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Short-term WASH interventions in emergency responses in low- and middle-income countries

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Systematic Review Summary 8

Water and sanitation

3ie International Initiative for Impact Evaluation

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Summary

Background

An increasing number of people are affected by natural disasters, disease outbreaks and conflict. Water, sanitation and hygiene (WASH) interventions are used in nearly all emergency contexts to help reduce the risk of disease by providing safe water, reducing open defecation and promoting hygiene practices. However, evidence to support emergency WASH interventions is limited, forcing responders to rely on past experiences or extrapolated evidence from development settings.

Interventions

Emergency WASH interventions differ from development interventions because of the speed, scale and approach that are taken in emergency response activities. The needs of emergency-affected populations are often immediate, requiring rapidly increasing access to water and sanitation services. These situations also require the promotion of activities that may be unfamiliar to the population (e.g. treating water with chlorine for the first time). The main components of emergency WASH interventions include water, sanitation and hygiene interventions. Within the spectrum of WASH, 13 specific interventions common in emergencies have been included in this review: pumping wells flooded with saltwater; well disinfection; large-scale source treatment; small-scale source treatment; chlorine-based household water treatment; filtration-based household water treatment; other household water treatment; latrines and latrine alternatives; hygiene promotion; hygiene kits; environmental hygiene; and multiple WASH interventions carried out as a package. This review aims to assess the effectiveness of these interventions.

Methods

A comprehensive and systematic search strategy was developed to identify published and grey literature. Studies were identified by using keywords to search nine peer-reviewed databases and more than 50 responding agency websites. Direct solicitation of individuals and agencies was also conducted through global email lists, conferences and personal contacts.

Identified studies were screened by title, abstract and then full text. To be considered for inclusion, interventions needed to be WASH projects carried out within 12 months of a disaster or outbreak, less than 12 months in duration, occurring in a low- and middle-income country (L&MIC) and restricted to 1995–2016. Quantitative (experimental and non-experimental designs) and qualitative methodological designs were eligible, and both peer-reviewed and unpublished grey literature documents were accepted for review.

Studies that met inclusion criteria were coded, then evaluated for bias. Findings for each intervention type were presented through a narrative synthesis that combined outcomes from quantitative and qualitative sources. Review objectives were to determine the effectiveness of emergency WASH interventions, through: 1) use of

interventions; 2) health impacts; 3) non-health outcomes; 4) contextual barriers and facilitators; and 5) cost-effectiveness.

Implementation evidence

This review synthesised findings from 106 published and grey literature studies that included 114 contexts. Interventions were implemented in 39 different L&MICs. Nearly half (43%) of the studies were from sub-Saharan Africa, with Haiti and Zimbabwe having the most reported interventions. Water interventions represented the most included evaluations, followed by hygiene interventions and the WASH package. Half of the evaluations were published or documented between 2010 and 2015, and 85 per cent were within the last 10 years.

Main findings

Relative to the five review objectives, primary findings include:

Health outcomes – evidence that WASH interventions reduce disease risk was limited; however, reduced transmission risk was most often documented through the use of chlorine and its protective residual.

Use of services – 12 of the 13 WASH interventions identified were theoretically able to improve WASH conditions and reduce the risk of disease transmission. There was clear evidence *against* one of the 13 interventions: pumping wells flooded with seawater. Seven of the 13 interventions were shown to be effective in the field at the beneficiary level. These included: dispensers; three types of household water treatment; latrines; latrine alternatives; and hygiene promotion.

Non-health outcomes – community perceptions and preferences that affected emergency WASH interventions included: the taste and smell of water treatments; a preference for radio and face-to-face communication; an overestimation of impact; trust and fear within a community; and ease of use for an intervention.

Contextual barriers and facilitators – intervention characteristics that influenced the success of emergency WASH interventions included: well-timed responses; experienced staff; multiple communication modes; community-driven interventions; and clear links with previous development interventions.

Cost-effectiveness – while some cost information was available, the quality was not sufficient to assess cost-effectiveness.

Policy and programming implications

Several aspects of emergency WASH interventions and humanitarian policy emerged as a result of this review:

Field evidence – grey literature, which generally reports on low-quality evaluation types, is a valuable resource for including field evidence from emergencies in reviews. As opposed to strong evaluation methodology, the strength of field evidence is in any consistent outcomes and themes across multiple contexts.

Expectations of reporting and evaluation – collecting consistent indicators is needed to facilitate comparisons between interventions.

Enabling conditions – improved understanding of previous development projects and local social influences would improve emergency interventions. Technical efficacy of WASH interventions is generally established; however, effective and rapid behaviour change remains a primary hurdle to many emergency WASH interventions.

Research implications

The evidence for emergency WASH interventions is low and lacking; thus, there is ample opportunity to greatly improve the evidence base with clear research implications:

Intervention gaps – while additional evidence would be useful for many WASH interventions in emergencies, evidence is particularly needed for the large-scale source-based water treatment interventions of bulk water treatment and water trucking; the small-scale source water treatment intervention of bucket chlorination; all sanitation interventions; the hygiene promotion intervention of handwashing specifically; the adoption of, and user opinion of, hygiene kit distributions; and the environmental hygiene interventions of household spraying and environmental clean-up. Lastly, formal economic analysis is needed for all WASH interventions.

Research methods – evaluation methodologies that require significant time and resources (e.g. randomised controlled trials) are generally not appropriate or necessary for emergency WASH interventions. Quasi- or non-experimental evaluations with consistent methods can provide sufficient evidence across emergency settings.

WASH package interventions – programmes involving multiple WASH interventions are commonly carried out by responders, but are complex and difficult to research. Investigation of synergies and spillover impacts from WASH interventions carried out in combination is needed.

Best practice comparisons – numerous best practice and guidance documents are available from United Nations agencies, donors and responding organisations, but often contradict each other. An analysis to identify inconsistencies and consolidate what is considered best practice and what is evidence-based is needed to align activities across the sector.

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Abbreviations and acronyms

ACF	Action contre la Faim
BWT	bulk water treatment
CLTS	community-led total sanitation
FCR	free chlorine residual
HWT	household water treatment
L&MIC	low- and middle-income country
PUR	PUR® Purifier of Water
NGO	non-governmental organisation
SODIS	solar disinfection
WASH	water, sanitation and hygiene

1. Introduction

1.1 The problem

Emergency events where water, sanitation and hygiene (WASH) interventions are needed are occurring at increasing rates and affecting an increasing number of people. These emergency events include natural disasters, conflict and disease outbreaks.

> *Natural disasters* – natural disasters (i.e. earthquakes, hurricanes, flooding events, disease outbreaks or droughts) affect more than 200 million people annually (EM-DAT, 2014). Climate change is expected to increase the scale and frequency of natural disasters, and the rapidly increasing urban and slum populations in disaster-prone regions are expected to increase the number of people impacted by natural disasters (Walker et al., 2012).
>
> *Conflict* – currently, 1.5 billion people are potentially threatened by conflict and violence (Institute for Economics and Peace, 2014, IISS, 2015). As a result, in 2015 there were more than 60 million displaced persons (refugees and internally displaced persons) worldwide, the highest number ever recorded (UNHCR, 2015). This large number causes enormous strain on limited funds and resources.
>
> *Disease outbreaks* – between 1980 and 2013, 12,102 outbreaks of 215 human infectious diseases, including more than 44 million cases, were reported on the Global Infectious Disease and Epidemiology Online Network from 219 nations (Smith et al., 2014). The total number of outbreaks and the diversity of causal diseases (the number of diseases causing outbreaks) have both increased over time ($p<0.0001$).

As there is a growing number of people at risk and in need, evidence-based emergency WASH strategies are needed to support decision makers (Darcy et al., 2013, Parkinson, 2009). This is a summary of a systematic review of WASH interventions in emergencies.

1.2 The intervention

In almost all emergency contexts there is a basic need to establish access to WASH (Connolly et al., 2004, Toole, 1995, Toole, 1996). According to the *Humanitarian Charter and Minimum Standards in Humanitarian Response* (Sphere Project, 2011)*:*

> Water and sanitation are critical determinants for survival in the initial stages of a disaster. People affected by disasters are generally much more susceptible to illness and death from disease, which to a large extent are related to inadequate sanitation, inadequate water supplies and inability to maintain good hygiene.

Emergency WASH interventions should provide access to safe water and sanitation and promote good hygiene practices with dignity, comfort and security (Sphere Project, 2011). The overall aim of all emergency WASH interventions is to promote safe practices that reduce preventable waterborne and communicable diseases (Sphere Project, 2011).

1.3 Rationale

Recently, two systematic reviews, 1) WASH interventions for cholera response (Taylor et al., 2015) and 2) the health impact of WASH interventions in emergencies (Ramesh et al., 2015), concluded there was a lack of evidence to support implementing WASH interventions in outbreaks and emergencies. The reviews found that the quality of evidence is low and limited to only a small portion of interventions, primarily focused on household water treatment (HWT). However, neither review had inclusion criteria that enabled a full appreciation of the scope of information in emergencies, ultimately leading to few included studies and a narrow scope of interventions. The work presented herein includes both published and grey literature, broader inclusion criteria and additional outcomes compared to the reviews described above.

In the absence of evidence, responders often default to familiar interventions using intuition and the idea that 'if it worked before it will work again' (Darcy et al., 2013, Loo et al., 2012, Steele and Clarke, 2008). Also, WASH interventions currently used in emergency responses are often ones shown to be efficacious and effective in development contexts, not emergencies (Darcy *et al.* 2013; Parkinson 2009). As the effectiveness of WASH interventions depends on contextual factors unique to each emergency (Bastable and Russell 2013; Loo *et al.* 2012; Parkinson 2009), contextually appropriate information on WASH intervention effectiveness may provide more relevant and effective guidance for responders and lead to better WASH interventions in emergencies.

1.4 Approach and structure of this report

The objective of this review was to assess the outcomes and impacts of short-term emergency WASH interventions in low- and middle-income countries (L&MICs) through a systematic review process that incorporated published and grey literature. Specific research objectives were aimed at addressing five knowledge gaps in emergency WASH interventions:

1. What are the effects of the use of services in emergency WASH situations?
2. What are the health-related outcomes in emergency WASH situations?
3. What are the non-health-related outcomes in emergency WASH interventions?
4. What contextual factors act as barriers or facilitators to implementation and uptake and the effectiveness in emergency WASH situations?
5. What is the cost-effectiveness of emergency WASH interventions?

1.4.1 Methodology

A brief description of the methodology used is described below, outlining data sources, inclusion criteria and evaluation. Additional detail for the search strategy, data processing and synthesis can be found in the protocol and full report (Yates et al., 2015).

A comprehensive and systematic search strategy was developed to identify published and grey literature. Studies were identified by using keywords to search nine peer-reviewed databases and more than 50 responding agency websites. Direct solicitation of individuals and agencies was also conducted through global email lists, conferences and personal contacts.

Identified studies were screened by title, abstracts and then full texts. From abstract to final inclusion, studies were independently double screened by two of the four expert reviewers. To be considered for inclusion, interventions had to be WASH projects within 12 months of a disaster or outbreak, less than 12 months in duration, in an L&MIC, describing an outcome of interest (Section 3) and restricted to 1995–2016. Quantitative (experimental and non-experimental designs) and qualitative methodological designs were eligible, and both peer-reviewed and unpublished grey literature documents were eligible for review.

Studies that met inclusion criteria were coded, then evaluated for bias. Quantitative and qualitative studies were evaluated separately with slightly different criteria, but in both, any bias of evaluation methods and clarity of reporting was considered. Evidence for each intervention and outcome was summarised for quality through a process considering consistency, effect size and generalisability. Findings for each intervention are presented through a narrative synthesis that combines outcomes from quantitative and qualitative sources.

1.4.2 Overview of report structure

The scope of this review was to investigate the outcomes and impacts of emergency WASH interventions in L&MICs. The report is separated into seven sections: an introduction (Section 1), a description of interventions (Section 2), intended theories of change (Section 3), implementation evidence (Section 4), impact evidence (Section 5), implications (Section 6) and conclusions (Section 7), followed by appendixes and references.

2. The interventions

Emergency WASH interventions differ from development interventions because of the speed, scale and approaches that are taken in emergency response activities. The needs of emergency-affected populations are often immediate, requiring rapidly increasing access to water and sanitation services. Emergency situations also require the promotion of activities that may be unfamiliar to the population (e.g. treating water with chlorine for the first time). The scale of emergency-affected populations can be in the millions of people, such as with the current Syrian refugee crisis. In terms of approach, emergency WASH interventions are also typically short-term and often unsustainable without significant external funding. The main components of emergency WASH interventions include water, sanitation and hygiene interventions, but these are made up of 13 more specific interventions common in emergencies as detailed below:

Well or spring repair – access to potable water is critical for disaster-affected populations. Existing water sources can be damaged or rendered no longer potable because of a disaster, or can be overwhelmed by a sudden influx of displaced persons. In an acute emergency, there is rarely time for new construction of water points. Thus, the most common water access interventions are to repair or clean existing wells or springs. The cleaning or repair of water sources are often a one-time intervention that restores water points familiar to the affected population.

1) Pumping out saltwater intrusions – saltwater flooding can occur because of a hurricane, storm surge or tsunami. Agencies pump wells to remove saltwater and debris, then chlorinate to disinfect the well. Pumping wells flooded with seawater is expected to reduce the impact of saltwater intrusion (as measured by salinity or conductivity) and increase the recovery time of the well (the time it takes for water to refill the well).

2) Well disinfection – chlorine is used to disinfect contaminated wells. Liquid and powdered chlorine are both used through two primary approaches: shock and pot chlorination. *Shock chlorination*, where a single dose of chlorine is added directly into the well, is intended to quickly clean the well. The well can be, but is not always, closed for several hours to one day to allow the chlorine to dissipate. *Pot chlorination*, where a porous container filled with sand and powdered chlorine is inserted into a well, is intended to slowly disperse chlorine and treat water over an extended time.

Source-based water treatment – the aim of source-based water treatment is to improve water quality at the point of collection. Most source-based treatments use chlorine solution or chlorine tablets to treat water; they may also include processes that help to reduce the turbidity (cloudiness) of the water.

3) Large-scale source-based water treatment – bulk water treatment (BWT) is a general term that includes systems that are operated by agencies without beneficiary involvement, often able to treat between 1,000 and 15,000 L of water per hour. Treatment and storage could be in semi-permanent tanks or temporary

bladders. *Water trucking* where water is supplied to affected populations at their location in tanker trucks is also included in this category of intervention.

4) Small-scale source-based water treatment – small-scale source treatment occurs at the source, and is applied to one container at a time. It includes chlorine dispensers and bucket chlorination. *Chlorine dispensers* involve hardware installed next to a water source and dispensing chlorine solution. A local promoter refills the dispenser and conducts community education, and a supply chain of chlorine refills is established. Users treat water by turning a valve that dispenses a controlled amount of chlorine solution. *Bucket chlorination* is a common emergency response activity where a person is stationed near a water source and adds a known dose of chlorine directly into the recipients' water collection container.

Household water treatment – HWT interventions are used in contexts where affected populations have access to water, but where water quality is not adequate. HWT interventions are dependent on beneficiary understanding and use of distributed materials. Often, jerrycans or buckets are distributed concurrently to encourage safe storage of treated water.

5) Chlorine-based HWT – the most common HWT products distributed in emergencies are chlorine products, such as tablets, liquid solutions or flocculant/disinfectant sachets. The effective treatment dose depends on the initial water quality and container size. *Chlorine tablets* are small tablets of 7–167 mg sodium dichloroisocyanurate used to treat 1–20 L of water (e.g. Aquatabs®). *Liquid chlorine* is a small bottle of 1–1.25 per cent sodium hypochlorite (e.g. WaterGuard), sized so one cap is used to treat 20 L of water, or commercial bleach, where the dosage is generally in drops. *Flocculant/disinfectant sachets* are well suited for turbid water. Users add the contents of a sachet to 10 L of water, stir for five minutes, wait five minutes for the solids to settle, filter the water through a cloth into a second bucket and wait 20 minutes before drinking.

6) Filters – water filters, including simple screens, and ceramic, sand and hollow-fibre filters, are usually easy to use and remove harmful microbes larger than the filters' effective pore size. Biosand and pot filters are less common in emergency responses as their size and fragility presents distribution challenges.

7) Other HWT – solar disinfection (SODIS), boiling, flocculation and safe storage are HWT options also used to improve household drinking water, but these are less common emergency response activities.

Sanitation – sanitation interventions in emergency responses aim to isolate faeces from the environment. Minimising open defecation and ensuring proper management of faeces in a latrine or latrine alternative reduces exposure to potentially infectious waste and can reduce ongoing disease transmission.

8) Latrines – latrines are temporary or semi-permanent structures made from cement, plastic, bricks or local materials intended to isolate faeces from the environment. Latrines are constructed for individual households or in clusters to serve large communities or camps. Community-led total sanitation (CLTS) is a

sanitation strategy, but for the purposes of this review it is considered social mobilisation and is described below.

9) Latrine alternatives – latrine alternatives (e.g. disposable single-use defecation bags) are used as a temporary solution in the initial days after an emergency or where latrines cannot be built. Beneficiaries defecate into bags and dispose of these through a collection system established by an emergency agency.

Hygiene – hygiene interventions aim to educate the population, promote safe practices and reduce the risk of disease transmission from the environment.

10) Hygiene promotion – hygiene messages educate affected populations on disease risks and transmission routes. Often, in emergencies, hygiene promotion is condensed into key messages, such as the need to wash hands at critical times. Promotion can be at schools, in large community groups or at the household level.

> *Social mobilisation* is a subset of activities within hygiene promotion that describes strategies for responders to engage and *facilitate* communities to address identified risks with local solutions. The most notable example is CLTS programming. CLTS is widely used in development settings to motivate communities to build their own latrines; specifically, no materials are provided to the population. In CLTS activities, an outside facilitator aims to influence the population to become free of open defecation and find their own local solutions to address this problem.

11) Distribution of soap and/or hygiene kits – hygiene kits equip affected populations to act on hygiene promotion. Hygiene kit distributions often provide populations with HWT products, soap, buckets, feminine hygiene materials, toothbrushes and other materials, depending on the context. Hygiene kits can be distributed as standalone packages, or as a component of a larger distribution of non-food items that includes materials such as blankets, cooking pots or other materials. Cash, material subsidies and vouchers are an alternative to providing hygiene kits and offer flexibility to disaster-affected households.

12) Environmental hygiene – environmental hygiene efforts aim to protect populations from existing or new risks by reducing environmental pathways of disease transmission. Environmental hygiene interventions can include collecting rubbish, disinfecting household objects or even improving land drainage. Household spraying is an environmental hygiene intervention where a disinfectant (mostly chlorine) is sprayed on household surfaces by trained responders to prevent inter-familial transmission of disease.

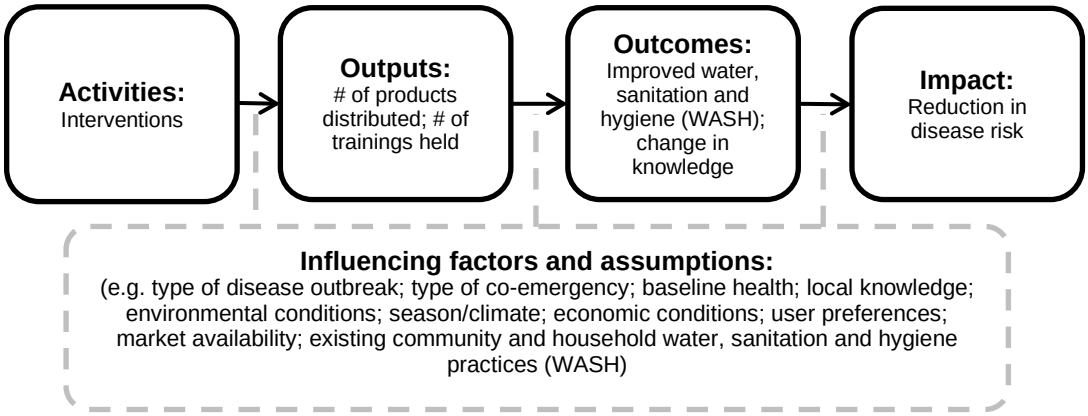
WASH package – responders commonly conduct interventions concurrently; these consist of multiple individual WASH interventions.

13) WASH package – interventions are carried out in combination with several interventions including components of water, sanitation and hygiene.

3. Theory of change

The goal of all WASH interventions is to reduce the risk of disease transmission. For this review, a theory of change model was developed for WASH interventions in order to describe the theoretical route from intervention activities to outputs, outcomes and impacts and to identify influencing factors and assumptions (Figure 1).

Figure 1: Theory of change template



Review objectives were established at three locations along the causal chain as intermediate outcomes, final impacts, or influencing factors and assumptions.

Intermediate outcomes: use of interventions is a general term that includes three specific indicators as a necessary step in the theory of change: self-reported use, confirmed use – [measuring or observing free chlorine residual (FCR)] and effective use. Most notably, measured HWT interventions, but also these apply to other interventions like the use of latrines or hygiene kits. Nested within use, an intervention's technical ability to improve WASH conditions (i.e. efficacy) was also considered. This is further explained below.

Final impact: health-related outcomes through reduced disease risk is the primary aim of all emergency WASH interventions. Health impact data was included if beneficiary morbidity and mortality impact was self-reported or clinically measured. *Cost-effectiveness* is a final impact that is separate from reducing disease risk, but affects sustainability and is a primary concern for responding agencies and donors.

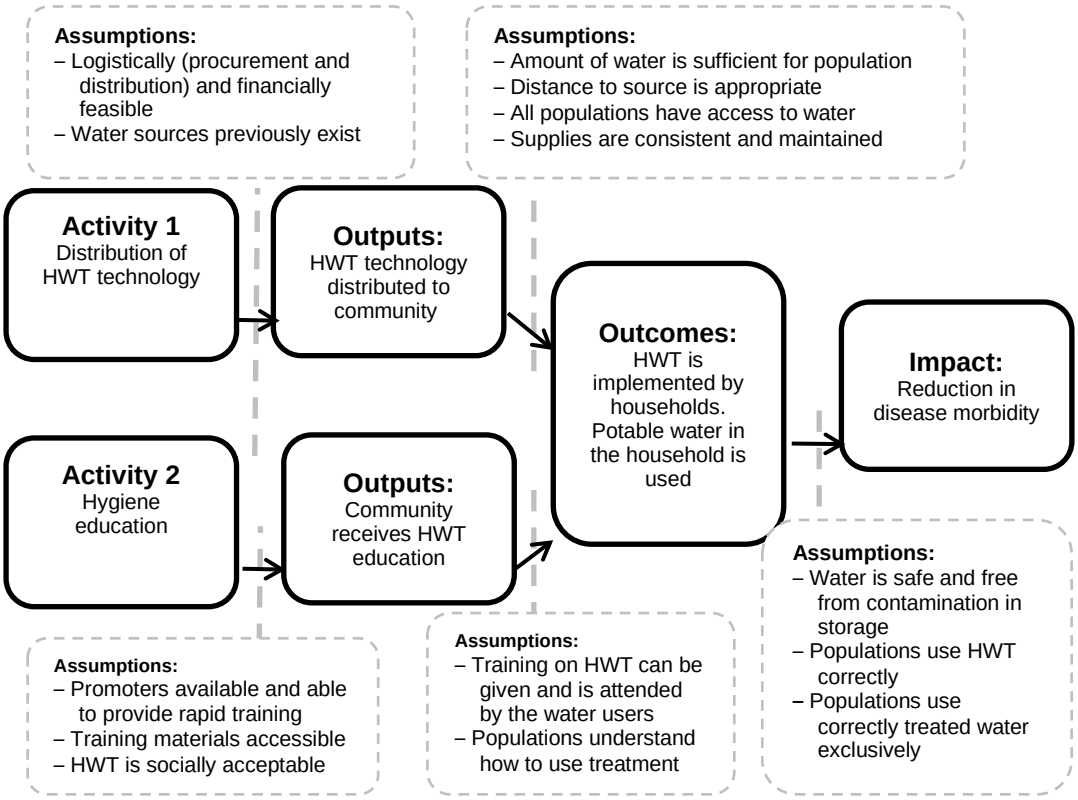
Influencing factors: non-health-related outcomes and *contextual factors* can influence the success or failure of an intervention. These include: preferences of the population on the use of interventions (e.g. ease of use, taste or smell of water); quality of life improvements (e.g. feeling safer, time savings); or agency preferences for interventions.

For most emergency WASH interventions, the technical efficacy is known and thus feasibility to break disease transmission routes is established. However, there remains a gap between the provision of WASH services (i.e. providing access to safe

water or sanitation) and actual reduced disease risk. To achieve impact, populations must have not only access to WASH services, but also knowledge on how to correctly and consistently use these services. Thus, *efficacy* is the theoretical potential for breaking transmission routes, and answers the question, 'Could the intervention work?' *Effectiveness* includes contextual factors of the intervention such as implementation quality, the natural environment, cultural and social preferences, and answers the questions, 'Was the intervention implemented correctly?' and 'Did the intervention have the outcomes and impacts that are possible and were intended for the target population?'

To illustrate the difference between efficacy and effectiveness, the theory of change model is applied to a combined HWT and hygiene education intervention and is depicted below (Figure 2). In this example, a water filter and hygiene education are distributed to households; both are known to be efficacious from previous laboratory and field studies. The assumptions detailed at each stage of the model show the steps necessary to achieve correct and consistent use in the target population, i.e. effectiveness. Additional specific models for other interventions are included in the protocol (Yates et al., 2015).

Figure 2: Theory of change example – household water treatment (HWT) with hygiene education



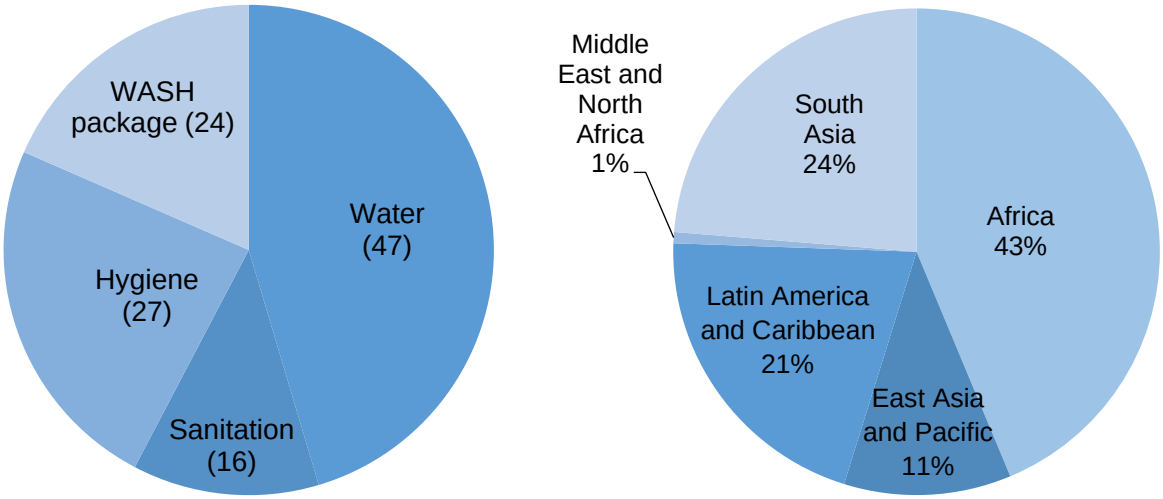
4. Implementation evidence

Overall, 15,026 documents were identified in the systematic review process. After applying the three selection filters, 106 documents with 114 interventions met inclusion criteria. Please note that several documents reported multiple separate evaluations from different countries or emergencies.

Water interventions represented the most included evaluations (n=47, 41%), followed by hygiene (n=27, 24%) and the WASH package (n=24, 21%) (Figure 3). Sanitation interventions were represented in 16 evaluations (14%). Additionally, other core emergency interventions such as dead body management, nutrition interventions and clinic activities could be considered (partial) WASH interventions but were not included in the review. The included evaluations described WASH interventions in 39 countries, with the highest frequency of evaluations from Haiti and Zimbabwe. Africa was the most common World Bank region, while South Asia and Latin America and the Caribbean were also strongly represented (Figure 3).

Half of the evaluations (57 out of 114) were published or documented between 2010 and 2015, and 85 per cent (97 out of 114) were within the last 10 years. The high proportion of documents in the last decade coincides with several major emergencies, including the South-East Asian tsunami in 2004; cholera outbreaks in Zimbabwe and Haiti in 2008 and 2010; the earthquake in Haiti in 2010; flooding in Pakistan in 2010; and typhoons in the Philippines and Bangladesh in 2013 and 2008. The WASH cluster system was established during this time and the reporting requirements of non-governmental organisations (NGOs) increased, creating the recent knowledge base. However, there is a lack of interventions relating to the 2014 West African Ebola outbreak and the Syrian conflict, likely due to the time lag in reporting data from emergencies.

Figure 3: Included studies by sector and World Bank region



An equal number of evaluations were identified from the peer-reviewed (n=57, 50%) and grey literature (n=57, 50%). Although the overall number of evaluations was balanced between published and grey literature, differences were seen in the interventions covered, with water having more published evaluations and hygiene and the WASH package having more grey literature evaluations.

Studies were conducted by organisations varying from local governments to university academics, but most were carried out by NGOs (74%, 79 out of 106). Overall, at least 35 different agencies had documents that were reviewed in the identification process; however, ACF and Oxfam contributed the largest number of studies in the identification process. This was represented in the included studies, as documents submitted from these two organisations accounted for a substantial portion of the evidence base (33%, 35 out of 106).

5. Impact evidence

The evidence from this review validates the causal chain developed for the review that is presented in Section 3. Interventions with access to WASH services and measured high use also had large and significant reductions in diarrhoea (Johnston, 2008, Doocy and Burnham, 2006, Meyer Capps and Njiru, 2015, Puddifoot, 1995, Roberts et al., 2001). However, breakages along the causal chain are also apparent and are attributable to contextual and social barriers. Through this review, we identified three common breakages along the WASH causal chain (Figure 4).

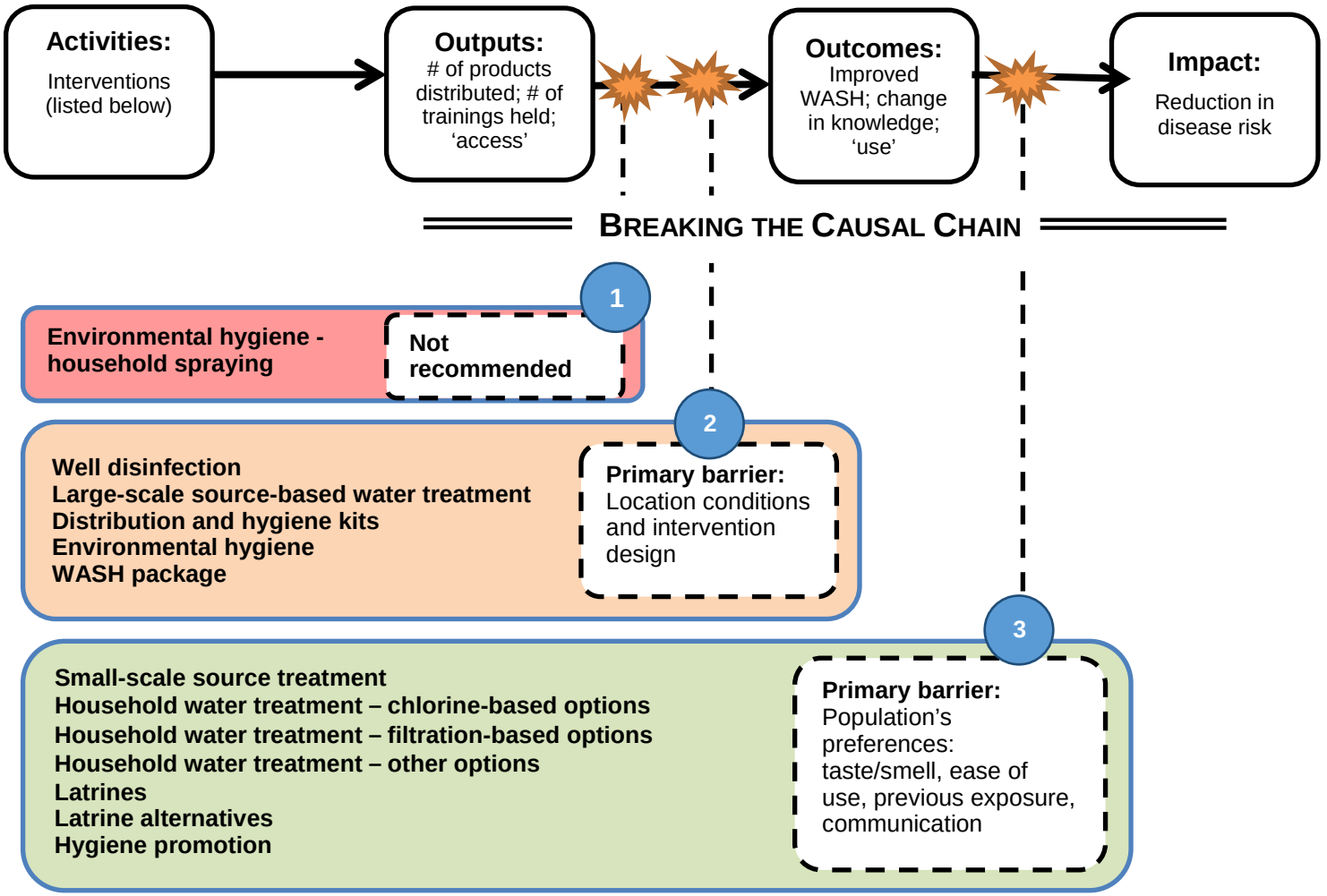
Causal chain break 1 – there was one intervention that was not efficacious and would likely have a negative impact on WASH conditions: saltwater intrusion pumping. Saltwater intrusion pumping was clearly ineffective and likely delayed the time before beneficiaries could use a well. Additionally, although there was less evidence for this, household spraying was also suspected to be ineffective with negative social effects.

Causal chain break 2 – five interventions had minimal beneficiary involvement but known efficacy; thus intervention design and implementation were primary barriers to impact. Source treatments like bulk water systems or well disinfection can be efficacious but were not evaluated at the beneficiary household level. Similarly, review objectives were primarily limited to outcome measures or influencing factors for hygiene kits, environmental hygiene and WASH package interventions. Effectiveness for disease impact was not evaluated and remains a gap in the literature.

Causal chain break 3 – the barrier between effective outcomes and impact (disease reduction) is primarily behavioural preferences that impact use. Wide variation in use was documented for the remaining interventions (HWT, small-scale source treatment, latrines, latrine alternatives and hygiene promotion) and was dependent on the familiarity of products, ease of use, personal preferences for taste and smell and culture. Education and promotion were also key factors that could facilitate or hinder impact of emergency WASH interventions.

Summary descriptions of each of the 13 interventions are presented in the main text below. For detailed descriptions of activities, methods and individual studies, please refer to the full report.

Figure 4: Breakages in the causal chain



5.1 Water source interventions

There were four specific water source interventions identified in the review: saltwater intrusion cleaning, well disinfection, large-scale water treatment and small-scale source treatment. Water source interventions were not regularly evaluated at the household level, and often there was no attempt to evaluate impact or even monitor use. Beneficiaries also overestimated the impact of these interventions with regard to reducing salinity and improving access to safe water with FCR. Evaluations varied between cross-sectional studies and case studies, and both had inconsistent methodologies that undermined comparisons. General findings and conclusions for each water source intervention are described below, with a summary of evidence in

Table 1.

Saltwater intrusion cleaning – all studies concluded that there was no evidence that pumping wells improved WASH conditions; instead, it likely delayed the well recovery process. The consensus was that alternative water sources should be used until salinity levels naturally decrease.

Well disinfection – the studies showed that one-time shock chlorination did not provide residual protection for more than a few hours and did not impact microbiological contamination. Traditional pot chlorination inconsistently maintained measurable FCR for 1–4 days. In comparative evaluations, albeit with inconsistent methods, pressed HTH® tablets with a pot chlorination approach maintained FCR for 3–4 days and were implementing agencies' preferred mode of well disinfection.

Large-scale source treatment – BWT is not well documented in emergency response settings. While the technology is well understood, BWT may be overly promoted in inappropriate settings. Water trucking is widely used as an emergency activity to provide potable water; however, in two limited evaluations, both showed high levels of microbiological contamination.

Small-scale source treatment – base rates varied among studies, but treatment dispensers were deemed to be an appropriate option if certain contextual conditions were met. Knowing the treatment promoter and being able to easily access the dispenser were consistently identified as significant factors in dispenser use. Experienced staff were also described as a key factor to success. Bucket chlorination, a known emergency activity, was not evaluated.

Table 1: Summary of evidence for water source interventions

Intervention	Number of studies	Quality of outcomes			Overall evidence
		Health	Use	Non-health	
Saltwater intrusion cleaning	6	No evidence	No evidence	High	High
Well disinfection	6	No evidence	No evidence	Moderate	Moderate
Source treatment – large scale	4	No evidence	No evidence	Low	Low
Source treatment – small scale	3	No evidence	Moderate	No evidence	Moderate

5.2 Household water treatment

HWT products are interventions used in the home to improve the microbiological quality of household drinking water. They include chlorine products, flocculant disinfectants and filters, as well as several less common interventions. Evaluations were primarily cross-sectional, providing weak evidence, but were conducted at the beneficiary level. Conclusions for each HWT intervention are described below, with a summary of evidence in

Table 2.

Chlorine tablets – reported and confirmed use varied widely (reported use: 1–84%, n=9; confirmed use: 1–87%, n=11). Use was low when products were distributed in hygiene kits with minimal hygiene education provided, or there were alternative treatment methods. Although the tablets' simplicity and ease of use was generally appreciated, strong knowledge of water treatment practices was associated with higher use. Concerns over correct dosing were also present, with tablets supplied in different-sized storage containers and in different doses.

Liquid chlorine – liquid chlorine interventions included programmes that promoted, distributed, marketed and redeemed vouchers for chlorine solutions. Some communities had previous exposure to liquid chlorine products and exposure to sustainable development activities promoting these products. This is believed to have contributed to relatively higher use of liquid chlorine (reported use: 6–88%, n=6; confirmed use: 1–69%, n=6) than chlorine tablets, which were predominantly distributed within hygiene kits (as mentioned above).

Flocculants/disinfectants – where sufficient training and access occurred, high rates of use were consistently observed (reported use: 6–83%, n=3; confirmed use: 4–95%, n=6), leading to significant reductions in diarrheal disease. Community preferences varied, but the PUR® Purifier of Water (PUR) was consistently preferred over other treatment options. The training requirements, however, were quite high when training was not provided reported and confirmed use were low.

Filters – water filters consistently had high use (<3 months: 53–100%, n=3; $\geqslant 3$ months: 0–96%, n=7) and beneficiaries appreciated the improved taste of water when using filters. However, use declined over time and functionality diminished with turbidity of water. Also, distributions were smaller than those for chlorine treatments.

Other household water treatment – SODIS, boiling, flocculation and safe storage are not typical HWT strategies in an emergency, and there were a limited number of evaluations. Diarrhoea reductions were documented; some, but not all of these were significant. These HWT interventions were reported to be simple, sustainable and accepted by communities.

Table 2: Summary of evidence for household water treatment

Intervention	Number of studies	Quality of outcomes			Overall evidence
		Health	Use	Non-health	
HWT – chlorine tablets	12	Very low	Moderate	Moderate	Moderate
HWT – liquid chlorine	9	No evidence	Moderate	Moderate	Moderate
HWT – flocculants/ disinfectants	7	Low	Moderate	Moderate	Moderate
HWT – filtration	6	No evidence	Moderate	Moderate	Moderate
HWT – SODIS, safe storage, alum and boiling	5	Low	Very low	Moderate	Low

5.3 Sanitation, hygiene and the WASH package

Evaluations for sanitation, hygiene and WASH package interventions were primarily high bias, grey literature field commentaries with weak evidence. Conclusions for each intervention are described below, with a summary of evidence in Table 3.

Sanitation - latrine and latrine alternatives – different latrine designs were better suited for acute and recovery phases of emergencies; they were also able to target vulnerable populations and reduce disease transmission. In two contexts, latrine alternatives were successful as a temporary intervention in an acute emergency. Use of latrine alternatives was higher when promoted for use in the household rather than in community cubicles.

Hygiene promotion – the studies showed that multiple channels of hygiene education are preferable for addressing a wide audience and reinforcing key messages. Open communication, enabling a dialogue with beneficiaries, was also positively described by emergency responders and beneficiaries. Consistently, radio messages and face-to-face communication were most liked, preferred or trusted by beneficiaries. Community mobilisation and community-driven approaches like CLTS received consistently positive evaluation in seven countries. These approaches were shown to increase awareness, trigger behaviour change and facilitate local solutions. Other outcomes noted included a high output of structures (mostly latrines) built with local materials. CLTS approaches were also associated with ‘trust’ and ‘community cohesion’.

Hygiene kit distribution – hygiene kits were not a primary intervention, but were often used as a mode to equip emergency-affected populations with the materials necessary to improve hygiene practices and deliver HWT products. Contents, quantity and timely distribution (i.e. pre-positioned stock and quick release of funding) were identified as important influencing factors.

Environmental hygiene – field reports of household spraying did not have clear evidence against the intervention, but suggested that the activity should not be carried out because it may give a false sense of effectiveness while possibly stigmatising the household. Jerrycan cleaning and using household disinfection kits were identified in the review; however, outcomes were weak and require further discussion and research. Environmental clean-ups are common emergency response activities, but no evaluations of these interventions were identified in the review.

WASH package summary – water point rehabilitation, hygiene kit distributions and hygiene promotion were the most frequently included individual activities in WASH package interventions for disease outbreak and non-outbreak emergencies. The qualitative field commentaries had consistent descriptions of anecdotal health impacts and non-health behaviour change impacts. Expert staffing and rapid response timing were consistently identified as critical factors driving programme success.

Table 3: Summary of evidence for sanitation, hygiene, and the WASH package

Intervention	Number of studies	Quality of outcomes			Overall evidence
		Health	Use	Non-health	
Sanitation – latrines	13	Low	Low	Moderate	Low
Sanitation – latrine alternatives	3	No evidence	Low	Low	Low
Hygiene promotion	18	Low	Low	Moderate	Moderate
Hygiene kits	12	No evidence	Low	Moderate	Low
Environmental hygiene	4	Very low	Low	Low	Low
WASH package	23	Low	No evidence	Low	Low

5.4 Methodological quality and heterogeneity

Overall, the quality of evidence in the studies reviewed was low. This was attributed to weak study designs that lacked control groups and had a high likelihood of spillover effects. The weak study designs were expected from the onset of protocol development, but still greatly undermined the ability to establish a strong evidence base. The protocol methodology was intended to include weaker study designs that would complement stronger designs; however, only 9 per cent of studies (10 out of 106) had any type of control group. Fewer than 4% (4 out of 106) were randomised controlled trials and none were in the same intervention category. The majority of quantitative study designs were weak cross-sectional designs relative to true experimental designs. The anticipated comparisons described in the protocol were undermined by a lack of data quality and could not be carried out. For example, the WASH interventions were not targeted to a specific gender, age range or other demographic among the PROGRESS-Plus subgroups. Additionally, the intervention setting (urban, rural, peri-urban) was not regularly reported, and with some

interventions covering a wide geographic area with large populations, it was not possible to compare across intervention settings. It was also difficult to assess whether a WASH intervention was in the same geographic location as the emergency. Timing of the intervention or evaluation was not consistently documented, limiting the ability to compare interventions conducted at different stages of the emergency (less than two weeks, initial three months, up to one year). Formal heterogeneity analysis with I^2 could not be completed as reported outcomes remained too different for direct comparison. For example, confirmed use of an HWT intervention was the clearest outcome measure identified by measuring FCR; however, reporting thresholds varied between 'detectable', >0.0 mg/L, >0.1 mg/L, $\geqslant$0.2 mg/L and $\geqslant$0.5 mg/L.

5.5 Additional information

An evidence map comparing quality of evidence with evaluation methodology for the 13 interventions is presented in Appendix A.

No cost-effectiveness studies were identified; however, some economic and cost information was found and is summarised in Appendix A.

6. Implications

6.1 Policy

Through a systematic review process, we investigated emergency WASH interventions through five research objectives: 1) use of interventions; 2) health impact; 3) non-health outcomes; 4) contextual barriers and facilitators; and 5) cost-effectiveness.

6.1.1 Objective 1: Use of interventions in emergency WASH

Emergency WASH interventions are implemented in a variety of contexts and there is no silver bullet intervention that is universally applicable in all circumstances (Clarke and Steele, 2009). Through this review, we identified 13 WASH interventions and found that 12 could be efficacious, i.e. theoretically able to increase access to safe water and sanitation or improve hygiene and thus reduce the risk of disease transmission. Well pumping to reduce salinity after a coastal flood was the only intervention that had evidence that it was not efficacious, while the efficaciousness of household spraying was unclear. For the remaining interventions, WASH conditions improved, although effectiveness varied and outcomes were conditional based on the emergency context and cultural and social preferences.

6.1.1 Objective 2: Health impact in emergency WASH interventions

Evidence that WASH interventions reduce the disease burden in an emergency is limited, but is seen through reduced disease risk and reduced transmission risk.

Reduced disease risk – interventions directly measuring a health impact were few and were mostly for HWT. Chlorine tablets, PUR, SODIS and safe storage were assessed as having a low or very low quality of evidence as there were only one or two evaluations for each intervention type. While a disease risk reduction was observed in all interventions, often significantly, the limited number of studies meant a limited application of the results at the broad scale. Additionally, latrine use and CLTS interventions also documented reduced disease risk, but evidence for this was of very low quality.

Reduced transmission risk – interventions that evaluate the risk of transmission through non-health indicators were more often evaluated in emergencies than interventions that reduce disease risk. Interventions documenting FCR in drinking water are known to reduce disease transmission and had a *moderate quality of evidence*; these included well disinfection, dispensers and chlorine-based HWT (liquid chlorine, chlorine tablets and PUR). Environmental hygiene interventions using chlorine to clean jerrycans reduced short-term transmission risks with measurable FCR and had a *low quality of evidence.*

6.1.3 Objective 3: Non-health-related outcomes

In the review, five community perceptions and preferences that affect the success of emergency WASH interventions were established.

Taste and smell – aesthetic changes to the taste and smell of water when using HWT products can hinder use in some populations (particularly when chlorine-based HWT products are used) or encourage use in others.

Preferred communication – radio and face-to-face communication were consistently reported as the most 'liked', 'trusted' and/or 'valued' forms of communication.

Overestimation of effectiveness – community perception severely overestimates the outcomes and impacts of some WASH interventions, particularly household spraying and water source interventions.

Trust and fear – social mobilisation and open communication between community members and responders can build trust and community cohesion.

Ease of use – some of the simplest interventions (HWT with basic filters, safe water storage with the provision of jerrycans, jerrycan disinfection) reported high use and disease risk reduction. These incremental improvements required minimal behaviour change, and thus little to no promotion, but still reduced the risk of disease.

6.1.4 Objective 4: Contextual barriers and facilitators

Five programme design and implementation characteristics were identified in the review as associated with more effective programmes.

Timing – pre-positioned stock, quick release of funding and early triggers for rapid scale up were important factors leading to an effective response, particularly with hygiene kit distribution and HWT interventions.

Experienced staff – experienced staff who could rapidly scale up appropriate interventions were identified as critical to success in dispenser and WASH package programmes.

Communication – multiple modes of communication that reinforce key messages, with strong radio and face-to-face components and simple clear instructions, were found to be most preferred by communities.

Community-driven engagement – engagement in the community empowers and builds trust. Community-driven interventions, i.e. CLTS can increase awareness, trigger behaviour change and facilitate local solutions.

Linking development and relief – pre-existing knowledge of an intervention (e.g. knowing how to use an HWT product) increased familiarity and use. Linking development programmes to emergency response activities was found to be successful in multiple contexts.

6.1.5 Objective 5: Economic outcomes of WASH interventions

Economic outcomes of WASH interventions in emergencies were not able to be assessed as there were only minimal economic outcomes in the evaluations included in the review (see Appendix A for additional information). However, with increasing global needs in excess of US$28 billion, severe funding gaps remain and cost-effectiveness will be an increasing priority (Lattimer, 2016). Establishing cost-efficient programming is necessary, but this must also be balanced with basic human rights to guarantee safe water and sanitation to all populations.

6.2 Programming

Emergency WASH interventions can be improved through a better understanding of previous development projects and local social influences. Technical efficacy of WASH interventions is generally established; however, effective and rapid behaviour change remains a primary hurdle to many emergency WASH interventions. An increased programming effort is needed to engage with communities in order to better understand the barriers and facilitators of interventions.

Monitoring and evaluation of emergency interventions need to be consistently carried out at the beneficiary level. Collecting consistent indicators is needed to facilitate comparisons between interventions. With usage as the primary barrier to most WASH interventions, the impact cannot be evaluated simply through the reporting of activities or access to outputs at the community level (e.g. the number of water points restored or the number of people receiving hygiene messages). In order to improve WASH interventions, monitoring and evaluation should assess the impacts at the beneficiary and household levels.

6.3 Future research

Through this review, we identified that the evidence for impact achieved by emergency WASH interventions remains low. We also identified significant evaluation gaps for interventions that are well known. While additional evidence would be useful for many WASH interventions in emergencies, evidence is particularly needed for the large-scale source-based water treatment interventions of bulk water treatment and water trucking; the small-scale source water treatment intervention of bucket chlorination; all sanitation interventions; the hygiene promotion intervention of handwashing specifically; the adoption of, and user opinion of, hygiene kit distributions; and the environmental hygiene interventions of household spraying and environmental clean-up. Lastly, formal economic analysis is needed for all WASH interventions.

Previous systematic reviews of emergency WASH interventions similarly identified intervention gaps; thus, further systematic reviews are not likely to provide better insight for the sector until more consistent and improved-quality field evaluations are conducted and made accessible to the international community. Evidence can be improved simply by measuring consistent outcomes through consistent evaluation methods. With respect to the current evidence gaps, quasi-experimental evaluations

such as stepped-wedge designs and non-experimental studies (cross-sectional evaluations and case studies) can advance the overall evidence base in this sector. To increase access and transparency, responders should also consider, and be supported in, publishing results and lessons learned.

Systematic research efforts would be able to address the synergies of WASH package interventions and compare best practice recommendations. Programmes involving multiple WASH interventions simultaneously are commonly carried out by responders to emergencies. However, these are complex and difficult to research. Complex evaluation strategies, which help investigate synergies and spillover impacts of a combination of WASH interventions, are needed. Numerous best practice and guidance documents are available from United Nations agencies, donors and responding organisations but these often contradict each other. An analysis to identify inconsistencies and consolidate what is considered best practice and what is evidence-based is needed to align activities across the sector.

7. Conclusions

We found that, through outcomes and impacts, some WASH interventions are successful at increasing access to water and sanitation services and reducing the risk of disease. However, programme design, implementation characteristics and community psychosocial aspects are critical to programme success. Overall, in emergency contexts, we found that, with few exceptions, WASH interventions consistently reduced both the risk of disease and the risk of transmission of disease. Additionally, WASH interventions have the potential for positive non-health impacts. Program design, implementation characteristics and community cultural and social aspects were found to be critical to program success. It is recommended interventions be simple, and that responders establish open communication with beneficiaries. Access to quick and flexible funding, pre-positioned stock and links between development interventions and emergency response are also important considerations. As humanitarian needs increase globally, continuing to implement WASH interventions in emergency response and improve the field evidence for emergency WASH interventions remain imperative. Improved understanding of previous development projects and social influences could also improve emergency interventions. As humanitarian needs increase globally, continuing to improve the field evidence for emergency WASH interventions remains imperative.

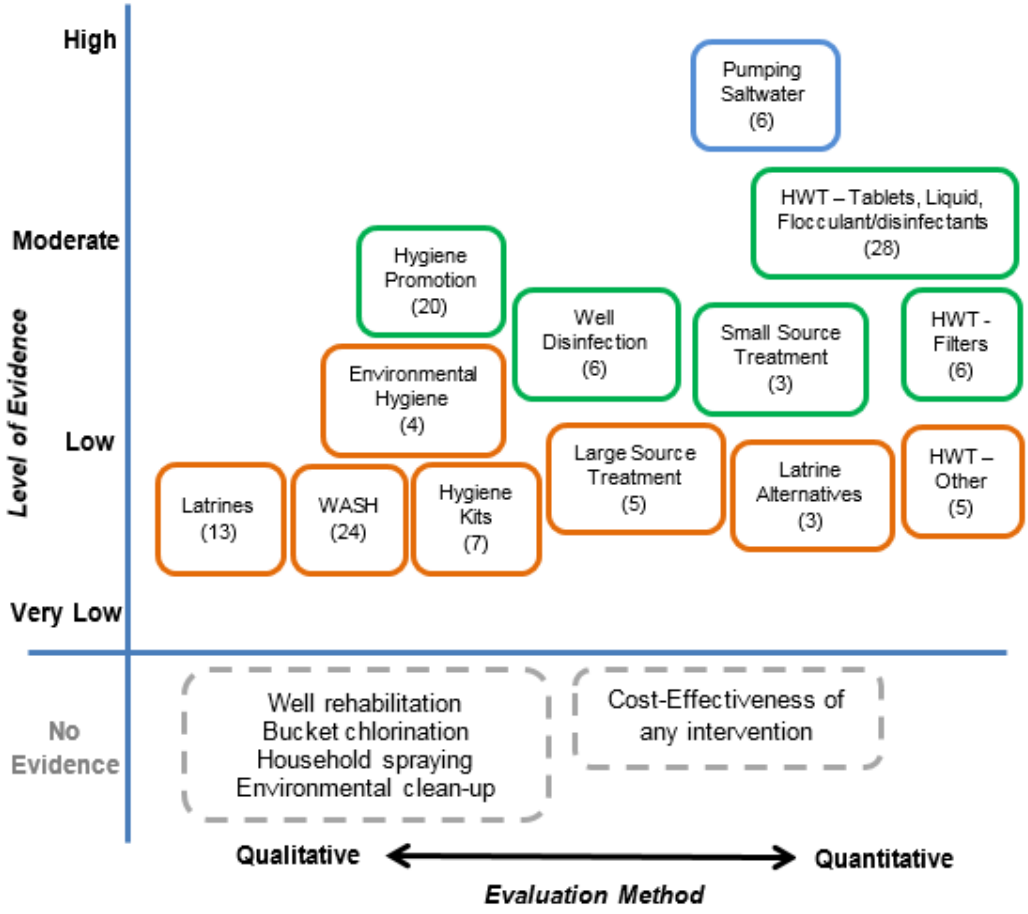
Appendix A: Supplemental information

Evidence map

A summary of the state of evidence identified in this review is presented below in Figure A1. The quality of evidence is shown against the methodology identified within each intervention. The colours serve to help differentiate the level of evidence between interventions (blue: high evidence; green: moderate evidence; orange: low evidence). The positioning of the interventions is relative to the interventions identified and is simply intended to orient the reader within the body of evidence. Some studies are included in more than one intervention category.

Pumping wells contaminated with saltwater was the only intervention with a high level of evidence (evidence against). Repairing water sources (saltwater pumping and well disinfection), source-based treatment and HWT had more evaluations, a better evidence base and were assessed more quantitatively. Hygiene, sanitation and the WASH package had a lower quality evidence base that was more qualitative. Overall, the evidence remains low and lacking with several known interventions not identified or underrepresented in the review: bucket chlorination, bulk water treatment, handwashing, household spraying, water trucking and environmental clean-up.

Figure A1: Summary map of evidence found in the review



Cost-effectiveness description

No evaluation in the review conducted cost-effectiveness analysis. Many documents included unsupported comments such as ‘costly’, ‘too expensive’ or ‘cost too much’, but without a rationale or alternative intervention appropriate for the context. Examples of economic and cost-related information in the review include:

Costs of items: HWT (Imanishi et al., 2014, Dunston et al., 2001, Tokplo, 2015, Handzel and Bamrah, 2006, Clasen and Boisson, 2006), hygiene kits (Gartley et al., 2013, Plan, 2013) or large-scale treatment options (Dorea et al., 2009).

Cost per outcome: Acute chlorine HWT interventions cost about US$1/day for a household with confirmed FCR in Nepal and Kenya (Lantagne and Clasen, 2012).

Willingness to pay: Evaluating the potential for sustainable HWT interventions: at US$0.027/PUR sachet, ‘almost all were not willing to buy it’ (Hoque and Khanam, 2007, Colindres et al., 2007).

Cost recovery: In a chlorine solution project in Madagascar, a bottle of chlorine solution able to treat 1,000 L cost about US$0.46 (Dunston et al., 2001). However, this price did not include promotion and indirect costs and was estimated to have 46 per cent cost recovery.

Cost of a latrine: Project-related costs to build latrines were: for a private latrine, US$130; for a private latrine with shower, US$220; for a communal latrine, US$850 (Pinera et al., 2005). In another study, the approximate costs of a temporary latrine on a monthly basis included an initial cost of US$25/unit/day with desludging; costs were later negotiated to US$9–13/unit/day with a six month contract (Eyrard, 2011). Elsewhere, just material costs of about US$6.75 were quoted (Singh, 2012).

Costs per beneficiary: Overall costs per beneficiary were reported, but this did not incorporate the value of the gift in-kind materials – the primary component of the intervention in question: result 1: □3.54 per person, result 2: □6.80 per person; in-kind cost not reported (Gauthier, 2014).

Vouchers: Vouchers valued at US$70 were used in a special market day, where beneficiaries (2,184 households) could negotiate prices and select their own items (Pennacchia et al., 2011).

Total project costs: NGO reports also noted absolute costs to a donor (Grayel, 2011, Pennacchia et al., 2011, Martin, 2011).

Intervention efficacy and effectiveness

Through this review, we identified 13 WASH interventions and found that 12 could be efficacious: theoretically able to increase access to safe water and sanitation or improve hygiene and thus reduce the risk of disease transmission. For the interventions that improved WASH conditions, effectiveness varied and outcomes were conditional based on the emergency context and cultural and social preferences (Table A1).

Table A1: Intervention efficacy and effectiveness

Intervention	Efficacious	Effectiveness	Outcomes and impact
Saltwater intrusion cleaning	×	Not reported	All documents advise not to pump wells.
Well disinfection	•	Not reported	Free chlorine residual (FCR) can be maintained for several days in some contexts.
Source treatment – large scale	✓	Not reported	Established technology able to consistently provide safe water.
Source – treatment small scale	✓	•	Dispenser use varies with context; bucket chlorination effectiveness not reported.
HWT – chlorine tablets, liquid chlorine, PUR	✓	•	Population's previous exposure, taste and ease of use are major factors.
HWT – filtration	✓	•	Effective use declines over time; improved taste.
HWT – other (SODIS, safe storage, alum and boiling)	✓	•	Solar disinfection (SODIS), alum and boiling not always effective in field setting; recontamination likely.
Latrines	✓	•	Location (proximity), cleanliness and privacy are factors.
Latrine alternatives	✓	•	Location (in home), privacy and ease of use are factors.
Hygiene promotion	✓	•	Face-to-face and radio preferred communication; social mobilisation beneficial.
Hygiene kits	•	•	Population, timing, items and quantity of items influence effectiveness.
Environmental hygiene	•	•	Jerrycan cleaning can be efficacious; household spraying was 'not recommended'.
WASH package	•	•	Each component varies; staffing, funding, preconditions are also factors.

✓ Evidence • Conditional evidence × Evidence against intervention

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Systematic Review Summary Series

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