on this classification, as at 2015, 76% of the global population use improved sanitation. Since approximately 68% of the 76% population with improved sanitation did not share, they were counted as basic sanitation services. Sewer connections were available for 36% of the non-shared improved sanitation, with the rest using septic tanks, latrines and other improved on-site sanitation facilities, therefore falling under the 'safely managed' sanitation level (WHO & UNICEF 2017).

Fuller *et al.* (2014) estimated that over 761 million people rely on some form of shared or public sanitation facilities. A systematic review by Heijnen *et al.* (2014a) showed that over 27.3% of households use shared sanitation globally; however, the proportion varies greatly based on demographic and geographic differences (Table 1). In Africa, for example,

Table 1 | Global use of shared sanitation (modified from Heijnen *et al.* 2014a)

Region	Shared sanitation (%)	Remarks
Africa	44.6	Over 70% in Ghana, Liberia and Sierra Leone
Americas (Central and South) ^a	14.2	Highest proportion of shared sanitation in Haiti (51.2%)
South-East Asia	31.3	Bangladesh and Nepal have percentages above the regional figure (39.6 and 31.7%, respectively)
Western Pacific	16.4	Only Lao People's Democratic Republic and Socialist Republic of Vietnam have averages below the regional figure
Eastern Mediterranean	7.7	
Europe	2.5	Has the lowest proportion of populations using shared sanitation facilities

^aThe countries with data reviewed were Belize, Bolivia, Colombia, Cuba, Dominican Republic, Guyana, Haiti, Honduras, Nicaragua, Peru and Suriname.

close to 44% of the population is reported to rely on some form of shared sanitation, which is the highest proportion of the population using this type of sanitation worldwide. A number of countries in Africa, such as Ghana, Liberia and Sierra Leone, also have figures far above the regional average (Table 1). South-East Asia follows with the next highest proportion of use of shared sanitation (31.3%).

Improved sanitation has been shown to reduce diarrhoeal diseases by 22–36% (Cairncross *et al.* 2010; Clasen *et al.* 2010) and protect against STH infections (OR = 0.46–0.58) (Ziegelbauer *et al.* 2012). Despite the increased use of shared sanitation in recent times, there is divided opinion on the usefulness of the approach. One school of thought (Schouten & Mathenge 2010; Katukiza *et al.* 2012) opines that public or shared latrines are best suited to deal with highly populated dwellings in the cities because of space availability. However, others believe that shared sanitation may be a contributory factor to infections (Fenn *et al.* 2012; Heijnen *et al.* 2014b; Patil *et al.* 2014; Pickering *et al.* 2015).

The impact of shared sanitation on health outcomes is usually measured and reported using the odds ratio (OR). This is a measure of association between an exposure and an outcome of interest (Bland & Altman 2000). In the case of sanitation in this review, it measures the use of shared sanitation and the incidence of different health outcomes, such as diarrhoea. This measure is usually used in case-control studies, but has also found widespread use in cross-sectional and cohort studies (Zhang & Yu 1998; Reilly *et al.* 2005; Knol *et al.* 2012). An OR of 1 indicates that the exposure had no impact on the outcome, >1 indicates higher chances of the outcome and <1 suggests lower chances of the outcome (Bland & Altman 2000).

Although the situation is partly case-specific, it is important for local authorities, public and environmental health practitioners and other key policy-makers to consider the relationship between shared sanitation and the incidence of different diseases, especially diarrhoea within rapidly developing cities. This information will be useful in the design and implementation of appropriate interventions, especially within informal settlements or slums. The current contribution reviews the global literature on shared sanitation with the objective of investigating the potential linkages between the use of shared sanitation facilities and the incidence of diarrhoea and STH infections.

METHODS

Data extraction

This review is based on literature searches using the following databases for all publications up to 3 October 2018: Pub Med; Web of Science, ScienceDirect and Google Scholar. The publications emerging from the searches were screened manually for relevant information. Articles that met the criteria were analysed to extract data/information on the causal relationship between the use of shared sanitation facilities and the incidence of diarrhoea and STH infections. Information such as case studies used, types of shared sanitation studied and measured outcomes were also collated. Additionally, information on the type of sanitation was recorded for the control populations, where stated. The limitations associated with the respective studies were noted.

Assessment of bias and quality of evidence

The quality of methods was judged by assessing the representativeness of the study sample and the nature of the population from which the sample was drawn (Zaccai 2004). Observational studies were assessed using the Strengthening of the Reporting of Observational studies in Epidemiology (STROBE) statement (Elm *et al.* 2007), serving as a guideline. Additionally, the Cochrane EPOC (Effective Practice and Organisation of Care) (Øvretveit & Gustafson 2003) was used as a guideline to review studies that stated specified intervention groups/populations.

Data analysis

Data on the populations studied and measured outcomes, specifically diarrhoeal and helminth infections, were collated from all the publications based on the selection criteria mentioned above. The overall OR for the association between shared sanitation and the outcomes was determined using Stata SE (Stata Corp, USA), according to Altman (1991). These odds were calculated using the data presented in the reviewed literature on the number of people who had diarrhoea or STH infections and used

shared sanitation and the number of people using private toilets who had diarrhoea or STH infections.

RESULTS AND DISCUSSION

Evidence of a direct link between shared sanitation and diarrhoea

The literature search revealed 43 out of 162 articles on shared sanitation that used epidemiological methods to assess the association between sanitation and diarrhoeal diseases. However, only 14 of these 43 articles reported a direct link between the use of sanitation and diarrhoeal disease infections, and an additional eight reported on improved sanitation and helminth infections. Based on the JMP (WHO & UNICEF 2017) definition for improved sanitation, which considers any form of shared sanitation as unimproved, it was assumed that improved sanitation in these publications referred to private sanitation facilities.

The overall reported ORs for diarrhoea associated with the use of shared sanitation represent overwhelming evidence that shared sanitation increases the incidence of diarrhoea (overall OR of 2.39 [95% CI 1.15–8.31], Figure 1). The epidemiological link between the use of shared sanitation and the incidence of diarrhoea was originally addressed by Chakraborty & Das (1983) from studies in India. They found an average of 1.6 episodes of diarrhoea per year in slums where shared sanitation was frequently used, compared with 1.4 per year for private latrine use. This is similar to reports from

South Africa (Moshabela *et al.* 2012), where shared latrine use was linked to 25.3% of diarrhoea cases as compared with 23.7% associated with private latrines.

Access to sanitation has, in general, been reported as a means to reduce diarrhoeal infections (Mahamud *et al.* 2012), which is not the general conclusion that one should make according to the data shown in Figure 1, when compared with private sanitation facilities. The relationship between shared sanitation and the increase in the prevalence of different diseases, especially diarrhoea, is evidenced by several studies (Ghosh *et al.* 1994; Mahamud *et al.* 2012; Moshabela *et al.* 2012). Contamination of contact surfaces in a sanitation facility may be one major route of exposure for the users. Flores *et al.* (2011) found a wide variety of microorganisms associated with humans on contact surfaces in public restrooms. Likewise, Kanayama Katsuse *et al.* (2017) found 86.9% of warm-water nozzles contaminated with different bacteria including methicillin-resistant *Staphylococcus aureus*. Some studies have also reported more faeces on the slabs of shared latrines than private ones (Huda *et al.* 2018). Using volunteers, Burton *et al.* (2011) showed that touching of door handles and railings in public places contaminated hands with pathogens of faecal origin. Contact with surfaces contaminated with these pathogens as well as the high excretion numbers by infected individuals may, therefore, be the main contributing factors to diarrhoeal diseases associated with shared sanitation. This may also secondarily affect young children that do not use these shared facilities themselves.

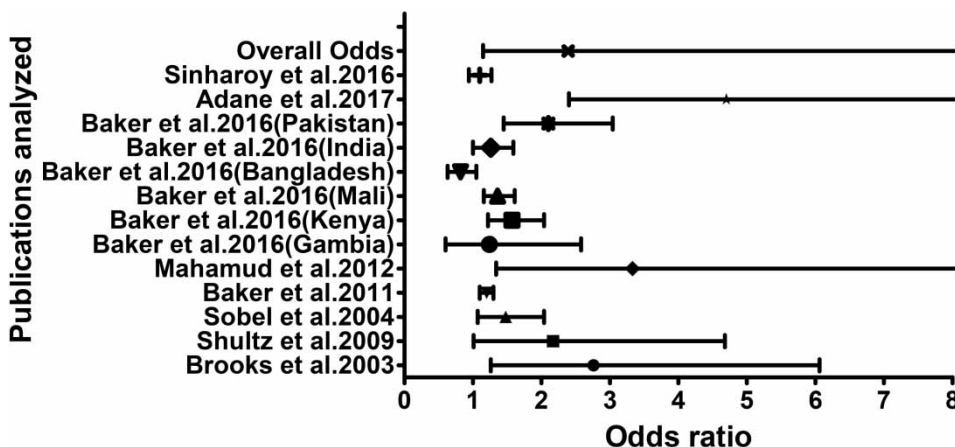


Figure 1 | Odds ratio for diarrhoea incidence associated with the use of shared sanitation.

The survival of microorganisms on inanimate objects and surfaces does, however, depend largely on the persistence of the individual microorganism species (Abad *et al.* 1994; Kramer *et al.* 2006). For example, some microorganisms may die within minutes by air-drying, while spore-forming microorganisms, such as *Clostridium* spp., represent the other end of the scale and survive for extended time periods under such conditions (Mkrtchyan *et al.* 2013). Pathogens that may be transmitted via the faecal–oral route and have low infectious doses include pathogenic strains of *Salmonella* spp., *Campylobacter* spp., *Shigella* spp. as well as rotaviruses and *E. coli* 0157 (Griffin *et al.* 1994; McDonnell *et al.* 1995; Doré *et al.* 2000). These are among the main pathogens associated with sanitation-related diarrhoeal diseases. Doses of as low as 10–100 viral particles are reported to result in infection for rotavirus and norovirus (Koopmans *et al.* 2002). With excretions of over 10^{11} viral particles of norovirus and rotavirus per gram of faeces by infected individuals, sanitation facilities may be hotspots for their transmission and may account for part of the positive correlation between shared sanitation use and diarrhoeal infections in the studies reviewed by Heijnen *et al.* (2014a). Norovirus shedding may last for 18 h to 28 days after an infection, with a peak on the fourth day (Atmar *et al.* 2008; Aoki *et al.* 2010), while infection with *Shigella* generally lasts for a week (DuPont *et al.* 1970) but may be established as a carrier-ship with long-time excretion for more than a year. With the use of shared sanitation, one infected user may, therefore, result in an extended period of transmission to many others through contamination.

Shared sanitation is the most common in crowded areas of cities where the number of people using a single facility may be high, concomitantly increasing the possibility of contamination and transmission. For instance, Weaver *et al.* (2017) established that the use of shared sanitation with one household resulted in relative risks of influenza-like infections of 2.1 (95% CI 1.2–3.6) against relative risk of 3.1 (95% CI 1.8–5.2) for sharing of sanitation with more than one household. Within household and community settings, children may be particularly vulnerable to the risks posed by shared sanitation. For example, Fuller *et al.* (2014) in reviewing data from 435,205 children under 5 years from 51 countries showed that the use of shared sanitation resulted in the crude diarrhoea prevalence

ratios (PRs) of 1.09 (95% CI 1.06–1.12) for this group. Despite the overwhelming evidence that shared sanitation leads to an increase in diarrhoeal diseases, recent studies in India (Heijnen *et al.* 2015; Berendes *et al.* 2017) reported a weak relationship between the use of shared sanitation and the increased incidence of diarrhoea; 0.82% of individuals using shared sanitation had diarrhoea compared with 0.77% in users of private sanitation. The use of shared sanitation in West Africa is also reported to result in lower diarrhoeal disease incidence (adjusted PRs of 0.91 (95% CI 0.86–0.97)) (Fuller *et al.* 2014) than the rest of Africa and other regions globally. Exclusion of the data from West Africa from the regional and global assessments reveals a much higher impact of shared sanitation on diarrhoeal diseases. For instance, the rest of Africa reported 10–32% higher prevalence of diarrhoea among users of shared sanitation than the use of private toilets, compared with figures from West Africa (Fuller *et al.* 2014). Private sanitation use is not common in most areas of West Africa, especially in crowded urban and rural areas. Therefore, the alternative to shared sanitation is mainly open defaecation (Adubofour *et al.* 2013). Open defaecation is the lowest level of sanitation under the JMP categorisation. Therefore, its use exposes the population to higher levels of pathogens, thereby increasing the risks of diarrhoeal infections. This supports the argument that despite the increase in the use of shared sanitation globally, the level of uptake varies across different regions largely due to economic differences (Heijnen *et al.* 2014a; Tumwebaze *et al.* 2014).

Shared sanitation and soil-transmitted helminth infections

The relationship between STH infections and the use of shared sanitation is under-investigated. The findings from the few reported investigations are summarised in Figure 2 showing an overall protective effect of shared sanitation. An OR of 0.49 (95% CI 0.28–0.89) was determined for these studies (Figure 2), which shows a lower impact and a protective effect of shared sanitation on STH infections contrary to diarrhoeal infections. From studies performed in Laos, the possible protective effect with the use of

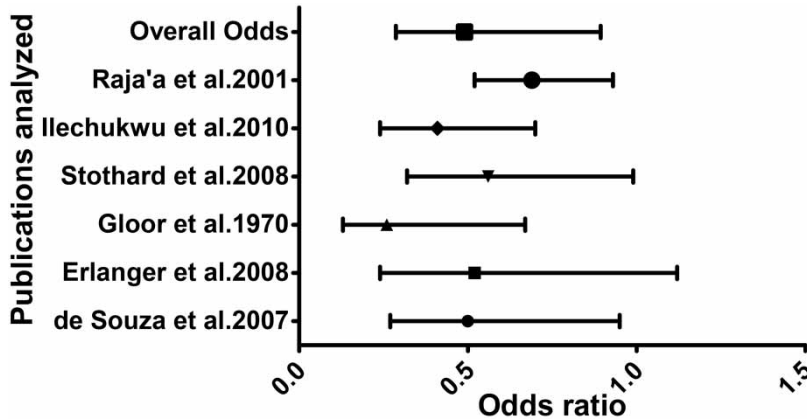


Figure 2 | Odds ratio for helminth infection associated with the use of shared sanitation.

improved sanitation and helminth infections is also evident (Erlanger *et al.* 2008).

An OR <1 as reported here indicates a lower impact of the exposure as compared with ORs >1 reported for the diarrhoeal infections. This lower impact could be attributed to differences in transmission mode for these parasites. STH infections are mainly transmitted through ingestion of the infective eggs (except for hookworm) either in soil, water or food that is contaminated with faeces, whereby the use of shared sanitation may have reduced these contaminations.

The highest reduction in STH infection with access to improved sanitation has been reported for *A. lumbricoides* and *T. trichiura* (Ziegelbauer *et al.* 2012; Oswald *et al.* 2017), but this does not apply to hookworm infections (Strunz *et al.* 2014), partly due to the different mode of transmission of the two parasites. Hookworm infection is through skin penetration by the infective larvae in most cases and rarely through ingestion of the eggs, whereas *Ascaris* spp. is mainly transmitted by egg ingestion only.

Hookworm infections have been the main focus among the helminth infections in the reported literature (Gloor *et al.* 1970; Olsen *et al.* 2001; Nguyen *et al.* 2006). Only one of the studies reviewed (Asaolu *et al.* 2002) reported on *Ascaris lumbricoides* infection associated with access to improved sanitation. Since hookworms mostly infect through penetration of the skin by the infective larvae (Bethony *et al.* 2006), the use of shared sanitation outside the household may expose the population to possible infections when visiting shared sanitation facilities with

bare feet. Stothard *et al.* (2008) found that the use of household latrines resulted in an increased risk of infection and having an infected household member also led to much higher risks of infection. These could be attributed to contamination of the household environment, exposing household members to the infective eggs after a period of latency. For instance, in Kenya, it was found that location of toilet facilities outside the household premises led to significantly higher prevalence of STH infection (Worrell *et al.* 2013) as compared with facilities within household premises.

Oswald *et al.* (2017) did not find any protective association between shared sanitation usage and STH infections in Ethiopia, and concluded that the association between shared sanitation and STH infections is complex, requiring further investigation. Poorly maintained toilet facilities have been shown to be a focal point for reinfections (Campbell *et al.* 2014). Therefore, despite the importance of the availability of sanitation facilities, transmission could still be high.

Monitoring of shared sanitation facilities

Despite reports of an increase in diarrhoeal disease due to the use of shared sanitation, monitoring of these facilities is limited. Most of the monitoring focuses on schools, healthcare facilities, workplaces, public spaces (e.g. markets), hotels, refugee camps and orphanages (Cronk *et al.* 2015). Only a limited number of monitoring programmes focus on shared sanitation facilities used by the general community in public spaces. It should also be noted that

monitoring of school sanitation facilities (through questionnaires) is recommended by the United Nations Education, Scientific and Cultural Organization (UNESCO) and is mainly implemented by local and national authorities (Carrizo *et al.* 2003). For other settings, there are a number of monitoring tools or systems in place, for example, the Health Management Information Systems (HMISs) used for monitoring sanitation in health facilities (WHO 2010). Monitoring of shared sanitation facilities in public spaces, or those used by the general public, is done by local government authorities in some countries (Cronk *et al.* 2015), but the data generated are usually not in the public forum.

Importantly, these follow-up systems often do not include an assessment of the quality of these facilities and therefore the health risks involved in their use. This is a serious oversight, given Bain *et al.* (2014) estimate that more than a quarter of improved sanitation sources have faecal contamination. Year-round availability of water within these shared or non-household sanitation facilities is also a major challenge that is rarely considered (Kostyla *et al.* 2015; Shields *et al.* 2015).

Limitations of reviewed studies

A number of limitations were identified in the reviewed literature. For instance, only a few studies employed a random selection of study areas and participants, which can potentially lead to skewed results. The reliance on self-reporting is also questionable; participants may fail to report all cases of diarrhoea, which may affect the outcome of the studies. Another major limitation identified is the exclusion of confounding factors. Most of the studies considered in this review report on direct links between sanitation use and diarrhoea, but do not consider confounders or effect modifiers. These include hygiene behaviour, solid waste disposal practices and access to potable water among others. Other issues such as cost, distance and waiting time for access to these sanitation facilities may also affect their use and hence the study outcomes as well (Tiimub *et al.* 2009; Biran *et al.* 2011). We believe that the maintenance of the facilities and the availability of protective measures such as water and soap should also be considered in studies of this nature. It has been shown that if sanitation facilities are poorly maintained or

inappropriately used, the health of the users and the convenience of using the facilities may be impacted (Kimani-Murage & Ngindu 2007; Buttenheim 2008; Owusu 2010). A study in Uganda, for example, found that only 12% of 1,019 respondents had access to clean shared toilets, which was attributed to a number of users, perception that cleaning behaviour warranted huge effort and lack of cleaning intention of users (Tumwebaze 2014). This is in contrast to findings by Massa *et al.* (2017) who found 74.2% of shared latrines to be generally clean. These contrasting results call for more research in this area.

CONCLUSIONS

This literature review presents evidence for the role of shared sanitation in the transmission of diarrhoeal diseases, with children under 5 years slightly less affected than others. Only a few studies report a direct link between shared sanitation and the incidence of diarrhoeal diseases, but an analysis of ORs provides overwhelming evidence of an association. Data from six world regions argue for shared sanitation contributing to the increased incidence of diarrhoea. However, some studies have found shared sanitation facilities to provide a protective effect against diarrhoea, especially in West Africa, where private sanitation is less available than elsewhere. Information on the potential protective association between shared sanitation and STH infections, in contrast, is limited. The mode of transmission of STH differs from that of other pathogens, and there is a need for more empirical evidence on STH infections in the context of shared sanitation – especially the quantified role of shared sanitation on soil-transmitted helminths. Future studies on shared sanitation and its impact on disease incidence (or ORs) should also account for the disease-transmission effects of key factors such as contamination of contact surfaces, maintenance routines and access to water. This gap represents an important oversight in presently available studies, such as those reviewed here. There is a need for local authorities to factor in the maintenance and monitoring of all shared sanitation facilities and make their reports part of publicly available databases if possible. Despite the limited information on the direct link between shared sanitation and incidence

of diarrhoeal/STH infections, this literature review demonstrates that the relationship deserves close attention in future practice and research.

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COMPETING INTERESTS

The authors alone are responsible for the views expressed in this article, and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated. The authors declare no other competing interests exist.

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