Evidence review and research priorities: Water, sanitation, and hygiene for emergency response

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Contents

This review was undertaken by the SHARE consortium at the request of the UK Department of International Development.

SHARE is a five year DFID funded research programme consortium that aims to generate rigorous and relevant research that can accelerate progress on sanitation and hygiene.

This review was written by the following researchers of the London School of Hygiene and Tropical Medicine (LSHTM): Joe Brown, Aurelie Jeandron, Sue Cavill, Oliver Cumming. The authors wish to thank Andy Bastable (Oxfam GB) together with those agencies and individuals involved in the Stoutenberg workshops.

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Summary

Water, sanitation, and hygiene (WASH) interventions can interrupt diarrhoeal disease transmission and reduce the burden of morbidity and mortality associated with faecal-oral infections. We know that a rapid response of effective WASH infrastructure and services can prevent or lessen the impact of diarrhoeal outbreaks that can exacerbate human suffering accompanying humanitarian crises. In this review summary, we present an overview of current knowledge about what works to prevent disease in emergency WASH response.

Evidence suggests that providing safe water, safe excreta disposal, and basic hygiene measures such as hand washing are effective interventions both within emergency settings as well as in longer-term development. Recent experience from humanitarian relief suggests progress has still to be made in meeting the basic WASH needs of people in crisis, however. We propose the following immediate priorities for research and innovation:

Innovative sanitation options for difficult settings. To identify and/or develop new emergency kits that are appropriate to a number of difficult settings including: high water tables, urban settings, unstable soil situations (Bastable and Lamb, 2012). In addition, improved promotional messaging is required for rapid uptake and consistent use of sanitation options. More work is needed to address critical unknowns about how to effectively deliver sanitation in both urban and rural emergency settings.

Technologies for water provision for dispersed communities. Whilst there is an abundance of technologies available for bulk water treatment for rapid provision of clean water in emergencies, the picture is less clear when it comes to providing water for dispersed affected populations (Bastable and Lamb, 2012; Luff 2012; Johannessen, 2011). There is a need to modify or develop technologies for rapid distribution in dispersed emergency situations to ensure faster, more predictable, and longer lasting access to safe drinking water.

Approaches to promote consistent, correct, and sustained use of water quality interventions. Point-of-use (POU) water treatment and safe storage has been shown to be a promising option for rapid access to safe water in relief settings. Documented low adherence may, however, limit the protective effects of these interventions (Clasen and Lantagne, 2012). More research is needed on whether new technologies, new approaches, or new behaviour change interventions - or more likely a combination of all three - may play a role in providing sustained access to safer water at the point of consumption.

Effective hygiene hardware and software. Hand washing stations (i.e., Happy Taps), safe water in sufficient quantity, and the availability of soap can contribute to more effective hygiene. Rapidly deployable hand washing stations have not been systematically evaluated in a humanitarian setting. More effective hygiene promotion strategies to encourage hand washing with soap and other healthy behaviours may also benefit those affected by emergencies.

1. Introduction

This review was commissioned by the UK Department for International Development (DFID) and undertaken by the SHARE Research Programme Consortium. In this document, we review the peer-reviewed literature to summarise the available evidence for WASH in humanitarian and emergency settings. Based on the review, we propose a number of areas for critical research to improve WASH response.

Methodology for literature review

This overview is based on the results of a search for peer-reviewed observational or experimental studies published in English after 1990 on WASH in emergencies. Medline, EMBASE and Global Health databases were searched with OVIDSP system with the search terms indicated in ANNEX 1.

A total of 312 references were identified. After duplicates were removed, these were manually screened on the basis of title and abstract for relevance. Only peer-reviewed articles were retained. In addition to the articles identified in a search of databases, the following journals were searched manually for relevant articles: *Journal of Water and Health, Waterlines, Disasters*. A selection of the articles retained were also screened for relevant additional references. Whilst we provide a brief summary (Table 2) of the relevant grey literature (Table 1) and links to key documents (Table 2), we have not attempted a summary of the voluminous existing unpublished documentation related to WASH in emergencies.

In this review of published literature, we have focused on water supply, water quality, sanitation, and personal hygiene. We have excluded topics related to vector control, solid waste, and drainage, although these have obvious points of intersection with the selection, implementation, and maintenance of WASH services in emergency settings.

Data availability

Most disaster response experience related to water, sanitation, and hygiene is not recorded in the peer-reviewed literature. Communication of findings in the form of peer-reviewed research or case-studies is understandably a secondary consideration after more immediate needs are met. Moreover, crisis situations themselves are often not suited to controlled research and experimental methods may not be applied for ethical, logistical, financial, or human resource reasons. Therefore, few experimental studies of WASH interventions are conducted in humanitarian settings. Of the available observational and retrospective studies, case-studies are most common and report context-specific data on acceptability, use, and impact of strategies employed. Whilst these studies are useful as “snapshots” of the success of available practice, they may be more a commentary on the operational and programmatic responses to specific emergency situations themselves rather than controlled experiments of specific WASH interventions. Furthermore, publication bias – more frequent reporting of “positive” than “negative” experiences – may limit the availability of information on interventions and approaches that have not been shown to work. In this review, we attempt to both summarise the available published research (from the few available experimental and quasi-experimental studies) and also to identify the critical knowledge gaps (across a range of case studies) that could be bridged by better, more focused applied research.

Objectives
The objectives of this review are to:

1. Summarise current evidence of water, sanitation, and hygiene in emergency settings, with a specific focus on what works in reducing risks of faecal-oral disease transmission

2. Identify research gaps in the peer-reviewed literature for WASH in emergencies

3. Suggest priorities for research on WASH in humanitarian settings based on a broad assessment of recent experience in the sector

2. Context in the sector

Water, sanitation, and hygiene (WASH) measures are intended to protect health by reducing exposure to pathogens. Their implementation in non-emergency settings is supported by a wealth of evidence suggesting significant health gains as well as other benefits (Bartram and Cairncross, 2010). In emergency settings, rapid WASH provision can prevent outbreaks and an escalation of the total burden of disease and death associated with natural or man-made disasters. Outbreaks of diarrhoeal diseases, including dysentery and cholera, are common in emergencies. Faecal-oral diseases may account for more than 40% of deaths in the acute phase of an emergency, with greater than 80% of deaths in children under 2 years of age (Connolly et al., 2004). In some emergencies and post-emergency situations, diarrhoea can be responsible for the majority of deaths. During the Kurdish refugee crisis of 1991, for example, one estimate was that 70% of total deaths were attributable to diarrhoea (including cholera) (Toole and Waldman 1997). Post-response case studies and outbreak investigations have identified unsafe water (at source and point of use), lack of water (quantity), poor sanitation access or use, scarcity of soap and hand washing, and contaminated foods as risk factors for transmission. Kouadio et al. (2009) summarize infectious disease outbreaks following natural disasters and conflicts, many of which are directly related to WASH.

Emergency situations are challenging environments for WASH implementation and recent experience from Haiti and elsewhere has highlighted the limitations of current emergency sanitation options (and to a lesser extent safe water supply and hygiene promotion) within humanitarian response (Patel, Brooks, Bastable, 2011; Schultz et al, 2009). The need for more suitable approaches and technologies for rapid deployment to emergencies has been widely acknowledged in the humanitarian sector and discussed at the recent Stoutenberg workshops (Johannessen 2011).

The need for improved WASH strategies for emergencies has generated a number of new approaches that have been explored by relief organizations, leading to rapid innovation. There remains insufficient confidence and evidence of what works, what doesn't, and why in emerging processes, technologies, and approaches for humanitarian WASH services, however. Unknowns persist about which strategies are suitable for the immediate emergency phase and which technologies, practices, and approaches may permit a transition towards more sustainable solutions and future resilience.

3. Evidence review

The following three sections briefly review available evidence on WASH in humanitarian settings, with a brief description of research priorities identified. Tables 3 – 6 provide summaries of key studies on sanitation (Table 3), water supply (Table 4), water quality (Table 5), and hygiene (Table 6).

3.1 Sanitation

Effective sanitation can prevent disease and rapid response is important. Whilst basic options exist, innovation is needed to meet known challenges.

Summary of the peer-reviewed literature

Safe excreta disposal is the first line of defence against faecal-oral pathogen transmission. Sanitation options for the humanitarian context have been widely studied and it is widely recognised that no one solution is appropriate for all cases (Wisner and Adams 2002; Harvey and Reed 2005; Howard 1996). Excreta need to be contained in the quickest time possible to prevent the spread of infection (Sencan et al., 2004), but currently available options may not be adequate to meet the challenge of rapid response. Some emerging sanitation solutions are not developed or refined enough to be available for immediate dispatch in the first phase of an emergency.

Sanitation is often a defecation field, trench latrine or communal latrine solution until the immediate emergency phase is over, during which capacity is quickly overwhelmed by the numbers of users, pits fill up and become a hazard, and maintaining hygienic conditions becomes a challenge. Open defecation, and the use of plastic bags (flying latrines) are commonly practised alternatives (Patel et al., 2011). Lora-Suarez et al. (2002) noted a significant increase in giardiasis among children associated with shared sanitation (compared to individual household sanitation) following an earthquake in Colombia. Standards recommend no more than 20 people per latrine (Table 1), but for maintaining hygienic conditions one household per latrine is ideal.

Problems with safe excreta disposal were particularly evident in Haiti (Johannessen 2011; Bastable and Lamb, 2012). The inability to dig pit latrines - due to a high water table, concrete sites, or lack of permission - slowed the aid effort considerably. Agencies took weeks to construct wooden raised latrines with small holding tanks. In 2009 similar problems were experienced in the floods in Greater Manila, Philippines. The use of “porta-loos” as a temporary measure in these contexts proved inadequate due to high cost and small storage capacity. Such examples illustrate that agencies may be poorly equipped to deal with the rapid provision of safe excreta disposal in urban emergency contexts.

Priorities for targeted research and further innovation

Wastewater and faecal sludge treatment and disposal

There is a clear need for innovation in managing wastewater and faecal sludges that are generated in the humanitarian context. Innovative, decentralised wastewater treatment options (membrane bioreactors, constructed wetlands, anaerobic filters) have been studied (e.g., Paul 2005; Randall et al. 2008) but have not been widely adopted. Current solutions for sludges, such as de-sludging and sludge disposal and treatment kits, may be too costly and require skilled management, and may result in health risks where the sludge is finally dumped. There has been some innovation with de-sludging (Oxfam GB has been experimenting with a diaphragm mud pump and a supernatant water pump), but more work remains to be done to drive down costs and expand the range of appropriate, practical

options. Where and how waste is disposed of is critically important to containing faecal-oral disease (Howard, 1996).

Containment and chemical disinfection of waste and wastewater from cholera and other infectious-disease impacted environments has been practised using chlorine, lime, and other means although the effectiveness of these strategies *in situ* in reducing target microbial contaminants has not been formally assessed and deserves greater attention.

Sanitation under challenging conditions

Implementing effective excreta containment under challenging physical conditions such as unstable soils, high water tables, and in flood-prone areas remains a challenge both in the development and post-emergency context (Djonoputro et al. 2010). Alternative systems may be required, including lining of pits to prevent pits from collapsing or building raised latrines (when digging down is not an option). There is potential to develop new technologies (such as septic tanks that can be rapidly constructed in areas with a high water table) as well as a need for more research on the effect of existing and emerging strategies for sanitation on available water sources.

Some settings may require unconventional approaches. Technical solutions need to be innovative and responsive to the specific physical, social and cultural circumstances of the disaster-affected population. There has been some experience with people using a *Peepoo bag* (a double bag system containing powdered urea which prevents bad smells and speeds up the biodigestion process) or simple biodegradable bags (Patel et al., 2011), although more research is needed to characterise the role of Peepoo or conventional bags in meeting emergency sanitation needs and their implications for sludge treatment and disposal.

Design

Some sanitation options may benefit from design improvements for specific contexts. Plastic sheeting as a superstructure material, used in rapid response, that gets ripped has implications for dignity and security and often means the latrine isn't used (Johannessen 2011). Oxfam have done some innovative work with prefabricated superstructure(s) that can be shipped or easily assembled with local materials and easily erected over latrines on site. Sanitation options that are user-friendly for women, men, children, and disabled persons exist, but innovation may increase available options' acceptability, effectiveness in excreta containment, safety, and maintenance over time. Pre-existing preferences and practices for excreta disposal may need to be considered carefully in designing and implementing sanitation options that will be used consistently. This is an area of rapid development by sectoral stakeholders, but focused research is needed to evaluate and implement emerging options.

Promotion

Whilst better design, implementation, and perhaps most importantly, regular maintenance to ensure hygienic conditions, may encourage consistent use of available sanitation options, other activities to support healthy behaviours and safe excreta disposal may be needed. This must come from an understanding of what drives these behaviours in the target population, and the careful formative research required is often not feasible in the humanitarian context. Methods for rapidly assessing and then incorporating into programming drivers of sanitation adoption, access, and use are needed.

3.2 Water supply and water quality

There is strong evidence that both sufficient water (quantity) and safety (quality) are critical to interrupting disease transmission in humanitarian settings. Better models are needed for rapid delivery of water to dispersed populations and more research is needed to support adherence to water quality interventions.

Summary of the peer-reviewed literature

There are established and accepted methods for water provision in emergencies (e.g., Sherlock 1988) although context-specific factors such as political, economic, social, and environmental constraints may impact how these are put into place (Shelley 1994), how effective they are, whether they may result in increased risk of vector-borne diseases such as malaria or dengue (Bayoh et al. 2011). Installation may be complex, requiring special expertise, and time-consuming, slowing response time and the delivery of safe drinking water in the critical early stages of response. The pursuit of more sustainable water supplies in the first instance may delay response time but may have longer-term advantages (Randall et al. 2008). The process of selecting from available technologies itself may not be straightforward in rapid response, where there is a need for immediate access to potable drinking water but acknowledgement that the supply needs to be sustainable. The need for immediate water provision often takes precedence, justifiably. The delayed water supply response following the 1999 earthquake in Turkey, for example, was linked to higher faecal-oral disease seroconversion in children (Sencan et al. 2004, hepatitis A and E viruses).

There is evidence that sufficient water (quantity) for health and well-being, including hygiene needs, is protective against disease in emergency settings, and international standards exist for water provision in emergencies (Table 1). Cronin et al. (2008) observed that households reporting diarrhoea within the previous 24 hours had a mean 26% less water available. In a seven-country review of 51 camps from 1998-2000, Spiegel et al. (2002) concluded from a systematic risk factor analysis that camps with lower than the recommended 15 litres of water per person per day had significantly higher under-5 mortality. Following the arrival of 800,000 Rwandan refugees into the Democratic Republic of the Congo in 1994, 85% of the first month's 50,000 deaths were due to diarrhoeal diseases (mainly cholera and shigellosis). The primary risk factor was lack of access to water: the per-capita water allowance was 0.2 L per day in the first week of the crisis (Connolly et al. 2004). Further, water that is supplied must be accessible and acceptable to users. Atuyambe et al. (2011) found that the inconsistent nature of tanked water provision as well as taste acceptability issues resulted in camp residents using untreated surface water. This also underscores the importance of prior knowledge about water safety among the population being served. Water supplies must be both safe and acceptable to users, although quantity may take precedent over quality (Luff 2004) in terms of delivering a wide range of health benefits, including those that are primarily linked to hygiene.

There is some evidence that community ownership of water supplies and demand-driven approaches may increase the sustainability of water supplies (Boydell 1999), but how anything but a top-down, supply-side solution for water provision can be effected in an emergency situation is unclear. In many cases, there would be ethical obstacles to requiring community investment in these types of situations. Transition to a longer-term, sustainable approach to water supply following an emergency often requires a change of approach. Solutions that are both rapidly deployable and come with a plan for the transition to long-term sustainability are needed, especially if new systems and services make communities more resilient against future emergencies. The management of water supplies in post-emergency transition has received some attention (e.g., Pinera and Reed 2008), but the well-known institutional, financial, environmental, and social constraints that limit water infrastructure services in low-income settings threaten access to safe water once any special attention (funding, human resources) that may have been the result of an emergency has been redirected.

Water quality interventions (point-of-use treatment and safe storage)

There is evidence that drinking water quality at the point of consumption is an important determinant of risk of disease, so a number of studies have focused on point-of-use (POU) water treatment in humanitarian response (Gupta et al. 2007; Steele et al. 2008; Clasen and Boisson 2006). Water quality interventions such as POU water treatment and safe storage have been studied for their effectiveness in reducing risk of diarrhoeal diseases (including cholera) in emergency response and refugee camp situations. Current evidence is suggestive of protective effects of both active treatment as well as safe water storage (such as narrow-mouth containers or containers with controlled access) with documented effects against cholera (Hatch et al. 1994; Shultz et al. 2009; Hashizume et al. 2008; Reller et al. 2001) and diarrhoeal diseases in general (Roberts 2001; Hashizume et al. 2008; Walden 2005; Doocy and Burnham 2006; Kunii et al. 2002; Mourad 2003). The evidence for health impact of these interventions should be interpreted in light of the known, potentially significant sources of bias common in these studies (Schmidt et al. 2010) and the lack of placebo-controlled trials showing a reduction in disease. Chlorination, chlorination preceded by flocculation, boiling, ceramic filters have been studied in humanitarian settings. Work by Lantagne (2011) has shown that the use of POU water quality interventions in emergencies has the greatest likelihood of success when effective technologies are distributed to households with contaminated water who are familiar and comfortable with the option before the emergency, and have the training and support necessary to use the option after the emergency.

Critically, consistency of use or adherence may limit the impact of POU water treatment, and some cases of low adherence exist in studies conducted in humanitarian response. Mong et al. (2001) reported 50% adherence to POU chlorination and Clasen and Boisson reported approximately the same level of adherence to POU ceramic candle filtration at 16 weeks post-implementation. Colindres et al. (2007) reported 45% adherence to a POU combined flocculent-disinfectant at 3 weeks after distribution. Atuyambe et al. (2011) reported "unsuccessful" uptake of boiling in Uganda due to taste acceptability issues in the target population. Water quality interventions can only protect public health if they are used correctly and consistently, and adherence is especially important when the risk of disease associated with untreated water is high.

Research needs: water supply and water quality

Research is needed to modify or develop technologies for rapid distribution in emergencies so that beneficiaries in dispersed emergency situations have faster, more predictable and longer lasting access to safer drinking water. This includes both rapid deployment of drinking water treatment and distribution methods for safeguarding water to the POU. Because safe water may be distributed and subject to recontamination, appropriate distribution methods to the POU with a focus on protecting water quality are needed. Dedicated safe storage containers or packaged water distribution may be needed to safeguard quality. The challenge of rapidly providing 15+ litres per person per day of safe water (and the means to protect it from recontamination) is formidable.

Also, more research is needed on appropriate means of creating high adherence to POU water treatment and safe storage through effective technology design and behaviour change. The available evidence from POU interventions in the humanitarian context suggests that water quality interventions may be protective against disease but high adherence is probably required to maintain health impact. A number of studies of POU water treatment from non-emergency settings have shown reduced use of interventions over time, raising questions about the potential for sustained use (Luby et al. 2001; Mausezahl et al. 2009; Brown et al. 2007) and therefore health impact when untreated water is unsafe.

3.3 Hygiene

The role of hand washing in preventing faecal-oral disease transmission is known, including in outbreaks. Promotion of hand washing with soap involves behaviour change, which can be slow. Are there rapid approaches that work? Is there a role for hardware?

Summary of the peer-reviewed literature

Hygiene interventions can interrupt faecal-oral disease transmission and hand washing with soap in particular may be critical in outbreaks. Peterson et al. (1998) demonstrated that regular soap distribution (240 g bar soap per person per month) resulted in a 27% reduction in diarrhoeal disease among households with consistent soap availability in a refugee camp in Malawi, and two studies have suggested a protective effect of hand washing with soap against cholera in outbreaks (Hutin et al. 2003; Reller et al. 2001). Soap availability and use behaviour is also critical, however, and user preferences and knowledge must be addressed, as suggested by data from a Ugandan emergency response in 2010 (Atuyambe et al. 2011) where hand washing was limited by soap type preferences and inconsistent availability. These factors suggest that hygiene promotion in emergencies is recommended and should accompany soap provision.

There are examples of innovative hygiene promotion approaches such as Community Health Clubs that have been promoted in IDP camps in Uganda. No peer-reviewed studies exist on the associated hygiene "hardware" such as hand washing stations or hygiene kits that may promote healthy hygiene behaviours in an emergency context. Rapidly deployable hardware that may aid in hygiene promotion is an area of potentially important innovation for WASH emergency response.

Research needs: hygiene

Hygiene hardware innovation and research may facilitate more effective behaviour change. Hand washing stations (such as the Happy Tap, Figure 1) or personal hygiene kits may increase uptake and consistency of hand washing. Their use in humanitarian response should be formally assessed.

Hygiene promotion software that rapidly increases hand washing and healthy hygiene behaviours should be the focus of innovation and evaluation. Soap distribution may need to be supplemented by specific supporting activities to be most effective. Given the critical role of hand hygiene in protecting health – especially during an outbreak – hand washing behaviours may merit further research to make the available interventions more effective.

Figure 1. The Happy Tap handwashing station, introduced by WaterSHED-Asia. Image courtesy of WaterSHED-ASIA and USAID. http://www.watershedasia.org/usaid-and-launches-innovative-handwashing-device-at-investor-forum-in-vietnam/.

3.4 Cross-cutting themes

In addition to specific areas of research for water, sanitation, and hygiene, we have identified three cross-cutting themes for research and innovation on WASH in emergencies:

1. The potential to bridge the humanitarian-development gap

Emergency response happens within the longer-term development process (Davis 1988) and WASH strategies that promote or are consistent with sustainable development over time are needed. Also, many refugee or displaced persons camps are in existence for long periods, up to many years (e.g., Sudan, Palestine: Walden 2005; Mourad 2003). WASH technologies sometimes fail to provide for the longer-term or transitional needs of disaster-affected communities, and this is a wasted opportunity.

In emergencies, long term solutions and systems thinking are needed and this needs to be reflected in technology choice. However, innovation in design would also have relevance outside of emergencies - many of the same issues can be found in the development context. For example, latrine flow slabs are expensive, there are issues of de-sludging, etc. Innovation and research could therefore make products available more quickly, locally and cheaper through a developed distribution network. We need to improve our understanding about which approaches and technologies are good for the immediate emergency phase and which technologies, practices, and approaches, permit a transition towards more sustainable solutions.

2. Inclusion

Whilst there are examples of good practice, it should be noted that there is no systematic approach or guidelines to issues of inclusion in the emergency context. The WASH response should be inclusive with respect to:

Women and girls

Safety concerns of women and girls have been documented challenges potentially affecting access to and use of sanitation options in a humanitarian context (Atuyambe et al. 2011). Although we found no published evidence that location (relative to living quarters) of sanitation (or water source), shared or collective sanitation versus individual, or amenities (lighting, locks, and other design elements) of sanitation options have been linked with violence or threats of violence against women, this is a frequently cited issue and there is evidence that this perception persists and may affect the design and implementation of excreta disposal options. These perceptions should be accounted for in placement of sanitation and water points and lighting options should be appropriately considered. No one can be expected to use a latrine if the conditions are perceived to be unsafe.

Females are generally responsible for managing water, protecting water quality, and maintaining domestic hygiene, and this is also true in emergency settings. Water provision, water quality interventions, and hygiene promotion must therefore focus on women and girls, include their active participation and empowerment, and account for their needs and preferences in response strategies (Nawaz et al. 2010). Because water collection and may be a primary responsibility of women and girls, accessibility and safe transport of water should be designed with this in mind. This may impact siting of water sources and provision of means to carry water safely and without injury. If household water treatment options are being considered, women's preferences and needs should be consulted and included.

Although guidelines for meeting menstrual hygiene needs exist (e.g., Sphere standards), more work is needed to characterise appropriate strategies (Sommer, 2012). Safe, hygienic, and private options for cleaning or disposal of cloths and other materials are needed and preferences for this may vary. The needs and preferences of women should be accounted for in planning and implementation of services for meeting menstrual hygiene needs.

Pregnant or lactating women may benefit from water quality interventions and from increased water access. As with other vulnerable groups, the needs of women who are pregnant or nursing should be considered in the WASH response.

People with disabilities

The World Bank estimates that 20% of the world's poorest people are disabled, yet little attention has been paid to the needs of unrestricted access to WASH. This is especially true in the humanitarian context. Innovation for sanitation access must include careful consideration of meeting the needs of people with disabilities. Some refugee and displaced persons populations may have a high percentage of people with disabilities, and this may be especially true after natural disasters that have resulted in bodily harm (Wolbring 2011).

Children

Children need different excreta disposal facilities depending on age. If nappies are distributed, waste management is an issue, however with non-disposable nappies there is the problem of washing. Providing potties for children is an option where children are afraid of falling into a pit latrine or the other reasons why children might not want to use a toilet such as darkness, snakes and other animals, the smell, and dirtiness. Few sanitation options have been documented specifically for use by children, although they are among the most susceptible group to faecal-oral disease. Options for safe handling and disposal of children's waste are needed for emergency settings.

People living with HIV/AIDS

Populations affected by HIV/AIDS are especially susceptible to WASH-related illnesses and appropriate WASH responses may need to consider this and other vulnerable populations in response. High levels of HIV itself can lead to interruption in WASH services and increased

vulnerability to disease (Moss 2004). Co-infections, including diarrhoeal diseases, are known to influence HIV disease progression and are associated with higher risk of mortality, although more research is needed to fully characterise the links between WASH and HIV/AIDS. Diarrheal diseases may also cause individuals on antiretroviral therapy (ART) not to absorb therapeutic dosages of the medication (Isaac 2008, Brantley 2003, Bushen 2004) and may inhibit absorption of essential nutrients (Filteau 2009), leading to further declines in health. Care of HIV+ individuals in emergency settings should be accounted for in the design and implementation of WASH services.

3. Design innovation for rapid deployability

Rapid deployability is a priority for design and implementation for water supply, water quality interventions, sanitation, and hygiene measures. More suitable approaches and technologies are needed for rapid deployment to new major emergencies (Johannessen 2011). Rapid WASH response to emergencies can prevent follow-on infectious disease outbreaks, which can dramatically increase morbidity and mortality. During the 1991 Kurdish refugee crisis, delayed response was associated with high levels of mortality (Yip and Sharp, 1993); many more examples exist. The current situation could be improved through more innovative WASH technologies and approaches suitable for emergency situations. These designs need to be highly adapted to the context and at the same time be sustainable for the longer term. The private sector has a key role to play in innovating and supplying appropriate technologies for humanitarian settings. Whilst there are kit-based and other rapidly deployable solutions (particularly for water), this is an area that deserves further research and innovation to improve response time post-emergency.

The technologies deployed for WASH services and other NFRI (non-food related items) are still relatively *ad hoc* and improvised. The 'Interagency Plastic Slab' and 'Oxfam Bucket' are steps in the right direction, but much more is required as the humanitarian community works towards consensus of what works and what doesn't and seeks to establish competitive supply chains and agreed standards and approaches.

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Annex 1. Search strings for literature review

		Number of results in		
		EMBASE	MEDLINE	Global Health
Emergency setting				
1	exp disaster/ or exp mass disaster/ or exp disaster planning/ or exp natural disaster/			
2	exp refugee/			
3	1 OR 2			
Health impact, intervention studies				
4	(Impact* or intervention* or trial* or effectiveness or efficacy).mp			
Limits				
5	limit to (human and english language and yr="1990 -Current")			
Sanitation				
6	(sanit$ or latrine$1 or toilet$1 or ecosan or bathroom$1).mp			
7	((f?ece$1 or f?ecal or excreta or waste or refuse) adj3 (disposal or management or collection or contamination or treatment)).mp			
8	(sewage or sewer$1 or sewerage or drainage).mp			
9	(((soil-transmitted or soil-borne or intestinal) adj3 (helminth or helminthes or parasite$1 or worm$1)) or enteroparasite$1).mp			
10	6 OR 7 OR 8 OR 9			
11	10 AND 3 AND 4 AND 5	86	123	48
Water				
12	(water adj3 (suppl$3 or drinking or clean or safe or treatment or source or availability or volume or quantity or collection or storage or distribution or utility or quality or contamination or packaged or unsafe)).mp			
13	12 AND 3 AND 4 AND 5	73	80	59
Hygiene				
14	((hygien$ adj3 (food or domestic or personal or education or promotion or behaviour)) or soap or handwashing or hand washing).mp			
15	14 AND 3 AND 4 AND 5	12	8	5

Annex 2. Best practice guidance: the grey literature

There is an extensive grey literature outlining "what works" and best practice in the delivery of WASH interventions in emergency settings, spanning intra-agency briefing notes, project reports, training packs and lessons learnt or case study papers. Table 1 summarises recommendations for best practice in the WASH response according to the widely cited Sphere Project (Sphere 2011), and Table 2 illustrates the diversity of documents providing guidance for good practice in emergency response. Much of the knowledge about "what works" is the mostly tacit knowledge held by the humanitarian workers who are mobilised in response and who learn on the job or by trial and error. Institutional memory is therefore diffuse and grows organically with additional experience from each crisis.

One of the challenges for practitioners seeking guidance has been the often diverse, and sometimes disparate, sources of information emerging from practitioners when this accumulated experience is communicated. Knowledge sharing has occurred not just through published papers but also through various sector forums – both online and traditional – as well as training and capacity-building activities held within and between operational agencies. Technical enquiry services, for example those offered by RedR, Practical Action, DEWPoint and KnowledgePoint, have played an important role in responding to *ad hoc* requests for guidance.

Some agencies, particularly INGOs and UN agencies, have published conference proceedings, technical guidance manuals, and other documents in order to share knowledge. Much of the best practice literature has historically reflected in-agency policy rather than broader sector-level consensus but has laid important foundations for inter-agency dialogue.

There have been various communities of practice and inter-agency meetings convened over the last twenty years to share learning and ideas. Perhaps the most significant recent initiative was the establishment of the WASH Cluster. The 'cluster approach' was one pillar of the reforms agreed in 2006 by UN agencies and other organisations active in the field of humanitarian response. The WASH Cluster has three key responsibilities: (1) setting standard and policy; (2) building response capacity; and, (3) providing operational support. Under the first objective of standard setting, the WASH Cluster seeks to both consolidate and disseminate standards and to identify best practice. The cluster has played an important role in both providing a platform for the sharing of learning, and providing a source of information for those seeking guidance through its website.

Another, more formalised attempt to improve guidance within the sector is the Sphere project and its Sphere Handbook, now in its third edition (Sphere 2011). Rooted in a rights-based and people-centred approach, the Sphere Handbook provides minimum standards for humanitarian responses across six sectors, including WASH. The guidelines are the result of "sector-wide consultations… involving a wide range of agencies, organisations and individuals, including governments and United Nations" and are generally accepted by the humanitarian sector as representing "best practice". Table 1 summarises the key standards and examples of the recommended indicators from the Sphere Project.

Table 1. Selected water, sanitation, and hygiene recommendations for emergency response (Sphere 2011).

Water		Sanitation		Hygiene	
Standard	**Indicators**	**Standard**	**Indicators**	**Standard**	**Indicators**
Water quantity	Total basic water needs: 7.5-15 litres per day	**Environment free from human faeces**	All sanitation situated >30 m from any groundwater source	**Hygiene Promotion Implementation**	All facilities are appropriately used and maintained
	Max. distance to nearest water point <500 m; queuing time <30 mins		Toilets are used (and children's faeces disposed of) hygienically		All wash hands after defecation/ cleaning children, before eating/preparing food
Water quality	No faecal coliforms per 100ml at point of delivery and use	**Appropriate and adequate toilet facilities**	Max. of 20 people use each toilet	**Identification and use of hygiene items**	All have access to hygiene items and these are used effectively
	No outbreak of water-borne or water-related diseases		Security threats are minimised, especially to women and girls		All women and girls of menstruating age are provided with appropriate menstrual hygiene materials
Water facilities	Household has min. 2 clean water collecting containers				
	At least 1 washing basin per 100 people				

Table 2. Selection of grey literature on WASH interventions in emergencies

Type of document	Selected references	Link
Books and manuals	John Hopkins and IFRC, 2008, Public Health guide for emergencies, 2nd ed.	*http://www.jhsph.edu/refugee/publications_tools/publications/_crdr_icrc_public_health_guide_book/public_health_guide_for_emergencies*
	Jan Davies and Robert Lambert (2002) Engineering in Emergencies: A Practical Guide for Relief Workers. Practical Action Publishing	
	MSF, 1994, Public Health engineering in emergency situations	*http://www.msf.org.uk/books.aspx*
	ODI, Chalinder, A., 1994, Good practices review: Water and sanitation in Emergencies	*http://www.odihpn.org/hpn-resources/good-practice-reviews/water-and-sanitation-in-emergencies*
	ACF International network, 2005, Water, sanitation and hygiene for populations at risk	*http://www.actioncontrelafaim.org/fileadmin/contribution/8_publications/pdf/wsh_acf.pdf*
Technical guidelines	Oxfam, 2006, Guidelines for water treatment in emergencies	*http://policy-practice.oxfam.org.uk/publications/water-treatment-guidelines-for-use-in-emergencies-126732*
	House, SJ and Reed, RA (1997) Emergency Water Sources: Guidelines for selection and treatment, WEDC, Loughborough	
	ADPC, 2000, Tools and resources for post-disaster relief	*http://www.adpc.net/v2007/IKM/ONLINE%20DOCUMENTS/downloads/DANA-tool-postdis.pdf*
	IFRC, 2008, Household water treatment and safe storage in emergencies	*http://www.ifrc.org/Global/Publications/Health/water-and-sanitation/142100-HWT-en_LR.pdf*
Technical briefing notes	OXFAM, 2010, The use of Poo-bags for safe excreta disposal in emergencies	*http://policy-practice.oxfam.org.uk/publications/the-use-of-poo-bags-for-safe-excreta-disposal-in-emergency-settings-136535*
	WHO and WEDC, 2011, Technical notes for emergencies	*http://wedc.lboro.ac.uk/resources/who_notes/WHO_TN_ALL.pdf*
	SUSANA, 2009, Sustainable sanitation for emergencies and reconstruction situations	*http://www.susana.org/lang-en/library/rm-susana-publications?view=ccbktypeitem&type=2&id=797*
Conference proceedings	World Water Week, 2009, Abstracts volume, Workshop 5: Safe water service in post-conflict and post-disaster context	*www.worldwaterweek.org/documents/.../2009_Abstract_Volume.pdf*
	OXFAM working paper, 1995, Proceedings of an international workshop: sanitation in emergency situations	*http://policy-practice.oxfam.org.uk/publications/sanitation-in-emergency-situations-proceedings-of-an-international-workshop-hel-121065*

	31st WEDC International Conference, 2005, Paul P., Proposals for a rapidly deployable emergency sanitation treatment system	*http://www.wedc-knowledge.org/wedcopac/opacreg.dll/fullnf?Search_link=AAAA:5822:59734193*
Lessons learned	ALNAP, 2008, Flood disasters: learning from previous relief and recovery operations	*http://www.alnap.org/resources/lessons.aspx*
	OXFAM, 2011, Urban WASH lessons learned from post-earthquake response in Haiti	*http://policy-practice.oxfam.org.uk/publications/urban-wash-lessons-learned-from-post-earthquake-response-in-haiti-136538*
	UNICEF, 2010, Community led total sanitation: Part of the emergency response in flood-affected villages in central Mozambique	*http://www.unicef.org/mozambique/Lesson_Learned_-_CLTS.FINAL_(11_11_2010).pdf*
Strategic documents	UNICEF, 2010, Core commitments for children in humanitarian action	*http://www.unicef.org/publications/index_21835.html*
	Global WASH Cluster, Strategic Plan 2011 - 2015	*http://oneresponse.info/GlobalClusters/Water%20Sanitation%20Hygiene/restricteddocuments/Global%20WASH%20Cluster%20Strategic%20Plan%202011-2015%20Vs3.doc*
	WELL, 2006, A strategic approach to water and sanitation in disasters	*http://www.wedc-knowledge.org/wedcopac/opacreg.dll/fullnf?Search_link=AAAA:M:129812990105*
Websites	WEDC publications	*http://wedc.lboro.ac.uk/knowledge/bookshop.html*
	WASH cluster website	*http://oneresponse.info/GlobalClusters/Water%20Sanitation%20Hygiene/Pages/default.aspx*
	Tearfund International learning zone	*http://tilz.tearfund.org/Topics/Water+and+Sanitation/*

Acronyms: IFRC International Federation of the Red Cross and Red Crescent Societies; MSF Medecins Sans Frontieres; ODI Overseas Development Institute; ACF Action Contre la Faim; ADPC Asian Disasters Preparedness Centre; ALNAP Active Learning Network for Accountability and Performance in Humanitarian Action; WHO World Health Organization; WEDC Water, Engineering and development centre; SUSANA Sustainable Sanitation Alliance; UNICEF United Nations Children's Fund.

Table 3. Systematic studies: sanitation

Authors (year)	Site, type of emergency, number affected	Study type	Sample size	Exposure measure(s)	Outcome measure(s)	Findings	Interpretation, implications, & comments
Ahmed 2008 (data from 2007)	Bangladesh, floods, millions	Observational, cross-sectional	880 households from selected eight flood affected areas; Households with latrines having at least 3 rings and 1 slab were selected for the study	Latrine, household, and user characteristics	Damage to and use of latrines as a result of flood impacts	Non-expert construction (95% CI 0.15-0.29: OR 1.58: p<0.001), had exposed rings (95 % CI 1.12-1.99; OR 1.50; p <0.005), installed below homestead level (95 % CI 4.05-7.67; OR 5.58; p <0.001) and were flooded under water (95 % CI 9.78 – 21.27; OR 14.42; p <0.001).	73% latrines were damaged during the flood, leading to increases in open defecation.
Schultz et al. 2009 (data from 2005)	Kenya, refugee camp, 90,000+	Case-control post-outbreak investigation	90 cases, 170 controls	Household and individual characteristics, including WSH	Cholera	Sharing a latrine with three or more households: (MOR = 2.17 [1.01, 4.68])	Increased risk of cholera related to shared latrines, possibly low per-capita latrine access

Atuyambe et al. 2011 (data from 2010)	Uganda, landslide, 5000	Post-disaster cross-sectional survey of WSH	397 participants and 27 key informant interviews	Household and individual characteristics	Behaviours and use of WSH	Latrines were few (23 for 5000 people), shallow, dirty (70% reported flies, 60% fecal littering), not separated by sex and had limited privacy and no light at night; Cultural beliefs may prohibit latrine sharing among groups of people, such as in-laws or between families (Mukungu 2000[1]).	Access to safe, clean, and sufficient numbers of latrines recommended for effective excreta disposal; shared latrines may not work due to cultural taboos
Kunii et al. 2002 (data from 1998)	Bangladesh, floods, millions	Retrospective risk factor analysis	517 participants	Household and individual characteristics, including WSH	Self-reported diarrhoea	Low latrine use associated with diarrhea risk	Low sanitation access or use increases risk
Puddifoot 1995 (data from 1992-1993)	Nepal, refugees, 86,000+	Longitudinal observational study of latrine (Ventilated Improved Double Pit) access and diarrhea	Unstated. 8000 latrines were built	Latrine access	Diarrhoea	Diarrhoea fell from 6.6 cases/100 to 3.5 cases/hundred post-intervention; construction of 1 latrine per 10 persons resulted in disease reduction	87% of participants had never before used a latrine; concurrent hand washing messaging may have contributed to reduction in disease; innovative kit-based model with participatory construction

[1] Mukungu DM: Rural sanitation problems in Uganda–institutional and management aspects. Schriftenr Ver Wasser Boden Lufthyg 2000, 105:377-381.

Sencan et al. 2004 (data from 1999)	Turkey, earthquake, 17225 deaths and hundreds of thousands affected	Seroprevalence of HAV and HEV and risk factor analysis	476 children	Water and sanitation provision	Seroprevalence of HAV and HEV in children	Areas remaining without access to sanitation and water supply at significantly higher risk	Rapid service provision critical
Patel et al. 2011 (data from 2010)	Haiti, earthquake, 1.5 million internally displaced persons	Longitudinal observational trial. One settlement used Peepoo bags for 2 weeks, followed by 2 weeks' use of standard grocery-sized bags. Another settlement used grocery bags for 4 weeks	54 households/290 people (Peepoo followed by standard bags), 391 households/1921 people (standard bags)	Peepoo and standard bag excreta disposal	Household use of and preferences for Peepoo and bag excreta disposal; diarrhoea	49% of households reported preference for Peepoo or bag excreta disposal; Peepoo was preferred due to its ability to reduce odour; diarrhoea reduced from 42% to 36% post-trial ($p<0.03$)	Population had pre-trial experience with bag defecation; improper use common; advantages and disadvantages documented; Peepoo may require a dedicated container also
Lora-Suarez et al. 2002 (data from 2000-2001)	Colombia, earthquake, 1184 deaths, 5000 injured, 80% houses destroyed	Cross-sectional survey	217 children aged 3-13 in 194 households	Water and sanitation access, house and food storage hygiene	Presence of Giardia cysts in stools	Communal latrines as a risk factor compared to household latrine (95% CI 1.2-16; OR 3.9; $p=0.01$)	Shared latrine increases risk of giardiasis; Pre-disaster prevalence unknown, small sample size
Moll et all. 2007 (data from 2000-2002	Central America, hurricane, 10,000 people killed, 3.6 million people affected	Post-disaster, cross-sectional before and after WASH interventions	800 households in 8 study areas in 4 countries	Water and sanitation access, household characteristics and hygiene behaviour	Reported incidence of diarrhoea in children under 3	Level of access to private or shared latrine in the community associated with a decreased risk of diarrhoea. (95% CI 0.57-0.94; OR 0.73; $p=0.015$)	Access to latrines in the community may decrease the risk of diarrhoea in young children. Association only in univariate analysis.

Table 4. Systematic studies: water supply

Authors (year)	Site, type of emergency, number affected	Study type	Sample size	Exposure measure(s)	Outcome measure(s)	Findings	Interpretation, implications, & comments
Cronin et al. 2008 (data from 2005-2006)	Ghana and Kenya, refugee camps (10,000 in Ghana, 50,000 in Kenya)	Observational, cross sectional	840 households (Ghana), 285 households (Kenya)	Water consumption, others	Diarrhoea cases	Households reporting a case of diarrhoea within the previous 24 hours collected a mean 26% less water than others	Households should have access to sufficient quantity of water (15 or 20 litres per person per day)
Spiegel et al. 2002 (data from 1998-2000)	Seven countries, multiple postemergency phase camps	Retrospective analysis using multivariate regression	678,296 across 51 camps in 7 countries	Sphere standards for services and conditions	Under 5 mortality	Camps with less water per person and high rates of diarrhoea had higher <5 mortality	Strong evidence that water provision meeting basic water (quantity) needs is protective of health
Atuyambe et al. 2011 (data from 2010)	Uganda, landslide, 5000	Post-disaster cross-sectional survey of WSH	397 participants and 27 key informant interviews	Household and individual characteristics	Behaviours and use of WSH	Bottled water initially. Use of surface water due to inconsistent tank supply, taste issues with the treated water, slow progress on a gravity fed system	Tanker water must be accessible consistently and meet user expectations of taste acceptability – otherwise will seek other sources. Taste and water use preferences not accounted for in the response. Effectiveness of response limited by pre-existing knowledge of water safety.

Sencan et al. 2004 (data from 1999)	Turkey, earthquake, 17225 deaths and hundreds of thousands affected	Seroprevalence of HAV and HEV and risk factor analysis	476 children	Water and sanitation provision	Seroprevalence of HAV and HEV in children	Areas remaining without access to sanitation and water supply at significantly higher risk	Rapid service provision critical
Garandeau et al. 2006 (data from 2003)	Liberia, internally displaced persons, 180,000	Programmatic evaluation of hand-dug well chlorination	12 public wells	Operational parameters	Residual chlorine	0.2 – 1.0 mg/l residuals maintained at low cost	One of many water source-based interventions for quality protection
Mondal et al. 2001 (data from 1998)	India, flood-prone area	Observational, longitudinal	411 exposed to floods, 488 controls, in pre and post-flood season	Drinking water from tubewells vs water ponds	Reported diarrhoea incidence	Drinking water from tubewells protective against diarrhoea in both groups, pre and post floods	Weak evidence that protected water sources may decrease the risk of diarrhoea. Only univariate analysis performed.
Lora-Suarez et al. 2002 (data from 2000-2001)	Colombia, earthquake, 1184 deaths, 5000 injured, 80% houses destroyed	Observational, cross-sectional	217 children aged 3-13 in 194 households	Water and sanitation access, house and food storage hygiene	Presence of Giardia cysts in stools	Municipal water use (surface water source treated with chlorine) as a risk factor compared to camp individual tank filled by truck (95% CI 1.1-14; OR 3.5; p=0.02)	Water supply must be checked for presence of giardia cysts as chlorine is not effective against giardia cysts.
Abouteir et al. 2011 (data from 2010)	Gaza strip, conflict, 1 million refugees since 1948	Observational, case-control	133 cases of diarrhoea attending PHCC and 133 controls	Household characteristics	Attendance at PHCC for diarrhoea	Access to public municipal water in household protective against diarrhoea (OR 0.046, p=0.008)	Unrestricted access to water in household may have an impact on diarrhoea.

Swerdlow et al. 1997 (data from 1990)	Malawi, cholera outbreak, refugee camp, 74,000 people	2 case-control studies	50 cases and 50 controls, 245 "index case" households and 137 control households	Water source	Cholera	Drinking water from the river associated with illness in household (95% CI 1.4-6.4; OR 3.0)	Providing safe water source is crucial during cholera outbreaks.
Moll et all. 2007 (data from 2000-2002	Central America, hurricane, 10,000 people killed, 3.6 million people affected	Post-disaster, cross-sectional before and after WASH interventions	800 households in 8 study areas in 4 countries	Water and sanitation access in the community, household characteristics and hygiene behaviour	Reported incidence of diarrhoea in children under 3	Level of access to a protected water source less than 200m of house in community is associated with a decreased incidence of diarrhoea. (95% CI 0.47-0.78; OR 0.61; p<0.001) Animals having access to water source is a risk factor for diarrhoea. (95% CI 1.15-1.90; OR 1.48; p=0.002)	Access to a protected water source near the household may decrease the risk of young children diarrhoea. Association only in univariate analysis.
Moren et al. 1991 (data from 1988)	Malawi, cholera outbreak, refugee camp, 30,000 people	Case-control study	51 cases matched with 51 controls	Water consumption	Cholera	Consumption of water from shallow wells associated with higher cholera incidence (95% CI 1.0-20.8; OR 4.5; p=0.04)	Providing safe water source is crucial during cholera outbreaks.

Table 5. Systematic studies: water quality

Authors (year)	Site, type of emergency, number affected	Study type	Sample size	Exposure measure(s)	Outcome measure(s)	Findings	Interpretation, implications, & comments
Hatch et al. 1994 (data from 1988)	Malawi, refugee resettlement, 440,000	Case-control study	48 cases and 441 randomly selected controls	Household characteristics including WSH	Cholera	aOR: 0.02 (0.003 – 0.012) for water storage aOR: 0.3 (0.12 – 0.7) for metal cooking pots	Having any water containers with >10 l capacity or having metal cooking pots were protective against cholera; implication is that these protect water quality
Colindres et al. 2007 (data from 2004)	Haiti, tropical storm Jeanne, 2,800 deaths and thousands displaced	Observational, cross-sectional survey following distribution of a point-of-use water treatment sachet	100 households who had received the product and training	Household characteristics including WSH	Knowledge and use of a combined flocculent-disinfectant (PUR)	58% of households using PUR 3 weeks after implementation. Of those, Cl detected in 45% of household stored water	Low uptake resulting from a range of context-specific factors, including unsystematic distribution and late deployment
Schultz et al. 2009 (data from 2005)	Kenya, refugee camp, 90,000+	Case-control post-outbreak investigation	90 cases, 170 controls	Household and individual characteristics, including WSH	Cholera	Storing drinking water at home in sealed or covered containers was protective against cholera (matched odds ratio [MOR] = 0.49 [0.25, 0.96]),	Safe water storage associated with lower risk of cholera

Gupta et al. 2007 (data from 2005)	Indonesia, tsunami, millions	Cross-sectional study of household water quality	1127 households	Household and individual characteristics, including WSH	Household water quality (*E. coli* > 0 per 100 ml)	Having an improved water source, (Aceh Besar, adjusted odds ratio (aOR) 0.41, *P* < 0.01; Simeulue, aOR 0.48, *P* _ 0.02), using chlorine solution (Simeulue, aOR 0.41, *P* < 0.01), and having free chlorine in stored water (Aceh Besar, aOR 0.42, *P* < 0.01; Nias, aOR 0.28, *P* < 0.01) were protective	Point-of-use chlorination and access to an "improved" supply associated with safer water. Boiling – widespread in Indonesia – showed no effect on water quality.
Roberts et al. 2001 (data from 1993)	Malawi, refugee camp, 65,000	Randomized controlled trial	401 households total (1160 people); 100 households (310 people) receiving a safe storage container	Presence of a safe storage container; other water use characteristics including water consumption	Diarrheal incidence	31% less diarrhoeal disease (P = 0.06) in children under 5 years of age among the group using the improved bucket	Safe storage containers associated with improved water quality and reduction in risk of diarrhoea
Hashizume et al. 2008	Bangladesh, flood, millions	Pre-and post-flood observational study	350 (pre-flood), 422 (post-flood)	Household and individual characteristics, including WSH	Cholera and non-cholera diarrhoea	The risks of post-flood non-cholera diarrhoea and cholera were significantly higher for those using "unsanitary toilets".	Importance of excreta containment and sanitation maintenance in a disaster context.

Mong et al. 2001 (data from 2000)	Madagascar, cyclone, 11,700 received relief kits from a larger affected population	Post-disaster observational study of point-of-use intervention (household chlorination and safe storage)	123 households	Reported water storage and treatment practices	Household water quality, post-implementation use of intervention	Free chlorine residuals greater than 0.2 mg/L were found in almost half of the water samples tested 5 months after the disaster, lower *E. coli* counts in Jerry cans than buckets	Low (~50%) long-term adherence to point-of-use chlorination. Safe water storage protective of water quality.
Reller et al. 2001 (data from 2000)	Madagascar, cholera outbreak, 37000 cases and 2200 deaths	case–control study to investigate risk factors for cholera transmission	32 cases, 49 controls	Water quality, water use, other possible exposures with links to outcome	Cholera	Drinking untreated water increased risk of cholera ([OR]=5.0; 95% confidence interval [CI]=1.3, 25.4). Boiling and using point of use chlorination were protective.	Point-of-use water treatment and water quality indicators suggest protective effect of safe water during a cholera outbreak.
Walden 2005 (data from 2004)	Darfur, refugee camp, 6900 households	Shigellosis outbreak pre- and post-event study	328 households (pre) and	Water quality, water treatment intervention (container disinfection using chlorine) during outbreak	Bloody and watery diarrhea	Cases of bloody and watery diarrhea fall dramatically after intervention; no statistics given	Weak evidence supportive of protective effect of water quality during outbreak

Atuyambe et al. 2011 (data from 2010)	Uganda, landslide, 5000	Post-disaster cross-sectional survey of WSH	397 participants and 27 key informant interviews	Household and individual characteristics	Behaviours and use of WSH	Uptake of recommended practice (boiling) unsuccessful due to pre-existing beliefs and preferences for the taste of unboiled water	Water quality interventions may be constrained by pre-existing beliefs and practices
Doocy and Burnham 2006 (data from 2004)	Liberia, refugee camp, 3000 households	Randomized controlled trial of a flocculent-disinfectant (PUR) for point-of-use water treatment (unblinded)	2215 participants in 400 households	Presence of the intervention, water quality	Self-reported diarrhea	Intervention associated with reduced diarrhoea incidence by 90% and prevalence by 83% over controls. High reported compliance (95%) indicated by disinfectant residuals.	Water quality interventions in an emergency context may yield significant health gains.
Kunii et al. 2002 (data from 1998)	Bangladesh, floods, millions	Retrospective risk factor analysis	517 participants	Household and individual characteristics, including WSH	Self-reported diarrhoea	1.0% and 6.7% of the respondents treated water before drinking, by boiling and chlorination, respectively, despite high perceived risk (75% reporting that water sources were contaminated)	Open-top storage containers, lack of access to water treatment tablets, and smaller water storage containers were found to be risk factors for diarrhoea
Mourad 2003 (data from 2001)	Gaza, refugee camp, approximately 83,000	Cross-sectional study and risk factor analysis	1625 households	Household and individual characteristics, including WSH	Self-reported diarrhea and intestinal parasites	Both outcomes associated with water source and water handling measures suggestive of water quality issues	Links between water quality and heath in a non-emergency camp context

Steele et al. 2008 (data from 2007)	Uganda, internally displaced persons, 1.6 – 2.0 million	In situ trial of water storage disinfection practice	13 households	Water storage disinfection practices	Recontamination of water stored in Jerry cans as measured by thermotolerant coliforms	Regular, high strength disinfection of storage containers may safeguard water quality	Water storage container disinfection may be an effective recommended practice where recontamination impairs water quality
Clasen and Boisson 2006 (data from 2003)	Dominican Republic, flooding, tens of thousands	Randomised, controlled trial of ceramic candle filters for point-of-use water treatment; follow on cross-sectional study 16-months post-implementation	80 households	Access to ceramic filter	Household drinking water quality	70.6% of samples met potable standards in intervention households versus 31.8% of control households; 48.7% of filters still in use 16 months post-implementation	Evidence for water quality impact and log-term use of ceramic candle filters
Mondal et al. 2001 (data from 1998)	India, flood-prone area	Observational, longitudinal	411 exposed to floods, 488 controls, in pre and post-flood season	Water storage with narrow neck and lid ("appropriate storage") vs wide-mouth vessels ("inappropriate")	Reported diarrhoea incidence	Appropriate storage protective against diarrhoea in exposed group during flood season (RR=0.69, p<0.01)	Weak evidence that appropriate household water storage may decrease the risk of diarrhoea. Only univariate analysis performed.
Moll et all. 2007 (data from 2000-2002	Central America, hurricane, 10,000 people killed, 3.6 million people affected	Post-disaster, cross-sectional before and after WASH interventions	800 households in 8 study areas in 4 countries	Water and sanitation access, household characteristics and hygiene behaviour	Reported incidence of diarrhoea in children under 3	Covering household water storage associated with a decreased risk of diarrhoea. (95% CI 0.11-0.93; OR 0.32; p<0.001)	Appropriate storage of water may decrease the risk of diarrhoea in young children. Association only in univariate analysis.

Swerdlow et al. 1997 (data from 1990)	Malawi, cholera outbreak, refugee camp, 74,000 people	2 case-control studies	50 cases and 50 controls, 245 "index case" households and 137 control households	Water source	Cholera	Putting hands in the water container associated with individual illness (95%CI 1.3-26.8; OR 6.0) Drinking water from the river associated with illness in household (95% CI 1.4-6.4; OR 3.0)	Providing narrow-mouth water storage vessels may have a protective effect during cholera outbreaks.

Table 6. Systematic studies: hygiene

Authors (year)	Site, type of emergency, number affected	Study type	Sample size	Exposure measure(s)	Outcome measure(s)	Findings	Interpretation, implications, & comments
Peterson et al. 1998 (data from 1993)	Malawi, refugee camp, 64,000	Observational, longitudinal Intervention: bar soap distribution (240g per person per month) with no other education	1417	Presence of soap in the household at surveillance points	Diarrhoeal disease incidence	RR: 0.73 (0.54 – 0.98)	Regular soap distribution alone resulting in 27% reduction in diarrhoea among households with soap present compared with others
Hutin et al. 2003 (data from 1995-1996)	Nigeria, cholera outbreak, 5600 cases and 340 deaths	Case-control	102 cases of cholera, 77 controls	Individual and household characteristics, including WSH	Cholera	Hand washing with soap before eating food was protective: AAOR=0.2; 95% CI: 0.1–0.6)	Hand washing with soap may reduce risk of infection in an outbreak scenario
Reller et al. 2001 (data from 2000)	Madagascar, cholera outbreak, 37,000 cases and 2200 deaths	Case–control study to investigate risk factors for cholera transmission	32 cases, 49 controls	Water quality, water use, other possible exposures with links to outcome	Cholera	Using soap to wash hands was protective against illness (OR=0.2; 95% CI=0.0, 0.7).	Hand washing with soap may reduce risk of infection in an outbreak scenario

Mondal et al. 2001 (data from 1998)	India, flood-prone area	Observational, longitudinal	411 exposed to floods, 488 controls, in pre and post-flood season	Handwashing always with soap after defecation Handwashing before having food	Reported diarrhoea incidence	Handwashing always with soap after defecation protective against diarrhoea in both groups, pre and post floods (RR=0.48 pre flood; RR=0,46 post-flood) Handwashing before eating protective against diarrhoea in both groups during flood seasons (RR = 0,64 exposed group; RR=0,54 control group)	Hand washing with soap after defecation or before eating reduces risk of diarrhoea, including during floods but not more than in non-exposed population. Weak evidence, only univariate analysis performed.
Roberts et al. 2009 (data from 2006)	Uganda, Internally displaced population, 650,000 IDPs	Observational, cross-sectional	1206 individuals in 28 camps	Absence of soap	SF-8 psychometric health status score	Absence of soap associated with lower physical health score	Presence of soap may protect against infectious diseases and may improve overall physical health status.

Moll et all. 2007 (data from 2000-2002	Central America, hurricane, 10,000 people killed, 3.6 million people affected	Post-disaster, cross-sectional before and after WASH interventions	800 households in 8 study areas in 4 countries	Water and sanitation access, household characteristics and hygiene behaviour	Reported incidence of diarrhoea in children under 3	Appropriate handwashing behaviour of food preparer associated with a decreased incidence of diarrhoea. (95% CI 0.53-0.90; OR 0.68; p=0.006) Appropriate handwashing behaviour of child care giver associated with a decreased incidence of diarrhoea. (95% CI 0.52-0.87; OR 0.67; p=0.002) Presence of soap in the household associated with a decreased incidence of diarrhoea (95% CI 0.52-0.94; OR 0.70; p=0.02)	Promoting a more hygienic behaviour may decrease the risk of young children diarrhoea. Association only in univariate analysis.