

Can and should sanitation and hygiene programmes be expected to achieve health impacts?

RICHARD C. CARTER

Although the anticipated health benefits are not the only reason for undertaking sanitation and hygiene programmes, they do represent an important part of the justification. Studies and reviews over recent years have shown, however, that the health impacts of sanitation programmes can be quite small or even negligible. They have also provided no solid evidence that integrated (water, sanitation, hygiene) programming has any greater effect than addressing one or two of these components alone. Two questions arise: first, whether a certain level of sanitation usage and hygiene practice within a community is needed in order to achieve a measurable health impact (i.e. whether a minimum percentage of the population should be using safe sanitation); second, whether sanitation and hygiene interventions undertaken without accompanying water supply improvements are likely to have significant health benefits. In this opinion paper some plausible and practically relevant answers to these questions are extracted from the relevant literature. The conclusions are that a high level of sanitation usage (well over 65 per cent) and widespread handwashing practice are necessary to achieve significant health impact; and that in situations where water services are poor, sanitation and hygiene interventions, while valuable for other reasons, are unlikely to have significant health impacts. Sanitation and hygiene programmes may be justifiable even if they do not immediately achieve high levels of compliance and corresponding water supply improvements are not made; however, the justification should not be presented on the grounds of short-term health benefits.

Keywords: sanitation, hygiene, health, programmes

WHEN GOVERNMENTS AND NGOS UNDERTAKE sanitation and hygiene programmes in low-income countries, they usually do so in expectation of beneficial impacts on the health of the individuals, households, and communities involved. Health benefits often focus on diarrhoeal disease (both morbidity and mortality), but numerous other conditions may be involved too, including acute respiratory infections (ARIs), undernutrition, and stunting including that caused by environmental

Richard C. Carter (richard@richard-carter.org) is a researcher, educator and consultant at Richard Carter & Associates, UK (www.richard-carter.org).

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enteropathy, a range of insect-borne diseases, and so-called neglected tropical diseases (NTDs) including intestinal worm infections, trachoma, schistosomiasis, and Guinea worm disease.

It is clear that a key justification for undertaking sanitation and hygiene improvements is to improve health, and that justification is the focus of this paper. However, other (non-health) impacts are important too, including comfort, convenience, security, and social status. These are not considered further here. It has been argued elsewhere (Carter, 2013; Schmidt, 2014) that an undue focus on the health impacts of WASH programmes may be a distraction from the necessity of getting sanitation and water services to all, a necessity which was recognized as a human right at the UN General Assembly in December 2015. Nevertheless, we turn our attention to sanitation, hygiene, and their health impacts.

In the design of sanitation and hygiene programmes, the general question arises as to how best to undertake such work in order to realise the greatest likelihood of achieving the desired health impacts. Two particular questions arise, and these are the focus of the rest of this paper:

- Is there some threshold level of sanitation access and use below which health impacts are likely to be limited?
- If sanitation and hygiene programmes are undertaken in situations where access to water supply is very poor, is it reasonable to expect health benefits?

Threshold level of sanitation access and use

Sanitation and hygiene can usefully be seen as public goods. My use of safe sanitation and my practice of good hygiene may be more relevant to your health than your own practices. As a mother, if I feed my child with a hand which is contaminated with faeces, I am likely to infect the child. As a child, if I defecate in the open, I am exposing you (another child or adult) to faecal pathogens. Consequently the idea that most or all members of a community need to have access to sanitation, to use it, and to practise good hygiene as a prerequisite for achieving health impacts is at least logical. However, is there evidence for this so-called herd protection?

Sanitation and hygiene programmes with poor access to water supply

Programmes focusing only on sanitation and hygiene (without a water supply component) are often undertaken. It is assumed that the sanitation component will safely contain faeces or remove them from human contact, while hygiene promotion will lead to improved hygiene practices, especially handwashing. However since water is needed for maintaining latrine or toilet cleanliness (especially in the case of pour-flush toilets, but also to keep latrine slabs clean), and since water is required for personal hygiene (especially washing hands and faces) and household hygiene, it appears reasonable to think that integrated water, sanitation, and hygiene programmes are likely to have greater impacts on diarrhoeal disease than those which focus only on sanitation and hygiene. The question arises, however, is there evidence for this supposition?

The presence and absence of evidence

Before going on, an important matter concerning evidence needs to be considered. In some aspects of this subject, evidence exists. For example there are now a few randomized controlled trials (RCTs) which have investigated the health impacts of improved sanitation. These provide evidence that intervention X in context Y led to health impact Z. However, in at least two cases (Clasen et al., 2014; Pickering et al., 2015) the observed effects on diarrhoeal disease were negligible. The conclusion that the particular sanitation programme under study led to no reduction of diarrhoeal disease is correct; the extrapolation of the evidence to conclude that improved sanitation cannot lead to such impacts would not be. It is worth noting that both trials just referred to studied rural sanitation interventions where one would expect smaller effects than in high density urban environments (Schmidt, 2015); also neither intervention achieved the high levels of sanitation use that we argue later in this paper are necessary for significant impacts on health.

Furthermore, care needs to be taken in assuming that the absence of evidence amounts to evidence of absence of effect. An absence of evidence may arise either because a specific question has not been adequately researched, or because the effect sought is particularly difficult to demonstrate. Moreland and Craig (2003) illustrate the latter by the following example:

If someone were to assert that there is an elephant on the quad [quadrangle], then the failure to observe an elephant there would be good reason to think that there is no elephant there. But if someone were to assert that there is a flea on the quad, then one's failure to observe it there would not constitute good evidence that there is no flea on the quad.

Sometimes the absence of formal research evidence needs to be addressed in other ways, using logic, common sense, professional judgements, and intuition. After all, these are the tools for formulating the hypotheses which often drive research.

Is there evidence of herd protection provided by sanitation and hygiene?

Cairncross et al. (1996) provided some of the conceptual basis for answering this question, in their distinction between the public and domestic domains in the transmission of disease:

an intervention aimed only at the domestic domain, such as the provision of household latrines to control hookworm, is unlikely to have any impact on transmission in the public domain such as that caused by open defecation in the fields. On the other hand, an intervention to prevent public domain transmission of diarrhoeal diseases such as the disinfection of public water supplies will not prevent domestic transmission, for example in contaminated weaning foods.

Widespread practice of open defecation and poor hand hygiene are likely to be at least as important in the public domain as in the 'private' domain of the household compound.

Scott (2006) made the following statement:

The most important determinants of the health benefits of latrines/toilets are whether they are a) used consistently by *everyone* [my emphasis] and b) adequately cleaned and maintained. A combination of these two factors will ensure that faeces are kept out of the environment and further human contact.

The key word in this context is 'everyone'. A high level of compliance (use) is considered essential for health impacts. The reality however is that men, menstruating girls and women, and infants often do not use safe latrines/toilets. High levels of compliance are hard to achieve in the short term. Such changes involve cultural shifts which, in the absence of sudden shocks, may only happen gradually.

Prüss-Ustün et al. (2008) say this:

Sanitation reduces or prevents human faecal pollution of the environment, thereby reducing or eliminating transmission of diseases from that source (although other sources, such as animal excreta, may remain important). Effective sanitation isolates excreta and/or inactivates the pathogens within faeces. High-tech solutions are not necessarily the best: some simple latrines can be very effective, while untreated sewage distributes pathogens in the environment and can be the source of disease. Interventions that work in rural areas may be very different from those in urban areas. *There has been increasing recent interest in 'total sanitation' – i.e. achieving a level of overall sanitation in a community that will significantly reduce disease* [my emphasis].

The final sentence is the key here. It is also worth noting that concentrated fixed point defecation (e.g. in school latrines) may constitute an increased rather than reduced health risk if insufficient attention is given to anal cleansing and hand washing.

Clasen et al. (2014) believe that inadequate extent of latrine usage may fail to clean up the environment to the level necessary to see an impact on child health. The recent Orissa (Odisha) RCT of sanitation in India (Clasen et al., 2014) showed negligible impact on a range of environmental and health indicators of an intervention which raised mean coverage from 8 per cent to 63 per cent, and with low and erratic levels of actual usage. The authors gave this opinion:

Insufficient coverage and use of latrines seem to be the most likely causes for the absence of effect, because no evidence showed that the intervention reduced faecal exposure. Although mean coverage of latrines increased substantially in the intervention villages, more than a third of village households (on average) remained without a latrine after the intervention.

In other words the sanitation programme which was studied failed both to safely contain excreta and to bring about high levels of improved sanitation use.

Vyas et al. (2013) present evidence from rural and urban populations in Cambodia supporting the contention that sanitation is a public good and not merely of private benefit:

Open defecation affects everyone who is exposed to it in the community, and not just those households who practice open defecation themselves ... Cambodia's

sanitation policies would best prioritize collective community-wide behaviour change interventions to stop open defecation and create demand for sanitation.

Andrés et al. (2014) examined household survey data in rural India, finding a large (47 per cent) reduction in diarrhoea prevalence between children without sanitation access in villages with low coverage, compared with children with sanitation in villages with complete coverage. The key finding however was that only a quarter of this effect was due to the child's access to his or her own sanitation facilities, while three-quarters came from the high sanitation level in the village.

Duflo et al. (2015) undertook a study of health impact in the Rural Health and Environment Programme (RHEP) in India which provided universal access within a village to hygienic latrines and in-home piped water at the same time, at a reasonable cost. The authors estimated a reduction in episodes of severe diarrhoea of 30–50 per cent, compared with a null effect on diarrhoea shown in two RCTs on sanitation (Pickering et al.'s 2015 study has followed, and shown the same finding in relation to sanitation-only). The authors comment as follows:

These positive and large results differ from the null findings of two recent cluster-randomized trials evaluating sanitation-only interventions in rural India, one in Orissa (Clasen et al., 2014) and the other in Madhya Pradesh (Patil et al., 2014). We do not view our results as contradictory, for two reasons. First, RHEP is a package of a communal water tank, piped water to the home, and household latrines and bathing facilities. This evaluation therefore does not provide information on the effectiveness of the individual components, but the contrast with the RCT results suggests that this 'full package' is important. Second, latrine use was relatively low in the two RCTs, which likely limited their health impact (Brown and Clasen, 2012). We speculate that providing a tap for piped water at the toilet reduced barriers to maintenance and hygienic use, but further research is needed to understand the factors that motivate or impede use of sanitation facilities (Coffey et al., *sic* 2014; Gertler et al., 2015).

There are reasons to suggest that Duflo et al.'s conclusions may not be free of bias, given that (a) the study was not randomized, and (b) it found a large reduction in malaria/fever, an effect which presumably was unconnected to improvements in water and sanitation.

Pickering et al. (2015) say this in regard to their study in Mali:

Although sanitation access in CLTS villages increased by 30 percentage points, universal coverage was not achieved; *it is possible that sanitation coverage must be above a certain threshold to adequately prevent transmission of diarrhoeal pathogens within rural communities, however there is inadequate evidence from previous research to support this hypothesis* [my emphasis].

Pickering et al.'s study showed no change in self-reported diarrhoea prevalence at a level of coverage of sanitation of 65 per cent (from 33 per cent at baseline). It did however see a beneficial effect on stunting.

Fuller and Eisenberg (2016) constructed a transmission model which included the possibility of herd protection. They remarked that:

Our model simulations and literature review suggest that the indirect effects from a sanitation intervention are a larger component of the total effect compared with those from a drinking water or hand hygiene intervention. If sanitation can reduce the rate of shedding pathogens into the community environment, all surrounding households will benefit regardless of their own sanitation practices. In our model, sanitation provides no direct benefit to the household.

The authors do however comment as follows:

Immunization policy is often based on reaching a threshold of vaccination coverage, often less than 100 per cent, at which transmission will be interrupted and the disease eliminated. It is unclear, however, whether such a threshold exists for WASH interventions. Interventions for the control of infectious diseases can provide indirect protection to nonusers. Although the mechanism behind herd protection varies by pathogen and transmission cycle, the goal of providing sufficient coverage to interrupt transmission transcends these differences.

In another paper Fuller et al. (2016) conclude that:

Our study highlights that a household's sanitation practices can provide herd protection to the overall community. Studies which fail to account for the positive externalities that sanitation provides will underestimate the overall protective effect. Future studies could seek to identify a threshold of sanitation coverage, similar to a herd immunity threshold, to provide coverage and compliance targets.

While this article was in review, a new paper (Hunter and Prüss-Ustün, 2016) added to the evidence on this question. The authors present a modelling study of the impacts of sanitation on health, a key conclusion being that mortality in under-5s reduces as sanitation coverage increases to 20 per cent, but there is then little change until coverage reaches about 70 per cent. Total- or near-total sanitation is necessary to see significant reductions in child mortality.

Overall the literature would appear to lead to the following conclusions:

1. There is a general and well-founded belief among professionals that it is necessary to achieve 'total sanitation' or compliance as close as possible to totality in order to achieve a clean environment and significant health impact.
2. Levels of access to safe sanitation in the region of 60–65 per cent (with usage probably less than this, especially in parts of South Asia including India) are probably not sufficient to see significant impacts on diarrhoeal disease.
3. The existence of a threshold for interruption of diarrhoeal disease transmission is thought possible – herd protection is real – but there has been insufficient research to date to quantify this level.

4. In the absence of such research evidence it is reasonable to assume that a very high level of sanitation usage (compliance) is needed – significantly greater than 65 per cent.

Doing sanitation interventions in communities with poor water services

Cairncross et al. (2003) draw this conclusion:

This [the potential of hand washing to reduce diarrhoea incidence by over 40 per cent] does not mean that only hygiene promotion is more cost-effective than water and sanitation, though it is cheaper. It is almost impossible to practise good hygiene without a ready supply of available water, and excreta disposal is hardly hygienic without sanitation. Water and sanitation are prerequisites for good hygiene.

This would appear to present a strong argument, on health grounds, for ensuring that people enjoy both water *and* sanitation services *and* practise good hygiene.

In 2004 Cairncross and Valdmanis concluded that ‘... the simplest plausible assumption is that the impacts of water supply, sanitation and hygiene promotion on diarrhea are independent and additive to one another’.

Regarding the additive effects of water, sanitation, and hygiene, Scott (2006) comments as follows:

While both Esrey et al. (1991) and Fewtrell et al. (2005) found that the effects of water supply, sanitation and hygiene promotion interventions on diarrhoea were not additive, logic and understanding of the F-Diagram and the major transmission routes for faecal–oral diseases would suggest that each should have an independent effect on the transmission and prevalence of this disease classification, including diarrhoeal infections. Reasons for Esrey et al. and Fewtrell et al. failing to find an additive effect of multiple interventions may relate to programme implementation and the difficulties involved in attempting to implement multiple project components at the same time. Indeed, experience suggests that single focused messages are most likely to yield a desired impact on behaviour and that a household’s motivations for investing in water supply or sanitation facilities tend to be very different. Thus, at the current time, despite a lack of evidence, it is suggested that programmers work on the assumption that the effects of water and sanitation interventions are independent, while hygiene promotion be viewed as a necessary component of either to ensure correct, consistent and sustained use and maintenance.

Schmidt and Cairncross (2009) argue that the evidence suggesting no added benefit of combined (water, sanitation, hygiene) interventions is based on studies which are characterized by high levels of respondent, observer, and publication bias (for an accessible summary of more than 30 types of bias in research see Indrayan, nd). Such bias, if true, could tend to conceal the additive effect of different types of interventions.

Brown et al. (2013) comment that

Recent research [citing Hunter et al. 2009] has shown, however, that even such improved water supplies may be subject to faecal contamination (ibid.) and that even occasional exposure to unsafe water – for example, from intermittent service or inadequate treatment – can undermine health benefits.

The reference here is to breakdowns in water services. However the same argument applies to consumption of contaminated drinking water even where sanitation access and usage are high.

The more recent systematic reviews of health impact from various aspects of WASH have all failed to show an additive or cumulative effect of water, sanitation, and hygiene. Doing an integrated WASH programme would appear to have no greater impact than doing only sanitation or only water supply. To explain this, the following view is expressed in DFID's 2013 Evidence Paper:

... a number of authors have commented that the health impact of combined interventions such as sanitation plus water supply is no greater than the impact of a single intervention. This apparent anomaly becomes clear when it is understood that the comparison is not between studies of combined interventions and studies of single interventions, but between studies of combined interventions and other studies of combined interventions (DFID, 2013: 45).

In other words we may not be able to distinguish clearly between the individual contributions of water, sanitation, and hygiene because all interventions considered in the few studies which contribute to the systematic reviews included some elements of each. Other views in the literature make the obvious point that hygiene and sanitation cannot be practised effectively if water supply is limiting. If it is true that the rigorous studies which are included in systematic reviews are largely examining integrated WASH programmes (not programmes doing these components in isolation), then those programmes which address only sanitation and hygiene would be expected to have less health impact than ideal (integrated) programmes.

Duflo et al. (2015) express the view that 'the full package' of water and sanitation is needed for health impact.

Fuller et al. (2015) undertook an analysis of demographic and health survey (DHS) data from 74 countries, concluding as follows:

The impact of water and sanitation varied across surveys, and adjusting for socio-economic status drove these estimates towards the null. Sanitation had a greater effect than water infrastructure when all 217 surveys were pooled; however, the impact of sanitation diminished over time. Based on survey data from the past 10 years, we saw no evidence for benefits in improving drinking water or sanitation alone, but we estimated a 6 per cent reduction of both combined (prevalence ratio = 0.94, 95 per cent confidence limit 0.91–0.98).

Overall the literature would appear to lead to the following conclusions:

1. An adequate supply of water is needed, not only for direct use and consumption, but also for maintaining adequate hygiene and cleanliness of sanitary facilities.
2. Logically, and by reference to the well-established routes of transmission of faecal–oral pathogens, the effects of improvements in water, sanitation, and hygiene would be expected to be mutually reinforcing (although not necessarily in a simple additive fashion).
3. However the posited reasons for RCTs and other research studies failing to demonstrate this additive effect are speculative, unclear, and unconvincing. More investigation and analysis is needed to answer this point.
4. In order to reduce diarrhoeal disease, improvements to water services should accompany sanitation and hygiene interventions, at least where water services are inadequate to support greater use in household and personal hygiene.
5. In undertaking WASH programmes it is reasonable to assume that sanitation and hygiene interventions will bring about only limited health impacts if access to adequate quantities of water is absent. Integrated WASH programming is needed.

Conclusions

In order to have significant health impacts, sanitation and hygiene programmes need to achieve very high levels of usage or compliance at community level. They also need to address water access problems where these are critical. Unless high levels of usage are achieved, and unless water is available in sufficient quantities for both personal hygiene and keeping latrines or toilets clean, then significant health benefits should not be expected. This is not to say that sanitation and hygiene programmes which cannot achieve these goals are not worthwhile. The numerous reasons other than health benefits for which such programmes are undertaken are justification enough. To quote Schmidt (2014), ‘Even if there was no health impact, the educational, developmental and gender-related benefits of water and sanitation access are large enough to merit investment’.

A systematic review of the impact of sanitation programmes on indicators of faecal exposure (Sclar et al., 2016) has recently found very little evidence that such programmes are effectively interfering with the faecal–oral transmission pathways of disease which are summarized in the well-known ‘F’-diagram (Wagner and Lanoix, 1958). In view of this and the continuing gap between access to improved sanitation and its consistent and correct use, future research and practice should focus more on putting in place the prerequisites for health impacts (latrine or toilet use, handwashing, and elimination of open defecation) than attempting to measure those impacts. In short, a far higher priority should be placed on figuring out how to do sanitation programmes better. Perhaps a

good starting point for such research would be in-depth analysis of those few programmes which are: (a) achieving very high levels of latrine and toilet use; and (b) removing faecal pathogens from the household and public domain – following a ‘positive deviance’ (Green, 2016) approach which many are increasingly talking about.

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