

THE IMPACT OF WATER, SANITATION AND HYGIENE ON KEY HEALTH AND SOCIAL OUTCOMES: REVIEW OF EVIDENCE

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Photo on front cover:
Women from Podumkhana village collect water from a pump designed by UNICEF
(India, 2009) | © UNICEF/UNI79307/Pietrasik

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Acronyms

CRPD	Convention on the Rights of Persons with Disabilities
DALYs	Disability-adjusted life years
DFID	UK Department for International Development
DHS	Demographic and Health Survey
EED	Environmental Enteric Dysfunction
ETEC	Enterotoxigenic Escherichia coli
GBV	Gender-based violence
HP	Hygiene promotion
HWWS	Handwashing with soap
IASC	Inter-Agency Standing Committee
MDA	Mass drug administration
MDGs	Millennium Development Goals
MHM	Menstrual hygiene management
MHPSS	Mental health and psychosocial support
MM	Maternal mortality
NTDs	Neglected tropical diseases
POU	Point-of-use
PPSSP	Programme de Promotion des Soins de Santé Primaires
RCT	Randomized controlled trial
RV	Rotavirus vaccine
SDGs	Sustainable Development Goals
STH	Soil-transmitted helminth
UNICEF	United Nations Children's Fund
VAWG	Violence against women and girls
WASH	Water, sanitation and hygiene
WHO	World Health Organization
WinS	WASH in schools
WT	Water treatment

Executive summary

This evidence paper looks at 10 areas identified collaboratively with the United Nations Children's Fund (UNICEF) on which WASH can plausibly have a strong impact: diarrhoea, nutrition, complementary food hygiene, female psychosocial stress, violence, maternal and newborn health, menstrual hygiene management, school attendance, oral vaccine performance, and neglected tropical diseases. Together, these areas cover the most significant sector outcomes associated with the distinct life course phases¹ that UNICEF seeks to help to address through its WASH activities. UNICEF's strategic vision on WASH is to achieve universal and sustainable water and sanitation services and the promotion of hygiene, with a focus on reducing inequalities especially for the most vulnerable children, wherever they are; both in times of stability and crisis.

The paper highlights a number of points where evidence-based consensus has been established, or is emerging in these areas, and these are summarized here:

1. Despite discussion in recent years around the best approach for estimating the proportion of the diarrhoeal disease burden attributable to poor WASH, there is strong consensus that the majority of this disease burden is due to poor WASH;
2. WASH plausibly influences child growth in multiple ways. While the magnitude of effect for WASH interventions on undernutrition is less clear, there is a strong and growing consensus, in both the WASH and nutrition sectors, that WASH is an essential component of strategies to reduce undernutrition, and that efforts should be concentrated on the first 1000 days—from conception to a child's second birthday;
3. Inadequate food hygiene practices can lead to high levels of microbial contamination of food, and interventions focusing on critical control points may reduce this contamination. While we need to better understand how to change behaviour sustainably through such interventions, and to assess their impacts on child health, there is growing consensus on the importance of integrating food hygiene components into both WASH and nutrition programmes;

¹ Adolescence; Pregnancy; Delivery and 0.7 days newborn; Post-natal to one year; Childhood (1-5 years); School age children.

4. Although the evidence base remains largely qualitative in nature, it is increasingly accepted that inadequate access to WASH can expose vulnerable groups—particularly women and girls—directly to violence. This may cause psychosocial stress due to the perceived threat of such violence, adding to other causes of psychosocial stress such as the perceived threat of harassment, or the threat of being unable to meet basic needs;
5. WASH plausibly affects maternal and newborn health through multiple direct and indirect mechanisms, and WASH coverage in delivery settings in low and middle-income countries is extremely low. There is a consensus that safe WASH in health facilities—and in other delivery settings—is critical for accelerated progress on maternal and newborn health;
6. Further rigorous research is needed on the impact of poor MHM on social and health outcomes, but the challenges and barriers associated with MHM among schoolgirls and women are well documented through qualitative studies. Few would contest that a girl or woman without access to water, soap, and a toilet, whether at home, school, or work, will face great difficulties in managing her menstrual hygiene effectively and with dignity. Furthermore, there is consensus on what is required to enable safe, dignified management of menstrual hygiene: knowledge, materials and facilities;
7. In many countries, it has been reported that poor WASH facilities act as a barrier to student attendance and enrolment. This affects girls in particular, but especially girls post-menarche, when their MHM needs may not be addressed. Until recently, there was little robust evidence to support this but there has now been a least one rigorous intervention study supporting the positive effect of improved WASH on school attendance—for both boys and girls—when services are well designed and managed. In addition, there is a growing body of evidence around successful approaches to increasing access to WASH in schools;
8. While the evidence for the impact of WASH on oral vaccine performance is only suggestive and further research is needed to demonstrate its effect, there is a recognition that routine immunization campaigns may be a useful entry point for promoting safe hygiene among caregivers;

9. While investments to address NTDs remain largely focused on treatment measures such as mass drug administration (MDA) campaigns, there is strong consensus, supported by good evidence, that WASH plays an important role in preventing the transmission of these diseases;
10. The distribution of WASH-related mortality and morbidity is inequitable, and falls disproportionately on the poor, on women and on children. There is a clear consensus that for WASH policy and programmes to be effective, they must address this inequality.

For each area, the most recent updates in knowledge are presented, as well as persisting knowledge gaps and ongoing studies where relevant, and the evidence is assessed and rated according to an established methodology (articulated in sections 1.2 and 1.3). In essence, the evidence reviewed in this paper has been graded as ‘good’, ‘suggestive’, or ‘weak’, as per the criteria below:

- **Good evidence:** several good quality studies showing a consistent effect. For example, randomized trials with a low risk of bias, or observational studies showing a large effect size with a low potential for confounding;
- **Suggestive evidence:** some studies show an effect, but the statistical support is weak due to insufficient study size. Or studies show significant effects, but there is a risk of bias and confounding due to study design;
- **Weak evidence:** no studies have been done, or where they have been done, they have shown inconclusive results.

While the structure and content of this evidence paper has been tailored to support the development of the new UNICEF’s Strategy for WASH 2016-2030 - by providing a concise overview of the present evidence base on the influence of WASH on number of key health and social outcomes, it has broader relevance to the WASH sector as a whole, and, in some cases, to other sectors.

Introduction

Aims

This paper was commissioned by UNICEF and undertaken by the DFID-funded Sanitation and Hygiene Applied Research for Equity (SHARE) research programme consortium.

This evidence paper aims to provide evidence for specific elements of UNICEF's forthcoming WASH Strategy, 2016-2030. In particular, it seeks to present the evidence on the importance of WASH to other outcomes beyond child diarrhoea.

A key rationale for investing in WASH is the importance of WASH to other Sustainable Development Goal (SDG) outcomes. The essential inputs that the WASH sector provides, in the form of services and hygiene promotion, have multiple impacts beyond the WASH outcome itself, such as nutritional status, or education. Furthermore, these far-reaching effects of WASH can be felt beyond the immediate impact, can have a cumulative effect throughout the life course of an individual, and can often also affect the lives of their offspring (Ben-Shlomo & Kuh, 2002; Campbell et al., 2014).

This paper describes the contribution of WASH to outcomes in other sectors and summarises the evidence for investment in these areas. The paper considers the following outcomes to which UNICEF is committed: diarrhoea, nutrition, complementary food hygiene, violence and female psychosocial stress, maternal and newborn health, MHM, school attendance, oral vaccine performance, NTDs, and disability.

With this in mind, the objectives of this evidence paper are specifically to:

- Review the best available evidence with regard to strategic priorities of UNICEF;
- Provide an accessible guide to existing evidence on how WASH can affect women and child health and well-being and other development outcomes, with a particular focus on outcomes that include but go beyond those traditionally measured by the WASH sector (see below for topics);
- Present the available evidence on the benefits of WASH interventions on health;
- Identify what we do and do not know, and assess the robustness of the available evidence relating to the impact of WASH and the effect of WASH interventions on these outcomes.

This evidence paper does not make specific recommendations on what UNICEF should or should not do, but instead identifies key points for consideration in defining and implementing UNICEF's Strategy for WASH 2016-2030 in the following areas:

1. Assessing the scale of the problem
 2. Evidence of impact
 3. Evidence of what works
 4. Remaining knowledge gaps
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To achieve this, each thematic chapter addressing a different outcome will cover:

1. **The problem:** The extent to which this issue affects child health and well-being;
 2. **Can WASH have an impact?:** An assessment of the plausible impact of WASH;
 3. **The effect of WASH interventions:** A review of the evidence specifically for the effects of WASH interventions.
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Liberia, 2007. A girl carries a large pail of water, outside her school in the village of Selega in the north-central Lofa County.

Interpreting the evidence on WASH

WASH brings together several interventions, which are frequently implemented by multiple agencies, often delivered separately but sometimes together. These interventions affect a wide range of direct outcomes, beyond just health outcomes. As a result, the evidence is complex and, therefore, difficult to classify.

Nonetheless, expectations on the quality of evidence needed to justify interventions have increased in recent years, and consensus has formed around rules of best practice for analysis, weighing and combination of such evidence.

In many policy-making domains, the systematic review and the Randomized Controlled Trial (RCT) have emerged as the gold standard for quality of evidence as they are judged to reduce systematic error - or bias - to the greatest extent possible (Jüni et al., 2001). However, aside from RCTs and their meta-analysis, there are a wide range of observational study designs, including ecological, cohort, cross-sectional and case-control studies, some of which do not have a specified intervention and/or control. Increasingly in the WASH sector, various econometric methods are also being employed to interrogate cross-sectional and longitudinal data to address important questions (Spears, 2012).

Beyond this, there are of course a wide range of qualitative approaches which can be employed in isolation or in combination with quantitative methods, and which are essential to many areas of research, in particular those which are highly sensitive. For example, eliciting information from people about violence - possibly of a sexual nature - experienced while tending to their urinary, defecation or MHM needs, can be a difficult process, provoking feelings of shame or inadequacy. Beyond these methods and approaches, a very broad range of research disciplines is actively engaged in WASH research; epidemiologists, economists, microbiologists, geographers, anthropologists, statisticians, and engineers, to name but a few. As a result of this, the WASH literature may be unwieldy, but it is rich and voluminous, reflecting the broad challenge of delivering interventions which require both changes in infrastructure and in behaviour, and which influence people's lives in many different ways.

Assessing the quality of such a body of evidence is difficult to do objectively. The GRADE approach uses algorithms for weighing and combining evidence from these different levels (Guyatt et al., 2008) to reduce the partiality of human judgement in an objective manner. However, careful consideration is required to interpret the

outcome of GRADE when navigating questions with high biological plausibility, but where very few intervention studies have been conducted. Four specific challenges relating to the WASH literature should be highlighted:

- 1. Subjective outcomes:** There are ethical and logical arguments against studies using the principal health outcome of interest: death from diarrhoea. However, the alternative outcomes, particularly self-reported diarrhoea morbidity, have proven to be more subjective and subject to bias than was originally believed. For example, the 2007 systematic review on point-of-use (POU) water treatment by Clasen and colleagues drew the conclusion from nearly 40 rigorous RCTs that drinking water quality improvements were associated with reductions of nearly 50% in diarrhoea rates. However, when the handful of blinded studies were isolated they showed no impact on diarrhoea - suggesting that the overall impact may have resulted from a placebo effect or courtesy bias (Schmidt & Cairncross, 2009). This weakness in the evidence base is relevant to any behaviour change intervention for which, by its very nature, allocation cannot usually be blinded.
- 2. Logistical challenges of randomization:** There are political, ethical and practical complications associated with randomising an intervention like water supply and sanitation, or even allocating it by individual household. This is because of the much appreciated non-health benefits of WASH—for example, time saved on water collection (Churchill et al., 1987)—and the impossibility of providing water and sanitation without the knowledge of the studied population.
- 3. Complex exposure-outcome relationship:** In addition to the three basic dimensions of WASH, there are various levels of service and a variety of combinations of the three. For example, practically every intervention study of sanitation is in fact a study of water and sanitation.
- 4. Importance of context:** A standpipe isolated in the desert is a different level of service from a standpipe in a village where half the households already have household connections. Quite apart from the variation in technology between different settings, there are often important differences in programme design and execution; hygiene promotion implemented effectively in one setting may have been much less effective in another. An epidemiological study in this sector is thus meaningless unless it is seen in the context of the setting in which it was carried out.

There is clearly a tension that exists between achieving internal and external validity that should be taken into account when designing studies. If a study is to provide high-quality evidence of health impact, it must be designed to exacting standards of rigour, eliminating the potential for confounding and for bias due to extraneous factors. However, often the more ‘rigorous’ the study the more it achieves internal validity, potentially at the cost of becoming less relevant to the wider context and existing programmes and policy issues.

Box 1: Bradford Hill’s ‘viewpoints’ for assessing causality

1. **Consistency** - in a systematic review the impact was similar for the more rigorous studies (Curtis & Cairncross, 2003);
2. **Strength of association** - in a study focused on domestic transmission of a single pathogen, handwashing prevented 85% of secondary cases (Khan, 1982);
3. **Temporal sequence** - handwashing by mothers just before preparing the family’s food has a greater impact than at other times (Luby et al., 2011);
4. **Dose response** - one study found the impact of a sewer system construction project on diarrhoea in a neighbourhood increased with the proportion of households connected to the sewers (Barreto et al., 2007);
5. **Specificity** - for example, water treatment affects diarrhoea, but not malaria;
6. **Coherence** - (i.e. laboratory and epidemiology results cohere) - more faecal bacteria in drinking water is associated with more frequent diarrhoea (Moe et al., 1991);
7. **Biological plausibility** - given the number of faecal pathogens present in a community’s waste, it is not surprising that excreta disposal helps to prevent excreta-related disease (Feachem et al., 1983);
8. **Analogy** - in particular, sanitation helps to prevent intestinal worm infections; it can therefore be expected to prevent transmission of other faecal pathogens, such as those causing diarrhoea;
9. **Experimental evidence** - this refers to intervention studies, ideally randomized trials, many of which have been carried out for household water treatment.

Review methods

This evidence paper is not a systematic review. Our methods have been heuristic, based on existing systematic reviews where possible and exploratory reviews on a range of topics, and supplemented with more recent studies. Wherever possible, we rely on published systematic review-based meta-analyses to estimate the magnitude of effect for a given WASH intervention on a given outcome.

This paper takes a broad perspective, allowing for a range of exposures and outcomes, a variety of settings in which studies have been carried out and the application of judgement based on an assessment of the available evidence. In assessing causal evidence, our approach

was generally informed by the criteria or ‘viewpoints’ famously proposed by Bradford Hill (1965). Box 1 broadly illustrates these, with reference to WASH. For the purpose of this evidence paper, we have used a pragmatic set of five applied viewpoints from which to appraise the evidence base for WASH interventions. That is, whereas Bradford Hill’s viewpoints are for assessing the evidence for causality in an association, the following viewpoints are used in this paper to appraise the strength of support for implementation of each intervention. The first viewpoint is internal validity, which assesses the rigour of the studies demonstrating cause and effect, including randomization, blinding, etc. The second assesses the ease of going to scale, which requires relevance to programme conditions in the field. The third looks at the sustainability of the intervention, assuming reasonable effort is devoted to maintaining it. The fourth and fifth evaluate other substantial health benefits in addition to impact on diarrhoea and significant non-health benefits respectively.

For this evidence paper, we have been asked to show which relationships are supported by firm evidence and which by relatively weak evidence. Throughout this paper, we consider the type of evidence but also seek to grade the strength of the evidence according to the following three categories:

- **Good evidence:** several good quality studies consistently show an effect. For example, randomized trials with a low risk of bias, or observational studies showing a large effect size with a low potential for confounding;
- **Suggestive evidence:** studies show an effect, but statistical support is weak due to insufficient study size. Or studies show significant effects, but there is a risk of bias and confounding;
- **Weak evidence:** no studies have been done, or where they have been done, they have shown inconclusive results.

WASH and diarrhoea

The problem

Diarrhoea is defined as the passage of three or more loose or liquid stools per day (World Health Organization [WHO], 2013). But globally, diarrhoeal diseases are caused by infectious agents such as bacteria (e.g. *E. coli*, salmonella, shigella, campylobacter), viruses (e.g. rotaviruses, noroviruses and adenoviruses), and protozoa (e.g. cryptosporidium, amoeba and giardia). However, the aetiology of diarrhoeal diseases varies from region to region. Rotavirus is the main cause of severe and moderate diarrhoea (Lozano et al., 2013; Kotloff et al., 2014). Only a small proportion of diarrhoea cases result from non-infectious conditions (such as intoxication or non-infectious inflammatory diseases) (WHO).

Most diarrhoeal deaths are among children under the age of five (Prüss-Üstün et al., 2014), and within low-income countries, the very poor suffer much more from diarrhoea than others (Howling & Kunst, 2010). In both low and middle-income countries, diarrhoeal disease is the second leading cause of morbidity and mortality among children under the age of five (Lim et al., 2012; Walker et al., 2013; Murray et al., 2015), and the leading cause of death in sub-Saharan Africa (Prüss-Üstün et al., 2014). Approximately 1.5 million children under the age of five died of diarrhoeal disease in 2012 (Prüss-Üstün et al., 2014).

Diarrhoeal disease can also affect a child's nutritional status, with the associated health and socio-economic consequences (discussed in the following section). One multiple country study found that 25% of stunting in children under the age of two could be due to five or more diarrhoeal episodes (Checkley et al., 2008). Long-term exposure to faecal pathogens may also partially explain environmental enteric dysfunction (EDD) (Humphrey, 2009).

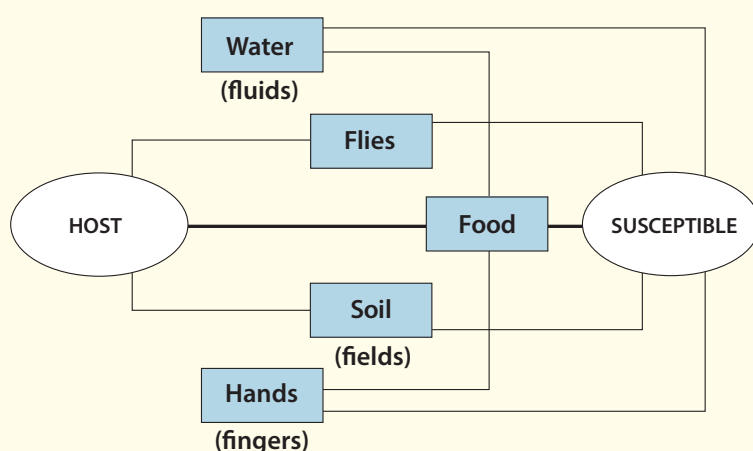
While most diarrhoeal diseases associated with poor WASH tend to be endemic, some are epidemic in nature - notably, cholera and typhoid fever. Cholera is an acute diarrhoeal disease that can kill within hours if left untreated, and it is a continual public health problem in many parts of the world. Researchers have estimated that every year there are roughly 1.4 million to 4.3 million cases, and 28,000 to 142,000 deaths per year worldwide (Ali et al., 2012). The majority of reported cholera cases and deaths occur in Africa (Gaffga et al., 2007). Furthermore, the continent suffers from explosive outbreaks that result in high levels of both morbidity and mortality.

How does WASH influence diarrhoeal diseases? Recent updates in knowledge

1. Can WASH affect diarrhoeal disease?

Diarrhoeal diseases are characteristically transmitted via the faecal-oral route. Poor WASH increases an individual's exposure to faecal pathogens through multiple pathways, as demonstrated in the 'F-diagram' below.

Figure 1: The 'F-diagram'



SOURCE: Cumming & Cairncross (2016); adapted from Wagner & Lanoix (1958) and Kawata (1978)

It has been estimated that in 2012 a total of 842,000 diarrhoea deaths were caused by inadequate WASH (502,000 from water, 280,000 from sanitation and 297,000 from hand hygiene). This represents over half of diarrhoeal diseases, or an estimated 1.5% of the total disease burden (Prüss-Üstün et al., 2014). Given what we know about disease transmission routes and possible barriers to these, the most recent estimate suggests that adequate WASH could prevent the deaths of 361,000 children under the age of five, or 5.5% of deaths in that age group (Prüss-Üstün et al., 2014). A different estimate, which includes WASH in addition to other interventions such as oral rehydration treatment and exclusive breastfeeding, suggests that 95% of diarrhoeal deaths in children under the age of five could be prevented by 2025, as a result of targeted scale-up of such proven interventions (Bhutta et al., 2013).

As diarrhoeagenic pathogens spread by many different interacting pathways, the different components of WASH interventions need to be well coordinated to be effective—although evidence is lacking on how best to combine different approaches. There is little doubt, however, that improving access to adequate amounts of water from an adequately distanced source, hygienic sanitation facilities and promotion of handwashing with soap should be the cornerstones of integrated WASH campaigns (Cairncross et al., 2010).

Sanitation and hygiene promotion are still the two most effective interventions for controlling endemic diarrhoea (Laxminarayan et al., 2006). An additional potentially critical intervention would be to improve food hygiene, which may prevent many diarrhoea deaths, especially in hot climates where food hygiene is difficult to maintain (Curtis et al., 2011). For more information read this paper's section on Complementary Food Hygiene.



Niger, 2009. A child near traditional clay water containers in his family's courtyard in the village of Fourra Guirké, in the southern Maradi Region.

With regard to cholera, although it is largely perceived to be a waterborne disease, person-to-person transmission, limited access to sanitation, an inadequate water supply and poor hygienic practices may contribute to the rapid progression of an epidemic. The WHO promotes safe drinking water, sanitation, personal hygiene, health education and food safety as specific control measures. However, this approach is not always implemented or indeed feasible in low-income settings, particularly in the context of an outbreak.

2. The effect of WASH interventions on diarrhoeal disease

The effect of interest here is the reduction in diarrhoeal disease as a result of improvements in WASH.

It is not necessarily helpful to separate out the three WASH interventions, as they act upon interlinked transmission pathways, and often cannot be provided in isolation from each other. Appropriate sanitation and hygiene behaviours both require adequate water supply. However, the literature on each intervention contains important lessons. Therefore, this section discusses water, sanitation and hygiene interventions individually.

Water: The global, Millennium Development Goal (MDG) era definition for an ‘improved’ drinking-water source is one that, by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly faecal matter (WHO/UNICEF, 2015). Improved sources include piped water to the plot or household, public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, or rainwater. However, these provide varying degrees of safety, according to their differentiated ability to protect from outside contamination. For example, systematically managed piped water from an improved point source of water reduces diarrhoeal disease risk by an estimated 73%, while that same water source is likely only to provide a 28% reduction if treated at point of use and stored in the household (WHO, 2014a).

The evidence suggests that improving water quality at the point of consumption can protect children from diarrhoeal diseases. A review by Wolf and colleagues in 2014, which included 61 studies for meta-analysis, suggests that water interventions could reduce diarrhoea by 34% (Wolf et al., 2014).

The effect on diarrhoea can vary according to different water interventions. Wolf and colleagues found a significantly higher effect from household-level interventions versus community-level interventions. These conclusions are consistent with the findings of previous systematic reviews (Fewtrell et al., 2005; Clasen et al., 2007; Waddington et al., 2009; Cairncross et al., 2010). Furthermore, specific improvements, such as the use of water filters and provision of high-quality piped water were associated with greater reductions in diarrhoea compared with other interventions (Wolf et al., 2014).

A subsequent prospective longitudinal cohort study, which examined the association between water quality and subsequent diarrhoea in children of the same household, found that each 10-fold increase in *E.coli* contamination in drinking water was associated with a 16% increase in diarrhoea (Luby et al., 2015).

As was pointed out by Cairncross and colleagues in their 2010 review, the bias associated with trials measuring the effect on diarrhoeal disease of water quality interventions is estimated to be high. While the relatively smaller effect of water quality interventions at the source could be due to subsequent contamination of the water on its way to the household or during storage, the bigger effect of POU household water treatment could also be due to bias in reporting. Indeed, the four blinded trials included in their analysis suggested only a 7% reduction in diarrhoeal disease. Issues of bias with the potential to affect the evidence base for water quality interventions have also been articulated elsewhere (Clasen et al., 2007; Schmidt et al., 2009). The more recent review, by Wolf and colleagues, addresses this issue using statistical methods based on empirical evidence (Wolf et al., 2014).

Sanitation: The global definition of an ‘improved’ sanitation facility is one that hygienically separates human excreta from human contact (WHO/UNICEF, 2015). A number of sanitation solutions fall within this category: the flush toilet, piped sewer system, septic tank, flush/pour flush to pit latrine, ventilated improved pit latrine, pit latrine with slab and a composting toilet. However, similar to the definitions for water, these are safe to varying degrees; the WHO has recently estimated that effective sewer connections provide an estimated 69% reduction in diarrhoeal disease compared to an estimated 16% reduction from improved sanitation without sewer connections - although this is based on limited evidence and should therefore be considered preliminary (WHO, 2014a).

A recent systematic review by Wolf and colleagues, which included 11 studies of a randomized, quasi-randomized, case-control or observational design, and addressed bias through statistical methodologies, found that improved sanitation can decrease diarrhoeal disease by 28%, and also that there are notable differences in illness reduction according to the type of improved water and sanitation implemented (Wolf et al., 2014). Sewer connections were associated with greater reductions in diarrhoea compared to other onsite or non-reticulated sanitation interventions. The underlying evidence for this is limited to a small number of studies and the extent to which any technology is appropriate, and to which the costs are justified, will depend on the setting.

These findings are broadly in accordance with the findings of previous systematic reviews in this area. Three recent systematic reviews of the impact of sanitation on diarrhoea estimated a mean decrease of 32–36% (Fewtrell et al., 2005; Waddington et al., 2009; Cairncross et al., 2010) consistent with earlier estimates by Esrey (1991). A Cochrane Review was conducted in 2010 but no pooled analysis was conducted due to the heterogeneity of included studies (Clasen et al., 2010).

Hygiene: According to a number of systematic reviews, handwashing with soap (HWS) has a significant effect on health and reduced diarrhoea. A Cochrane Review carried out by Ejemot and colleagues, which pooled data from five RCTs of community-based interventions in low or middle-income countries found a reduction of 32% in diarrhoea episodes among children (Ejemot et al., 2008). A number of other systematic reviews, many of which take into account trials beyond RCTs, have found a higher reduction in diarrhoea, of up to 48% (Esrey et al., 1997; Huttly et al., 1997; Curtis et al., 2003; Fewtrell et al., 2005; Waddington et al., 2009; Cairncross et al., 2010).

Although further evidence is required to assess the sustainability of HWS behaviour change interventions (Brown et al., 2013), one study in India by Cairncross and colleagues shows that persistent change in behaviour may be possible following an effective intervention. In this study several methods were used to study the sustainability of changed hygiene behaviour at various periods up to nine years after the conclusion of a multi-pronged hygiene promotion intervention in Kerala, India. Good handwashing practice was reported by over half of the adults in intervention areas, versus less than 10% of adults in a control area (Cairncross et al., 2005).



Philippines, 2013. Children stand outside portable toilets, in the Astrodome evacuation centre in Tacloban City – among the areas worst affected by Typhoon Haiyan.

WASH for cholera control: While a range of WASH interventions are frequently employed to control cholera outbreaks, a recent systematic review found that evidence regarding their effectiveness, and in particular those interventions with a focus beyond water quality, is often missing (Taylor et al., 2015). Given the insufficiency of studies measuring cholera as a health outcome, the review focused on studies evaluating the intermediary outcomes associated with implementing WASH interventions in cholera settings. Eighteen studies were reviewed, most of which were of poor quality. The majority of these studies collected information on water quality and POU treatment, and they predominantly evaluated interventions carried out by emergency organizations, rather than experimental interventions.

The review did not find well chlorination to be an effective cholera outbreak response. The available evidence suggests that this measure is poorly executed at scale, and that mainstream approaches to source water treatment are, on the whole, ineffective due to lack of coverage and monitoring of water quality (Taylor et al., 2015). POU water treatment, in particular chlorination products, was found to be the most popular intervention in cholera outbreaks, but with large inconsistencies in product use (Taylor et al., 2015). The four studies that evaluated the effect of a hygiene promotion intervention on community knowledge and cholera awareness found that increased knowledge did not correlate with better hygiene practices. This suggests a need for better, more evidence-based design of behaviour change interventions. The most popular communication channel used in these studies was mass media (Taylor et al., 2015). No study was found that evaluated a sanitation intervention alone.

The review highlighted a lack of evidence on the effect of water quantity on cholera. Since the review, findings from a study in the Democratic Republic of Congo (DRC), led by the London School of Hygiene & Tropical Medicine, suggest a detrimental effect of water supply interruptions on cholera and other diarrhoeal diseases (Jeandron et al., 2015). Through a time-series regression looking at the pattern of water supply and suspected cholera admissions over a five-year period, the study found that in the ten days following a day with no tap water supply to the town of Uvira (South Kivu, Eastern DRC), the suspected cholera incidence more than doubled. Tap water is not available citywide in Uvira, and the observed effect was higher in neighbourhoods that are generally better supplied by tap water.

WASH in humanitarian emergencies: WASH provision is an effective intervention within emergency settings, as well as in longer-term development (Brown et al., 2012), but emergency situations often present more challenging environments for WASH implementation (ibid.). However, a systematic review of the evidence on the effectiveness of WASH interventions on health outcomes in humanitarian crises, published in 2015, found an extremely limited evidence base. It found that over the past 33 years, only six published studies evaluated WASH interventions in relation to public health outcomes in humanitarian settings, and all of these evaluated water-related interventions, with only one study measuring hygiene as well and none providing evidence on the impact of sanitation interventions (Ramesh et al., 2015). Numerous methodological limitations precluded the possibility of a meta-analysis and constrained the ability to determine associative relationships (Ramesh et al., 2015). Among water-related interventions, two high-quality studies, one of which was blinded (Doocy et al., 2006), indicated that POU interventions at the household level are effective at controlling diarrhoea, statistically reducing either prevalence or incidence (Doocy et al., 2006; Moll et al., 2007).

What don't we know?

Although there is significant evidence highlighting the role of WASH in decreasing the incidence of diarrheal diseases, a number of areas remain under researched. These include:

- **Dominant transmission pathways:** Rigorous research is required to provide a greater understanding of what the dominant transmission pathways are in particular contexts and how they influence the selection of intervention strategies;
- **The role of 'WASH+':** A greater understanding is needed of the impact of non-traditional/new WASH interventions, such as safe disposal of child faeces, complementary feeding, hygienic play areas, and others;
- **Integration with broader diarrhoeal disease control:** Studies that look at how WASH efforts are integrated with broader diarrhoeal disease control strategies, notably existing (retrovirus) rotavirus and future (Enterotoxigenic Escherichia coli (ETEC) and Shigella) vaccines, are needed;
- **Gender:** A greater understanding is needed of the effect of gender roles and power dynamics on the prevalence of diarrhoeal disease in children;

- **Cholera control interventions:** Further investigation is required to identify the most appropriate interventions in different contexts, including emergencies settings, in order to ensure effective cholera control and the best use of limited resources (Taylor et al., 2015);
- **The effect of water quantity on cholera control:** While the above study in DRC (Jeandron et al., 2015) highlights the effect of water availability and reliability on cholera, further research is required to investigate whether the reduction in water supply causes reduced hygiene behaviours, or a reduction in water quality. This would have significant implications for intervention design;
- **Diarrhoeal disease control in humanitarian emergencies:** Further research is needed to address critical unknowns about how to effectively deliver sanitation and water in both urban and rural emergency settings (Brown et al., 2012). In addition, more research is needed on whether new technologies, new approaches or new behaviour change interventions may play a role in providing sustained access to safe water at the point of consumption through effective POU water treatment solutions (Brown et al., 2012).

Ongoing studies

The Global Enteric Multicentre (GEMS) three-year case-control study, coordinated by the University of Maryland School of Medicine's Centre for Vaccine Development, is the largest study ever conducted on diarrhoeal diseases in developing countries, enrolling over 20,000 children from seven sites across Asia and Africa. Important results have already been published with regard to the prevailing causes of severe and moderate diarrhoea (Kotloff et al., 2013), but the trial is ongoing. The WASH Benefits study aims to generate rigorous evidence about the impacts of sanitation, water quality, handwashing, and nutrition interventions on child health and development in the first years of life. The study is designed as two highly comparable cluster randomized trials in rural Bangladesh and Kenya. In each country, the study has six treatment arms and one control arm. In particular, the study seeks to determine whether there are larger reductions in diarrhoea when providing a combined water, sanitation and handwashing intervention compared to each component alone (Arnold et al., 2013). MAL-ED, a five-year, multi-site project led by the Foundation for the National Institutes of Health, studies specific enteric infections, looks at their relationship to malnutrition and intestinal infections, and

explores the consequences of these conditions on various aspects of child development. MAPSAN, a controlled, before-and-after study, will estimate the health impacts of an urban sanitation intervention in informal neighbourhoods of Maputo, Mozambique, including an assessment of whether exposures and health outcomes vary by localized population density (Brown et al., 2015).

Conclusion

There is good evidence that poor WASH contributes to the majority of the burden of diarrhoea and related adverse health effects, and strong consensus around this point. There is suggestive evidence that hygiene (i.e. handwashing) substantially reduces diarrhoeal diseases in the community. There is suggestive evidence that sanitation and household water treatment can reduce diarrhoea. There is suggestive evidence that increasing water quantity directly reduces the risk of diarrhoea and other WASH-related diseases. However, while biological plausibility is high, there is currently only weak epidemiological evidence that WASH interventions reduce mortality. Few studies have looked at the effect of WASH interventions on mortality - and those that have, have not been good quality.

There are significant challenges associated with experimentally assessing the impact of sanitation interventions on diarrhoeal disease, as discussed in the introduction (Section 1.2). However, despite heterogeneity across settings and a continued lack of clarity on the magnitude of the effect with regard to different types of intervention, few would contest the idea that drinking water that is safe from contamination, the safe containment of excreta, and hygiene practices that reduce transmission (including through food), can reduce diarrhoeal disease. Sustained behaviour change is key to these reductions - as illustrated clearly by the frequent relapse of certified defecation-free communities - and must therefore be a key focus in the design of effective WASH interventions.

A clean environment, by ensuring access to water, sanitation and hygiene, has historically been a key to improving health and survival in countries now regarded as developed. There is little evidence to suggest that equally impressive improvements in health and longevity cannot be achieved in low-income settings today through effective and sustainable WASH interventions.

WASH and undernutrition

The problem

Undernutrition is defined as “the outcome of insufficient food intake and repeated infectious diseases. It includes being underweight for one’s age, too short for one’s age (stunting), dangerously thin for one’s height (wasting) and deficient in vitamins and minerals (micronutrient malnutrition)” (UNICEF, 2006)

In 2014 at least 159 million children worldwide were stunted and at least 16 million children were severely wasted (WHO, 2015c). Undernutrition increases the risk of death from infectious diseases in childhood (Pelletier et al., 1995; Caulfield et al., 2004; Black et al., 2013; Olofin et al., 2013). It is responsible for an estimated 3.1 million deaths of children under the age of five annually and accounted for 45% of the global burden of child mortality in 2011 (Black et al., 2013). Evidence also suggests a negative impact of undernutrition on motor and cognitive development in children (Grantham-McGregor et al., 2007; Aburto et al., 2009; Walker et al., 2011; Walker et al., 2012; Black et al., 2013).

Significant progress has been made in the last three decades; the prevalence of stunting, wasting and underweight has decreased by 35%, 11% and 36% respectively worldwide since 1990 (Black et al., 2013). However, while this progress is close to the rate required to meet the 2015 MDG target, improvements have been unevenly distributed between and within different regions (WHO, 2015). Furthermore, at current rates improvements will fall well short of expectations defining the post-MDG agenda. For example, SDG target 2.2 pledges to “by 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under five years of age”. Yet current progress will not come close to achieving these agreed targets, which are embodied in the 13-year Comprehensive Implementation Plan (2012-25) on Maternal, Infant and Young Child Nutrition. This plan calls for a 40% reduction in the prevalence of stunting among children under the age of five by 2025, compared to the 2010 baseline (WHO, 2012a). The 56 countries participating in the Scaling Up Nutrition (SUN) movement have established or are establishing national goals geared towards meeting these global targets. However, at the current rate, the best that can be hoped for is a 20% reduction (Black et al., 2013). Fast demographic changes pose additional challenges in certain regions. For example, in Africa, with the current rate of population increase, stunting prevalence is actually going up (Black et al., 2013).

The necessary step-change in global efforts to reduce undernutrition will require a more comprehensive and ambitious approach, including the scale-up of high-impact interventions. For example, much more focus should be placed on the first two years of life. Studies suggest that the process of stunting is concentrated in the first 1000 days of a child's life, from conception to 2 years old (Kuklina et al., 2006; Martorell et al., 2010; Victora, 2010; Adair et al., 2013). Furthermore, studies looking at the impact of interventions targeted towards this age group strongly suggest that the first two years of a child's life present a “window of opportunity for preventing undernutrition” (Victora et al., 2010) and that nutrition interventions are most effective during this period.

Nutrition-specific interventions² cannot alone adequately address the current deficit in nutritional outcomes. A recent study has found that even if coverage of key evidence-based nutrition specific interventions were scaled up to 90% in the 34 countries with the highest burden of child undernutrition, there would still only be a 20% reduction in stunting (Bhutta et al., 2013). Nutrition-sensitive³ interventions, for which WASH is an integral part, are a key part of the solution.

How does WASH influence childhood undernutrition? Recent updates in knowledge

1. Can WASH affect childhood undernutrition?

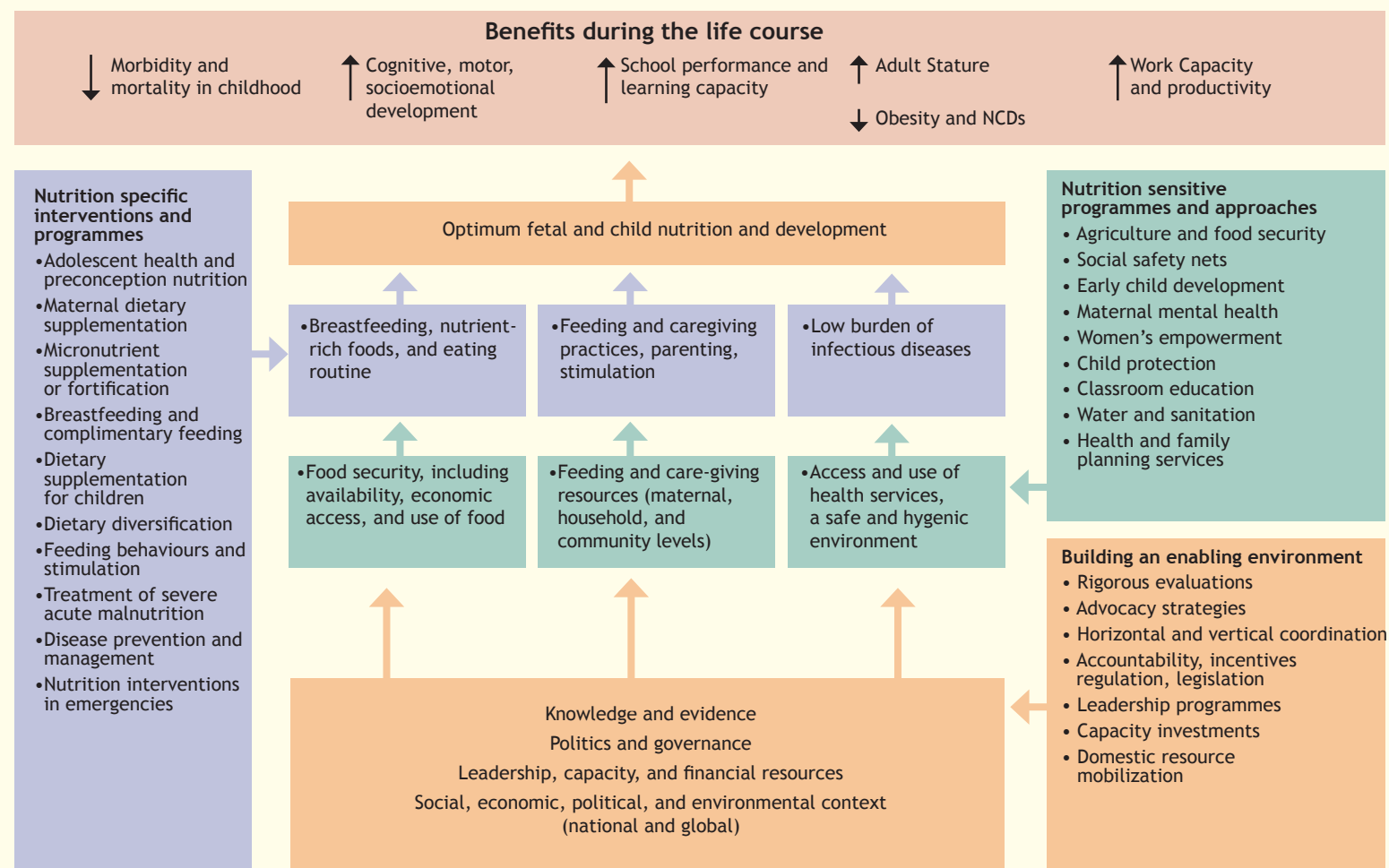
Achieving the goal of global food security - that, “all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life” (as defined by the World Food Summit of 1996)—requires a set of complex and often cross-cutting interventions and programmes (see Figure 2 below). While WASH interventions constitute only part of this broader picture, an appreciation of their influence on nutritional outcomes is of vital importance for the development of comprehensive solutions to this important issue for child health.

It has been estimated that environmental factors, including no access to water and sanitation and poor hygiene practices, may account for half of all undernutrition (Blossner & de Onis, 2005; Prüss-Üstün & Corvalan, 2006; Victora & Fall, 2008; World Bank, 2008). Further, one study has estimated that approximately 860,000 child deaths attributable to undernutrition could be prevented with improved WASH (Prüss-Üstün et al., 2008).

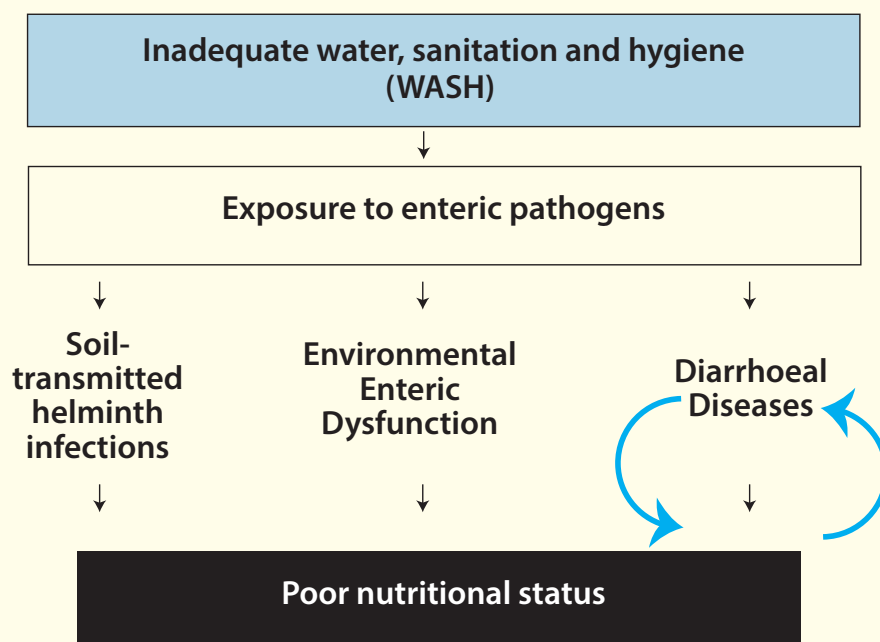
² Nutrition-sensitive interventions: Interventions or programs that address the underlying determinants of malnutrition and incorporate specific nutrition goals and actions (Black et al., 2013)

³ Nutrition-specific interventions: Interventions or programmes that address the immediate causes of suboptimum growth and development (Black et al., 2013)

Figure 2: Interventions and programmes required to tackle child undernutrition



SOURCE: Adapted from the Lancet Series on Maternal and Child Undernutrition and Overweight (Black et al., 2013), building on the UNICEF framework used in the 2008 series.

Figure 3: How WASH can affect childhood undernutrition

SOURCE: Adapted from Cumming et al., 2015

WASH could potentially affect childhood nutrition via at least three pathways: intestinal worms, EED and repeated bouts of diarrhoea (Dangour et al., 2013). All three of these pathways are mediated by enteric pathogen exposure that can be prevented with WASH.

Repeated bouts of diarrhoea: Diarrhoea, the leading cause of which is inadequate WASH (Prüss-Üstün et al., 2014), causes undernutrition (Checkley et al., 2008), which in turn reduces a child's resistance to subsequent infections (Lima et al., 2000; Checkley et al., 2008), creating a vicious circle (Brown et al., 2003). An estimated 25% of stunting is attributable to five or more episodes of diarrhoea before 24 months of age (confidence interval [CI]. 8-38%) (Checkley et al., 2008).

Parasitic worm infections: These infections, which are associated with inadequate water and sanitation, may limit growth and cognitive development (O'Lorcain & Holland 2000; De Silva et al., 2003; Bethony et al., 2006; Prüss-Üstün & Corvalan, 2006; Hall et al., 2008; Ziegelbauer et al., 2012). Hookworm and roundworm can also cause maternal anaemia and low birthweight (Brooker et al., 2008; Noronha et al., 2012).

Environmental Enteric Dysfunction: EED is a largely asymptomatic syndrome leading to chronic inflammation, reduced nutrient absorption of the intestine, and weakened barrier function of the small intestine. There are observational studies that suggest that this condition is associated with poor WASH and undernutrition (Haghighi et al., 1997; Humphrey, 2009; Keusch et al., 2014; Crane et al., 2015).

There are also several indirect social and economic pathways that may be as important as biological mechanisms in understanding the plausible impact of WASH on undernutrition. These include the time taken to collect and the cost of buying water, which may divert scarce resources from food and time spent feeding infants, and the chemical contamination of water (Cumming & Cairncross, 2015).

2. The effect of WASH interventions on undernutrition

The effect of interest here is the reduction in undernutrition as a result of improvements in WASH.

A number of observational studies have shown a robust association between WASH and childhood undernutrition (Spears, 2013; Spears et al., 2013; Liu et al., 2015; Rah et al., 2015). One study reported a strong association after adjustment between open defecation and stunting in 112 districts of India (Spears et al., 2013). However, the evidence on the effects of interventions to improve WASH on the nutritional status of children is less well established. A Cochrane Review on this topic, published in 2013 (Dangour et al.) ranked most available studies as poor quality, and the five cluster RCTs amenable to meta-analysis were mostly POU water treatment interventions, with none evaluating sanitation or water supply. Nonetheless, the review found suggestive evidence of a small benefit for children under the age of five, in terms of reducing stunting or wasting (a mean difference [MD] in Height-for-Age Z-score [HAZ] of 0.08, 95% CI [0.0-0.16]). A pre-specified individual participant data analysis found a larger effect for children under the age of 24 months (an MD of 0.25, 95% CI [0.14-0.35]).

Since 2013, five RCTs for the effect of sanitation on undernutrition have been published. Of these, two found a large effect on childhood stunting (Hammer & Spears, 2013; Pickering et al., 2015), while the remainder found no effect (Cameron et al., 2013; Clasen et al., 2014; Patil et al., 2014). It should be noted that the interventions for the trials reporting no effect also reported low levels of uptake and compliance, which may explain the absence of

an effect. By contrast, Pickering and colleagues report that access to sanitation was substantially increased, and open defecation reduced, as a result of the intervention evaluated in Mali, West Africa (Pickering et al., 2015), while the intervention evaluated by Hammer and Spears in India achieved more modest increases in sanitation access (Hammer & Spears, 2013). This epidemiological literature confirms what is well known by many WASH implementers: that the requisite changes in behaviour are hard to initiate and even harder to sustain over time.

What don't we know?

Over the last five years there has been markedly more attention dedicated to the influence of WASH on undernutrition, and the evidence base has developed. Nonetheless, evidence gaps remain. Going forward priority should be given to:

- **Understanding the benefits of integrated approaches:** Synergistic effects of WASH interventions delivered alongside nutrition interventions;
- **Quantifying the effect of targeted interventions:** In particular, the effect that WASH interventions targeting in-utero and early life nutrition have on early childhood development and growth;
- **Demonstrating the effect of WASH interventions on EED and specific enteric infections, and undernutrition;**
- **Understanding the intervention needs of informal urban settings:** Effect of onsite sanitation on child health in high density/informal urban settings;
- **Understanding different gender roles:** A greater understanding is needed of the effect of gender roles and power dynamics on the ability of WASH interventions to reduce child undernutrition, in particular given the role of women as caregivers in the household.

Ongoing studies

Three large new WASH intervention studies currently ongoing in Zimbabwe, Bangladesh, Kenya and Mozambique will go at least some way towards addressing the above evidence gaps. The SHINE trial, a cluster RCT, will evaluate the independent and combined effects of improved water, sanitation and hygiene, and improved infant diet on child health and anaemia between birth and 18 months of age (Humphrey, 2013). The WASH Benefits study, described on p.15-16, will measure the health and developmental benefits of

water, sanitation, handwashing and nutritional interventions among newborn infants in rural Bangladesh and Kenya (Arnold et al., 2013). The MapSan trial, described on p.16, will collect anthropometric measures to assess the effect on child growth as a specific outcome (Brown et al., 2015).

All of the trials will enable an assessment of whether WASH improvements can decrease EED, as well as an understanding of whether the impact of poor WASH on stunting is mediated by EED. The SHINE trial and WASH Benefits study will allow for both the independent effect of WASH interventions on stunting as well as the combined effect of WASH and nutrition interventions together to be assessed.

Conclusion

There is good evidence to suggest that interventions that focus solely on nutrition-specific strategies are insufficient for reducing undernutrition, and that WASH may have impacts on undernutrition via multiple biological and social mechanisms. There is also good evidence that strategies to tackle undernutrition must focus on the first 1000 days, from conception to a child's second birthday, after which the damage is largely irreversible.

While the evidence is less clear on the magnitude of the effect and on what interventions are the most efficacious for tackling this issue, the current evidence is sufficient to justify the inclusion of WASH interventions in strategies aimed at reducing undernutrition.

For WASH interventions to contribute more effectively to reducing undernutrition, modification may be required around targeting children under the age of two, understanding how this group is specifically exposed to enteric pathogens, and prioritising actions that target these age-specific exposure pathways.

WASH and complementary food hygiene

The problem

The period during which other foods or liquids are provided along with breast milk is considered the period of complementary feeding. Any nutrient-containing foods or liquids other than breast milk given to young children during the period of complementary feeding are defined as complementary foods (Brown et al., 1998).

It is important to an infant's development that the caregiver supplements breast milk with appropriate solid foods from six months. However, inadequate complementary food hygiene, as well as use of unsafe drinking water in food preparation, could account for a significant proportion of diarrhoeal diseases among infants and young children in low-income countries (Motarjemi et al., 1993; Islam et al., 2013). The incidence of diarrhoeal disease is higher in children after complementary food is introduced (Barrel et al., 1997) and peaks during the second half-year of infancy, as the intake of complementary food increases (Martinez et al., 1992). In low-income settings, the level of contamination in complementary foods can be higher than in drinking water (Esrey & Feachem, 1989; Lanata, 2003), though this varies between environmental settings (Toure et al., 2011; Islam et al., 2013). Keeping food free from faecal contamination is essential to inhibiting faecal-oral disease transmission (Curtis et al., 2011). Adequate food hygiene practices have been found to reduce the risk of diarrhoea by 33% (Sheth et al., 2006).

How does WASH influence complementary food hygiene? Recent updates in knowledge

1. Can WASH affect complementary food hygiene?

While many factors influence food-borne contamination, including: hot climate (Lanata et al., 2003), poor storage practices and insufficient cooking time (Motarjemi et al., 1993; Lanata et al., 2003), WASH plays a crucial role (Curtis et al., 2011), in particular through environmental contamination due to lack of sanitation, use

of contaminated water to wash serving utensils, and not washing hands prior to cooking and feeding. Figure 1 on page 16 shows the pathways of faecal-oral transmission of pathogens and infers the plausible influence of WASH on these.

2. The effect of WASH interventions on complementary food contamination and associated improvements in child health outcomes

The effect of interest here is the reduction in the contamination of complementary foods as a result of improvements in WASH.

Over the last 15 years a body of evidence around the impact of WASH interventions in reducing complementary food contamination has developed. The principles of Hazard Analysis and Critical Control Points (HACCP) (Motarjemi et al., 1999) have been successfully used to identify the pathways for contamination of complementary food and the associated critical points where controls could be applied to prevent, reduce or eliminate this contamination (Michanie et al., 1987; Sheth et al., 2000; Ehiri et al., 2001). A number of experimental studies in the last few years have tested this approach. Findings suggest that using the HACCP approach to identify points of contamination in the preparation, storage and reheating of complementary food, alongside evidence-based, innovative, behaviour change interventions can substantially reduce contamination of food given to young children.

One small-scale hygiene experiment using the HACCP model in peri-urban Bamako, Mali, proved to be effective in reducing the contamination of complementary foods (Toure et al., 2012). Using a similar approach, a small intervention study in Bangladesh was effective in reducing complementary food contamination in a different context (Islam et al., 2013). A further study in rural Nepal designed, delivered and evaluated an intervention designed using emotional drivers such as nurture rather than cognitive appeals to change the food hygiene behaviours of mothers (Gautam et al., 2015). A significant proportion (43%) of mothers were able to maintain all five key behaviours for several months and the intervention was successful in significantly improving the microbial contamination in children's food.

What don't we know?

A number of studies have identified contamination of complimentary food as an important transmission route of diarrhoeal diseases in young children. Despite this a number of evidence gaps remain, especially around identifying effective and scalable behaviour-change interventions. Going forward research should prioritize:

- **Identifying effective behaviour change interventions:** Successfully changing behaviours associated with routine hygiene and food preparation and cooking practices remains a challenge. More models of successful behaviour change, resulting from experimentation, optimization and adaptation grounded in context-specific formative work, as well as how to translate these into effective design of hygiene promotion programmes, are needed to secure sustainable food hygiene behaviour change;
- **Understanding the role of gender:** A greater understanding is needed of the effect of gender roles and power dynamics on the ability of interventions to alter target behaviours successfully;
- **Understanding the transmission pathways of key enteric pathogens:** A fuller understanding is required of which major enteric pathogens are transmitted via food, and what the associated disease risk is versus other pathways;
- **Quantifying the effect on child health:** Greater clarity is needed on the short and long-term health impact of contaminated complementary food during the critical developmental window of early childhood. This includes understanding the contribution of foodborne transmission to enteric infection and longer term conditions that develop as a consequence of growth faltering and how this relates to Early Childhood Development;
- **Identifying scalable interventions:** Further development and testing of strategies for scaling up complementary food hygiene interventions are required to demonstrate that these interventions can be cost-effective at scale.

Ongoing studies

Two studies that started earlier this year (2016) are further exploring the questions of effective behavior change and scale up. A food hygiene cluster RCT intervention in rural Gambia, led by University of Birmingham, aims to substantiate the findings of the complementary food hygiene behaviour intervention study in Nepal, through adaptation to a different context. It seeks to provide an intervention that can be scaled up, this time in low-income settings in Africa.

Meanwhile the community-based WASH and food hygiene RCT in Malawi, led by Malawi Epidemiology and Intervention Research Unit (MEIRU), is seeking to determine the effectiveness of combining WASH and food hygiene interventions on the incidence of diarrhoeal disease in children under the age of five. The study will entail developing, implementing and evaluating an integrated, community-based WASH and food hygiene intervention in Chikwawa District.

Conclusion

There is good evidence to suggest that inadequate food hygiene practices can lead to high levels of microbial contamination of food, and this is particularly concerning for the complementary food of children under the age of two. There is also good evidence that interventions focusing on certain critical control points may improve the levels of contamination of such foods. However, the extent to which behaviours can be sustainably changed through such interventions has yet to be further explored. In addition, more needs to be learnt as to the impacts on child health of food hygiene interventions.

While further research is needed, the current evidence base provides a clear case for integrating food-hygiene-specific components to both WASH and nutrition programmes to ensure that this important and often-neglected transmission pathway is given more attention.



Niger, 2015. A family standing next to large plastic containers bearing a combined total of 60 liters of water, the amount the family uses daily for drinking and cooking.

WASH, violence against women and girls, and female psychosocial stress

The problem

Poor access to safe water and sanitation can have profound impacts for women and girls, including but not limited to adverse pregnancy outcomes, maternal mortality, violence and psychosocial stress. The latter is one of the less studied associated outcomes to date.

Violence against women and girls (VAWG) is a violation of fundamental human rights, and a growing public health concern. Gender-based violence (GBV) occurs as a result of the differences in power between males and females. A large proportion of GBV is aimed at women and girls, due to the discrimination that they face in most societies and their lack of power relative to men and boys. However, the gender roles assumed by men and boys, and people with other gender and sexual identities, can also make them vulnerable to violence (House et al., 2014; Sommer et al., 2014). Other focuses include violence against those from specific social groups, particularly those who may be in vulnerable, marginalised or special circumstances; and violence that may occur between people of the same gender, such as between women or between men, or between men and boys (House et al., 2014). Beyond the physical impacts - rape, assault, molestation, beating or fighting can often lead to serious injury and even death - different types of violence can also have long-term psychological impacts (Sahoo et al., 2015), associated with harassment, bullying, discrimination or marginalization, and psychosocial impacts, associated with the fear of these acts of violence.

Psychosocial stress can be said to occur when a perceived threat (real or imagined) or a given outcome outweighs the individual's perceived ability to overcome the challenges associated with that outcome. While perhaps the most obvious relationship is that between the experience and/or threat of violence and the fear of that violence, it is not possible to fully understand women and girls' psychosocial stress in isolation from other gendered health-outcomes. For example, psychosocial stress is but one of a range of impacts associated with a woman or girl's inability to effectively manage her menstrual hygiene (see pages 34-36). It is also associated with maternal health (see pages 29-32, or with the stress involved in collecting water. Psychosocial stress contributes

directly to overall mental health. Broadly, mental and substance abuse disorders account for approximately 8% of the global burden of disease, with depressive disorders alone being the fifth leading cause of disability-adjusted life years (DALYs) in 2013 (Institute for Health Metrics and Evaluation, 2015).

This chapter aims to display the current evidence on violence and psychosocial stress, as two interlinked and often neglected diverse outcomes associated with WASH.

How does WASH influence violence and psychosocial stress? Recent updates in knowledge

1. Can WASH affect the levels of VAWG and their psychosocial stress?

While there is currently insufficient rigorous evidence to substantiate this claim there is reason to believe that the lack of any or adequate WASH facilities is likely to increase the vulnerability to violence in a given setting.

The Violence, Gender and WASH Practitioner's Toolkit, a collaborative piece published in 2014, offers an invaluable summary of the available case studies on this topic (House et al., 2014). These have been classified into the following forms of violence: sexual violence, psychological violence, physical violence and socio-cultural violence (House et al., 2014). To highlight a few examples, the case studies suggest that poor access to WASH services can lead to vulnerability, rape and assaults, and that fear of such assaults can prevent women and children from using sanitary facilities outside of the home at night. Children can be vulnerable to sexual violence in school or when left at home while the mother is out to undertake WASH-related tasks (House et al., 2014). A 2013 cross-sectional study by WaterAid India of 10,000 Dalit households across five states sought to identify and quantify the various forms of violence faced by Dalit women when collecting water or defecating in the open (WaterAid & the National Confederation of Dalit Organizations).

More recently, in 2015, using data from the 2008/2009 Kenya Demographic and Health Survey, Winter and Barchi (2015) explored the quantitative relationship between access to sanitation and experiences of violence. Among all respondents, women that did not have a sanitation facility had 38% greater odds of experiencing non-partner violence within the last 12 months compared to

women that reported using a sanitation facility (after controlling for marital status, residence, age, and experience of intimate partner violence). This relationship was modified by neighbourhood social disorganization - a measure based on neighbourhood poverty, residential stability, and ethnic diversity. Among women in highly disorganized neighbourhoods, the odds of experiencing non-partner violence in the last 12 months were 13 times greater for women practicing open defecation compared to women who reported using a sanitation facility. Conversely, there was no significant change in the odds of violence associated with sanitation facilities in neighbourhoods with higher cohesion.

The experiences that women and girls have accessing water and sanitation - including vulnerability to violence - can put them at risk for negative psychosocial outcomes. These experiences are shaped by socially constructed gender roles and behaviours that they are expected to perform (Sommer & Caruso, 2015). The negative outcomes can be further aggravated when the lack of appropriate and hygienic sanitation facilities, at home or in public places, forces women and girls to adopt a range of coping strategies. The risks are multiple and cumulative, occurring across the duration of a woman's life and with far-reaching implications for social justice and social equity.

A series of cross-sectional studies have offered insights into the negative impact of WASH on the psychosocial stress levels of women and girls (Wutich et al., 2008; Stevenson et al., 2012; Hirve et al., 2015; Sahoo et al., 2015; Kulkarni et al.). One study into the relationship between water insecurity and emotional distress in Bolivia found a strong association, after adjusting for various confounding factors, between female gender and water-related



South Sudan, 2012. Women cross a road that has been inundated with water after seasonal flooding, in the town of Bunj, Upper Nile State.

emotional distress. The authors conclude that water-related emotional distress results from people's struggles to negotiate access to water in the absence of regulation or established water rights, rather than as a result of water scarcity per se (Wutich et al., 2008).

A further study in Ethiopia, which tested the association between women's reported water insecurity and an established measure of psychosocial distress - the Falk Self-Reporting Questionnaire - found a significant association between women's water insecurity scores and psychosocial distress (Stevenson et al., 2012). A more recent study in rural India drew on this methodology with a focus on sanitation. This study found that sanitation practices encompassed more than defecation and urination, to include water carrying for use in personal hygiene, washing, bathing and MHM. Furthermore, during the course of these activities women encountered three broad types of stressors - environmental, social and sexual - the intensity of which were modified by the woman's life stage, living environment and access to sanitation facilities (Sahoo et al., 2015). A follow-up study developed a theoretically-grounded tool to quantify sanitation-related psychosocial stress, and found that inadequate access to a sanitation facility was an important determinant of sanitation-related stress, but, crucially, that improvements in quality of life due to sanitation infrastructure were indirect and mediated through the experience of access and using the facilities in question (Hulland et al., 2015).

Among slum dwellers in Dhaka, Gruebner and colleagues found in 2012 that a composite variable related to access to sanitation and garbage disposal had a statistically significant association with WHO-5 scores, a widely used measure of quality of life and mental health (Gruebner et al., 2012). Conversely, access to basic services - including water services - did not have a significant relationship with self-reported quality of life. Only job satisfaction, gender, and self-reported disease status had a stronger association with self-reported quality of life. Critically, the study did not provide gender-disaggregated data, however it establishes that access to basic sanitation facilities does impact overall quality of life.

Although biological markers of stress have been used in the wider psychosocial stress literature, only one WASH study was identified that had done this. In 2014, Henley and colleagues considered risk factors for elevated cortisol concentrations in hair, and found an association with feeling unsafe collecting water or using sanitation facilities within the groups studied (Henley et al., 2014).

The 2015 Inter-Agency Standing Committee (IASC) Guidelines for Integrating Gender-Based Violence Interventions in Humanitarian Action draws qualitative evidence to provide a number of examples of how humanitarian / acute emergency settings are likely to place women and children, and girls in particular, at greater risk of violence, including sexual violence. For example, girls and women in emergencies have few choices over where and how to access resources or facilities for drinking water, hygiene and sanitation. In the absence of appropriate emergency WASH facilities, girls and women, who are already at increased risk to violence for a range of reasons particular to emergency settings, face further increased risk to sexual violence when negotiating where and how to meet WASH needs. Furthermore, both female and male survivors may require exceptional access to WASH facilities as a result of urethral, genital and/or rectal traumas that render basic washing and hygiene activities difficult and time consuming.

2. The effect of WASH interventions on violence and psychosocial stress

The effect of interest here is the reduction in VAWG and women and girls' psychosocial stress as a result of improvements in WASH.

At the time of writing the authors were not aware of any studies seeking to evaluate and/or quantify the effect of WASH interventions on violence or psychosocial stress. However one 2010 study, which designed a matched cohort study to assess the impact and sustainability of a non-randomized, pre-existing sanitation mobilization, water supply, and hygiene intervention in rural India, found that it had a positive effect on feelings of privacy and safety for women and girls (Arnold et al., 2010). It found that private toilet owners were 28 percentage points more likely to report that women and girls feel safe while defecating during the day or night compared with households without private toilets (81% vs. 53%). Overall, the intervention increased the perception of privacy and safety for women and girls during defecation by 13 percentage points compared with controls (72% vs. 59%).

In the absence of rigorous, large-scale research findings, the Violence, Gender and WASH Practitioner's Toolkit brought together in 2014 a range of examples of promising good practice from the field that have the potential to reduce vulnerabilities associated with WASH programmes and services. These include participatory tools to assess and discuss safety and services, guidelines for siting, design and management of facilities, opportunities for the WASH sector to transform communities to reduce GBV, and many others

(House et al., 2014). For example, one programme undertaken in the Democratic Republic of Congo by Tearfund partner Programme de Promotion des Soins de Santé Primaires (PPSSP) adopted an integrated community-based approach that included health, WASH and protection, with separate but linked-in WASH and protection committees established. Highlights of the successes associated with the project include: almost two-thirds of women said that they could express their views and actively participate in decision-making in the community; community mechanisms were put in place to discourage early marriage; and domestic violence reportedly decreased. The programme was initially implemented as a pilot but following its success, the integration of the WASH, protection and other elements are now also being implemented into all projects supported by PPSSP (PPSSP & Tearfund, 2011).

During a humanitarian emergency, well-designed WASH programmes and facilities can help survivors deal with their injuries, as well as minimize the likelihood of stigmatization. The IASC Guidelines for Integrating Gender-Based Violence Interventions in Humanitarian Action provide standards and best practice of applying gender-based violence perspectives in the delivery of WASH knowledge, resources and facilities in emergencies (IASC, 2015).

What don't we know?

There is growing attention being given at a policy level to the psychosocial stress burden associated with poor WASH, especially among women and girls. There is a growing literature on this topic, with a number of papers recently published, and new studies underway, but there remains insufficient evidence as to the magnitude of this problem and which interventions and approaches are most effective in addressing it. While existing studies have helped to characterize the problem, and made significant strides in quantifying this outcome, more research is needed to:

- **Gain greater understanding of the various mechanisms:** What are the interaction between WASH and violence? Do these vary across different countries and contexts?;
- **Quantifying the magnitude of the effect:** Do adequate WASH facilities impact on the incidences of violence;
- **Understand the impact on sanitation practices:** greater exploration of the role that the association between VAWG and sanitation may play in women's sanitation practices;

- **Understand the psychosocial stress burden:** And what is its association with different deficits in WASH access in different settings such as distant water sources in rural settings or shared sanitation facilities in high-density informal urban settlements;
- **Understand which WASH interventions are the most effective:** In particular, which WASH provisions are most effective in reducing violence and psychosocial stress ;
- **Quantify the effect of WASH on stress:** There is a need to assess the effect of WASH interventions on measured stress, particularly among women and girls.

Ongoing studies

Researchers from the University of Oklahoma, the London School of Hygiene and Tropical Medicine, Texas A&M University, and SOPPECOM have partnered on a quasi-experimental, mixed methods study assessing changes in sanitation-related psychosocial stress, generalized psychosocial stress (Perceived Stress Scale), and quality of life (WHO-5) among 600 women aged 14 to 60 in villages receiving the Global Sanitation Fund's (GSF) sanitation intervention in 2016 - matched with 600 women in villages receiving the same intervention in 2017 or later. Additional outcome measures for this study include self-reported urogenital infections and perceived privacy and safety.

Conclusion

There is suggestive evidence that inadequate WASH can affect VAWG and on the psychosocial stress levels of women and girls. Evidence as to the effect of WASH interventions on violence or on psychosocial stress is currently weak.

While additional research is required to consider the precise nature of the interactions between poor WASH and violence and psychosocial stress, their magnitude, and how best to measure them, the wealth of case studies and other anecdotal evidence available leave little room to question that well-implemented WASH interventions can reduce vulnerabilities - and the perceived threat of vulnerability. The negative impact on women and girls of limited availability of water and sanitation resources, and the physical and social challenges associated with accessing those resources, are beginning to receive greater attention by the WASH sector, but there is a need for improved monitoring of these dimensions.

Thorough analysis of the context-specific needs and roles of those at risk of GBV related to WASH is crucial for the effective design of any WASH intervention, whether in an emergency or longer-term development setting. Furthermore, it is critical to engage women, girls and other at-risk groups in the design and delivery of WASH programming - as both employees in the WASH sector and as community-based advisers. This engagement not only helps to ensure effective response to life saving needs, but also contributes to long-term gains in gender equality and the reduction of GBV.

Actions taken by the WASH sector to prevent and mitigate the risk of GBV should be implemented in coordination with GBV specialists and actors working in other humanitarian sectors. WASH actors should also coordinate with partners addressing issues of gender, mental health and psychosocial support (MHPSS) in emergencies, HIV, age, disability and environment (GBV 2015 Guidelines, WASH Thematic Guide, p.40).



Burkina Faso, 2011. A sixth grade student at a Public primary school leaves the latrine carrying water.

Wash and maternal and newborn health

The problem

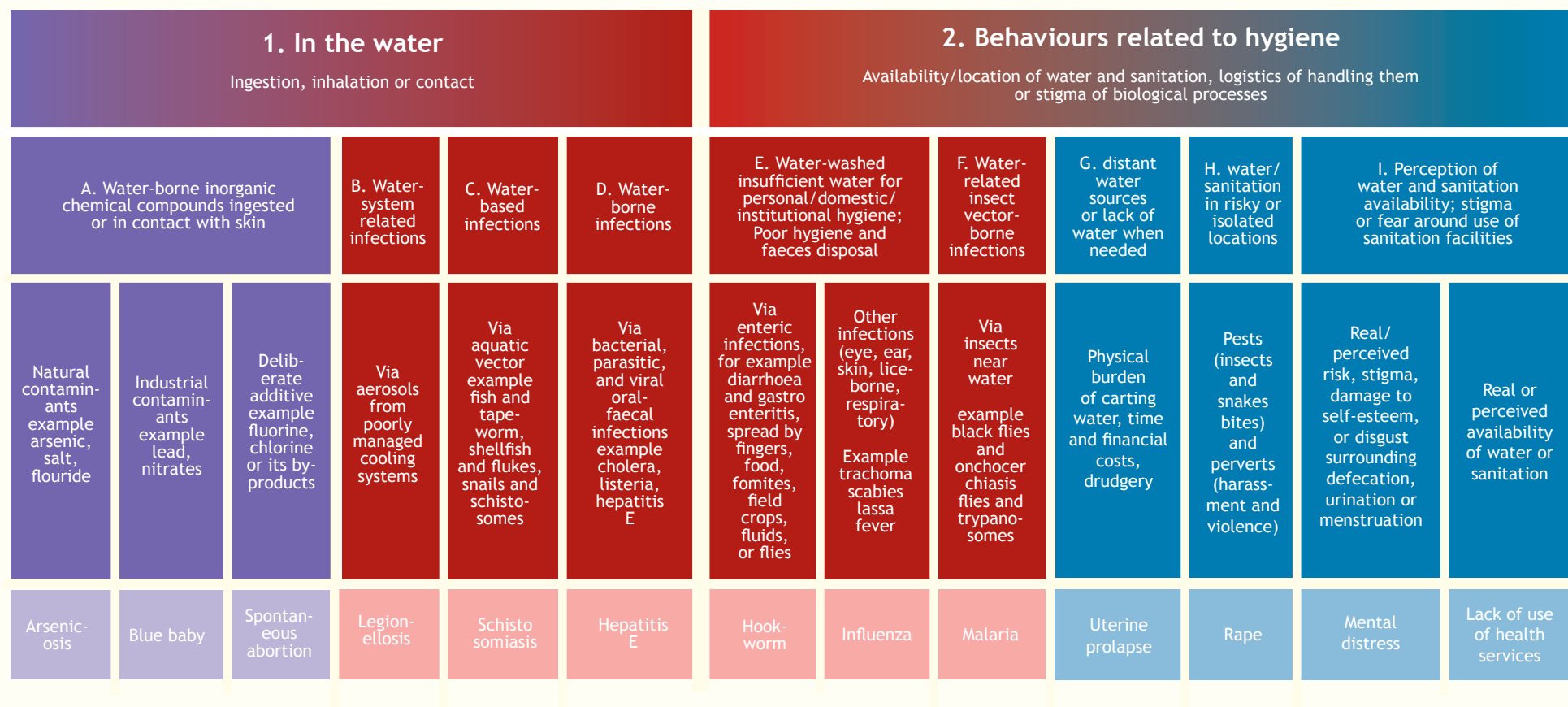
Maternal mortality (MM) is defined as “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes”. In addition, many more women become unwell with illnesses or conditions related to pregnancy and childbirth than actually die. Maternal morbidity is defined as “any health condition attributed to and/or aggravated by pregnancy and childbirth that has a negative impact on the woman’s well-being” (WHO, 2013).

The negative consequences of childbirth can go beyond the burden of mortality and morbidity experienced by the mother and newborn, affecting also the health of infants, children and other members of the family (Anderson et al., 2007). Progress towards attaining MDG 5 - reducing MM by three quarters between 1990 and 2015 - was slow and geographically and socioeconomically uneven (UNICEF et al., 2014). With an estimated 303,000 maternal deaths still occurring in 2015 across the globe (Alkema et al., 2015), it is clear that traditional maternal health interventions alone have not been sufficient to address this issue adequately.



Malaysia, 2014. A baby from the indigenous Kadazandusun ethnic group sleeps in a traditional cloth cradle in child-care centre in Penampang district, Sabah State.

Figure 4: Dimensions, components and examples of health effects in conceptual framework linking WASH with maternal and reproductive health.



SOURCE: Adapted from Campbell et al., 2014

How does WASH influence maternal health? Recent updates in knowledge

1. Can WASH affect maternal health?

There is a strong association between MM and WASH (Benova et al., 2014b), and the causal link between birth attendant handwashing and maternal infection has long been established, thanks to the work of Gordon, Holmes and Semmelweis (Gordon, 1795; Semmelweis, 1861; Gould, 2010;). Figure 4 (previous page) shows the multiple direct and indirect mechanisms depicted in a conceptual framework created by Campbell and colleagues in 2014. This framework identified 77 plausible chemical, biological and behavioural mechanisms linking WASH to adverse maternal and reproductive health. These are multiple and overlapping and may be distant in time from the immediate health outcome.

Poor sanitation increases the risk of soil-transmitted helminth (STH) infections (Bethony et al., 2006; Brooker et al., 2008; Noronha et al., 2012; Strunz et al., 2014), which can cause anaemia, listeria (Southwick et al., 1996), and increase the risk of maternal death. STH infections are also associated with spontaneous abortion and pre-term birth (Heymann, 2008; Semedo-Leite et al., 2012). Schistosomiasis, another risk posed by poor WASH (Grimes et al., 2014), is associated with ectopic pregnancy, anaemia and undernutrition (King et al., 2005; Swai et al., 2006; Abelgadir et al., 2012). Furthermore, there is evidence to suggest that repeated early childhood infections of this sort, or of diarrhoeal diseases, can cause stunting (Checkley et al., 2008; Guerrant et al., 2013) - which in turn can lead to an increased risk of obstructed labour and maternal mortality in later life (Konje et al., 2000; Neilson et al., 2003; Toh-adam et al., 2012; Tsvieli et al., 2012). Indirect effects of poor sanitation on maternal health include the increased risk of pre-eclampsia and anaemia, which can be caused by urinary tract infections arising from harmful coping mechanisms such as delayed urination or reduced water or food intake associated with lack of safe access to facilities (Schieve et al., 1994; Lennon et al., 2011; Massey et al., 2011; Minassian et al., 2013).

Unsafe water management can encourage the breeding of mosquitoes and associated transmission of malaria and dengue, which pose high risks to pregnant women (Heymann, 2008; Mota et al., 2012). Water collection can cause spinal injuries, hernias, genital prolapse, and an increased risk of spontaneous abortion (Florack et al., 1993; Jorgensen et al., 1994). It can also present substantial caloric expenditure and thus hinder weight gain. Distant

water sources, and the resulting reduced water consumption (Howard et al., 2003), can affect personal hygiene and increase risk of urinary and reproductive tract infections associated with pre-eclampsia and anaemia (Schieve et al., 1994; Minassian et al., 2013), as well as risk of infection during delivery and post-partum. Drinking unsafe water has been linked to higher rates of spontaneous abortion and stillbirth (Milton et al., 2005; Ekong et al., 2006; Cherry et al., 2008; Caserta et al., 2011; Khan et al., 2011).

Since the publication of Campbell and colleagues' conceptual framework, a systematic review has explored the effect of cholera on pregnancy outcomes (Tran et al., 2015). While the results are limited, findings suggest that maternal cholera, which is linked to poor WASH, is associated with adverse pregnancy outcomes, particularly foetal death.

2. WASH coverage and quality at delivery

Delivery represents a critical moment for potential infection of both mother and baby through poor WASH, and yet studies have found insufficient coverage and inadequate quality of WASH in birth settings. A 2014 study concluded using existing data sources that less than one-third of all births in Tanzania (home and facility) took place in a water- and sanitation-safe environment (Benova et al., 2014a). The 2015 UNICEF and WHO multi-country review of WASH services in health care facilities, drew on data from 54 low and middle-income countries and concluded that over one-third lacked access to even basic levels of water and did not have handwashing facilities, while just under a fifth lacked sanitation (WHO & UNICEF, 2015). A number of additional needs assessments in Bangladesh, India (Afsana et al., 2014; Steinmann et al., 2015) and Zanzibar (Fakih et al., 2016) also found WASH conditions to be sub-optimal in health facilities. Common findings include contaminated delivery beds, inadequate access to WASH facilities and poor WASH facility conditions of upkeep and cleanliness.

3. The effect of WASH interventions on maternal mortality and morbidity

The effect of interest here is the reduction in maternal mortality and morbidity as a result of improvements in WASH.

A systematic review (Benova et al., 2014b) considered available evidence on the links between WASH and MM but did not identify any interventional studies. A meta-analysis of adjusted estimates from four observational individual-level studies showed that

women living in households with poor sanitation were three times more likely to die from maternal causes than those with adequate sanitation access. Additionally, four of five ecological studies identified in this review showed that at a country-level, poor sanitation was associated with higher MM.

The only individual-level study that looked at the adjusted effect of water showed a significant association between poor water access and increased MM. Four of six ecological studies assessing water environment found that poor water environment was associated with higher MM on country level. There was only one facility-based study, which found an association between a combined measure of water and sanitation environment and a high risk of in-hospital mortality (Galadanci et al., 2011).

A study in Afghanistan found that women in households with unimproved water access had 1.91 higher odds of pregnancy-related mortality, compared to women in households with improved water access, and found an association between unimproved toilet facilities and higher pregnancy-related mortality, although this association was not statistically significant (Gon et al., 2014).

In 2015, an assessment of the association between poor sanitation during pregnancy and adverse pregnancy outcomes found that poor sanitation in general, and open defecation in particular, were strongly associated with each of the four composite adverse pregnancy outcomes studied, after adjusting for a broad range of biological and socio-economic factors. This is the first rigorous epidemiological study to demonstrate this relationship (Padhi et al., 2015).

4. How does WASH influence the newborn?

Mortality among newborns (up to 28 days after birth) has been reduced but did not declined at a pace sufficient to meet MDGs or pace matching progress seen in child health. There were 2.8 million deaths annually in this age group in 2013 (Oza et al., 2015).

Infections such as sepsis, tetanus, pneumonia and diarrhoea account for a substantial proportion (around a quarter) of these deaths and are directly relevant to WASH circumstances during childbirth and the immediate postpartum period through practices such as birth attendant handwashing, cleanliness of the perineum and delivery surface, hygienic cord care / cord cutting, bathing, and feeding practices. Many of these links have been established by good quality intervention studies in low and middle-income contexts (Mosha et al., 2005; Rhee et al., 2008; Darmstadt et al., 2009; Mullany et al., 2009; Blencowe et al., 2011; El Arifeen et al., 2012; Khan et al., 2013).

Some of the other causes of death, such as pre-term complications and small size for gestational age, which account for a third of newborn deaths and congenital malformations, can also be linked to WASH through the life course and maternal exposure to poor water, sanitation and hygiene environments during childhood, adolescence and adulthood (including during pregnancy). These include, for example, maternal malnutrition, exposure to chemical contaminants (such as arsenic or fluoride) and exposure to lead, but also include infections such as influenza and malaria (Campbell et al., 2014).

In addition to neonatal mortality, there are life-long and severe consequences to morbidity related to poor WASH exposures, such as malnutrition, delayed development and reduced cognitive function (Theiss et al., 2014).

The Every Newborn Action Plan, which has been endorsed by the World Health Assembly and ratified by many stakeholders and donors to reduce neonatal deaths and stillbirths to 10 per 1000 births by 2035, provides an evidence-based framework for scaling up of essential interventions across the continuum of care. It has the potential to prevent approximately three million deaths of newborns and mothers, every year (Bhutta et al., 2014; Akseer et al., 2015).

What don't we know?

Answering the following questions would further strengthen the case for increased investment, ensure that these investments are appropriately targeted, and ensure better tailoring/designing of interventions.

- **Synthesising the state of the evidence on key risk mechanisms:** Additional systematic reviews are needed to explore key potential risk mechanisms linking WASH to maternal and newborn outcomes (Campbell et al., 2014);
- **Quantifying cumulative risks across the female life course:** How does access to WASH at different points in a woman's life course affect these pathway(s) to MM (Benova et al., 2014b)?;
- **Testing the most effective WASH interventions:** What effects do different types of WASH interventions have on specific maternal health outcomes, and does the relative importance of these differ across various settings (Velleman et al., 2014)?;

- **Including a WASH dimension in Maternal Health programmes:**
How best can WASH be incorporated? This should include, for example, how to motivate the cleaning staff in health care facilities and making sure that staff have the resources for operation and maintenance of facilities (Afsana et al., 2014);
- **Understanding needs across different levels of facilities:**
Studies that link WASH exposures to maternal health outcomes at different service levels would support the development of more nuanced, targeted guidelines;
- **Attributable disease burden:** What maternal health disease burden is associated with poor WASH across primary, secondary and tertiary facilities? What is the contribution of poor WASH to nosocomial infections?;
- **Cost:** Better metrics on the cost-effectiveness of WASH interventions relative to other healthcare facility interventions improving maternal health outcomes are needed.

Ongoing studies

As part of the UNICEF/WHO-led global action plan on WASH in health care facilities, four taskforces have been set up, one of which is tasked with taking the research agenda forward. This taskforce is still in its nascent stage. In the meantime, several agencies including WHO, UNICEF and WaterAid, are continuing to carry out assessments of WASH coverage in birth settings in low and middle-income countries.

Conclusion

There is good evidence that WASH plausibly impacts on maternal and newborn health at the time of delivery and the immediate postpartum period through multiple direct and indirect mechanisms. There is good evidence that WASH coverage and conditions in delivery settings in low and middle-income countries is extremely poor. There is also suggestive evidence that WASH may have impact on reproductive, maternal and newborn health through multiple direct and indirect mechanisms (i.e. throughout the life course).

While further research is required for a greater understanding of the risks to MNH associated with WASH and the magnitude of the impacts, there is sufficient evidence to advocate for increased attention to this dimension by both WASH and MNH policy makers and practitioners. Encouraging a higher proportion of deliveries in healthcare facilities is a well-established strategy to tackle maternal and newborn mortality

in low-income countries. However, the coverage and quality of WASH in healthcare facilities is widely inadequate. Without combining such a strategy with strong infection prevention and control policies and procedures, including adequate access to and quality of WASH, maternal and newborn outcomes are unlikely to improve at the necessary pace.



South Africa, 2014. Sipiwe Khumalo, 37, Mother, and her newborn baby, Lundiwe.

WASH and menstrual hygiene management

The problem

Menstrual Hygiene Management (MHM) is defined as: “women and adolescent girls using a clean menstrual management material to absorb or collect menstrual blood, that can be changed in privacy as often as necessary for the duration of a menstrual period, using soap and water for washing the body as required, and having access to safe and convenient facilities to dispose of used menstrual management materials. Furthermore, they understand the basic facts linked to the menstrual cycle and how to manage it with dignity and without discomfort or fear” (drafted by WHO/UNICEF JMP Hygiene Working Group, 2012).

Approximately 52% of the female population is of reproductive age (Population Reference Bureau, 2011). Most of these women will experience menstruation - a natural part of the reproductive cycle - every month. Safe and dignified MHM requires education and knowledge, menstrual hygiene materials, access to facilities that provide privacy for changing materials and washing and drying menstrual cloths, access to water and soap, and access to disposal facilities and systems for used menstrual materials. The inability to adequately manage menstrual hygiene can have multiple and interrelated health and social effects (Kirk & Sommer, 2006).

How can WASH support safe MHM?

Recent updates in knowledge

1. Menstrual hygiene attitudes and practices

MHM practices differ across the world and are determined by factors such as socioeconomic status, personal preferences, local traditions and beliefs, knowledge and awareness, and access to the necessary resources. Understanding the influence of WASH on MHM requires an appreciation of these contextual factors. Several cross-sectional studies have been carried out in recent years investigating menstrual hygiene practices, attitudes, and experiences in different settings, reporting on the taboo associated with menstruation, misconceptions about what menstruation is, and different practices, social norms and restrictions (Goel et al., 2011; Mason et al., 2013; Tamiru et al., 2015; Trinies et al., 2015).

2. The effect of MHM on health and social outcomes

The effect of interest here is the reduction in adverse health and psychosocial outcomes associated with MHM as a result of improvements in WASH.

For health, the focus is on reproductive tract infections, while the social effects of ineffective management of regular menstruation may include school absenteeism and the exclusion from everyday tasks including touching water, cooking, cleaning, attending religious ceremonies, socialising or sleeping in one's own home or bed. All of these can have profound psychosocial effects on women and girls.

It is biologically plausible that poor MHM influences the health of women and girls. Use of inadequate absorbent materials and insufficient or ineffective cleansing are likely to provide a propitious environment for the development of urogenital infections (Das et al., 2014). Furthermore, a number of cross-sectional studies provide a rich and textured picture of the effect on the psychological well-being of adolescent girls associated with embarrassment, fear of stigma, anxiety, and school absenteeism (Sommer, 2009; Sommer, 2010; Sommer & Ackatia-Armah, 2012; Caruso et al., 2013; Connolly et al., 2013; Crichton et al., 2013; Haver et al., 2013; Long et al., 2013; Jewitt et al., 2014; Sommer et al., 2014; Sahoo et al., 2015).

However, while we know that menstruation presents significant challenges for women in lower-income settings, a 2013 systematic review to appraise the evidence on the health and psychosocial outcomes of the methods of menstrual hygiene management found no published quantitative evidence that improving menstrual practices improved women's reproductive health and attendance at school. There is a particular gap in the evidence base for randomized intervention studies that combine both hardware and software interventions for both health and social outcomes (Sumpter & Torondel, 2014).

However, there was good evidence that educational interventions can improve menstrual hygiene practices and reduce social restrictions other than attendance at school. Since this review, a case-control study in India on the effect of MHM practice on urogenital infections—the first to explore the relationship between MHM and such infections using both symptoms and laboratory-diagnosed health outcomes—concluded that interventions which ensure women have access to private facilities with water and educate women about safer, low-cost MHM materials could reduce

urogenital disease among women (Das et al., 2014). Further, a recent cluster randomized controlled feasibility study qualitatively evaluated both the success of an intervention to provide menstrual cups and commercial sanitary pads in improving MHM and the potential effect on school attendance in rural Kenya (Mason et al., 2015). Once comfortable, girls using cups or pads reported being free of embarrassing leakage, odour, and dislodged items, and only girls using traditional materials reported school absenteeism and impaired concentration. While future quantitative results will add precision to these findings, parents' narratives corroborate girls' accounts, particularly on improved comfort, security and well-being (Mason et al., 2015).

3. Effective approaches for safe MHM

WASH programmes to date have given MHM insufficient consideration (House et al., 2012), though there are indications that this is beginning to change. As a result, the needs of women and adolescent girls with regard to MHM are not often taken into account in the design and delivery of WASH programmes. The following observational studies have sought to evaluate the effect of some of recent programmatic attempts to better integrate MHM into WASH interventions. A UNICEF programme in Pakistan used formative research to improve their understanding of the factors influencing MHM in girls' schools in order to strengthen the design of interventions. Results showed significant improvement in MHM conditions in the targeted schools (Naeem et al., 2015). In the same year, a before-and-after study concluded that an intervention in India aimed at the sensitization of men and boys had successfully changed their understanding and perceptions of MHM (Mahon et al., 2015). The intervention created community groups and trained male teachers and masons (for example to design toilets and incinerators) to provide MHM services in school. Also in 2015, an evaluation of a play-based approach to MHM through WASH school programmes in Ghana found changes in awareness of and attitudes towards MHM, in teachers and school children (Dorgbetor et al., 2015).

In the absence of rigorous trials, a small number of manuals have been developed drawing on the existing body of qualitative studies to support practitioners to improve menstrual hygiene for women and girls in low and middle-income countries. One such manual is the Menstrual Hygiene Matter Manual produced by WaterAid (House et al., 2012). In 2013, the International Federation of Red Cross (IFRC) developed a set of recommendations for meeting the MHM needs of women and adolescent girls specifically in a humanitarian emergency context, drawing on operational research to evaluate two different MHM kits (IFRC, 2013).

There remains a need for more rigorous controlled intervention studies that combine hardware and software interventions, not only to better understand the health and social impacts of MHM, but also to identify the most effective approaches to realising safe MHM. Such solutions must be grounded in the local context, and designed according to the recommendations of girls and women (Sommer, 2010b).

What don't we know?

There are still several areas where knowledge is insufficient and additional research is called for, and these have been summarized in a recent concept note by Phillips-Howard and colleagues (2014). The following topics cover the broad areas where future research is needed:

- **Specific infections:** Recent research has shown a link between inadequate MHM and urogenital infections. Further evidence is required on the prevalence and transmission of specific infections;
- **Strength of the effect:** A greater understanding of the strength of the effect of inadequate WASH on MHM and, through this, on the health and social environment of women and girls is important to help advocate for increased attention in this area, and guide investments and interventions;
- **Measuring and monitoring 'good' MHM:** While MHM itself has been defined, universal agreement is still required on the definitions of outcome measures, such as targets to indicate successful implementation;
- **Understanding what works:** Formative research and impact studies of actual interventions on the ground is required to improve our understanding of what constitutes an effective WASH in Schools (WinS) intervention.

Ongoing studies

A number of studies continue to study important questions for MHM. MENISCUS is a feasibility and preparatory study for a cluster randomized trial on menstrual hygiene and safe male circumcision promotion in Ugandan schools. It is led by LSHTM and the Uganda Virus Research Institute (UVRI) and funded by the UK Medical Research Council (MRC). WASH in Schools for Girls, led by UNICEF in collaboration with Emory University and Columbia University, constitutes formative research on MHM in 14 countries, to enable the development of tools and recommendations for incorporating MHM effectively in WinS national policy and programming. A case-control study to examine the association of infections such as bacterial vaginosis (BV) and vulvovaginal candidiasis (VVC) with MHM practices is ongoing in Orissa, India, following on from the above-mentioned case-control (Das, 2014). Further, a cluster RCT is ongoing in western Kenya that follows completion of the above-mentioned pilot study showing safe cup use by rural Kenyan primary schoolgirls (Mason et al., 2015). Led by the Liverpool School of Tropical Medicine, the trial will examine the impact and cost-effectiveness of menstrual cups, compared or combined with a cash transfer, to improve the retention of rural girls in secondary school and protect their sexual and reproductive health (SRH).

Conclusion

Having the knowledge, facilities, and supplies to manage menstruation safely, from a health point of view, and with dignity and convenience, is fundamental to women's full participation in society, to the expansion of their freedoms and choices, and to the full realization of their rights to equality and self-determination.

There is good qualitative evidence of the challenges and barriers associated with MHM among schoolgirls and women. While the 2013 systematic review (Sumpter & Torondel, 2014) uncovered the weak evidence base for the effect of poor MHM on social and health outcomes for this cohort, this has since begun to be addressed, with two rigorous studies providing suggestive evidence of the effect of MHM on urogenital infections and school absenteeism respectively.

While more experimental research is undoubtedly needed for a greater understanding of the characteristics and magnitude of the health and psychosocial impacts associated with poor MHM, enough is known at present to warrant increased attention to this issue by the WASH and education sectors, as well as the reproductive health sector. In essence, few would contest that a girl or woman without

access to water, soap, and a toilet, whether at home, school, or work, will face great difficulties in managing her menstrual hygiene effectively and with dignity. Furthermore, we know what is required to enable safe, dignified management of menstrual hygiene: knowledge, materials and facilities. Better understanding the precise impacts of this problem (including the differentiated impact on minority and vulnerable groups, such as women with disabilities or in emergency settings) and how to measure them, as well as the most effective interventions to address these, will certainly provide a stronger case for investment in this area and greater guidance for policy and practice. However, evidence to-date provides grounds enough to advocate for greater policy and programmatic attention on this issue.



India, 2005. A girl carrying a water container on a one and a half hour walk home. During monsoons the roads are inaccessible, even by cars.

WASH and school attendance

The problem

There is evidence to suggest that school absenteeism is related to a decrease in academic performance, drop out rates and delays in academic development (Lamdin, 1996; Reid, 2003; Bener et al., 2007; Kearney, 2008; Moonie et al., 2008; Baxter et al., 2011).

While the available evidence is focused primarily on middle and high-income countries, there is no reason to believe that these impacts are not relevant in low-income countries.

The social and economic knock-on effects of reduced academic performance or, in some cases, drop out, are likely to be far-reaching for the individual, but also at the community, region and country. For example, under-attainment in school can affect a child's job prospects and their livelihood, as well as their social development, which in turn can hold back economic growth and social development in the locality.

How does WASH influence school attendance? Recent updates in knowledge

1. Can WASH affect school attendance?

The effect of WASH on school attendance or educational performance can manifest itself through five main pathways:

- **Pupil absence due to diarrhoeal disease and/or respiratory infections:** It was estimated that 194million school days would be gained due to less diarrhoeal disease if MDG targets for sanitation were met(WHO, 2004);
- **Girls' absence due to difficulty of managing MHM:** One contributing factor is a lack of appropriate WASH facilities, without which many girls are likely to miss school while they menstruate. Without the appropriate facilities girls cannot adequately manage their menstrual hygiene, resulting in particular in fear of embarrassment or teasing associated with unpleasant odours or stains (Sommer, 2010; McMahon et al., 2011);

- **Reduced cognitive function and performance associated with NTD infections and dehydration:** Some of the most severe consequences of chronic worm infections, which are strongly associated with WASH (see p.38 for further information) are those related to education, and intellectual achievement. Children subject to intense infections with whipworm miss double the number of school days as their infection-free peers (WHO, 2005). Similarly, heavy-intensity hookworm infections in children have been shown to produce growth retardation, impaired learning, increased absences from school and decreased future economic productivity (Miguel & Kremer, 2004). Dehydration is another potential cause of reduced cognitive function and performance (Hunter et al., 2014);
- **Truancy associated with fear of assault:** pupils of schools where WASH facilities do not provide adequate privacy and safety may fear assault or violence, which could lead to a decision not to attend school;
- **Pupil absence due to the need to fetch drinking water:** This can lead to missed classes, in particular if children have to make more than one trip per day to collect water (Fisher, 2004; Hemson, 2007). One study in 25 countries in sub-Saharan Africa estimated that, collectively, children spent 4 million hours per day collecting water, which made them unable to attend school (WHO, 2012b).

2. Effect of WASH intervention on school attendance

The effect of interest here is the reduction in school absenteeism as a result of improvements in WASH.

While there is sufficient evidence to support the plausibility of the above impact pathways, evidence from empirical studies on the effect of WASH interventions on school attendance remains limited.

A 2011 systematic review found insufficient evidence for or against the hypothesis that separate toilets for girls in schools may increase school enrolment and attendance for girls (Birdthistle et al., 2011). A more recent systematic review by Willmott and colleagues to assess the potential of hand hygiene interventions in schools to reduce absenteeism and illness, also found serious limitations with the available evidence. However, this review nonetheless concluded, on the basis of individual study findings, that such interventions might decrease absence and respiratory tract infections (Willmott et al., 2015).

One of the RCTs included in the 2015 review (Willmott et al., 2015) was the SWASH project, a cluster randomized trial of school-based WASH on pupil absence conducted in Nyanza Province, Kenya. The trial tested the effect of WASH interventions on pupil absence, diarrhoeal disease and reinfection with STH and found that the water treatment (WT) and hygiene promotion (HP) interventions combined reduced absenteeism by 39% in selected geographic areas. Adding a sanitation component (latrine provision) resulted in only marginally significant reductions. The impact was greater on girls, with a reduction of 58% in girls' absenteeism resulting from the WT and HP interventions alone, but no effect on boys (Freeman et al., 2012). The study also found that those pupils in the intervention schools where there was an absence of adequate water supply nearby showed a reduction in diarrhoea incidence and days of illness, suggesting that a comprehensive WASH intervention at the school level can be effective in preventing diarrhoea (Freeman et al., 2014). Furthermore, the comprehensive WASH intervention reduced reinfection rates and the prevalence and intensity of *Ascaris* infections, even with sub-optimal intervention compliance. The reduction in reinfection rates was only statistically significant among girls in the intervention schools. The authors suggest that this may be because girls are less likely to urinate or defecate in the open, and may therefore benefit more when latrines are new or clean, or when handwashing water and soap are available (Freeman et al., 2013).

A recent collaboration between Emory University and UNICEF, which investigated the personal challenges and needs that girls have during menstruation in the school setting (Caruso et al., 2013; Haver et al., 2013; Long et al., 2013) also focuses on the potentially increased impact on girls of WASH in schools. Furthermore, a study using annual school-level data from India, disaggregated by student sex and grade, found that while at younger ages girls and boys both benefit substantially from a latrine, regardless of whether it is sex-specific, pubescent-age girls do not benefit from unisex latrines and their enrolment increases substantially after the construction of separate, sex-specific, latrines (Adukia, 2014). A cluster randomized controlled feasibility study evaluating the impact of the provision of menstrual cups and commercial sanitary pads on school attendance in Kenya (Mason et al., 2015) suggested that those using the new materials did not report school absenteeism and impaired concentration.

What don't we know?

Further research is required to adequately investigate the impact of WASH interventions in schools, and in communities, on students' school attendance and performance. Evidence gaps that should be addressed include:

- **Developing effective measurements:** Further investigation is required on how to effectively measure education attendance and attainment as key outcomes of interest;
- **Effect of MHM interventions on girls' schooling:** This includes exploring interventions that address physical structures, taboos and harassment associated with MHM;
- **Identifying effective school-based WASH interventions:** Successfully changing behaviours associated with hand hygiene and sanitation practices in schools for boys and girls remains a challenge. More models of successful behaviour change, resulting from experimentation, optimization and adaptation grounded in context-specific formative work, as well as how to translate these into effective design of hygiene promotion programmes are needed;
- **Role of teaching staff:** Understanding how teachers, both male and female, can best contribute to a positive school environment for MHM for girls.

Ongoing studies

WASH in Schools for Girls, led by UNICEF in collaboration with Emory University and Columbia University, constitutes formative research on MHM in 14 countries to enable development of tools and recommendations for incorporating MHM in WinS national programming.

Conclusion

There is good evidence to suggest that WASH can affect school absenteeism through a number of mechanisms. There is suggestive evidence as to the effect of WASH interventions on school absenteeism. While systematic reviews point to the weak quality and limited quantity of studies seeking to quantify this relationship, a small number of studies carried out since then have begun to bolster this evidence base.

While further rigorous trials are required to explore the various mechanisms through which WASH can affect school absenteeism and to seek to effectively quantify these effects, there is nonetheless already a clear human rights mandate for the WASH and education sectors to work together to provide appropriate WASH in schools.



Sierra Leone, 2011. A boy washes his hands with soap after using a latrine at the Missionary Baptist primary school in Pendembu, Kailahun district.

WASH and oral vaccine performance

The problem

Vaccination is a cost-effective intervention for communicable disease control, preventing 2 million to 3 million deaths per year (WHO, 2014b). The success of vaccination as a public health strategy has been marked by a number of important milestones, including the eradication of smallpox in 1980, the reduction in the number of polio-endemic countries from 125 in 1988 to just four today (Jamison et al., 2006; GAVI, 2015), and a 78% decrease in global measles mortality between 2000 and 2008 (WHO, 2009; GAVI, 2015).

Oral vaccines are preferred to injectable vaccines, because they protect better against enteric infections and are more amenable to mass administration. However, clinical trials in sub-Saharan Africa and South Asia suggest that oral rotavirus vaccine (RV) efficacy varies significantly by region: from over 90% in Europe and North America to approximately 45% in high-burden countries in South Asia and sub-Saharan Africa (Walker et al., 2011). Despite the enormous potential for reducing the burden of communicable disease through immunization, oral RV appears to perform less well in low-income settings - where the need is greatest (Sack et al., 2008, Serazin et al., 2010; Clemens et al., 2011; Qadri et al., 2013). This phenomenon has been observed for other oral vaccines as far back as the early oral polio vaccine trials of the late-1950s (LeBrun et al., 1959; Plotkin et al., 1959; Horstman et al., 1960; Soares-Weiser et al., 2012).

How might WASH influence vaccine performance? Recent updates in knowledge

1. Can WASH affect vaccine efficacy?

A number of competing hypotheses have been proposed to explain the observed variation in oral vaccine performance, including maternal antibody interference (Ahmed et al., 2009, Qadri et al., 2013), malnutrition, (Ahmed et al., 2009; Snider et al., 2011; Rashidul et al., 2014) and the disease state of the host (Patel et al., 2013). However, many of these hypotheses have been tested in trial settings without confirmation (Rongsen-Chandola et al., 2014; Ali et al., 2015; Ali, A. et al., 2015; Saleem et al., 2015; Mychaleckyj et al., 2016).

One potential explanation for this is that enteric co-infections in low-income settings may result in reduced oral vaccine responses (Madhi et al., 2010). This is consistent with findings for vaccines for cholera (Simanjuntak et al., 1992), polio (John, 1976) and typhoid (Simaniuntak et al., 1991), as well as earlier generations of RVs (Georges-Courbot et al., 1991). Furthermore, there is growing interest in the potential role of sustained environmental exposure to enteric pathogens resulting from poor WASH, which may drive EED, a subclinical gut disorder (Humphrey 2009; Prendergast et al., 2012, Keusch et al., 2014); EED may plausibly reduce oral vaccine performance. If enteric co-infections reduce vaccine response in low-income settings, then reductions in environmental enteric exposures through improved sanitation and hygiene could potentially increase vaccine efficacy, making the two intervention strategies synergistic.

2. The effect of WASH interventions on vaccine efficacy

While plausible, there have been no rigorous intervention studies to demonstrate the effect of WASH improvements on vaccine efficacy to date.

What don't we know?

While the above hypothesis to explain reduced vaccine efficacy is plausible, further scientific evidence is required to substantiate our understanding of the contribution of improved WASH to vaccine efficacy.

- **Live oral vaccine efficacy:** An assessment of the impact of poor sanitation and hygiene on this effectiveness is required;
- **Effective integration strategies:** More work is needed to identify effective strategies for incorporating WASH behaviour change into vaccination programmes, or developing integrated programmes.

Ongoing studies

A number of important large-scale studies are underway that, when finalized, should significantly improve our understanding of the contribution of WASH to the optimization of oral vaccine efficacy.

A study entitled Exploration of the biologic basis for the underperformance of enteric vaccines in Zimbabwean infants, led by Queen Mary University of London, aims to better understand why the polio vaccine is less immunogenic when given to children in

developing countries compared to children in developed countries. It will evaluate the impact of intestinal health, HIV exposure, interference from passive maternal and breast milk antibodies and high-dose neonatal Vitamin A supplementation. The SHINE trial, conducted by the same group of investigators in Zimbabwe, is a cluster randomized, community-based trial investigating the independent and combined effects of improved infant diet and/or improved WASH on stunting and anaemia (NCT01824940). This trial will also evaluate the impact of WASH on oral RV immunogenicity in a subgroup of children. The MAL-ED study, described on p.16, studies specific enteric infections and their effect on child growth and development, including an evaluation of the immunogenicity of oral vaccines. The SaniVac trial (a controlled, before-and-after trial), a nested sub-study of the MapSan trial described on p.14 (Brown et al., 2015), will assess whether the performance of oral RV can be improved by a sanitation intervention that reduces environmental exposure to enteric pathogens in a low-income, high-burden setting. The intervention provides low-income households in informal settlements with improved shared sanitation. Outcome measures include enteric infections as indicated in stool samples, markers of EED, anthropometry, and salivary IGF1.

The PROVIDE study, coordinated by the Centre for Public Health Genomics, University of Virginia, is investigating the association of EED and other possible explanatory factors with oral polio and rotavirus vaccine failure in communities in Dhaka, Bangladesh, and Kolkata, India. One further study is currently underway in India, led by Vellore's Christian Medical College, on the impact of oral antibiotics and oral vaccine immunogenicity. While neither of these two studies includes an evaluation of a WASH intervention, their focus on the effect of EED and enteric infections on oral vaccine immunogenicity should shed further light on the role that WASH has to play in improving oral vaccine performance.

Conclusion

There is suggestive evidence that intestinal health is an important determinant of oral vaccine immunogenicity and that WASH may therefore have an effect on oral vaccine performance. Although research demonstrating the effect of WASH interventions is currently lacking, three ongoing trials are likely to make a significant contribution in this respect.

Irrespective of the benefits for vaccine performance, routine immunization campaigns may be a useful entry point for promoting safe hygiene among caregivers for young children (Velleman et al., 2013). Work is currently underway with the Ministry of Health of the Government of Nepal to pilot the integration of hygiene promotion messaging within immunization programmes.



Bangladesh, 2010. A boy is taking a vaccine from a volunteer during Measles Vaccination Campaign in a community clinic in Sirajgonj.

WASH and neglected tropical diseases

The problem

Neglected tropical diseases (NTDs) are a diverse group of communicable diseases that prevail in tropical and subtropical conditions (WHO). Several NTDs are related to WASH: trachoma, schistosomiasis, STH infections, neglected zoonoses, dengue haemorrhagic fever, dracunculiasis (guinea-worm disease) and lymphatic filariasis (elephantiasis). The following NTDs are discussed in more detail in this section: STH infections, trachoma, and schistosomiasis.

STH infections are among the most common infections worldwide and affect the poorest and most deprived communities. They are transmitted via eggs present in human faeces, which contaminate soil in areas where sanitation is poor (WHO). The most common STH infections are roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*) and human hookworm (*Necator americanus* and *Ancylostoma duodenale*). These infections together affect over 1 billion people globally (Bethony et al., 2006). There is still debate as to the global health impact of these worm infections, with estimates ranging between 4 million and 39 million DALYs (Brooker, 2010). The majority of the disease burden associated to STH infections is understood to be in children of school age. Moderate to heavy infections with whipworm and roundworm in children can lead to undernutrition and growth faltering (O’Lorcain & Holland, 2000). Moderate to heavy infections with any STH in children can also impair cognitive development (Jukes et al., 2008; Stephenson et al., 2000). Chronic and recurring hookworm infections throughout childbearing age can cause maternal anaemia, which contributes to a higher risk of low birth-weight, spontaneous abortions, higher risk of foetal morbidity and mortality, and higher morbidity and mortality for women (Brooker et al., 2008). Severe cases of roundworm can result in intestinal obstruction, and it has been estimated that this complication can explain 10,000 deaths per year (de Silva et al., 1997).

Trachoma is caused by the bacteria *Chlamydia trachomatis* and is the leading cause of infectious blindness in the world. The infection is transmitted through contact with eye and nose discharge of infected people, particularly young children who are the principal

reservoir of infection. The filth fly (*Musca sorbens*) is considered an important mechanical vector of the disease, by feeding on ocular and nasal secretions of infected people (WHO). The fly prefers to breed almost exclusively in scattered faeces.

Schistosomiasis is a disease caused by worms. Schistosomiasis is transmitted when people come into contact with fresh water infested with the larval forms of parasitic blood flukes known as schistosomes (WHO). It can cause chronic and often irreversible liver and kidney failure. Children are more likely to get infected than adults. Although these estimates require review, it is believed that 200 million people are infected worldwide, leading to the loss of 1.53 million DALYs. (Gryseels et al., 2006).

How does WASH influence NTDs transmission? Recent updates in knowledge

1. Can WASH affect STH, trachoma and schistosomiasis?

Evidence of the transmission pathways of the three above NTDs provides an indication of the impact of WASH on infection. The following section presents the evidence base with respect specifically to STH, trachoma and schistosomiasis.

STH: Inadequate sanitation is important for the transmission of STH. The majority of worm infections are transmitted through contact with soil contaminated with worm eggs coming from the faeces of infected humans. They enter the human host either through penetration of the skin (hookworm) or ingestion from contaminated hands or agricultural produce (roundworm and whipworm). Adequate sanitation prevents release of faeces into the environment, thereby preventing transmission.

Trachoma: Lack of hygiene and access to water plays an important role in trachoma transmission. *Musca sorbens* flies act as mechanical vectors of the trachoma. It has been estimated that *Musca sorbens* flies that breed in scattered human faeces account for over 70% of trachoma incidence (Emerson et al., 2004; Montgomery & Bartram, 2010). Inadequate personal hygiene, which is often predicated on the lack of enough water, leads to child-to-child transmission of trachoma as well as attracting the trachoma-carrying flies to unclean faces.

Schistosomiasis: Inadequate access to water plays a significant role in the transmission of schistosomiasis, as this can force households to rely on surface water sources for their domestic water needs. Snails that live in surface water are an essential intermediate host for the transmission to a human. They shed infected larvae into the water that will penetrate skin when a potential host comes into contact with contaminated water. For example, women or children collecting water, washing or bathing.

2. Effect of WASH interventions on NTD infection

The effect of interest here is the reduction in NTD infection or reinfection as a result of improvements in WASH.

At present, strategies to tackle these diseases focus on MDA programmes, which are not only costly, but have been shown to be associated with high re-infection rates (Ziegelbauer et al., 2012; Jia et al., 2012). There is evidence to suggest that progress would significantly improve through the integration into MDA programmes of WASH interventions, as preventive measures that address the environmental causes of these diseases.

STH: In 2012 a systematic review for the effect of latrine availability and use on STH infections found that the latter reduced the risk of combined STH infection by about 50% (Ziegelbauer et al., 2012). A more recent review considered all WASH interventions; 94 eligible studies were found, five of which were RCTs. Despite the overall low quality of studies, the review found that WASH access and practices were generally associated with reduced odds of STH infection (Strunz et al., 2014). Sanitation was found to be associated with lower odds of infection with any STH. While a lower effect from water supply and hygiene should be expected, given that infection occurs through contaminated soil, the review nonetheless found substantially reduced odds of infection associated with access to water and hygiene. For hygiene, three RCTs provided strong evidence linking hygiene practices - especially handwashing with soap - to reductions in STH infection (Balen, 2011; Bieri, 2013; Gyorkos, 2013). Despite the low number and quality of studies on the use of treated water and piped water, associations were also found.

Since the systematic review, three studies have been published that provide further evidence of the impact of WASH interventions on STH prevalence and reinfection. One cross-sectional study, in Kenya, points to the importance of WASH in explaining the variable

performance of school-based deworming programmes across the country and within counties (Nicolay et al., 2015). Another cross-sectional study, in Argentina, reports an association between poor sanitation and water according to the route of entry of STH infections to the human host - demonstrating the potential role of sanitation interventions in preventing STH skin-penetrators and improved water on stopping transmission of orally ingested STHs. (Echazú et al., 2015). This finding could have implications for the more effective design of interventions where specific transmission routes need to be targeted.

Trachoma: The SAFE strategy, adopted by the WHO Global Alliance for the Elimination of Trachoma by the Year 2020, includes four components: eyelid Surgery, Antibiotics, Facial cleanliness and Environmental improvement. WASH interventions play an integral role in components 'F' and 'E'. In 2012 a synthesis conducted by Cumming and colleagues of existing systematic reviews on these SAFE components concluded that there was sufficient evidence on all four elements to justify the urgent execution of this strategy in endemic regions (see table 1 below). In 2014, Stocks and colleagues

Table 1: Summary of systematic reviews on SAFE components

Review	S	A	F	E
	Non-WASH	WASH		
Evans et al., 2011				
Hu et al., 2010				
Rabiu et al., 2007				
Ejere et al., 2007				
Yorston et al., 2006				
Prüss-Üstün & Mariotti, 2000				
Emerson et al., 20				
Stocks et al., 2014				

SOURCE: Updated from Cumming et al., 2012

conducted a systematic review on the effect of water, sanitation and hygiene on the prevention of trachoma. This review substantiated the findings of earlier reviews focusing on the WASH related components of the SAFE strategy. Eighty-six eligible studies were found that reported an effect of WASH on trachoma, and the authors found evidence of an association between improved WASH conditions and exposures and reduced trachoma in 11 of the 15 meta-analyses conducted. The strongest association was found between facial cleanliness and lower levels of trachoma. A strong association was also found for access to sanitation, while the effect was smaller for distance to water source. While a number of studies reported an association between improved water quantity and reduced odds of trachoma, the low number of articles precluded the possibility of a meta-analysis. The review concluded that, despite the low quality of the studies included, there is strong evidence to support the 'F' and 'E' components of the WHO SAFE strategy, and the importance of WASH in trachoma elimination strategies (Stocks et al., 2014).

Schistosomiasis: The importance of WASH in preventing schistosomiasis has long been noted. In 1991, Esrey and colleagues concluded, based on four studies regarded to be rigorous on the effect of providing water supply and washing facilities, that the median reduction in schistosomiasis morbidity reached 77%. More recently, a systematic review on the relationship between water, sanitation and schistosomiasis has shown that existing studies substantiate this claim. The review found a total of 44 eligible studies reporting schistosomiasis infection in people who did or did not have access to safe water and adequate sanitation. Despite the largely poor quality of the studies, the majority of which were cross-sectional, safe water supplies were associated with significantly lower odds of schistosomiasis and adequate sanitation was associated with lower odds. Furthermore, the difference in infection rates between people with and without access to clean water and sanitation varied widely between studies. This suggests that the impact of water and sanitation on schistosomiasis transmission is mediated by many other social and environmental factors, which require further investigation (Grimes et al., 2014).

What don't we know?

Evidence suggests WASH contributes in varying degrees to NTD prevention and to treatment and care. As a result the provision of WASH is one of the five key interventions within the global NTD roadmap. However, in order to achieve further reductions in the transmission and burden of NTDs, especially those linked to poor WASH conditions, more evidence is needed to:

- **Understand the effect of different WASH interventions:** Using rigorous experimental studies to better understand the effect of WASH interventions on disease transmission pathways (Grimes et al., 2014; Stocks et al., 2014; Strunz et al., 2014);
- **Assess and quantify the magnitude of effect:** Assessment of the magnitude of the benefit from WASH interventions for NTDs (Strunz et al., 2014);
- **Understand the impact of shared sanitation:** Further investigation of the impact of sharing latrines or latrine maintenance on STH and trachoma is needed (Stocks et al., 2014; Strunz et al., 2014);
- **Understand the effect of treating water:** Further exploration of the effect of treating water on NTD infection (Strunz et al., 2014) is needed;
- **Characterise the role of geophagy:** The practice of eating earth, known as geophagy, will plausibly have an effect on infection or reinfection from STH, but further evidence is required to explore this (Strunz et al., 2014);
- **Understand the impact of WASH on Faecal STH egg count:** Further investigation of the relationship between faecal egg count—a proxy for intensity of infection—and WASH. Intensity of infection represents a more relevant predictor for morbidity than prevalence alone (Strunz et al., 2014).

Ongoing studies

Two large trials are currently ongoing which seek to address some of these gaps in knowledge. The WASH Benefits Study, details of which are on p. 15-16, will measure the health and developmental benefits of water, sanitation, handwashing and nutritional interventions among newborn infants in rural Bangladesh and Kenya, including effects on certain NTDs. The Mikono Safi Study, due to start late-2016, will be an RCT involving 20 schools (and 6000 children), and will explore the impact of a handwashing with soap behaviour change intervention targeted at school children on the prevalence and intensity of two soil-transmitted helminth infections (*A. lumbricoides* and *T. trichuris*) in this population. The study will entail developing, implementing and evaluating a scalable school-based HWWS intervention in Mwanza, Tanzania. It is a collaboration between the Mwanza Intervention Trials Unit in Tanzania and the London School of Hygiene and Tropical Medicine.

Conclusion

There is suggestive evidence on the effect of WASH interventions on STH, trachoma and schistosomiasis. However, while there is a continued need for further rigorous experimental studies to strengthen our understanding of and quantify this effect, there is nonetheless a strong rationale for action by the WASH sector in this area. The nature of the disease transmission pathways for the diseases in question renders the impact of WASH on this transmission highly plausible. As such, WASH interventions offer an obvious and potentially hugely effective barrier to this transmission.



Sierra Leone, 2011. A boy washes hands after using a latrine at Kathala Community Primary School in the village of Kathala, in Bombali District.

WASH and disability

The problem

According to the Convention on the Rights of Persons with Disabilities (CRPD), “persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others” (UNGA, 2006).

People with disabilities, older people and the chronically ill make up a considerable proportion of the global population. The World Disability Report reported in 2011 that an estimated 15% of the world’s population have a disability (WHO, 2011), 80% of whom live in low and middle-income countries (WHO, 2011; WHO, 2014). The Australian government estimates that only 3%-4% of people with a disability benefit from international development programmes (AusAID, 2011). Another population group likely to face similar barriers as a result of their frailty, physical or mental impairment are older people. It is estimated that there are 600 million people over 60 years old (OHCHR, 2011). By the end of the decade, this number is estimated to rise to 1 billion (HAI, 2013).

Disability disproportionately affects the poorest in society. The World Disability Report estimates that 80% of people with disabilities live in the developing world (WHO/World Bank, 2011) a finding which is consistent with Elwan’s suggestion in 1999, well over a decade ago, that among the poorest quintiles of populations in low-income countries, as many as 1 in 5 individuals are likely to have a disability (Elwan, 1999). This would suggest that almost every poor family in low-income countries is affected in some way by disability (Jones et al., 2002).

Disability is both a cause and a consequence of poverty (Jones et al., 2002). People with a disability are more likely to be poor due to the high cost of health services and assistive equipment, lack of education or employment, and discrimination (Jones et al., 2002). On the other hand, a number of factors associated with poverty increase the risk of impairment amongst the poorer quintiles of society, including poor nutrition, inadequate access to basic services and limited health services.

The rights of people with disabilities to the full and equal enjoyment of all human rights and fundamental freedoms are enshrined, promoted and protected in the CRPD. This includes

the rights to accessibility (Article 9) and the right to an adequate standard of living and to social protection (Article 28). The international community has also moved towards appropriately reflecting these rights in the new global development framework; disabilities are explicit in seven Sustainable Development Goals, with specific targets addressing equitable, inclusive and safe access to sanitation and water, especially for those in vulnerable situations.⁴ However, in practice, despite instruments and undertakings designed to protect persons with disabilities, examples persist across the globe of continued barriers in their participation as equal members of society and violations of their human rights. The Special Rapporteur for Persons with Disabilities has documented these amply in recent submissions to the UN General Assembly (Devandas-Aguilar, 2015; Heller, 2015).

The social model of disability, set out in 1970s by the Union of the Physically Impaired Against Segregation, sees three distinct types of barriers that people with a disability face to their participation in activities of daily life: environmental, institutional and attitudinal barriers (Jones et al., 2002). These are described in greater detail in the section below, with specific reference to inclusive and accessible WASH.

For most people with disabilities in low-income communities, safeguarding their human rights to life, food, water and shelter is a daily struggle (Seeley, 2001a; Singleton et al., 2001; Jones et al., 2002; UN, 2002). With regard to education, only 10% of all children with disabilities are in school and, of this number, only half actually complete their primary education (UNESCO, 2007). Furthermore, in many low-income countries only 5% to 15% of people with disabilities who need assistive devices and equipment are able to obtain them (UNICEF, 2015). In addition, the exclusion of people with disabilities has an impact on their families and communities, “in both human and economic terms” (Jones et al., 2002).

How does WASH affect people with a disability? Recent updates in knowledge

Access to water and sanitation is as much a human right for people with a disability as it is for the wider population, and, like the rest of the population, this group is vulnerable to diseases caused by faecal-oral contamination. Given the provision of accessible WASH facilities, people with a disability should experience the same rights and health-based benefits as the wider population.

4 UnEnable Disability-Inclusive Sustainable Development Goals Infographic. http://www.un.org/disabilities/documents/sdgs/disability_inclusive_sdgs.pdf

However, people with a disability are reportedly at a higher risk of having inadequate access to WASH facilities (OHCHR, 2011; WHO/World Bank, 2011). According to one estimate, households in the poorest quintile, those same households at risk of being affected by disability, are 5.5 times more likely to lack improved water access and 3.3 times more likely to lack adequate sanitation compared with the highest wealth quintile in the same country (White et al., 2016). Furthermore, more often than not, when facilities are present they are not accessible to those with a disability (Danquah, 2014; Danquah, 2015; White et al., 2015). The built environment “is so constructed that only a specific type of user can manoeuvre around it” (UNESCAP, 1995a).

Little is known about the impact of poor WASH on the lives of people with a disability and their families in low-income settings, as concluded by a literature review of water supply and sanitation access and use by people with physical disabilities carried out by Jones and colleagues in 2002 (Jones et al., 2002). This review, and a more recent mapping study (Jones et al., 2013) detailed barriers faced by individuals with physical limitations that impaired their access to WASH. These included the inability to carry out day-to-day tasks and household chores - such as washing clothes or dishes, and pouring water - were due to impairments, physical weakness or pain (Jones et al., 2002). Environmental barriers included inaccessible physical infrastructure or the environment, making it difficult to access water sources and sanitation facilities, as well as affecting the



Indonesia, 2007. A boy, assisted by his mother, leaves a wheelchair accessible latrine.

ability to transport water (Jones et al., 2002). Inaccessible toilets can force children with disabilities and caregivers with disabilities to wait until dark to defecate, increasing their risk of abuse (Devendas-Aguilar, 2015). Institutional barriers include negative stereotypes and discriminatory social policies about people with disabilities, which in turn validate and reinforce negative attitudes (Jones et al., 2002). Attitudinal barriers relate to the negative attitudes and behaviour of family, community members, and service providers. This “complex of cultural, social and economic rules” (UNESCAP, 1995a) can often be an even greater problem for people with disability than the impairment itself (Gunnarson, 1998).

Two recent studies have shed further light on the barriers faced by people with disability when accessing WASH facilities. An action-research project in Uganda and Zambia supported by WaterAid, the Water, Engineering and Development Centre (WEDC) and Leonard Cheshire Disability (LDC) to design and test inclusive WASH interventions, mapped the environmental, institutional and attitudinal barriers that people with disabilities, older people and the chronically ill face when accessing standard WASH services. Their findings echoed those found in 2002 by Jones and colleagues. The project found evidence that inaccessible WASH designs force people with physical impairments to crawl on the floor to use a toilet or defecate in the open (WaterAid, 2011). A high proportion of vulnerable household members are reliant on others to use the toilet, sometimes soiling themselves while waiting, and many limit their consumption of food and water to reduce the need to relieve themselves (Wilbur, 2014). There was also evidence that people with disabilities were considered contagious and therefore they were prevented from using communal facilities (Wilbur & Danquah, 2015).

While Wilbur and Danquah’s 2015 study did not focus on the barriers/challenges posed by the individual impairments themselves, focusing rather on external barriers, more recent research by White and colleagues in Malawi found an interesting variation between individuals with regard to the WASH barriers that they face, according to the nature of their individual impairments. For example, individuals with a physical disability faced predominantly physical barriers however this was not reported by those with hearing impairments, epilepsy or mental health challenges (White et al., 2016). Institutional barriers were faced by all, to some extent, although people with sensory impairments were found to be most significantly disadvantaged when it came to participation in WASH events and access to information (White et al., 2016). Furthermore, social barriers associated with traditional beliefs were reported to affect people with cognitive impairments, epilepsy and albinism more than others (White et al., 2016).

The effect of WASH interventions on the lives of people with a disability

The effect of interest here is the reduction of adverse health and social outcomes in people with disabilities as a result of improvements in WASH.

At the time of writing, the authors were not aware of any studies seeking to evaluate and/or quantify the effect of WASH interventions on the lives of people with disabilities. However, the existing literature on the nature of the barriers and challenges facing people with disabilities with respect to WASH, as well as studies to map existing best practice, suggest that WASH interventions can improve the quality of life of this vulnerable group and the realization of their rights.

Removing or reducing barriers is likely to be the primary means by which WASH interventions might achieve greater inclusion of people with disabilities (Danquah, 2014; Danquah, 2015). A checklist for WASH practitioners on inclusive WASH, developed by WaterAid and WEDC, following the action research in Uganda and Zambia (Danquah, 2014; Danquah, 2015) lists specific characteristics necessary in a WASH programme for it to be inclusive. This goes from the initial situation analysis and baseline through community mobilization and infrastructural plans, to monitoring and evaluation, shining a spotlight throughout on the needs of the most vulnerable in the community (WaterAid & WEDC, 2014a). The same authors have also developed a Compendium of accessible WASH technologies, which provides examples of inexpensive adaptations of standard WASH technologies that families can adapt to suit their needs and budgets (WaterAid & WEDC, 2014b).

According to White and colleagues, in addition to addressing the barriers identified, it is also important for programmes to understand WASH consequences, and WASH needs. Understanding consequences - the experiences associated with WASH barriers and needs, including increased pain and effects on health and self-esteem - can provide context that can inform priority setting and highlight the links between inclusive and accessible WASH, poverty, ill health and self-esteem for people with disabilities. Understanding WASH needs - anything that requires an individual to use WASH facilities differently due to their personal characteristics and impairment - can guide interventions towards provision of equitable and appropriate access (White et al., 2016).

In addition to these broader recommendations for WASH programmes, WEDC and WaterAid have drawn on their research in Uganda and Zambia (Danquah, 2014; Danquah, 2015) to draft a set

of practical recommendations for facilitators and everyone engaged with Community-Led Total Sanitation (CLTS) to make the process fully inclusive (Wilbur et al., 2014). In a similar vein, White and colleagues have drafted a proposed plan for 'CLTS+', to champion a more inclusive process, drawing on and as a follow on to their research in Malawi, soon to be published (White et al., 2016).

What don't we know?

Since the literature review in 2002 (Jones et al.,) key studies have improved our understanding of how poor WASH can affect the lives of people with a disability. However, a number of knowledge gaps remain, including:

- **Understanding the hygiene needs of girls and women with disabilities:** How does inaccessible WASH affect the ability of girls with disabilities to manage their menstrual hygiene with safety and dignity? What are the main bottlenecks to providing private and safe access for girls with disabilities?;
- **Understanding the WASH needs of people with disabilities in emergency settings:** How does inaccessible WASH in emergency settings affect people with disabilities?;
- **Measuring inequalities:** How can both intra- and inter-household inequalities be measured through existing monitoring systems?;
- **Quantifying the effectiveness of interventions:** What measurable effect do inclusive WASH programmes have on the lives of people living with a disability?;
- **Characterising the challenges faced by people with non-physical impairments:** What challenges do people with mental health, intellectual and psychosocial disabilities face?;
- **Understanding the impact of accessible WASH on schoolchildren with disabilities:** One-third of children out of school have a disability (UNICEF, 2013a). Further research is needed to understand the impact of improved WASH in communities and schools on school enrolment for children with disabilities.

Ongoing studies

Further results from studies in Malawi and Bangladesh as part of the DFAT-funded project ‘Disability and its impact on safe hygiene and sanitation’, are being prepared for publication in early 2017. These are expected to assess the impact of awareness raising and access to adaptive sanitation hardware for people with disabilities. Under the same project a revised questionnaire to assess the quality of access to WASH services for people with a disability has been prepared with the intention of pilot testing before the end of 2016. The Disability Centre at LSHTM is analysing survey data from Bangladesh, Malawi, India, Cameroon to explore the prevalence and nature of disability-related WASH access problems in these study populations. Findings from this analysis are expected in 2017.

Conclusion

There is suggestive evidence that inaccessible WASH provision has a negative effect on the lives of people with a disability. There is also suggestive evidence that well-designed, inclusively delivered, accessible WASH interventions can be effective in removing some of the external barriers facing people with disabilities, and need not cost more.

There is a need for rigorous research that builds a clearer picture of the effects of inaccessible WASH on people with disabilities and that further develops our understanding of how best to design and deliver WASH interventions that improve the lives of this often-vulnerable group. However, common sense and existing qualitative evidence makes a strong case for the need for WASH interventions to be fully inclusive in their approaches, if the human rights of people with disabilities are to be upheld and the new ambition for universal access and inclusive provision for WASH is to be achieved.

A recent mapping report by UNICEF (WASH and Disabilities) took the measure of inclusive and accessible WASH activities in UNICEF country offices globally. The study consolidated information about what constitutes good practice, and found and documented several examples of good practice in UNICEF country programmes. Drawing on these examples, the report finds broad agreement among WASH practitioners on the basic characteristics of good practice in accessible and inclusive WASH:

- Engage with the **enabling environment** (e.g. upstream policy advocacy, standards setting, addressing stigma, rights to information in multiple formats);

- Consult with and be **participatory** involving **children with disabilities** and **Disabled Persons Organizations (DPOs)**;
- **Comprehensively define accessibility** as combining sensitization and social norms as well as technical and hardware solutions.

Furthermore, the UNICEF report, which was validated through consultative processes with stakeholders, makes six recommendations vis-à-vis planning and delivery of inclusive WASH services:

1. Social/child Protection-WASH-C4D should collaborate in tackling stigma;
2. WASH strategies should prioritize collaboration with DPOs for upstream advocacy;
3. Regional and country offices should be equipped with inclusive WASH guidance and tools;
4. Knowledge-sharing about inclusive WASH activities should be incorporated into systems;
5. Global data/evidence monitoring on inclusive WASH should be advocated;
6. An investment case for inclusive and accessible WASH should be developed.

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