EVIDENCE SYNTHESIS
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WASH INTERVENTIONS IN DISEASE OUTBREAK RESPONSE

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Tufts University School of Engineering
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About this evidence synthesis
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The initial database and website searches took place between September 2015 and March 2016. The searches were re-run in September 2016 to check for updated studies.

About the research team
This evidence synthesis was conducted by Travis Yates (Tufts University), Jelena V. Allen (Consultant), Myriam Leandre Joseph (Consultant) and Daniele Lantagne (Tufts University).

There were no conflicts of interest in the writing of this report. Authors of this report are also authors of several included evaluations in this review; however, we maintained the systematic review procedure for all documents reviewed.

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Series editors
The report forms part of a series of humanitarian evidence syntheses and systematic reviews covering child protection, market support, mental health, nutrition, pastoralist livelihoods, shelter, urban contexts and water, sanitation and hygiene.

The reports and corresponding protocols (methodology) can be found at:

- https://www.gov.uk/dfid-research-outputs
- http://fic.tufts.edu/research-item/the-humanitarian-evidence-program/
- http://policy-practice.oxfam.org.uk/our-work/humanitarian/humanitarian-evidence-programme

The series editors are: Roxanne Krystalli, Eleanor Ott and Lisa Walmsley.

Photo credit
As part of Oxfam's cholera response in Juba, South Sudan, teams of public health volunteers have been teaching affected communities about the importance of keeping themselves and their environment clean. May 2014. Kieran Doherty/Oxfam.

CONTENTS

ABBREVIATIONS

ACF	Action Contre La Faim (Action Against Hunger)
CATS	Community Approach to Total Sanitation
CHW	Community health worker
CI	Confidence interval
CLEME	Community-Led Ebola Management and Eradication
CLTS	Community-Led Total Sanitation
DRC	Democratic Republic of Congo
FCR	Free chlorine residual
FGD	Focus group discussion
GRADE	Grading of Recommendations Assessment, Development and Evaluation
HH	Household
HTH	High test hypochlorite
HWT	Household water treatment
KII	Key informant interview
LMIC	Low and middle-income country
NFI	Non-food item
NGO	Non-governmental organization
OR	Odds ratio
PHAST	Participatory Hygiene and Sanitation Transformation
PICOS	Populations, interventions, comparisons, outcomes and study types
RCT	Randomized controlled trial
RR	Risk ratio
SWS	Safe Water System
SODIS	Solar disinfection
WASH	Water, sanitation and hygiene
WHO	World Health Organization
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund

0 EXECUTIVE SUMMARY

This evidence synthesis, commissioned by the Humanitarian Evidence Programme and carried out by a team from the Civil and Environmental Engineering Department of Tufts University, identifies, synthesizes and evaluates existing evidence of the impacts of water, sanitation and hygiene (WASH) interventions in disease outbreaks in 51 humanitarian contexts in 19 low and middle-income countries (LMICs).[1]

What are water, sanitation and hygiene (WASH) interventions?

WASH interventions are commonly implemented as part of emergency response activities (i.e. in response to disease outbreaks) in LMICs. WASH interventions are provided to large populations to reduce the risk of disease transmission in a variety of settings. This synthesis focuses on WASH interventions targeted at populations affected by cholera, Ebola virus disease (hereafter 'Ebola'), hepatitis E, hepatitis A, typhoid, acute watery diarrhoea and bacillary shigellosis (dysentery).

The review focuses on the following 10 WASH interventions:

1 well disinfection

2 source-based water treatment

3 household water treatment (HWT) – chlorine-based products

4 HWT – other products

5 community-driven sanitation

6 hygiene promotion

7 social mobilization

8 hygiene kit distribution

9 environmental hygiene

10 WASH package

'Outbreaks' are defined as follows, in accordance with World Health Organization (WHO) guidelines (WHO, 2016b):

- the occurrence of disease in excess of the normal baseline (two times the baseline) or a sudden spike in cases (two times the incidence of new cases)
- a single case of a communicable disease long absent from a population, or caused by a pathogen not previously recognized in that community or area
- emergence of a previously unknown disease
- a single case of particular diseases of interest (cholera, Ebola and hepatitis E).

The evidence synthesis aims to:

- verify the quality of existing evidence relating to WASH interventions in humanitarian settings
- help researchers identify the strengths and weaknesses of this evidence, and thus to recognize potential improvements and opportunities for future research
- assist practitioners and policy makers in evaluating the impact of choices and investments.

The research team:

- developed theories of change for the WASH interventions under consideration, documenting the theoretical route from intervention activities to outputs (products distributed, promotion carried out), outcomes (improved WASH conditions and knowledge) and impacts (reduction in disease risk); it also noted influencing risk factors and assumptions between each step (see the review protocol for details: Yates, Vijcic, et al., 2015)[2]

[1] The Humanitarian Evidence Programme is a partnership between Oxfam GB and the Feinstein International Center at the Friedman School of Nutrition Science and Policy, Tufts University. It is funded by the United Kingdom (UK) government's Department for International Development (DFID) through the Humanitarian Innovation and Evidence Programme.

[2] http://policy-practice.oxfam.org.uk/publications/impact-of-wash-interventions-during-disease-outbreaks-in-humanitarian-emergenci-605152

- mapped and documented existing relevant research (15,026 studies)
- filtered and selected the most relevant evaluations or studies for analysis (47)
- identified gaps in the studies, the strength of the evidence included and their findings
- synthesized the evidence in response to four key research questions.
  - What are the health impacts of WASH interventions in disease outbreaks?
  - What are important WASH programme design and implementation characteristics in disease outbreaks?
  - What are the population-related barriers and facilitators that affect WASH interventions in disease outbreaks?
  - What are the economic outcomes of WASH interventions in disease outbreaks?

What evidence was eligible for review?

Of the 15,026 studies identified in the systematic review process, 47 were deemed suitable following title, abstract and full screening:[3]

- the search criteria included studies published or written between 1995 and 2016 – those included in the review span the period 1998 to 2015[4]
- the review covered disease outbreak-affected populations in LMICs
  - 19 countries and 51 contexts are included, with the highest frequency of evaluations from Zimbabwe and Haiti
- only selected diseases of interest were eligible (cholera, Ebola, hepatitis E, hepatitis A, typhoid fever, acute watery diarrhoea and shigellosis)
  - cholera is the most researched and discussed disease, representing 86 percent (44/51) of the diseases in the included evaluations, followed by Ebola (4%, 2), acute diarrhoea (6%, 3), shigellosis (2%, 1) and typhoid fever (2%, 1)
- eligible interventions include water, sanitation, hygiene and WASH package interventions within 12 months of an outbreak of disease of interest
  - water interventions are the most evaluated (43%, 22/51 contexts), followed by hygiene and WASH package, which make up 29 percent (15) and 24 percent (12) of included interventions, respectively; sanitation is least evaluated, making up only 4 percent (2/51) of the included studies
- in terms of research design, 49 percent (25) of the studies were quantitative, 18 percent (9) qualitative and 33 percent (17) field commentary.

A roughly equal number of evaluations were identified from the peer-reviewed (26, 51%) and grey literature (n=25, 49%). Although the overall number of evaluations is roughly equal between published and grey literature, differences were seen by intervention, with water having more published evaluations and hygiene and WASH package having more grey literature evaluations.

What are the health impacts of WASH interventions in disease outbreaks?

WASH interventions consistently reduce both the risk of disease and the risk of transmission in outbreak contexts.

- **Reduced disease risk**: Evaluations of the health impacts of WASH interventions in disease outbreaks using measured change in disease rates were rarely conducted. Only six such evaluations were identified. Five of these involve less common HWT interventions (PUR, simple filters, SODIS and safe storage) and in all cases showed reduced disease rates. The sixth evaluation – a long-running Community-Led Total Sanitation (CLTS) intervention implemented before and during an Ebola outbreak – recorded a large and significant reduction in disease risk.

[3] See the review protocol (Yates, Vijcic, et al., 2015).

[4] The initial database and website searches took place between September 2015 and March 2016.

- **Reduced transmission risk**: Evaluations of the impact on risk of transmission of WASH interventions were more common than disease risk evaluations and included: well disinfection, chlorine dispensers and HWT (liquid chlorine, chlorine tablets and flocculant/disinfectants). Some evaluations also demonstrated reduced short-term transmission risk with environmental hygiene interventions.

Programme design and beneficiary preferences are important factors in ensuring WASH interventions reach their potential, as described in the following sub-section.

What are important WASH programme design and implementation characteristics in disease outbreaks?

The following four design and implementation characteristics are identified as important for effective programming.

- **Simplicity** – Some of the most basic interventions had a clear positive impact; interventions requiring little to no promotion led to incremental improvements that reduced the risk of disease and disease transmission.
- **Timing** – Prepositioned stock, quick release of funds and early triggers for rapid scale-up were important facets of a positive response, particularly with hygiene kit and HWT interventions.
- **Engagement in the community** – Community-driven interventions can increase awareness, trigger behaviour change and lead to local solutions.
- **Linking relief, rehabilitation and development** – Linking with pre-existing programming reduces the need for rapid beneficiary behaviour change, and is an opportunity for responding agencies to increase local cultural understanding for future emergency response programmes.

What are the population-related barriers and facilitators that affect WASH interventions in disease outbreaks?

Four community perceptions and preferences affecting the success of WASH outbreak interventions are identified.

- **Taste and smell**: Taste and smell of HWT may hinder use (e.g. chlorine treatments can have an off-putting smell or taste) or facilitate use (e.g. filters and flocculant/disinfectants improve taste)
- **Preferred communication**: Radio and face-to-face communication were consistently reported as ‘most trusted’ or ‘most valued’ for hygiene communication
- **Perception of risk**: Community understanding of some interventions overestimate effectiveness and risk reduction potential (i.e. household spraying and well disinfection)
- **Trust/fear***:* Social mobilization and open communication between the community and responders builds trust and greater community cohesion.

What are the economic outcomes of WASH interventions in disease outbreaks?

It was not possible to assess the economic outcomes of WASH interventions as no economic evaluations were found and only minimal cost information is reported.

What's the state of the evidence?

Overall, the amount and quality of evidence of the health impacts of WASH interventions in outbreaks is found to be lacking and low. As illustrated in the evidence map (see Figure 0.1), the review found better and more quantitative evidence relating to water interventions,

source-based treatment and HWT than to hygiene, sanitation and WASH package interventions, which tend to be assessed with lower quality and in more qualitative studies.

While the 47 studies analysed provided solid information to generate comments, there were some limitations of the evidence, including:

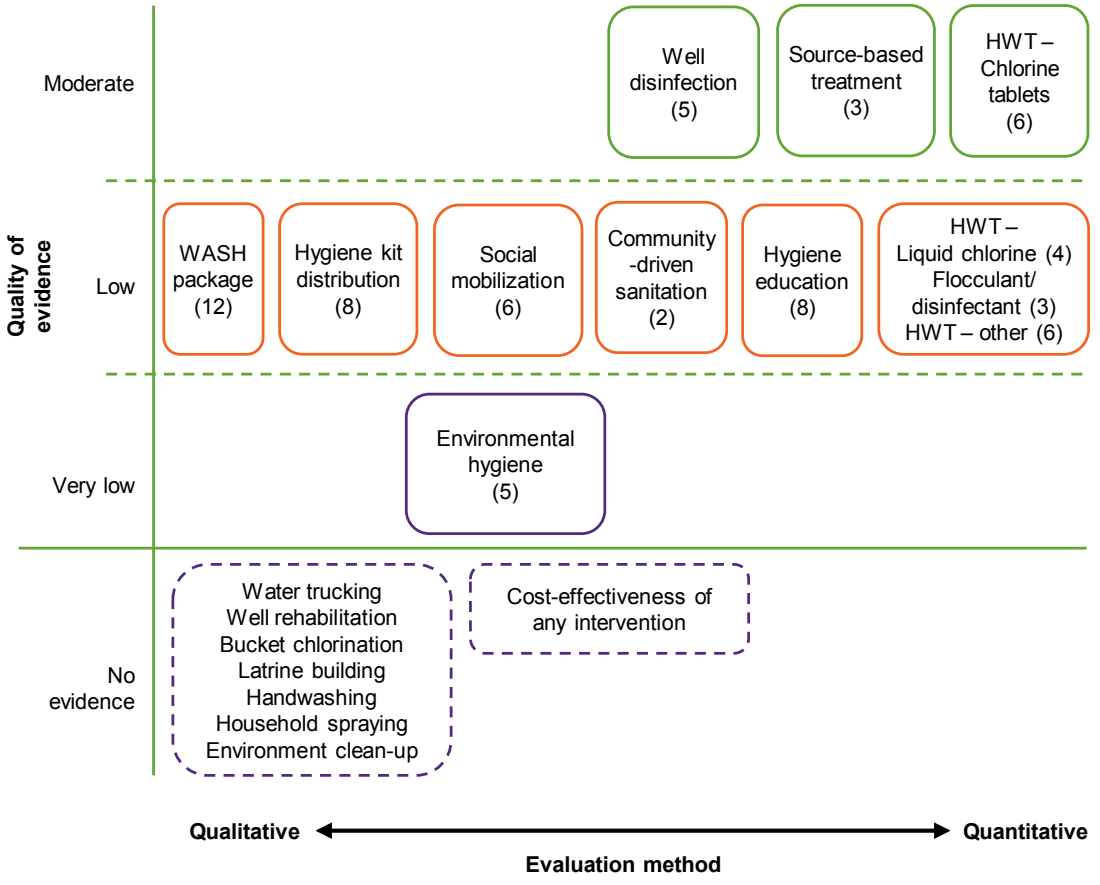
- none include high quality evidence relating specifically to health impacts
- while they show consistent findings, most are low quality cross-sectional study designs, only two randomized controlled trials are included in the review
- those that are quantitative studies (mainly published and relating to water interventions) have less risk of bias
- those that evaluate WASH package interventions tend to be field commentary, unpublished and with a high risk of bias
- none provide evidence of the impacts of well rehabilitation, bucket chlorination, latrine building, handwashing, household spraying, water trucking, environmental drainage/clean-up or cost-effectiveness of any intervention
- none provide formal economic analysis of WASH interventions in disease outbreaks.

This weak evidence base is attributed to two factors:

1 the prioritization of rapid response activities over research in emergency contexts

2 the difficulty of conducting research in the rapidly changing and unstable settings where disease outbreaks often occur.

Figure 0.1: WASH interventions in disease outbreaks – evidence map.
Source: The research team



Additional insights and observations

While WASH interventions in disease outbreaks are under-researched, it is likely that population-related barriers and facilitators will remain critical to the success of WASH interventions and remain context specific. As such, for the sake of more effective interventions in the future, the following activities should be considered:

- well-designed non-experimental and qualitative studies to increase the evidence base, particularly on well rehabilitation, bucket chlorination, latrine building, household spraying, handwashing, water trucking, environmental drainage/clean-up and cost-effectiveness
- developing templates and protocols for consistent and robust evaluations
- evaluating interventions at the beneficiary level
- identifying intervention factors that lead to more scalable and more timely responses
- increasing responders' understanding of community preferences and cultural differences.

Overall, we found low quality but consistent evidence that some WASH interventions are successful at reducing the risk of disease transmission, although programme design, implementation characteristics and community aspects are critical to programme success.

1 BACKGROUND

1.1 INTRODUCTION AND OBJECTIVE OF REVIEW

Water, sanitation and hygiene interventions (WASH) are commonly implemented as part of emergency response activities (i.e. in response to disease outbreaks) in low and middle-income countries (LMICs). However, there is a lack of evidence on the efficacy and effectiveness of these interventions (Blanchet et al., 2013; Ramesh et al., 2015). This weak evidence base is attributed to two factors: 1) the prioritization of conducting rapid response activities (over research) in emergency contexts; and 2) the difficulty of conducting research in the rapidly changing and unstable settings where disease outbreaks often occur.

The objective of this report is to assess the outcomes and impacts of WASH interventions during disease outbreaks in LMICs. We aim to address four knowledge gaps in WASH interventions during outbreak response:

1 How does the use of WASH interventions reduce disease outbreaks?

2 What are the programme design and implementation characteristics that are associated with more effective programmes?

3 What is the cost effectiveness of WASH interventions in emergency outbreak situations?

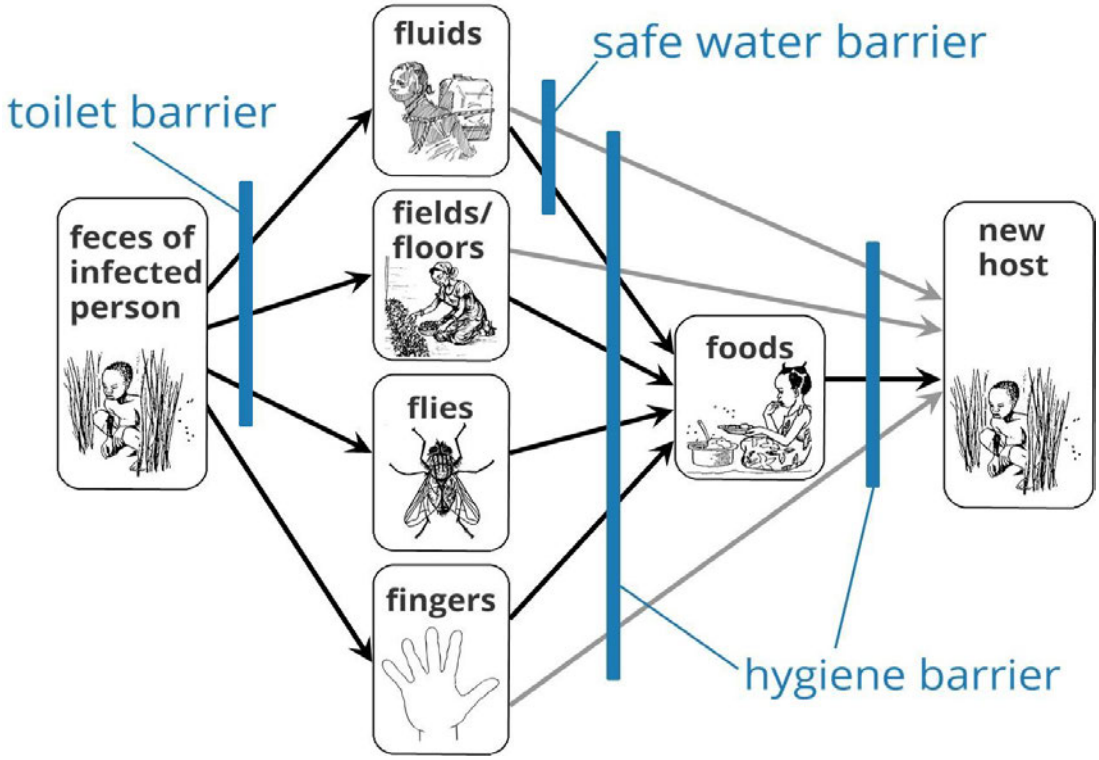
4 What are the barriers and facilitators to WASH interventions in outbreaks?

In the following sub-sections, the role of WASH interventions in outbreak response (Section 1.2), the theories of change for WASH interventions in outbreak response (Section 1.3) and the importance of the review (Section 1.4) are described.

1.2 OUTBREAK BURDEN AND THE ROLE OF WASH

An outbreak occurs when the number of disease cases increases above what would normally be expected in a defined community, geographical area or season (GIDEON, 2016). Between 1980 and 2013, 12,102 outbreaks of 215 human infectious diseases, including more than 44 million cases, were reported into the Global Infectious Disease and Epidemiology Online Network (GIDEON) from 219 nations (Smith et al., 2014). Furthermore, both the number and diversity of disease outbreaks have increased significantly from 1980 to 2013, although cases per capita have decreased. These increases are attributed to microbial adaption of pathogens; changing human susceptibility; climate change; changing human demographics; economic development; breakdowns in public health; poverty and social inequality; and war and famine.

Figure 1.1: F-Diagram. Source: Water 1st International 2015



Many of these outbreaks are preventable (Sphere Project, 2011), and WASH interventions are one key component to reducing the burden of disease associated with some outbreaks. WASH interventions can prevent and control waterborne diseases, diseases transmitted through the faecal-oral route and diseases transmitted by direct contact (Sphere Project, 2011, 2014; Watson et al., 2007). This F-Diagram depicts how WASH interventions can interrupt disease transmission routes (Figure 1.1).

There are three diseases of particular and current interest in outbreak response in LMICs: cholera, Ebola virus disease (hereafter 'Ebola') and hepatitis E.

Cholera is caused by ingestion of the bacterium *Vibrio cholerae* in contaminated water and food, and is a severe acute diarrheal disease that can cause death from dehydration within hours if untreated; with treatment a case fatality rate of <1 percent is expected (WHO 2016a). More than 90,000 deaths and 2.8 million cases are caused by cholera each year (Ali et al., 2012). Cases are currently increasing internationally (Gaffga et al., 2007), with a 47 percent increase between 2013 and 2014 alone (WHO 2016d).

Ebola is a viral haemorrhagic fever caused primarily by direct contact with an infected individual in late-stage disease or after death during unsafe burials; indirect contact with fomites (objects) or a bodily fluid-contaminated surface can also cause transmission. Case fatality rates in Ebola range from 50 to 90 percent (Legrand et al., 2007). The Ebola outbreak in West Africa in 2014–2015 was unprecedented in scale, with 28,626 cases and 11,323 deaths, and impacted the entire global community as it was declared a 'public health emergency of international concern' by WHO (WHO, 2016c).

Hepatitis E is a viral liver disease transmitted primarily via the faecal-oral route by contaminated water and is usually self-limiting in humans (Aggarwal and Naik, 2009). However, is some cases, particularly in pregnant women, hepatitis E can cause acute liver failure, and recently hepatitis E outbreaks have become more common in displacement camps (Boccia et al., 2006; Hakim et al., 2016).

All three of these diseases can be prevented and controlled with WASH interventions (Figure 1.2).

Figure 1.2: Diseases transmission and WASH mitigation for diseases of concern

Disease of interest	Transmission	Possible WASH management
Cholera	Faecal-oral	Safe water, sanitation and hygiene
Hepatitis E	Faecal-oral	Safe water, sanitation and hygiene
Ebola	Direct contact with bodily fluids	Precautionary personal hygiene measures, local (household or clinic), environmental control

While responders identified the diseases in Figure 1.2 as primary diseases of interest for the review, the other waterborne diseases of hepatitis A, acute (watery) diarrhoea, typhoid and dysentery were also within the scope of this review.

WASH intervention description

WASH interventions in outbreak situations are not necessarily intended to provide long-term sustainable access, but instead provide rapid relief to minimize the impact or spread of disease (Sphere Project, 2011). The main components of WASH interventions are:

Water – Water interventions in outbreak response aim to increase water quantity or water quality. Increasing water quantity is a necessary step in providing potable water, and also enables hygiene and sanitation practices. Use of water quality interventions at the source or in the household can reduce microbial contamination of drinking water.

Sanitation – Sanitation interventions in outbreak response aim to isolate faeces from the environment. Minimizing open defecation and ensuring proper management of faeces in a latrine or latrine alternative reduces exposure to infectious waste and can reduce disease transmission.

Hygiene – Hygiene messages promote awareness among affected or at-risk populations on the disease and transmission routes, while distribution of hygiene kits equip populations to act on hygiene messages. Environmental hygiene interventions reduce risks by disinfecting household objects and managing rubbish.

As the broad categories of water, sanitation and hygiene are not sufficiently specific for analysis, eight detailed WASH interventions commonly implemented in outbreaks were defined for the review, including three in water, two in sanitation and three in hygiene. The specific WASH interventions identified in the protocol are:

1 increasing access to water

2 source-based water treatment

3 household water treatment (HWT)

4 temporary or permanent latrines

5 latrine alternatives

6 hygiene promotion, including handwashing

7 distribution of soap and/or hygiene materials/kits

8 environmental hygiene.

Please note these eight interventions were modified to a group of 10 interventions after reviewing the included documents. Additional detail and description on each of the specific 10 interventions is provided in Section 3, Results.

Actors in outbreak response

Effectively responding to an outbreak requires collaboration between different actors.

- United Nations (UN) agencies lead emergency 'clusters' covering the range of humanitarian needs in an emergency (e.g. WASH, health, shelter). Different UN agencies lead specific areas of expertise within the overall response, requiring coordination between actors.
- WHO typically leads the UN response in disease outbreak settings by helping to manage and coordinate other UN agencies, local government and non-governmental organizations (NGOs). WHO also leads the Health Cluster, which is responsible for coordination of hospitals, clinics and temporary treatment units. United Nations Children's Fund (UNICEF) typically leads and coordinates the WASH Cluster in disease outbreaks.
- The Global Outbreak Alert and Response Network (GOARN) and Centers for Disease Control and Prevention also house expertise and resources dedicated to rapid response to outbreaks.
- Local governments are involved in many on-the-ground aspects of outbreak response, from agency coordination to treatment centres and municipal services.
- NGOs play a key role in working directly with the communities and in coordination. Additionally, some NGOs specialize in emergency response in outbreaks and manage treatment centres (i.e. Action Contre la Faim (ACF), Médecins sans Frontières and International Medical Corps).

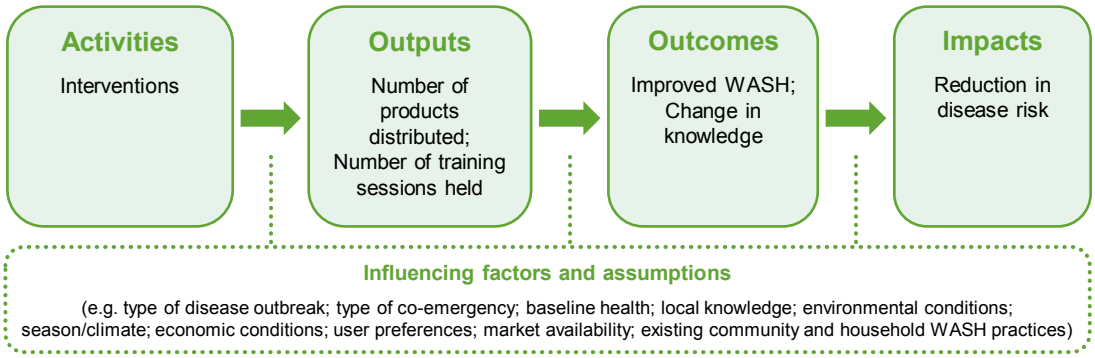
Collectively, these collaborators are referred to as 'responders' throughout this review.

1.3 THEORY OF CHANGE

The goal of all WASH interventions in outbreaks is to reduce the risk of disease transmission. For this review, a theory of change model has been developed for each of the eight initial WASH interventions described in the previous section that: 1) documents the theoretical route from intervention activities to outputs, outcomes and impacts (disease reduction); and 2) includes influencing factors and assumptions (Yates, Vujcic, et al., 2015). The theory of change template is presented in Figure 1.3, and the eight initial specific models are included in the protocol in Yates, Vijcic, et al. (2015).

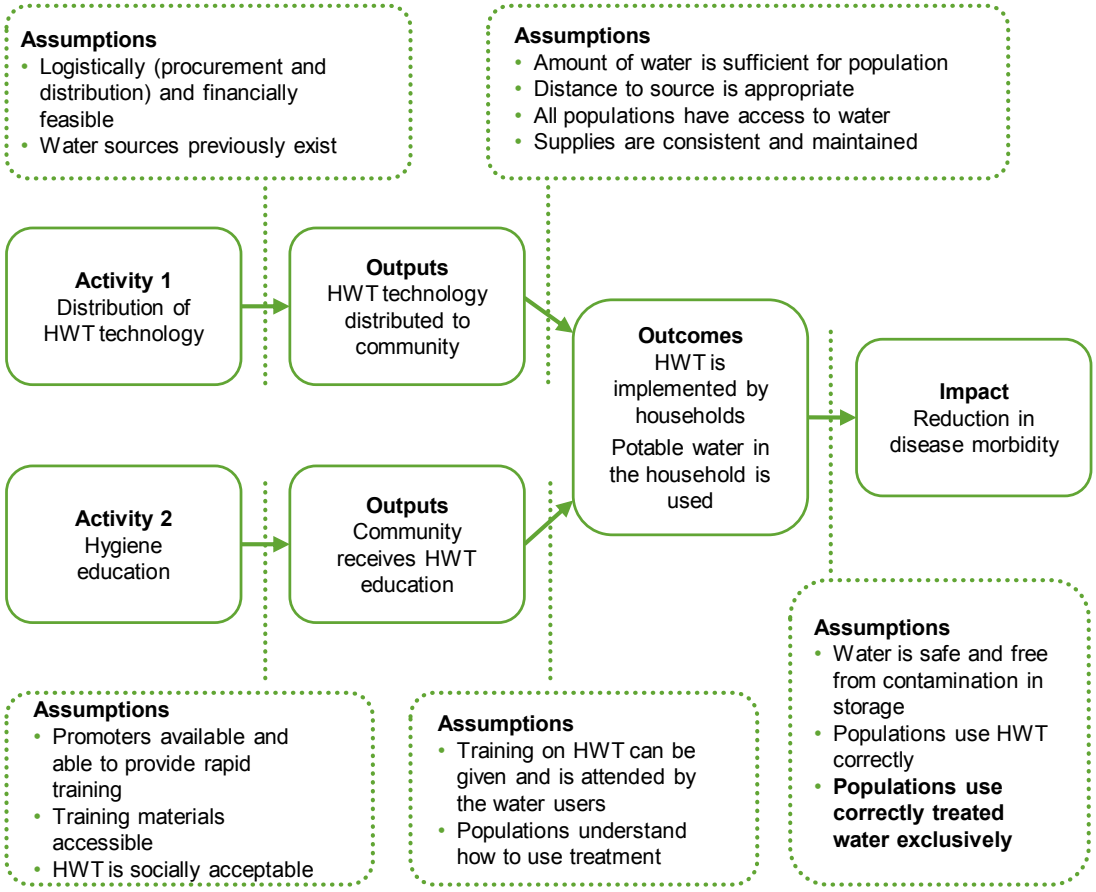
The extent to which WASH interventions are successful in interrupting transmission depends on their efficacy and effectiveness. *Efficacy* is the theoretical potential for breaking transmission routes, and answers the question 'Could the intervention work?' *Effectiveness* includes contextual factors of the intervention such as implementation quality, the natural environment, culture 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 in the target population?'

Figure 1.3: Theory of change template for WASH interventions.
Source: The research team, adapted from WHO (2014)



To illustrate the difference between efficacy and effectiveness, the theory of change for a combined HWT intervention and hygiene education intervention is depicted in Figure 1.4. 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, that is, *effectiveness*.

Figure 1.4: Theory of change: HWT and hygiene education example.
Source: The research team



As a part of a larger WASH review, a systematic review of cholera case-control studies was conducted, and is described in Box ‘Cholera case-control study review example’ on p. 6. The risk and protective factors identified in the case-control studies quantified the influence of assumptions in the causal chain and validated our theory of change models.

Cholera case-control study review example

A systematic review of cholera case-control studies identified 77 studies and nine exposure pathways represented by the F-Diagram (Figure 1.1), socioeconomic status and local customs (i.e. actions at a funeral) (Kaur 2016). Each exposure pathway consisted of a protective factor and the opposing risk factor. For instance, access to treated water was protective, and the lack of treated water was a risk. In total, 12 protective factors and 23 risk factors were identified in the nine exposure pathways. The most notable conclusions were that 50 percent (6/12) of the protective factors significantly reduced the odds of contracting cholera ($p<0.05$), yet all 23 risk factors significantly increased the odds of contracting cholera ($p<0.05$). This indicates that, for example, the *absence of* treated water or a latrine increases the risk of disease; however, the opposite, *access to* treated water or a latrine, is not always protective in preventing cholera. The WASH intervention theory of change was validated by noting that the influencing factors and assumptions play an important role in the impact of a WASH intervention. Improved WASH access or increased knowledge does not always translate to a reduction of disease, thus an appreciation of local customs, ease of use and other factors must be considered to achieve impact.

1.4 IMPORTANCE OF REVIEW

This review is important and timely for three reasons (which are then described in detail):

1 previously published reviews have not had sufficiently broad inclusion criteria or developed policy relevant recommendations

2 in the absence of evidence, decision making in outbreaks is sometimes inappropriate

3 disease outbreaks are currently increasing due to climate change and population growth.

Two 2015 reviews on WASH interventions conclude there is a lack of evidence to support implementing WASH interventions in outbreaks and emergencies (Taylor et al., 2015; Ramesh et al., 2015). The reviews found that the quality of evidence is low and limited to only a small portion of interventions, primarily focused on HWT. However, neither review had inclusion criteria that enabled a full appreciation for the scope of information in outbreak response, ultimately leading to few included studies and a narrow scope of interventions. Taylor et al. focused only on cholera and did not include grey 'unpublished' literature and Ramesh et al. only investigated health impacts for WASH interventions in emergencies. The work presented here includes both published and grey literature, broader inclusion criteria and additional outcomes compared with these 2015 reviews. Previous manuscripts have highlighted the need to inform global policy by identifying which WASH interventions are evidence-based and which need further research (Parkinson, 2009; Darcy et al., 2013). Ideally, the evidence base would draw from published literature, as well as grey literature and qualitative information through a clearly defined review (Brown et al., 2012). This review addresses these previously identified needs.

In the absence of evidence, WASH interventions currently used in outbreak response are often ones shown to be efficacious and effective in development contexts, rather than emergencies (Darcy et al., 2013; Parkinson, 2009). Additionally, responders often default to familiar interventions using 'intuition' and 'if it worked before it will work again' mentalities (Darcy et al., 2013; Loo et al., 2012; Steele and Clarke, 2008). As the effectiveness of WASH interventions depends on contextual factors unique to each disease outbreak emergency (Bastable and Russell, 2013; Loo et al., 2012; Parkinson, 2009), these unjustified assumptions have led to use of interventions in inappropriate situations (Dorea, 2012; Loo et al., 2012). Contextually appropriate information on WASH intervention effectiveness may provide more relevant and effective guidance for responders and lead to better WASH interventions in disease outbreaks. For example, in northern Uganda there are cultural beliefs that a disease outbreak was caused by 'bad spirits', not water, and responders need to understand the local beliefs and the potential impact on use of WASH interventions while responding (de Vries et al., 2016).

Lastly, the number and diversity of outbreaks is increasing (Smith et al., 2014), and outbreaks are anticipated to continue to increase as the factors contributing to outbreaks, such as climate change and increases in population density, intensify. A better understanding of the efficacy and effectiveness of WASH interventions in outbreaks can shape how WASH interventions are implemented to better reach and serve the target communities (Cairncross et al., 2013).

How to read this review

This review is intended to provide policy makers and responders with a comprehensive understanding of the available information on the effectiveness of WASH interventions in outbreak response. It is a systematic synthesis of relevant information intended for a reader with a basic understanding of WASH interventions. The reader is referred to the WASH Gap Analysis (Bastable and Russell, 2013), the Humanitarian Innovation Fund Problem Explanation Reports (Ali and Kadir, 2016; Ramos et al., 2016; Reed and Mena-Moreno, 2016; Tota-Maharaj, 2016; Grange, 2016) and NGO technical guidance documents for information outside the scope of this review.

2 METHODS

A protocol was developed to identify published and grey literature documents with quantitative and qualitative outcomes from a wide network of sources. The full protocol is available on the Oxfam Policy and Practice website.[5] Here, a brief summary of the methods for identification of studies, inclusion criteria, selection process and quality appraisal are presented.

2.1 IDENTIFICATION OF STUDIES

Database and website searching

A comprehensive and systematic search strategy was developed to identify published and grey literature. All search strings for the WASH interventions included terms related to emergencies, disasters and outbreaks as well as LMICs. Individualized search terms were developed for each of the eight initial WASH interventions from their associated theory of change, and included keywords and outcome and impact measures specific to that intervention (Yates, Vijcic, et al., 2015). The eight search strings were used in a total of nine peer-reviewed databases, in English (7), French (2) and English/Spanish (1) including: Cochrane Library, Google Scholar, IDEAS, LILACs, Ovid Medline (PubMed), Scopus, Web of Science, Academic Search Premier (English and French) and ArticleFirst. An example search string for HWT is shown in Box, 'Search string example – household water treatment' below.

Search string example – household water treatment

("household water treatment" OR "house hold water treatment" OR "HWT" OR "hwts" OR "safe storage" OR "SWS" OR "safe water system" OR "point of use" OR point-of-use OR "PUR" OR aquatab OR "bottled water" OR "chlorine solution" OR "HTH" OR "sodis" OR boiling OR "water treatment" OR filter OR chlorine OR alum… *more keywords*…)

AND

(outbreak OR emergenc* OR disaster* OR crisis OR "emergency response" OR "complex emergency" OR "natural disaster" OR flood OR tsunami OR outbreak OR earthquake OR drought OR disease OR endemic OR pandemic OR hurricane OR …*more keywords*…)

AND

("LMIC" OR "low and middle income" OR "low-and-middle-income" OR Afghanistan OR Libya OR Albania OR Macedonia OR Algeria OR Madagascar OR "American Samoa" OR Malawi OR Angola OR Malaysia OR Armenia OR Maldives OR Azerbaijan OR Mali OR Bangladesh OR … *more countries*…)

* indicates a word that has been truncated in order to search for variations of the word.

The journals most likely to have relevant research were also searched by hand. NGO, UN and other relevant emergency responder websites were searched with simplified keyword strings, as many sites were not equipped for complex word searches or did not have data repositories. For example, an NGO website without a data repository might be examined through the search bar with keywords like: 'water emergency' or 'disease outbreak.' The references list of all relevant review documents found in the search and all included evaluations was also reviewed to identify additional documents.

Open requests for information

Email requests for reports, data and general information (included in the term 'studies' hereafter) on WASH interventions in outbreaks were sent out to the Global WASH Cluster email list in September 2015 and February 2016 and to the Working Group of the International Network on Household Water Treatment and Safe Storage and personal contacts lists in September 2015. More than 75 organizations were contacted through email. Additionally, Evidence Aid posted requests for information on its Facebook page and sent

[5] http://policy-practice.oxfam.org.uk/publications/impact-of-wash-interventions-during-disease-outbreaks-in-humanitarian-emergenci-605152

email messages to specific people. Organizations and individuals were also approached at the Emergency Environmental Health Forum in Nairobi in October 2015 (where an oral presentation on this work was presented) and the University of North Carolina Water and Health Conference: Where Science Meets Policy in October 2015 (where a poster on this work was presented).

Additional searching and solicitation is described in Appendix B.

2.2 INCLUSION CRITERIA

Inclusion criteria were established in the protocol to define: populations, interventions, comparisons, outcomes and study types (PICOS) (Yates, Vujcic, et al., 2015). The definitions were developed to guarantee transparency in selection of included evaluations and were approved through a peer review process. General inclusion criteria are summarized in this section, with detailed criteria available in the protocol.

Populations – All age, gender and socioeconomic populations were eligible for inclusion, provided they lived in LMICs. Populations must also have been affected by cholera, Ebola, hepatitis E, hepatitis A, typhoid fever, acute watery diarrhoea, or bacillary dysentery (shigellosis). These diseases were selected because they are of particular and current interest in outbreak response as detailed in Section 1, or are common diseases where WASH interventions can break known transmission routes. For this analysis, we define an outbreak in accordance with WHO (WHO, 2016b) as:

- the occurrence of disease in excess of the normal baseline (two times the baseline) or a sudden spike in cases (two times the incidence of new cases)
- a single case of a communicable disease long absent from a population, or caused by a pathogen not previously recognized in that community or area
- emergence of a previously unknown disease
- a single case of particular diseases of interest (cholera, Ebola and hepatitis E).

While WASH interventions could assist in prevention or control of other transmission routes, these routes were not eligible for review, including vector-borne (e.g. malaria, Dengue fever); airborne (e.g. influenza A virus subtype H1N1); foodborne (e.g. food-related salmonella); and blood/sexually transmitted (e.g. hepatitis C, HIV) diseases.

Interventions: A WASH intervention was eligible for review if it targeted prevention or control of one or more included diseases and was carried out within 12 months of the start of the outbreak. Researchers identified eight initial interventions known to be part of outbreak responses: 1) increasing access to water; 2) source-based water treatment; 3) HWT; 4) temporary or permanent latrines; 5) latrine alternatives; 6) hygiene promotion, including handwashing; 7) distribution of soap and/or hygiene materials/kits; and 8) environmental hygiene. Please note municipal water supply is generally not considered an outbreak response activity and as such is not included in the review.

Comparisons: No specific comparisons were required for inclusion.

Outcomes: Evaluations were included if at least one intermediate outcome (use of service or economic analysis) or final impact (disease reduction or non-health outcomes) was reported.

- **Use of service –** Use of service is a general term that includes three specific indicators: self-reported use, confirmed use and effective use. *Self-reported use* is when a beneficiary reports the use of a product or event without additional verification; this indicator is often heavily biased. *Confirmed use* is when the evaluation tests, observes or confirms a product or service was used in some way (i.e. testing free chlorine residual (FCR) in household drinking water confirms the use of a chlorine water treatment method). *Effective use* is the percentage of households improving their environmental hygiene quality from contaminated to uncontaminated by using a particular intervention. Effective use is a measure of risk reduction that is often assessed via microbiological testing.

- **Economic analysis –** Economic analyses types included are: cost-benefit analysis, cost-utility analysis, cost per beneficiary, cost of products and cost per disability adjusted life-year averted.

- **Disease reduction –** Health impact data is included if beneficiary morbidity and mortality impact are expressed as an odds ratio (OR), risk ratio (RR), disease prevalence or incidence rate. Odds or risk ratios less than 1 show the intervention is protective; ratios greater than 1 reflect an increase in risk from the intervention. The intervention statistically significantly increases or decreases risk if the confidence interval around the point estimate does not include 1.

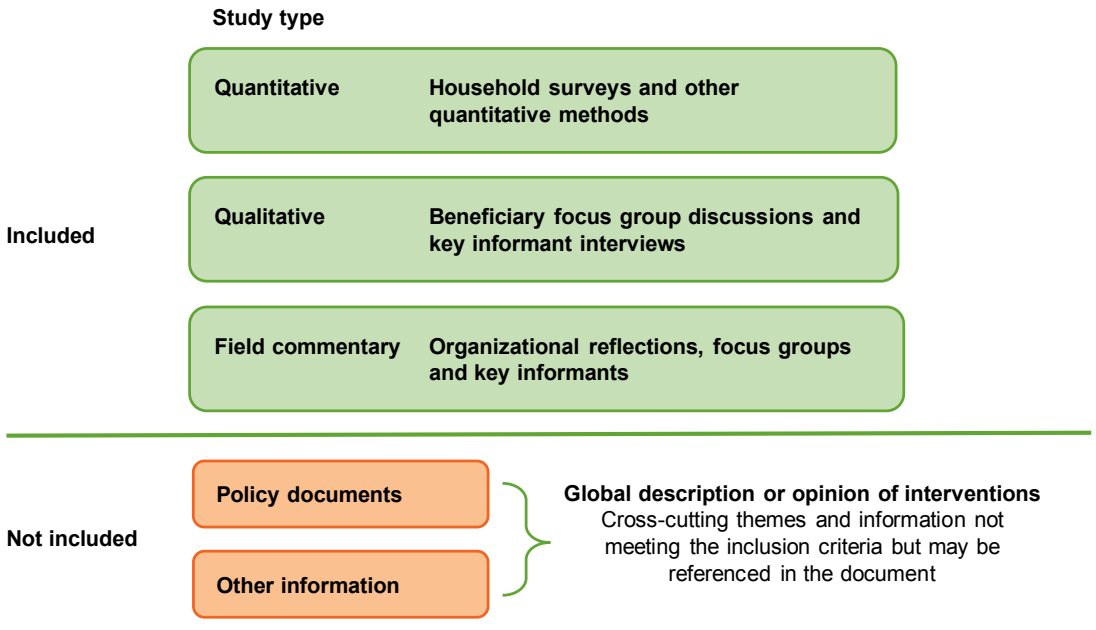
- **Barriers and facilitators –** Non-health related factors of preferences from the population on use of interventions (e.g. ease of use, taste or smell of water), quality of life improvement (e.g. feeling safer, time savings) and agency preferences for interventions are included.

Study types: Experimental, quasi-experimental, non-experimental, mixed-methods and qualitative methodological designs were eligible for review.

Document types: Both peer-reviewed and grey literature documents were eligible for review. Grey literature can include: quantitative or qualitative research and/or field commentary documents. However, personal blogs, diaries, newspapers articles, magazine articles, website postings, poster abstracts and legal proceedings/court documents are not included; these are collectively termed 'policy documents and other information'. Systematic review documents are not included, but individual references were screened for inclusion.

As the scope of this review is wide, for ease in comparing and presenting data, all included documents are categorized as quantitative, qualitative and/or field commentary (2.1). For the purpose of this review, quantitative documents include quantitative and mixed-method evaluations, typically including household surveys. Qualitative documents rely exclusively on beneficiary focus group discussions and key informant interviews. Field commentary documents are organizational or personal reflection on a particular intervention and sometimes also include focus groups or key informant interviews from NGO, UN or government staff (non-beneficiary).

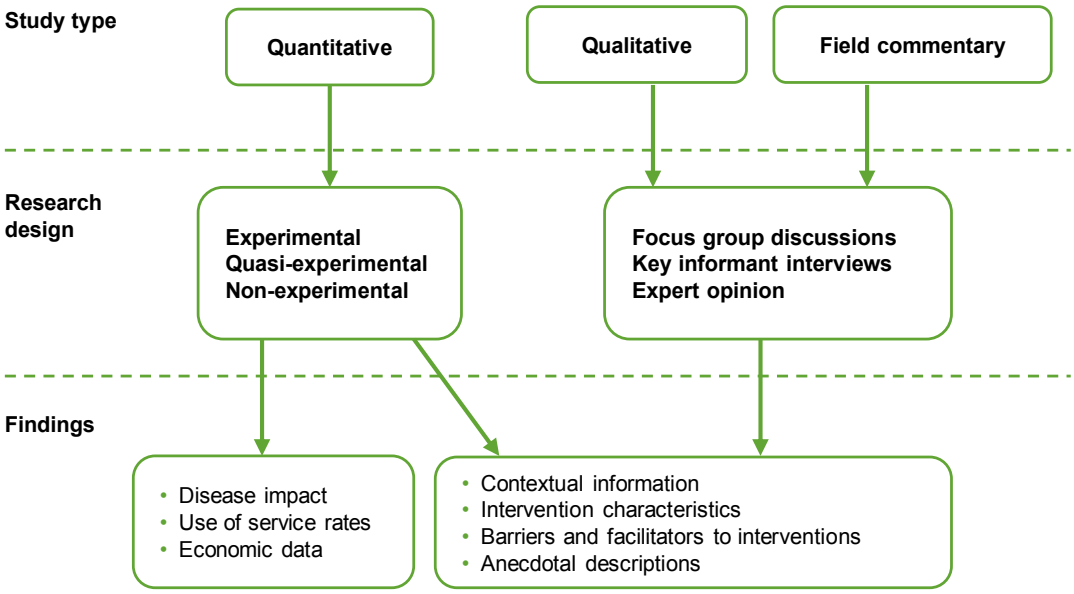
Figure 2.1: Study classification. Source: The research team



2.3 SYNTHESIS

Due to the included study designs, narrative synthesis is used to summarize the information in the review. Quantitative studies evaluate health, use and economic outcomes, as well as barriers and facilitators. Programmatic factors and beneficiary preferences are coded and summarized by theme for all study types (Figure 2.2). Comparison tables and figures are used to show differences and similarities within interventions. The quality of evidence for each outcome of an intervention follows the quality of evidence described in Section 2.4 and the protocol (Yates, Vijcic, et al., 2015).

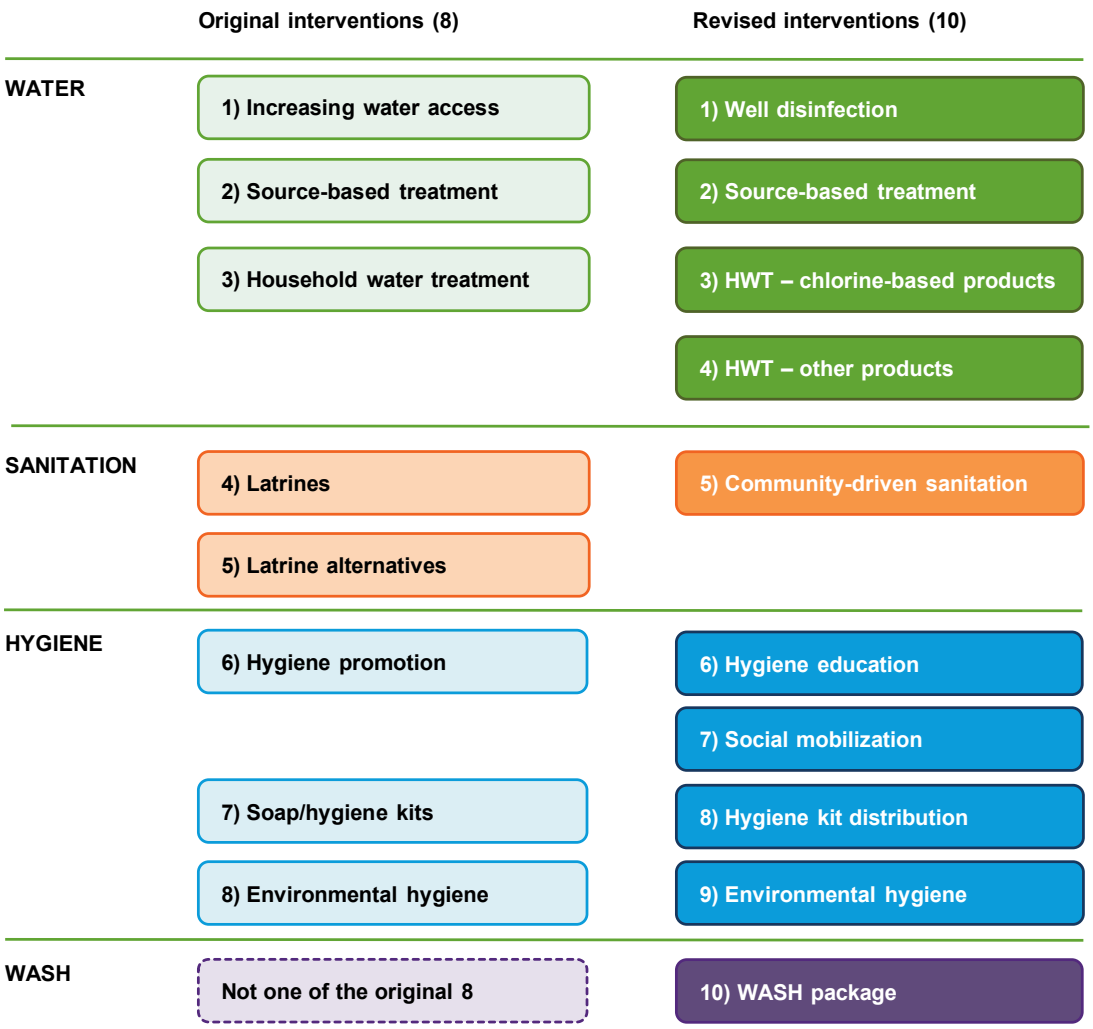
Figure 2.2: Source of data retrieval flow diagram. Source: The research team



The search strategy was tailored for eight different emergency WASH interventions; however, on review of the included studies, more specific intervention categories were found to be necessary to improve intervention comparisons. Ultimately, 10 intervention categories were determined by the research team to better describe the interventions; these are subsets of the original categories, including: four in water, one in sanitation, four in hygiene, and an additional category for WASH package interventions including aspects of water, sanitation and hygiene carried out in unison without a clear emphasis on any one intervention type (Figure 2.3).

Please note: these are primary intervention categories and may include several more specific interventions; for instance, HWT – chlorine-based products includes: chlorine tablets, liquid chlorine and combination flocculant/disinfectants.

Figure 2.3: Intervention categories. Source: The research team



2.4 SELECTION OF DOCUMENTS

All identified documents were screened according to the standards of Cochrane Intervention Reviews (Higgins et al., 2013) by title, abstract and full text review.

Title screening – A single researcher removed documents that were not: WASH related, from LMICs, published between 1995 and 2016 or field-based interventions. Any document that was questionable was included for review in abstract screening.

Abstract screening – Included documents from the title screening were independently assessed by two researchers based on the abstract or executive summary. In addition to the first filter criteria, long-term projects of more than 12 months and interventions in development or protracted contexts were eliminated. If a document was approved by either researcher, the document was included for full text screening.

Full text screening – Included documents from the abstract screening were independently assessed by two researchers to determine if they adhered to all the previous criteria and included at least one of the four intermediate outcomes or final impacts. The researchers needed to agree for the study to be included in the review. Any discrepancies were discussed by a third member of the research team for a final decision.

Throughout the screening process, references were managed with Endnote X7 (New York, NY, USA) and Microsoft Excel 2010 (Redmond, WA, USA).

Data collection and management

For included studies, data collection was done with a detailed coding sheet using Microsoft Excel 2010. Data collection included: author and publication details, type of intervention, context of the intervention, study design, study quality, effect estimation, outcomes, and barriers and facilitators to implementation. Data collection was completed by four research assistants and double screened to ensure accuracy.

2.5 QUALITY APPRAISAL

The quality appraisal included two parts: an assessment on the quality of each included study, and an assessment of the total quality of evidence for each WASH intervention.

Individual study assessment

Each included study was assessed for the potential risk of bias, with different tools used for quantitative and qualitative/field commentary evaluations. The risk of bias of a study is an important step that assesses the validity of the reported findings and conclusions. The full description of terms and processes are in the protocol and briefly summarized here.

Quantitative evaluations – To assess the risk of bias in quantitative studies, an assessment tool was developed based on the *Cochrane Handbook* 'Risk of bias' tool and formatted similarly to Baird et al., (2013) (Higgins and Green, 2008; Baird et al., 2013). The risk of bias was assessed through five categories.

- **Selection and confounding –** Addresses the bias within evaluation methodology design, selection of beneficiaries and matching concerns.
- **Spillover effects and contamination –** Addresses the issue of spillovers from the treatment to the control group. Not controlling for outside factors or for additional interventions in the area also has spillover effects.
- **Incomplete outcome** – Addresses the issue of whether analysis of all relevant outcomes was reported or whether there appears to be selective reporting. Loss to follow up or missing data can reduce the power of the research design as well as potentially introduce bias with unequal loss of sample between groups.
- **Selective reporting** – Authors use a credible analysis method and report on all intended outcomes. Some research is funded by manufacturers of products, which can lead to selective reporting of only favourable outcomes.
- **Other risks of bias** – This category is for any number of other risks of bias present in the report. Self-reported data is of particular concern for our analysis. Also, retrospective baseline data, data using inappropriate methods, and changing follow-up methods or procedures are examples of other potential biases. This is the most subjective of the five categories.

Each study was scored across the five categories as 'low risk,' 'medium risk', 'high risk' or 'unclear.' The summary risk of bias for an individual study is based on the number of 'low risk' assessments across the five categories. If there are four or more low risk assessments the study is considered low risk, if there are three it is medium risk and if there are two or fewer it is high risk.

Qualitative/field commentary evaluations: The qualitative assessment was adapted from Spencer et al. (2003) *Quality in Qualitative Evaluation: A framework for assessing research evidence* (Spencer et al., 2003). The quality assessment is evaluated on four appraisal categories:

- **Design** – The overall design of the research is considered, especially the targeting of the research population.

- **Bias** – How representative is the research population and are there obvious biases that affect the findings?
- **Data collection** – How was the data collected, recorded (audio, video, transcribed)? Who collected the information?
- **Clarity of findings** – Do the conclusions match what could be achieved from the study design? Is there an inherent logic to the conclusions?

Each study was scored across the four categories as 'low risk,' 'medium risk', 'high risk' or 'unclear.' The summary risk of bias for a qualitative/field commentary study is based on the number of 'low risk' assessments across the four categories. If there are three or more low risk assessments, the study is considered low risk, if there are two it is medium risk and if there is one or zero it is high risk.

Quality of evidence for each intervention

To establish the summary of evidence from multiple studies of varying qualities and study designs, a protocol was developed to establish transparency in communicating the overall evidence for outcomes and interventions. The summary of evidence protocol is based on a Grading of Recommendations Assessment, Development and Evaluation (GRADE) of evidence outlined in Cochrane Review; however, some modifications were made so there would be less emphasis on randomized controlled trials (RCT), which are known to be rarely carried out in humanitarian research. A three-step evaluation process was used to determine the level of evidence with transparency. The baseline of evidence (Step 1) is determined by the study design. Then, steps 2 and 3 downgrade or upgrade the baseline evidence considering biases, effect size, consistency and generalizability (Figure 1.2; see Appendix C for further description). The summary of evidence is described through four categories to give the reader levels of confidence in the quality for the outcomes and interventions. The four hierarchal categories mimic the GRADE conclusion definitions (Oxman and GRADE Working Group 2004):

- **High –** Further research is very unlikely to change our confidence in the estimate of effect or accuracy.
- **Moderate** – Further research is likely to have an important impact on our confidence in the estimate of effect or accuracy and may change the estimate.
- **Low** – Further research is very likely to have an important impact on our confidence in the estimate of effect or accuracy and is likely to change the estimate.
- **Very low** – Any estimate of effect or accuracy is very uncertain.

2.6 CONTINGENCY ANALYSIS AND DEVIATIONS FROM THE PROTOCOL

Considerations for missing data and meta-analysis techniques are described in the protocol; however, the low quality research designs identified and included in the review undermined the relevance of meta-analysis and therefore most contingency measures. Procedures to address unit of analysis issues, independent findings, economic synthesis, use of weighted average, pooled effect, forest plots and funnel plots are found in the protocol (Yates, Vijcic, et al., 2015) but not further described here because they were not used in the review. Formal heterogeneity analysis with I^2 could not be completed as reported outcomes were too different for direct comparison. Finally, the initial eight WASH intervention categories were expanded to 10 interventions and the intervention quality assessment was slightly adjusted from the protocol.

Case-control studies focusing on disease risk factors are not included in the main review, as cholera or other diseases were the outcomes (and as such well described) and the WASH interventions identified as significant (or not) are input variables, and self-reported and poorly described in the studies. A separate systematic review was conducted, summarizing cholera risk factors (See Box, 'Cholera case-control study review example', p. 6).

The anticipated comparisons described in the protocol are also undermined by the lack of data quality and could not be carried out. The WASH interventions are not targeted to a specific gender, age range or other demographic along the PROGRESS-Plus subgroups.[6] Additionally, the intervention setting (urban, rural, per-urban) is not always reported, and with some interventions covering a wide geographic area to large populations, it was not possible to compare across intervention setting.

[6] Place of residence, ethnicity, occupation, gender, religion, education, social capital, socioeconomic position, age, disability, sexual orientation, other vulnerable groups. Kavanagh, J., Oliver, S., Lorenc, T. *Reflections on developing and using PROGRESS-Plus. Equity Update*. 2008;2:1–3.

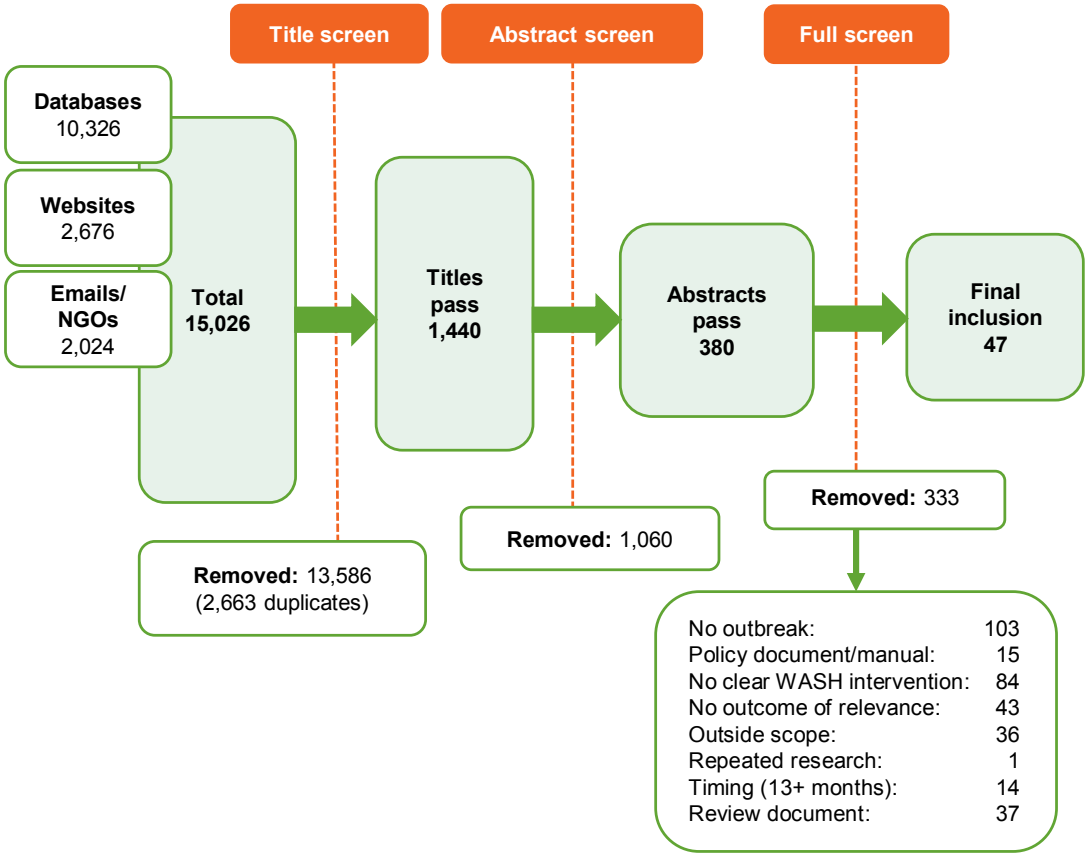
3 RESULTS

In this section, a general overview of the review findings is presented, followed by detailed results by WASH intervention in Sections 3.1 to 3.5. Several interventions related to outbreak response are briefly described in Section 3.6 and economic analysis results are presented in Section 3.7. Lastly, a summary of interventions and a revisit to the theory of change modelling is included in Section 3.8.

3.1 OVERVIEW

Overall, 15,026 documents were identified in the systematic review process, including 37 review documents (Figure 3.1). After applying the three selection filters, 47 studies describing evaluations with 51 relevant contexts were included. In September 2016, database searches were re-run for recent publications, but no additional studies were identified for inclusion.

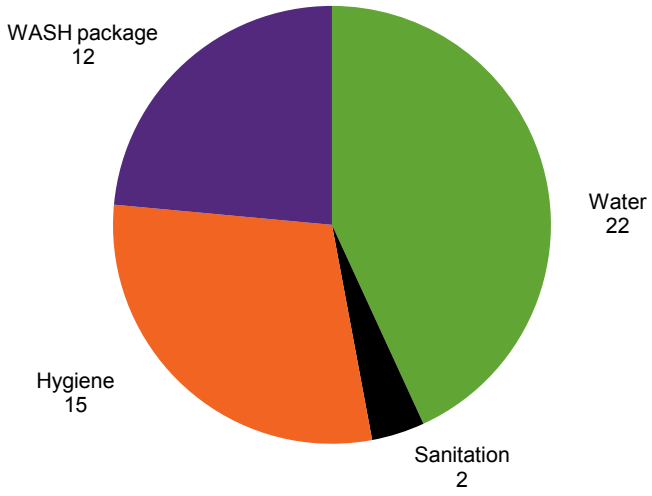
Figure 3.1: Screening process. Source: The research team



The included studies are summarized for comparison in tabular format in Appendix A.

The included studies describe WASH interventions in 19 countries, with the highest frequency of evaluations from Zimbabwe and Haiti. Cholera is the most researched and discussed disease, representing 86 percent (44/51) of the diseases responded to in the included evaluations; Ebola (2, 4%), acute watery diarrhoea (3, 6%), shigellosis (1, 2%) and typhoid fever (1, 2%) make up the other diseases evaluated.

Figure 3.2: WASH component summary. Source: The research team



Water interventions represent the largest grouping of included evaluations (n=22, 43%), followed by hygiene (n=15, 29%) and WASH package (n=12, 24%) (Figure 3.3). Sanitation interventions are represented by only two evaluations (4%) (Figure 3.2).

A near equal number of evaluations were identified from the peer-reviewed (26, 51%) and grey literature (n=25, 49%) (Figure 3.3). Although the overall number of evaluations is nearly equal between published and grey literature, differences are seen by intervention, with water having more published evaluations and hygiene and WASH package having more grey literature evaluations.

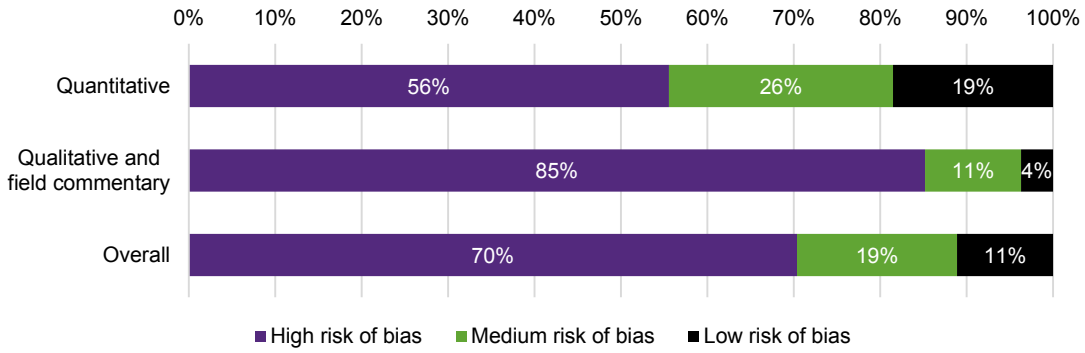
Figure 3.3: Included studies by intervention, evaluation and publication

Intervention (number)	Quantitative	Qualitative	Field commentary	Published or grey literature (P:G)
Water	**19**	**2**	**1**	**18:4**
Well disinfection (5)	2	2	1	5:0
Source-based treatment (3)	3	0	0	3:0
HWT – chlorine-based products (10)	10	0	0	6:4
HWT – other products (4)	4	0	0	4:0
Sanitation	**1**	**0**	**1**	**1:1**
Community-driven sanitation (2)	1	0	1	1:1
Hygiene	**5**	**4**	**6**	**7:8**
Hygiene promotion (7)	3	1	3	4:3
Social mobilization (3)	0	1	2	0:3
Hygiene kit distribution (1)	1	0	0	0:1
Environmental hygiene (4)	1	2	1	3:1
WASH package	**0**	**3**	**9**	**0:12**
WASH package (12)	0	3	9	0:12
Totals	**25**	**9**	**17**	**26:25**

Note: studies are allocated to one category in the figure to avoid double-counting, but may be in more than one category when described below.

The majority of the evaluations (70%, 38/51) have a high risk of bias (Figure 3.4). The quantitative studies are mostly completed on water interventions, are more likely to be published and have less risk of bias. For example, published water evaluations are 47 percent low risk of bias (9/19), while no other WASH interventions have a low risk evaluation (0/32). Conversely, the WASH package evaluations are field commentary, unpublished, high risk of bias evaluations. The risk of bias for each evaluation is documented in Appendix D.

Figure 3.4: Risk of bias summary. Source: The research team



Overall, the study designs are weak, as only 14 percent of studies (7/51) have any type of control group and less than 4 percent (2/51) are RCTs. Diversity of outcomes is also weak, with measured health impacts in only six (12%) of the interventions, and use is focused toward HWT interventions.

Sensitivity

The body of included evidence was sensitive to evaluation design, implementing organization and grey literature. The review is sensitive to the inclusion of low quality research designs; if they were not included the review would be limited to HWT studies, leaving the other eight interventions identified with no evidence. While studies were conducted by organizations varying from local governments to university (academics), most (80%, 41) were by NGOs. Overall, at least 27 different agencies had provided documents that were reviewed in the identification process; however, ACF and Oxfam contributed the largest amount of studies in the identification process. This is represented in the included studies, of which documents submitted from these two organizations account for 45 percent (23) – a substantial portion of the evidence base. Lastly, grey literature contributes to nearly half (49%, 25/51) of the included studies. These factors are fundamental to the review, and as such sensitivity was not investigated by individual intervention or outcome.

3.2 WATER: SOURCE-BASED INTERVENTIONS

The source-based interventions of well disinfection and chlorine dispensers are assessed in six studies in eight contexts. While well rehabilitation and water trucking were listed as outbreak activities in some documents, none of the included evaluations assess these activities.

Well disinfection

Disinfecting a contaminated well with chlorine is a common intervention in outbreak response, and is achieved through shock or pot chlorination.

- **Shock chlorination** – A single dose of chlorine is added directly into the well, 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** – A porous container filled with sand and powdered chlorine is inserted in a well, intended to slowly disperse chlorine and treat water over an extended time.

Five evaluations were identified that describe four slightly different approaches to well disinfection with chlorine (note that two studies evaluated multiple methods) (Figure 3.5):

1 a shock dose of liquid chlorine (bleach)

2 pot chlorination with powdered chlorine, sand and gravel in a pierced jerry can

3 pot chlorination with locally pressed chlorine tablets in a perforated container

4 floating pot chlorinator (commercial plastic mushroom-shaped device used with swimming pools).

All of these approaches require an understanding of chlorine dose with respect to chlorine concentration and water volume. The amount of organic content and withdrawn water also impact the amount of chlorine needed for treatment. Ideally, the FCR for water treatment would be greater than or equal to 0.2mg/L and less than or equal to 2.0mg/L – which is the range ensuring water treatment but not exceeding taste or guideline thresholds.

Figure 3.5: Well disinfection comparison. Source: The research team

Author (year) Country Bias	Context Approach	Evaluation	Findings
Rowe (1998) Guinea-Bissau High risk	Outbreak cholera – Urban 1) Liquid chlorine: bleach added to achieve 30mg/L in well	Cross-sectional 10 shallow (hand dug) wells monitored every 24 hours until FCR degraded	• 40% of wells had FCR >0mg/L after 24 hours (median 24 hours; range 0-6 days)
Libessart (2000) Somalia High risk	Endemic cholera – Urban – internally displaced persons (IDP) 1) Liquid chlorine: 1% chlorine solution 2) Pot chlorination: 5L jerry can with gravel, sand and chlorine layers (chlorine not described). 3) Pressed chlorine tablets: 125g of high test hypochlorite (HTH) (75% chlorine) pressed into a tablet, inserted into a pierced pipe	Cross-sectional FCR measured at different times over several programming cycles: 1) 1% liquid chlorine: 173 wells over 1 year; 2) Jerry can pot chlorination: 919 tests over 3 months; 3) Pressed tablet pot chlorination: 98 tests (duration not reported)	• 1) 69% of sample had FCR >0mg/L; n=178 samples. FCR lasted about an hour • 2) 87% of sample had FCR >0mg/L; n=919 samples • 3) 94% of sample had FCR >0mg/L; n=98 samples
Garandeau (2006) Liberia High risk	Cholera – Peri-urban – IDPs 1) Liquid chlorine: 5% chlorine bleach, twice per day. 2) Pot chlorination: 4L jerry can with gravel, sand and powdered chlorine layers (0.5L calcium hypochlorite granules, 65% chlorine) 3) Pot chlorination with pressed chlorine tablets: 70g calcium hypochlorite (65% chlorine) pressed into a tablet, 1–2 tablets suspended in a pierced plastic bag with 2L of sand 4) Floating pot chlorinator: Floating pool chlorinator, 200g trichloroisocyanuric acid tablets	Cross-sectional 12 hand dug wells (3 protected and 9 unprotected) used over 9 weeks with different chlorination techniques, FCR measured	• 1) FCR was >0.2mg/L for less than 1 day. • 2) Chlorine granules dissolved too quickly, spiking the well up fast (FCR up to 10mg/L) • 3) FCR stable between 0.2–1.0mg/L in all wells for 3–6 days • 4) FCR could be stable with close monitoring but pots not locally available and interfered with drawing water
Guevart (2008) Cameroon Low risk	Cholera outbreak – Urban 1) Pot chlorination (with perforated bag), including powdered chlorine (calcium hypochlorite, 70% chlorine) and ~1kg sand	Cross-sectional 18 wells (2 villages – 9 wells each) 36 chlorinations – FCR measured daily	• FCR remained >0.2mg/L for 3 days, after 4 days half of the wells were <0.2mg/L
Cavallaro (2011) Guinea-Bissau Low risk	Cholera outbreak – Urban and rural 1) Pot chlorination in 1.5L plastic bottle with gravel, sand and HTH, 15g per 1,000L of well water (70% chlorine)	Cross-sectional 30 wells – FCR and TCR measured daily for 1–3 days after inserting chlorinator	• FCR was >0mg/L FCR in 73% of wells (19/26) after 24 hours; 42% (11) >0mg/L after 48 hours; 31% (8) after 72 hours

While all five evaluations describe well disinfection, the approach and sampling varies and thus evaluations are heterogeneous. Additionally, beneficiary use, soil and well conditions could influence results, but are not sufficiently described for sub-group comparisons. Results are described by three variations of pot chlorination (traditional, floating pot and pressed tablet) and shock chlorination.

Traditional pot chlorination – Pot chlorination with pierced jerry cans had mixed results, but did have the negative effect of spiking wells in Liberia to levels approaching 10mg/L. Pot chlorination in Somalia and Cameroon did not report spikes, but also did not detail the time frame for FCR levels. A small 1.5L pot chlorinator had limited success in Guinea-Bissau with 73 percent of wells maintaining FCR for 24 hours, and 31 percent for three days or more (Cavallaro et al., 2011). Pot chlorination was successful in providing consistent FCR for three days in Cameroon (Guevart et al., 2008), which is similar to results seen in a pot chlorination intervention in Angola that was not outbreak related and not included in the review, but did reduce microbiological contamination in wells (Godfrey et al., 2003).

Floating pot chlorinator – Floating pot chlorinators could provide consistent chlorine residual, but required regular adjustments and were not locally available.

Pressed tablet pot chlorination – Calcium hypochlorite pressed into HTH tablets are assessed as the best well treatment option by implementing agencies in both comparative evaluations (Garandeau, Trevett, and Bastable, 2006; Libessart and Hammache, 2000). Pressed tablets were locally made and maintained appropriate levels of FCR for 3–4 days.

Shock chlorination – Single and regular repeated doses of liquid chlorine solution are consistently determined by studies to be ineffective at maintaining FCR for more than a few hours (Rowe et al., 1998; Libessart and Hammache, 2000; Garandeau et al., 2006). The chlorine residual lasted only a short time, yet the community perceived (when asked) that a single dose of chlorine would protect the well for up to six months (Rowe et al., 1998).

Well disinfection summary

Shock chlorination did not provide residual protection for more than a few hours. Traditional pot chlorination inconsistently maintained measurable FCR for 1–4 days. In comparative evaluations both with high risk of bias, pressed HTH tablets in pot chlorination maintained FCR for 3–4 days and was the preferred mode of well disinfection by the implementing organizations (Figure 3.6). Despite variations in interventions and sampling strategies, conclusions are consistent for traditional pot chlorination, pressed tablets and shock chlorination. The disconnect between community perception and actual safe water noted in one study is an important consideration for any well disinfection intervention.

Figure 3.6: Well disinfection summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	-	-	-
Use	-	-	-
Barriers and facilitators	5	Moderate	Variations in interventions and different sampling method but conclusions were consistent for each treatment group Pot chlorination was evaluated with four studies of high and low quality, maintaining FCR for 1–4 days Pressed chlorine tablets pot chlorination was evaluated by two studies of low quality but was preferred by implementing agencies in comparative studies because FCR was maintained for 3–4 days Liquid chlorine interventions consistently provided FCR for less than one day

Source-based treatment

Source-based treatment is water treatment that occurs at the source itself. Chlorine dispensers and bucket chlorination are two source-based water treatment interventions used in outbreak response.

- **Chlorine dispensers** – A chlorine 'dispenser' programme includes hardware installed next to a water source that dispenses chlorine solution, a local 'promoter' who refills the dispenser and conducts community education and a supply chain of chlorine refills. Users treat water by turning a valve that dispenses a controlled amount of chlorine solution.

- **Bucket chlorination** – A person is stationed near a water source and adds a known dose of chlorine directly into the recipient's water collection container.

Evaluations were identified in the review only for dispensers. Dispensers were used in three different cholera contexts: Haiti, Sierra Leone and Democratic Republic of Congo (DRC) with three different NGOs (Yates, Armitage, et al., 2015). Results over two acute evaluations (2–8 weeks after installation) and three sustained evaluations (4–7 months after installation) focused on reported use, confirmed use and effective use (Figure 3.7). Spillover effects from other water treatment options were present and assist in explaining results, as the municipal water system in DRC was functional in the sustained evaluation and 32 percent of households in Haiti reported using chlorine tablets, which is an alternative treatment method. Through regression analysis of household survey data, speaking to the promoter within the last month and collecting water from a source with a dispenser are factors consistently associated with higher use across the different contexts.

Figure 3.7: Source-based treatment comparison

Author (year) Country Bias	Context Approach	Evaluation	Use outcomes		
			Reported use	Confirmed use	Effective use
Yates, Armitage (2015) Haiti Low risk of bias	Cholera outbreak – Rural 60 dispenser sites 20L and 5L dose per site 1 promoter/site	Cross-sectional (cluster) 298 households (HH)	Sustained		
			55%	9%	4%
Yates, Armitage (2015) Sierra Leone Low risk of bias	Cholera outbreak – Peri-urban 50 dispenser sites 20L dose per site 32 promoters/50 sites	Cross-sectional (cluster) 300 HH (initial and sustained)	Initial		
			26%	11%	10%
			Sustained		
			31%	18%	10%
Yates, Armitage (2015) DRC Low risk of bias	Endemic cholera – Rural and peri-urban 100 dispenser sites 2 – 20L doses per site 1 promoter/site	Cross-sectional (cluster) 300 HH (initial and sustained)	Initial		
			76%	34%	28%
			Sustained		
			75%	5%	0%

A fourth case study in the same evaluation was conducted in a non-outbreak situation, and had much higher results (>79% reported use, confirmed use and effective use in initial and sustained evaluations). Acknowledging the low effective use rates in Figure 3.7, the three implementing organizations gathered at project end and reflected on factors that led to success. These included: 1) appropriate source selection; 2) chlorine solution quality and supply chain; 3) dispenser hardware installation and maintenance; 4) integration into a larger WASH programme; 5) promoter recruitment and remuneration; 6) experienced programme staff; 7) partnering with local organizations; 8) conducting ongoing monitoring; and 9) having a sustainability plan.

Source-based treatment summary

Use rates varied, but dispensers are deemed to be an appropriate option if the certain contextual conditions, discussed previously, are met (Figure 3.8). Through low risk studies, promotion and access are consistently significant factors in use of the dispensers.

Figure 3.8: Source-based treatment summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	-	-	-
Use	3	Moderate	Variation in reported, confirmed and effective use – context specific, promotion and accessibility as factors
Barriers and facilitators	3	Moderate	Speaking with promoter and easy access to dispenser associated with higher use

3.3 WATER: HOUSEHOLD WATER TREATMENT AND SAFE STORAGE

HWT products (also called point-of-use water treatment products) are interventions used in the home to improve the microbiological quality of household drinking water. These may be distributed as a sole intervention or included as one of several items in a hygiene kit. Distributions also sometimes include hygiene promotion.

Household water treatment – HWT products (chlorine products, filters, solar disinfection and boiling) disinfect, remove or inactivate harmful pathogens. HWT products are used at home, relying on the beneficiary to understand instructions and use materials correctly.

Hygiene kit distributions – Hygiene kits, a type of non-food items (NFI) distribution, provide outbreak-affected populations with materials to reduce the risks of disease transmission. HWT products, soap, water storage containers and household disinfection materials are commonly included items in hygiene kits.

Hygiene promotion – Hygiene promotion related to HWT products typically include printed instructions on how to use a product or a community health worker giving a lesson on correct use. Community health workers may also share outbreak-related information.

HWT is the most studied intervention with 16 evaluations, some of which use multiple products. Overall, ten used chlorine-based products (six with chlorine tablets, four with liquid chlorine), three used flocculant/disinfectants, two used filters, one used solar disinfection and one used boiling. Additionally, safe storage of water was evaluated in two evaluations.

HWT – chlorine-based products

Chlorine is often distributed in outbreak response, particularly in cholera response, because it effectively inactivates most bacterial and viral pathogens, leads to residual protection, is low cost and is easy to use and transport. Users add one tablet or measured amount of liquid (usually 1 capful) to low-turbidity water, wait 30 minutes and drink. Higher turbidity water can be treated by doubling the dose. There are two chlorine-based HWT options used in outbreaks: tablets and liquid.

- **Chlorine tablets** – Small tablets of 7–167mg sodium dichloroisocyanurate used to treat 1–20L of water (e.g. Aquatabs®).
- **Liquid chlorine** – Either a small bottle of 1–1.25 percent sodium hypochlorite, sized so one cap is used to treat 20L of water (e.g. WaterGuard) or commercial bleach, where the dosage is generally in drops.

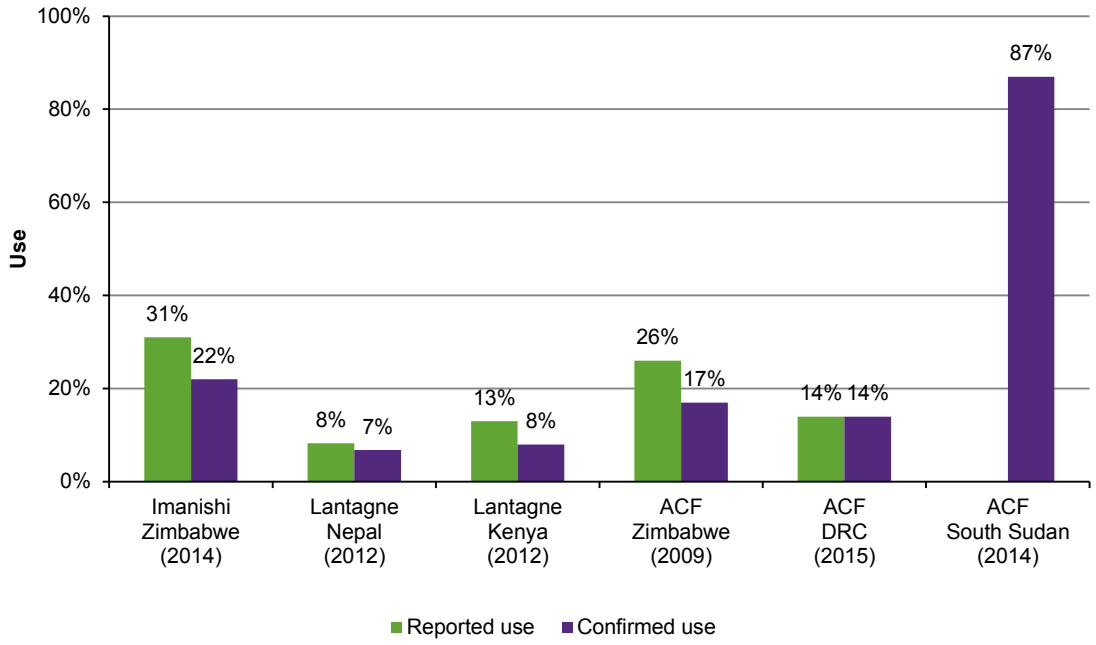
Note: combination flocculant/disinfectants also use chlorine to disinfect drinking water, but have another chemical agent to reduce turbidity. For this review, combination flocculant/disinfectants are also considered within the HWT – chlorine-based products category and described further below in a dedicated sub-section.

Reported use, confirmed use and effective use are all outcome metrics reported for chlorine-based HWT options. Among the nine chorine-based evaluations, eight measure reported use, eight measure confirmed use and seven report both. Effective use is measured in one evaluation. Individual assessments of chlorine tablets and liquid chlorine are separated for further analysis in the following sections.

Chlorine tablets

Chlorine tablets were used in six evaluated contexts (Figure 3.10). The free distribution of chlorine tablets was through a hygiene kit in all contexts. The distributed tablets (67–167mg) were intended to treat 10–20L of water. Evaluations included both reported and confirmed use in five out of six contexts (Figure 3.9). The reported use ranges between 8 and 31 percent, while confirmed use ranges between 7 and 87 percent with a noticeable outlier Figure 3.9). The heterogeneity of context, intervention and evaluation was too high to calculate summary statistics or conduct meta-analysis.

Figure 3.9: Chlorine tablet evaluations with reported and confirmed use. Source: The research team



The noticeable outlier is a grey literature evaluation with a high risk of bias from a cholera response in South Sudan (ACF 2014a). A possible explanation for the outlier is that hygiene promotion was conducted before the distribution of the HWT products, and as such the beneficiary population reported high cholera knowledge. Overall, 92 percent of households reported a visit before the hygiene kits distribution and 84 percent reported attending an awareness session; additionally, 82 percent of households reported that drinking chlorinated water prevents cholera. The evaluation was also 1–3 weeks after distribution, which could explain higher recall and use.

Figure 3.10: Chlorine tablet comparison

Author (Year) Country Bias	Context Approach	Evaluation	Findings	
			Reported use	Confirmed use
Imanishi (2014) Zimbabwe Medium risk of bias	Cholera outbreak – Large geographic area Three chlorine tablets distributed by different organizations: Oasis 67mg, Aquatabs 67mg, Aquatabs 167mg in hygiene kits with door-to-door promotion and information, education and communication materials to 51,000 HH	Cross-sectional 458 HH	31% of HH reported use	22% of HH confirmed use (FCR >0.0mg/L)
Lantagne (2012) Nepal Low risk of bias	Cholera outbreak – Extreme rural Local NGOs using pre-positioned hygiene kits. 1,565 HH received Aquatabs® and also liquid chlorine (WaterGuard, Piyush) with hygiene promotion	Cross-sectional 400 HH	8.3% of HH reported use	6.8% of HH confirmed use (FCR ≥0.2mg/L)
Lantagne (2012) Kenya Low risk of bias	Cholera and flooding – Extreme rural Pre-positioned hygiene kits. Aquatabs® and PUR® Purifier of Water included to 5,592 HH	Cross-sectional 409 HH	13% of HH reported use	7.9% of HH confirmed use (FCR ≥0.2mg/L) (Effective use: 5.3% of HH)
ACF (2009) Household Zimbabwe High risk of bias	Cholera outbreak – Large geographic area Aquatabs® distributed HH as part of an NFI kit with bucket and lid (~33,000 – kits, other contents not described)	Cross-sectional 218 HH	26% of HH reported use	17% of HH confirmed use (FCR >0.5mg/L)
ACF – Tokplo (2015) DRC High risk of bias	Endemic outbreak – Large geographic area Distribution of chloramine tablets in hygiene kits with promotion to 3,000 HH	Cross-sectional 384 HH	14% of HH reported use	14% of HH confirmed use (FCR 0.3–0.6mg/L)
ACF (2014) Hygiene kits post distribution monitoring (PDM) report South Sudan High risk of bias	Cholera outbreak – Large geographic area 7,348 hygiene kits with promotion including: Aquatabs, filter cloth, PUR packets and bucket	Cross-sectional 351 HH	Reported use not measured	87% of HH confirmed use (FCR >0.1mg/L)

The taste and smell of chlorine tablets was reported as a barrier to use in five contexts within three countries (ACF, 2009; Lantagne and Clasen, 2012; Imanishi et al., 2014; Ruiz-Roman, 2009). Part of the reason for the taste and smell objections may have been confusion between the appropriate tablet dose and water storage container size, as some respondents did not have the appropriate water storage container for the tablet size distributed and this may have led to high doses and unfavourable taste (Imanishi et al., 2014; ACF, 2009). Additionally, sometimes multiple tablets were distributed, leading to confusion in users. Knowing an HWT method before the outbreak was an indicator of use in Zimbabwe (Imanishi et al., 2014) and Nepal (Lantagne and Clasen, 2012), where familiarity and ease-of-use of chlorine tablets were also described.

Chlorine tablet summary

The quality of evidence for individual studies is mixed, but reported and confirmed use are consistently low, with one outlier with high bias (Figure 3.11). Hygiene promotion and alternative treatment methods could also factor into the low use. Although the simplicity and ease-of-use of tablets were appreciated, it is noted that having a storage container of appropriate size for the tablet is helpful and having multiple tablets distributed in the same emergency could be confusing.

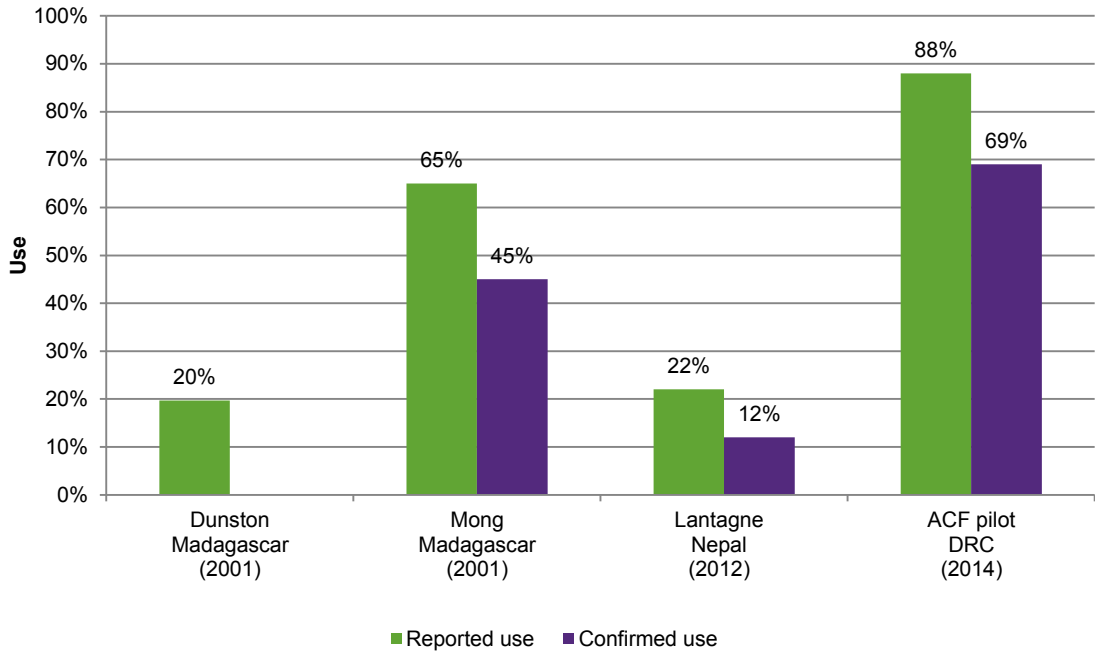
Figure 3.11: Chlorine tablet summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	-	-	-
Use	6	Moderate	Reported use ranged between 8–31% and confirmed use ranged between 7–87%; with the outlier from South Sudan removed the range is 7–22%
Barriers and facilitators	5	Moderate	Chlorine taste/smell, ease-of-use and familiarity influence use and acceptance

Liquid chlorine

Liquid chlorine is evaluated in four contexts in three countries (Figure 3.13). Reported use ranges between 20 and 88 percent, and confirmed use ranges between 12 and 69 percent (Figure 3.12). As heterogeneity and bias of the studies is high, meta-analysis was not conducted.

Figure 3.12: Liquid chlorine evaluations with reported and confirmed use. Source: The research team



Some of the heterogeneity could be explained by the active promotion of liquid chlorine before the outbreaks in the two studies with higher use rates in the DRC (Tokplo, 2015) and Madagascar (Mong et al., 2001). Cost may explain the low use in Madagascar (Dunston et al., 2001) as the free distribution of the same product had much higher rates in the same area (Mong et al., 2001). Excessive dosing is observed in Madagascar (FCR >3.5mg/L) (Mong et al., 2001) and taste is only noted as a hindrance to use in Nepal (Lantagne and Clasen, 2012).

Figure 3.13: Liquid chlorine comparison

Author (Year) Country Bias	Context approach	Evaluation	Use outcomes	
			Reported use	Confirmed use
Mong (2001) Madagascar High risk of bias	Cholera outbreak and cyclone – Peri-urban Liquid chlorine and 5 gallon flexible jerry can distributed to 11,700 HH with some education about use. Distribution in area with programme before emergency	Cross-sectional 123 HH	65% of HH reported use	45% of HH confirmed use (FCR ≥0.2mg/L)
Lantagne (2012) Nepal Low risk of bias	Cholera outbreak – Extreme rural Local NGOs using pre-positioned hygiene kits. 1,565 HH received liquid chlorine (WaterGuard®, Piyush®) but also Aquatabs® with hygiene promotion	Cross-sectional 400 HH	22.2% reported use (2 products: WaterGuard® 6.3%; Piyush® 15.8%)	11.8% of HH confirmed use (2 products: WaterGuard® 3.5%; Piyush® 8.3%) (FCR ≥0.2mg/L)
Dunston (2001) Madagascar High risk of bias	Cholera outbreak – Urban Liquid chlorine marketed to community. Jerry cans available but not distributed	Cross-sectional 375 HH	19.7% of HH reported use	No confirmed use measured
ACF (2014) DRC High risk of bias	Endemic cholera – Large geographic area Distribution and promotion of liquid chlorine with vouchers to 834 HH	Cross-sectional 32 HH	88% of HH redeemed voucher (proxy for use)	69% of HH confirmed use

Liquid chlorine is more often linked to long-term development approaches, including promotion (compared with distribution), cost-recovery, social marketing (Dunston et al., 2001), local production (Date et al., 2013) and vouchers (ACF, 2014b). These programme types were all used in liquid chlorine programming, and not described in other interventions. Liquid chlorine was also more regularly used in endemic situations, as areas with endemic or repeated outbreaks are responded to like a development project, occasionally scaling up ongoing interventions.

Liquid chlorine summary

Liquid chlorine interventions include programmes that promote, distribute, market and redeem vouchers for chlorine solutions. Previous exposure to liquid chlorine in development settings before an outbreak and products distributed at no cost could explain some of the heterogeneity in use, although three of the four studies are high bias. Links to development programming may have contributed to relatively higher use of liquid chlorine than chlorine tablets, which were predominantly distributed in NFI kits (Figure 3.14).

Figure 3.14: Liquid chlorine summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	-	-	-
Use	4	Low	Reported use ranged between 20–88% Confirmed use ranged between 12–69%
Barriers and facilitators	4	Low	Exposure to liquid chlorine in non-emergency setting (familiarity), free distribution, flexibility of intervention programming

Combination flocculant/disinfectants

Combination flocculant/disinfectants, such as P&G Purifier of Water (formally PUR® and referred to as 'PUR' for this report), are well suited to treat turbid water. To use the sachet, users add the contents to 10L 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.

PUR is evaluated in three evaluations, with intermediate outcomes and health impact evaluated. Reported use from two studies ranges between 6 and 78 percent, while confirmed use ranges between 4 and 95 percent. Only one evaluation measured both reported and confirmed use, which were 6 percent and 4 percent respectively (Lantagne and Clasen 2012) (Figure 3.15).

Household knowledge is a factor that may explain some of the variability in use and is commented on in all three studies. High use is attributed to high knowledge of correct use of PUR in South Sudan, as 78 percent of households could demonstrate all the steps required to use PUR. It is noted that while >90 percent had confirmed use, PUR use could not be separated from Aquatab® use as both were distributed in the same hygiene kit (ACF 2014a). High use rates (95%) are also reported from an RCT in Liberia where households were also provided all materials necessary to use PUR at no cost, received extensive training and were visited weekly. High use is also attributed to beneficiaries acknowledging improved water quality, taste and health. However, in a study in Kenya, PUR was distributed through an NFI distribution with minimal promotion. Only 2.3 percent of households could describe the five steps necessary for PUR, translating to similarly low reported use of 5.9 percent, confirmed use of 3.7 percent and effective use of 2.3 percent (Lantagne and Clasen 2012).

Health impact is reported in one evaluation (with high use, in Liberia) where PUR reduced diarrhoea incidence by 67 percent (adjusted RR 0.33; 95% CI 0.30–0.37) and diarrhoea prevalence by 77 percent (adjusted RR 0.23; 95% CI 0.21–0.25) (Doocy and Burnham 2006).

Figure 3.15: PUR comparison

Author (Year) Country Bias	Context Approach	Evaluation	Use outcomes	
			Reported use	Confirmed use
Doocy (2006) Liberia Low risk of bias	Cholera outbreak – IDP camp PUR with all necessary equipment compared with distribution of 10L buckets only	RCT 200 HH in intervention and 200 HH in control group.	Not measured	95% of HH confirmed use (FCR >0mg/L)
Lantagne (2012) Kenya Low risk of bias	Cholera outbreak – Extreme rural Pre-positioned stock. Distribution of Aquatabs® and PUR® Purifier of Water in an NFI kit to 5,592 HH	Cross-sectional 409 HH	5.9% of HH reported use	3.7% of HH confirmed use (FCR ≥0.2mg/L) (Effective use: 2.3%)
ACF (2014) South Sudan High risk of bias	Cholera outbreak – Urban/peri-urban Aquatabs® distributed in NFI kits to 7,348 HH. Kit also included: bucket, PUR® Purifier of Water packets and filter cloth	Cross-sectional 351 HH	78% of HH could demonstrate correct use of PUR	Aquatabs and/or PUR, >90% of HH had FCR (range 83–100%)

Flocculant/disinfectant summary

High rates of use correspond with significant diarrheal disease reduction in one low risk intervention. The wide range of use is attributed to the availability and amount of hygiene promotion given to beneficiaries; this is consistent across all interventions (Figure 3.16).

Figure 3.16: PUR summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	1	Low	67% reduced diarrhea incidence and 77% reduced diarrhea prevalence
Use	3	Low	Reported use ranged between 6–78%, n=2 Confirmed use ranged between 4–95%, n=2
Barriers and facilitators	3	Low	Knowledge (promotion) influenced use, improved the taste

HWT – other products

Fewer non-chlorine HWT interventions were identified in the review. Studies documenting filtration, solar disinfection, safe storage and boiling HWT interventions are described in the following sections.

Filtration

HWT filter types include simple screens, ceramic, sand and hollow-fibre filters. All these filters are generally effective at removing protozoa and bacteria, and some hollow-fibre filters can also remove viruses.

In a large study of >40,000 people in an endemic cholera area in Bangladesh, two simple filters (a small nylon screen of 150µm mesh size and a folded piece of sari cloth) were used with intervention group participants and compared with a control group (Colwell et al., 2003). Hospital-recorded cholera morbidity was reduced by approximately 40 percent in both the nylon and sari cloth filter groups (nylon filter RR: 0.59; sari cloth RR: 0.52), with more than 90 percent following the filtering instructions. After five years, participants were revisited, and households in the sari cloth group were more likely to report use of some method of water treatment (35% compared with control at 23% and nylon group at 26%). Sari filter use was also identified to have a protective reduction in morbidity that extended to neighbours of filter users (Huq et al., 2010). Filter use was identified as simple, improved water appearance, was culturally acceptable and led to improved water appearance and taste (Huq et al., 2010; Colwell et al., 2003).

SODIS

Solar disinfection (SODIS) uses heat and ultra-violet (UV) radiation from the sun to inactivate bacteria, viruses and protozoa in drinking water. Users place a clear container (i.e. 1.5L plastic bottle) on their roof in the sun for 6–48 hours, depending on amount of direct sunlight, and then drink the water.

SODIS is evaluated in one study in a development context in Kenya that led into an outbreak evaluation when cholera began in the project area (Conroy et al., 2001). The intervention consisted of the distribution of 1.5L clear plastic bottles with instructions to give children under 5 years old only SODIS-treated water. SODIS was effective at reducing self-reported cholera rates by 88 percent in these children (OR=0.12; 95% CI 0.02–0.65; p=0.014).

Safe water storage

Safe water storage is storing water in a way that reduces the risk of contaminants in the water (i.e. a bucket with a lid and spigot or a narrow-mouthed jerry can rather than an open container where water is accessed with a ladle).

Two evaluations isolating safe water storage were identified in the review; both of these are low bias. The control group in the PUR evaluation in Liberia received jerry cans, and this alone significantly reduced diarrhoea rates by 16 percent from the preceding week (OR=0.84, 95% CI 0.82–0.86) (Doocy and Burnham, 2006). The second evaluation is from a Malawi refugee camp. ‘Improved buckets’ with a spout and a permanent partial lid were provided as the intervention in an RCT and compared with regular open buckets as the control (Roberts et al.,

2001). Diarrhoea rates were reduced by 31 percent in children under 5 years and 8 percent overall for the intervention group; however; neither reduction was statistically significant (p=0.06 and p=0.26). Improved buckets were effective at reducing bacterial contamination; geometric mean faecal coliforms were reduced by 69 percent in improved buckets compared with regular buckets over six hours after storage. The community preferred the improved buckets to chlorination, as chlorine was associated with a bad taste and smell.

Boiling

Promotion of boiling is not generally a common outbreak response strategy as it is energy intensive and does not provide residual protection. However, the materials for boiling are often available in the household, and previous education campaigns mean beneficiaries are often aware of boiling. The baseline awareness and reported practice of boiling varies quite widely in the HWT evaluations so far described. For example, boiling was not a promotional activity, but 14 percent of households reported boiling in DRC (Tokplo, 2015) compared with 81 percent in Madagascar (Mong et al., 2001). Only one high risk evaluation included in this review promoted boiling as a response intervention as part of a hygiene campaign for cholera in Guinea-Bissau (Einarsdóttir et al., 2001). After the campaign, 40 percent of households reported boiling water; however, 66 percent reported using lemon to treat water, no households reported consistent use of either method, and no confirmed use evidence was collected.

Summary of other HWT interventions

Filtration, SODIS, safe storage and boiling HWT interventions were all implemented in non-acute endemic outbreak contexts. The quality of evaluation design is higher than that of chlorine or PUR studies, but is not generalizable for other contexts without multiple studies of the same intervention (Figure 3.17). HWT interventions are consistently reported to be simple, sustainable and accepted by the communities.

Figure 3.17: HWT – other products summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	4	Low	Simple filters, SODIS and safe storage led to significant reduction in diarrhea in some populations
Use	2	Very low	Simple filters and boiling had relatively high use, but was limited to self-reported measures
Barriers and facilitators	3	Low	Simple interventions had little to no promotion or instructions but had relatively high reported use and acceptability

3.4 SANITATION

The goal of sanitation programmes in outbreak response is to break transmission by isolating faeces from the environment, either using output-driven approaches (such as latrine construction) or community-driven approaches.

Output driven – Latrines are designed and built by responders according to a pre-planned number to meet guidelines or based on budget (Sphere Project, 2011). Community involvement in these programmes generally varies from no involvement to volunteering labour/materials, or community members being engaged through a cash-for-work project.

Community driven – Community-driven approaches focus on specific promotion to 'trigger' the community to address its sanitation needs with local materials. Community-Led Total Sanitation (CLTS), Community Approach to Total Sanitation (CATS) and Participatory Hygiene and Sanitation Transformation (PHAST) are all community-driven approaches. Communities are engaged through a facilitator with a specific process and encouraged to build their own latrines from locally available materials. CLTS is a sanitation strategy that focuses on hygiene education and community mobilization to stop open defecation. Similarly, CATS and PHAST use community mobilization, but also provide some material assistance to help build latrines.

Please note, no evaluations of output-driven sanitation were identified in the review. In some documents and evaluations seen in the review, particularly in community mobilization and WASH package interventions, sanitation is listed only as an activity and not evaluated.

Community-driven sanitation

Two community-driven sanitation interventions were identified in the review: one CLTS and one PHAST intervention (Figure 3.18).

A CLTS programme in Liberia was implemented for five years before Ebola erupted in Liberia; the CLTS programme continued throughout the outbreak. In a mixed-methods medium bias survey that included 551 household surveys, households in villages that achieved 'open defecation free' through CLTS were 17 times less likely to have cases of Ebola than non-CLTS communities (OR=0.06, p<0.001) (Meyer Capps and Njiru, 2015). Additionally, villages that were triggered by CLTS but had not yet accomplished the open defecation free goal had eight times fewer Ebola cases than communities not in the project.

In a Northern Uganda camp for internally displaced persons (IDP), a PHAST approach including community health clubs was trialled in the midst of a cholera outbreak (Waterkeyn et al., 2005). The evaluation is a high bias field commentary. It is reported that the programme led to more than 8,000 latrines and 6,000 bath shelters constructed in less than four months. Overall, 15,000 people attended weekly hygiene meetings, and group cohesion and peer pressure were noted as mechanisms effective in changing behaviour.

Figure 3.18: Community-driven sanitation comparison

Author (Year) Country Bias	Context Approach	Evaluation	Findings
Meyer-Capps (2015) Liberia Medium risk of bias	Ebola outbreak – large geographic area CLTS project (running for 5 years – carried on through Ebola outbreak) in 6,865 HH	Mixed methods Retrospective control groups matched 239 HH in intervention and 312 HH in control group 16 focus groups	• HH in CLTS communities 17 times less likely to have cases of Ebola than non-CLTS communities (OR=0.06, p<0.001) • 'Trust' important feature in programming • Beneficiaries trusted: 1) health workers, 2) radio, then 3) NGOs for sources of information by both CLTS and non-CLTS communities
Waterkeyn (2005) Uganda High risk of bias	Cholera outbreak – IDP camps Community mobilization through community health club and PHAST approaches. Community trainers, drama presentations, 20 hygiene topics, delivered in groups, peer pressure to keep them. Certificate if attended 20 sessions. Community provided own materials but would receive a concrete 'sanplat' (latrine floor)	Field commentary	• Group cohesion and peer pressure adjusted hygiene behaviour and improve hygiene practices • Motivation of >15,000 beneficiaries: built 8,500 latrines, 6,000 bath shelters, 3,400 drying racks and 1,550 handwashing stations in a 4-month time frame • Rapid, scalable and cost-effective

Sanitation summary

While output-driven sanitation evaluations are not identified in the review, outcomes of community-driven sanitation interventions were associated with 'trust' and 'cohesion' developed by engaging the communities (this is further described in Section 3.5); albeit the evidence is limited to only two studies, one with high bias. As outbreaks affect entire communities, a community-driven response could be well suited for outbreak response (Figure 3.19).

Figure 3.19: Community-driven sanitation summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	1	Low	Ebola rates 17 times less in open-defecation-free communities than in communities with no CLTS intervention
Use	-	-	-
Barriers and facilitators	2	Low	Trust, cohesion and peer-pressure were positive facilitators for community-driven intervention

3.5 HYGIENE

In the following sections, hygiene interventions are sub-categorized as hygiene promotion (including hygiene education and social mobilization), distribution of hygiene kits and environmental hygiene (jerry can disinfection, household disinfection and environmental clean-up).

Hygiene promotion

Hygiene promotion is the sharing of personal and environmental hygiene-related information to educate emergency-affected populations with the goal of reinforcing or changing behaviour. In an outbreak context, hygiene promotion must provide accurate information, adapt to changing conditions and appropriately address concerns and fears of the community. Hygiene promotion is separated into two approaches: *giving* hygiene education messages and *facilitating* social mobilization.

Hygiene education

Hygiene education is the delivery of hygiene messages by responders to outbreak-affected populations to improve knowledge and encourage practices (i.e. instructions on using HWT products; messages about handwashing with soap). Eight documents were identified in the review that evaluate hygiene education with preferred message delivery and health impacts (Figure 3.20).

Figure 3.20: Hygiene education comparison

Author (Year) Country Bias	Context Approach	Evaluation	Findings
Einarsóbttir (2001) Guinea-Bissau High risk of bias	Cholera outbreak – Rural Hygiene promotion to support treating water (and other hygiene practices). Radio, TV, health staff, poster, word-of-mouth, song, theatre group; 53 HH surveyed	Cross-sectional 53 HH	• Received communication: 94% report hearing at least one message: 1) Radio (45%); 2) Word of mouth (41%, despite no door-to-door messaging); 3) poster (24%) • Barriers: Language issue with radio messages; posters not effective as many people were illiterate; transmission routes not well described. Many thought transmission was through the air; spirit sacrifices done frequently
Date (2013) Kenya High risk of bias	Cholera outbreak – Rural Evaluation of promotional activities with distribution of HWT and hygiene kits (not described); 723 HH surveyed	Cross-sectional with comparison group 358 intervention HH and 365 control HH	• Social contacts (friends, family and neighbours) primary information source of HH aware of the outbreak

Author (Year) Country Bias	Context Approach	Evaluation	Findings
Contzen-Mosler (2013) Haiti Medium risk of bias	Cholera outbreak – Urban Evaluation of communication strategies after cholera intervention (not specific to one intervention)	Cross-sectional 811 HH survey	• For both faeces and food-related handwashing, the most effective modes of hygiene were: material distributions with demonstrations and radio spots. Spontaneous/ unplanned promotions by friends and neighbours also influential • Focus groups, hygiene days and stickers/posters/paintings were rated as less likeable, less convincing and less trustworthy than other methods
Williams (2015) Haiti Medium risk of bias	Cholera outbreak – Large geographic area Evaluation of communication strategies after cholera interventions (not specific to one intervention)	Qualitative 18 focus groups assess regional preferences	• Community health worker and megaphone going house to house were the best way to reach the communities • Most 'trusted' vender of HWT products was pharmacies • Self-reported increase in handwashing as a result of messaging • Self-perceived reduction in diarrhea reported from community in focus groups
Wall (2011) Haiti Medium risk of bias	Cholera outbreak – Large geographic area Evaluation of communication after cholera and earthquake (not specific to one intervention)	Qualitative 15 focus groups	• Multiple channels of communication to share and listen, reinforcing and listening in complementary ways • Cholera treatment centres were initially rejected by population due to fears about the origin and response to the disease • The assessments of overall effect on communication efforts on cholera, as 'too many organizations were involved and too many techniques used'
WHO (no date) Guidance on Communication – Case study South Africa High risk of bias	Cholera outbreak – Large geographic area Hygiene campaign, messages: water storage, personal hygiene, safe refuse disposal, food handling, use of HWT Mode: health workers, schools, religious leaders; some religious services use to recruit volunteers	Field commentary	• Red Cross (working in specific areas) reported (unverified) a sharp decline in mortality rates following education programme
WHO (no date) Zimbabwe High risk of bias	Cholera outbreak – Large geographic area Messages: Cholera prevention, control, food preparation, handwashing, use of HWT (tablets/sachets) Mode: T-shirts and drama presentations used, 310,000 flyers, 14,000 posters in three languages distributed to 250,000 people	Field commentary	• Reported change in behaviour – not attending funerals, reducing physical contact (hugs, shaking hands) • Response built on existing programming • Unwillingness to drink chlorinated water • Lack of resources and devaluing currency
ACF – Matemo (2014) Kenya High risk of bias	Cholera and hepatitis E outbreak – Refugee camp Hydrogen sulfide test used as part of hygiene promotion as a visual aid to assist hygiene messaging as well as test water samples	Field commentary	• Communication improved. Feedback to communities with tangible explanations that 'clear doesn't mean safe'

Hygiene message delivery is assessed in five evaluations through quantitative and qualitative evaluation methods. The studies' biases are medium to high in all studies, but findings are consistent across multiple countries and contexts. Common factors that were evaluated are:

- person sharing the message (i.e. community health worker, NGO, friend, neighbour, family member, local leader)
- how it was shared (i.e. radio, TV, posters/pamphlets, theatrical skits, face to face)
- location (i.e. home, school, place of worship, community).

Some form of face-to-face communication was highlighted as positive by beneficiaries in all five evaluations (Williams et al., 2015; Matemo, 2014; Contzen and Mosler, 2013; Date et al., 2013; Einarsdóttir et al., 2001; Wall and Chéry, 2011). Additionally, material demonstrations (i.e. instruction on HWT), visits by community health workers and conversations with friends and family were consistently highlighted as positive. Short radio 'spots' or radio communication were also consistently preferred or trusted by communities.

Delivering simple, clear messages was a notable challenge in four studies. Different and conflicting messages undermined the response in the Haiti cholera and Liberia Ebola response (Wall and Chéry, 2011; Meyer Capps and Njiru, 2015). There were also doubts if hearing a message on the radio translates to a realistic understanding of the local situation (Wall and Chéry, 2011). Difficulties with language, dialect differences (Einarsdóttir et al., 2001) and errors in printed information were additional challenges noted (Neseni and Guzha, 2009).

Health impact is qualitatively described as an observed sharp decline in morbidity following the education programme in South Africa and a community-perceived reduction in diarrhoea rate in Haiti (WHO, no date; Williams et al., 2015). Differences in behaviour are also noted with an increase in HWT use in Kenya (Date et al., 2013) and reducing physical contact (i.e. hugs, shaking hands) in Zimbabwe during a cholera outbreak (WHO, no date).

Hygiene education summary

Hygiene education is assessed through a combination of quantitative, qualitative and field commentary approaches. Despite high bias, the same modes of communication (face to face and radio) were consistently found to be preferred (Figure 3.21). Impact on health and use were also reported with weak evaluations.

Figure 3.21: Hygiene education summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	2	Low	Anecdotal descriptions of disease or disease risk reductions
Use	1	Very low	Reported use of HWT increased
Barriers and facilitators	8	Moderate	Face-to-face communication and radio are preferred and trusted by the community

Social mobilization

'Social mobilization' is a term to describe strategies for involving or engaging communities in the outbreak response, with responders *facilitating* communities to address identified risks with local solutions. Six documents in five countries use a social mobilization approach in their outbreak response (Figure 3.22). Risk of bias is high, with two-thirds of the studies being field commentaries.

Figure 3.22: Social mobilization comparison

Author (Date) Country Bias	Context Approach	Evaluation	Findings
Meyer Capps (2015) Liberia Medium risk of bias	Ebola outbreak – Large geographic area CLTS	Matched controls. 239 project HH: 312 non-project HH	• HH in CLTS communities 17 times less likely to have cases of Ebola than non-CLTS communities (OR=0.06, p<0.001) • Beneficiaries trusted: 1) health workers, 2) radio, then 3) NGOs as sources of information
Waterkeyn (2005) Uganda High risk of bias	Cholera and hepatitis E outbreak – IDP camps Community health clubs and PHAST	Field commentary	• Group cohesion and peer pressure adjusted hygiene behaviour and improve hygiene practices • Motivation of >15,000 beneficiaries built 8,500 latrines, 6,000 bath shelters, 3,400 drying racks and 1,550 handwashing stations in a four-month time frame
Wall (2011) Haiti Medium risk of bias	Cholera outbreak – Large geographic area Various communication strategies from many organizations	Qualitative 15 focus group discussions	• Maintaining relationships and sharing difficult information, open channels of communication
Institute of Water and Sanitation Development – Neseni (2009) Zimbabwe High risk of bias	Cholera outbreak – Large geographic area Social mobilization, WASH activities	Field commentary	• Social mobilization considered most impactful to reduce disease transmission
International Federation of Red Cross and Red Crescent Societies – Rees-Gildea (2013) Sierra Leone High risk of bias	Cholera outbreak – Large geographic area Social mobilization Sensitization programme to 350,000 people	Field commentary	• Decrease in case fatality rate assessed to be more influenced by social mobilization than case management
ACF (2015) Sierra Leone High risk of bias	Ebola outbreak – Peri-urban Community-Led Ebola Management and Eradication (CLEME), as modified CLTS approach with community-driven action. ACF also involved in other aspects of the response	Field commentary	• Social mobilization better than case management • Community ownership and trust • 80% of communities planned isolation rooms; 'tippy tap' handwashing widely promoted

Through a mixture of research methods that are high and medium risk of bias, community mobilizers were engaged with the community to have a conversation and ask questions. Compared with a purely education campaign that is 'top-down,' designed to deliver or extract information (Contzen and Mosler, 2013), community-mobilization (engagement) approaches were conducive to NGOs: listening to communities, dispelling fears and stigmas and learning how to adapt to the context. For example, a 'dialogue-based' approach by NGOs led to an improved understanding of the community, leading to a better response as viewed by the community (Wall and Chéry, 2011).

Social mobilization is qualitatively assessed in high risk of bias studies to reduce disease transmission better than disease case management (ACF, 2015; Rees-Gildea, 2013; Neseni and Guzha, 2009). The CLTS programme in Liberia Ebola response (described in Section 3.4) had a strong and significant reduction in disease risk (Meyer Capps and Njiru, 2015).

Stronger community relationships are also described in three of the social mobilization evaluations (Wall and Chéry, 2011; Waterkeyn et al., 2005; ACF, 2015). For example, an NGO piloted a community mobilization project based on CLTS methodology tailored to Ebola management (ACF CLEME). Isolation rooms and handwashing stations were most commonly constructed by the community, but community ownership and trust are also noted as important project results. A combined community health club and PHAST approach was trialled in the midst of a cholera outbreak in Northern Uganda IDP camps with 'group cohesion' as a factor to success (Waterkeyn et al., 2005).

Policy documents (not included in the review) also describe strong support for community engagement. A learning document for haemorrhagic fever outbreaks notes that, 'community engagement and social mobilization are key aspects of reducing transmission rates' (Oxfam, 2014).

Social mobilization summary

Hygiene education and social mobilization are not mutually exclusive, but interventions that use community engagement approaches were consistently supported in outbreak contexts by beneficiaries and NGOs (Figure 3.23). Community empowerment and trust led to reductions in disease risk through adaptable approaches.

Figure 3.23: Social mobilization summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	4	Low	Anecdotal descriptions of disease impact and significant quantitative approaches that reduced risk of Ebola evaluated (Meyer-Capps)
Use	-	-	-
Barriers and facilitators	4	Low	Trust and ownership consistently documented

Hygiene kit distribution

Hygiene kit distributions (e.g. NFIs) are mentioned in 17 evaluations. HWT products, soap and safe water storage containers are most commonly included. The primary goal of most hygiene kit distributions is to deliver HWT products and/or support hygiene activities addressed in other sections of this report. There are two hygiene kit interventions not described in other sections but included in the review (Figure 3.24).

Figure 3.24: Hygiene kit comparison

Author (Year) Country Bias	Activities	Evaluation	Findings
UNICEF – Ruiz Roman (2009) Zimbabwe High risk of bias	Cholera outbreak – Large geographic area ~200,000 HH hygiene kit distribution from several organizations; recommended kit included: One 20L bucket, one 20L bucket with tap, one bar of soap, 30 water purification tablets, three ORS sachets, and one pack of information, education and communication materials	Mixed-methods 307 HH, 6 focus group discussion, 23 key informant interviews	• 87% of HH reported receiving a hygiene kit; only 33% reported receiving all 5 recommended items (differences in kits) • 59% of HH requested additional quantities – mostly from families of 6 or more • Soap was reported to be the most used item (not quantified)
CRS – Pennacchia (2011) DRC High risk of bias	Endemic cholera – Urban and rural NFI fair: US$70 voucher for 2,184 beneficiaries (HH) – special NFI market created for voucher programme Also WASH activities described in Figure 3.28, including construction/rehabilitation of water sources and hygiene stations and hygiene promotion	Cross-sectional 332 HH surveyed for voucher impact	• Vulnerability score dropped from 3.2 to 1.6 three months after voucher programme, ≥2.9 is the threshold for emergency intervention • Voucher – beneficiaries 'empowered' to choose their own needs • More than US$150,000 spent in local markets • Beneficiaries thought prices (via voucher market) were competitive, 80% thought prices were at or below market • 85% of vendors said they reduced prices through negotiation

Also referencing other documents included in this review, hygiene kits facilitate HWT products, hygiene promotion and are common to outbreak response. Hygiene kits are not often evaluated as standalone interventions, but barriers and facilitators of hygiene kits are described throughout studies included in this review. Interventions were facilitated when supplies were pre-positioned (Simpson et al., 2009; DeGabriele and Musa, 2009; Neseni and Guzha, 2009; Ruiz-Roman, 2009; Lantagne and Clasen, 2012) and when supplies were distributed in a timely manner (Neseni and Guzha, 2009; ACF, 2007). Vouchers were used to offer flexibility and choice to beneficiaries (Pennacchia et al., 2011), whereas standardized kits were barriers to families with different sizes and needs (Gauthier, 2014; Simpson et al., 2009).

Hygiene kit summary

Hygiene kits are an intervention to equip outbreak affected populations with materials necessary to improve hygiene practices. Most NFI interventions are assessed as HWT interventions, quality of bias is high, but barrier and facilitating factors are consistent. Contents, quantity and timely distribution are important factors (Figure 3.25).

Figure 3.25: Hygiene kit summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	-	-	-
Use	-	-	-
Barriers and facilitators	8	Low	Quantity of materials not adequate or adaptable, and timeliness of delivery are important factors – especially to enable HWT and hygiene messages pre-positioning

Environmental hygiene

Environmental hygiene efforts aim to protect populations by reducing environmental transmission of disease. In outbreak response, environmental hygiene includes:

- **jerry can disinfection** – cleaning jerry cans with chlorine solution
- **household disinfection** – sanitizing a home or building that is potentially contaminated with chlorine solution (i.e. an Ebola patient's home)
- **environment clean-up** – rubbish collection, drainage and landscape improvements that aim to remove contaminated solid and liquid wastes.

Environmental hygiene interventions are discussed in four evaluations included in the review, evaluating jerry can disinfection and household disinfection hygiene kit interventions.

Jerry can disinfection

Jerry can disinfection is investigated in three evaluations, all in camp settings and all assessed with no beneficiary input (Figure 3.26).

Figure 3.26: Jerry can disinfection comparison

Author (Year) Country Bias	Context Approach	Evaluation	Findings
Steele (2008) Uganda High risk of bias	Endemic cholera – IDP camp Disinfecting jerry cans with 3% sodium hypochlorite solution using two different cleaning methods: 1) Fill halfway with disinfectant solution, seal, shake for 1 minute, decant back into stock solution; n=9 2) Fill with stock solution, let sit for 1–5 minutes, decant back into stock solution; n=4	Quantitative Jerry cans from 13 HH borrowed then revisited 3-5 days after cleaning	• Data indicates that both methods are equally effective (low sample size); Method 1 had more consistent lower coliform counts than Method 2 • Overall: 92% (11/12) had reduced *Escherichia coli* bacteria (*E. coli*) after cleaning; 75% (9/12) had <5 *E. coli* after cleaning; 42% (5/12) had <1 *E. coli* after cleaning • One-time disinfection did not affect recontamination 3–5 days later
Walden (2005) Sudan High risk of bias	Shigellosis – IDP camp Disinfecting jerry cans with 5% chlorine solution: 100–150mL added to each bucket with stones (as abrasives), sealed, shaken vigorously, dumped, refilled with 1% chlorine solution; 15–20 minutes/container	Field commentary Case report	• On average, the FCR remaining in the containers was 0.2mg/L, n=172 • Number of watery and bloody cases of diarrhea continued to decline after the disinfection • One week later, observations were that people were keeping containers clean
Roberts (2001) Malawi High risk of bias	Cholera outbreaks – refugee camp Buckets were chlorinated with 2.5mg/L solution 8 times over 2 months	Cross-sectional 24 buckets	• Faecal coliform virtually eliminated for 4 hours, but increased after 6 hours • Stock solution concentrations were considerably lower than intended on several occasions, leading to inadequate chlorination

All three jerry can cleaning methods were assessed to reduce disease risk with very weak evaluation methods. Chlorine concentration degradation is noted in all three documents (Steele et al., 2008; Walden et al., 2005; Roberts et al., 2001), although the chlorine residual reported in Roberts et al (2001) is not a suitable chlorine concentration for cleaning inanimate objects; however, the evaluation focused on HWT, not cleaning. One-time disinfection did not have a long-term impact on re-contamination.

Household disinfection

Household spraying is described as an activity in five documents (Neseni and Guzha, 2009; Gauthier, 2014; Grayel 2014, 2011, 2012) but is not assessed. A known outbreak activity, household or community spraying has several drawbacks, as described in Box, 'Household spraying with chlorine solution' below.

Household spraying with chlorine solution

During the Haiti cholera outbreak, an NGO had initially set an objective to disinfect 80% of contamination sources in households within 48 hours using household spraying (Grayel 2011). Spraying was ultimately abandoned due to: 1) concern of patients being stigmatized; 2) logistical, financial and staffing resources required; 3) false sense of protection to households, which counters prevention messages; and 4) likely limited impact as only 15–20 percent of people who shed cholera into the environment develop symptoms; and the benefits of spraying the households of sick people are thus limited.

Documents not included in the review also describe the limitations of household spraying. In the Ebola response in West Africa, household spraying did not include bedding and other possible routes of transmission, thus spraying was 'incomplete' and likely ineffective (Nielsen et al., 2015). The UNICEF Cholera Toolkit also suggests that one-time household spraying is often carried out too late, is resource intensive, has no evidence of effectiveness and can stigmatize the household (UNICEF, 2013); however, it is recommended that families should thoroughly clean the house with soap and chlorine solution.

As an alternative to household spraying by sending disinfection teams to patients' households, Médecins Sans Frontières provided cholera patients with a self-disinfection kit for the household in the cholera outbreak in Haiti. After a 30–40 minute group hygiene session, kits were given to the patient or caretaker, including: 0.5–1 kg of soap, a 14L bucket, a 10L jerry can, 3.8L of bleach, a cloth, a scrubbing brush and an instruction book (Gartley et al., 2013). In this high bias evaluation, self-reported use of the disinfection kits is 98 percent, with 94 percent of recipients reporting the instructions were clear and simple; however, no verification on correct use or reduced transmission was reported. A significant increase in use ($p<0.05$) is reported when the hygiene session explained how to use the contents together and encouraged sharing with friends and family.

Environment clean-up

No evaluation on improving local environment conditions is identified in the review, although several organizations report activities or results such as 'improved garbage practices' (Dinku, 2011), construction of solid waste areas and drainage improvements (Pennacchia et al., 2011), and decongestion and rehabilitation of sewer pipes (Neseni and Guzha, 2009).

Environmental hygiene summary

Jerry can disinfection interventions are assessed with very weak research designs, but consistent results (Figure 3.27). Household disinfection and environment clean-up are common emergency response activities, but no evaluations of these interventions is identified in the review except for one evaluation of household disinfection kit distribution with only self-reported outcomes where families cleaned their homes themselves.

Figure 3.27: Environmental hygiene summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	4	Very low	Very weak evaluation methods consistently reportedly reduced disease transmission from chlorine disinfection
Use	1	Very low	Use of distributed hygiene kit is high bias with high use rates
Barriers and facilitators	3	Low	Chlorine solution needs constant monitoring for jerry can disinfection campaigns – consistently reported

3.6 WASH PACKAGE

WASH interventions are regularly implemented in combination by responders to address multiple possible transmission routes and provide comprehensive protection to beneficiaries. Overall, 13 WASH package evaluations from eight countries were identified in this review; all 13 are high bias grey literature documents and 11 are field commentary documents.

The specific interventions included in the WASH package mirror the results already described, with more water and hygiene interventions evaluated than sanitation interventions (Figure 3.28). However, the water interventions included in WASH package are not source or water treatment, as seen in the individual intervention evaluations, but well rehabilitation and water trucking. While well rehabilitation and water trucking are described as activities in WASH package interventions, they were not evaluated either as individual activities or within WASH package interventions.

Figure 3.28: WASH package comparison

	Well rehabilitation	Water trucking	New borehole	Latrine construction	Sanitation promotion	Hygiene promotion	NFI distribution
DeGabriele (2009) Zimbabwe	✓	✓	-	-	✓	-	✓
Neseni (2009) Zimbabwe	✓	✓	-	✓	-	✓	✓
El-Mahmid (2009) Zimbabwe	✓	✓	-	-	-	✓	✓
ACF (2007) Somalia	✓	✓	-	-	-	✓	✓
ACF (2012) Chad	✓	-	-	-	-	✓	✓
ACF – Grayel (2014) DRC	✓	-	-	✓	-	✓	✓
Simpson (2009) Zimbabwe	✓	✓	✓	-	-	✓	✓
ACF – Dinku (2011) Ethiopia	✓	-	-	-	✓	-	✓
Gauthier (2014) South Sudan	✓	-	-	-	✓	✓	✓
Pennacchia (2011) DRC	✓	-	✓	✓	-	✓	✓
International Organization for Migration (IOM) – Condor (2011) Haiti	✓	✓	-	-	-	✓	-
Tearfund – Ngegba (2002) Sierra Leone	✓	-	✓	✓	-	✓	-
ACF – Grayel (2011) Haiti	-	✓	-	✓	-	✓	✓

From the WASH package documents, barriers and facilitators are reported with health (3) and behavioural changes (5).

Health impacts – According to clinic data, diarrhoea rates decreased by 74 percent after the WASH package intervention programme in DRC (Pennacchia et al., 2011). Similarly, the Ministry of Health reported that the cholera attack rate 'continued to decrease' with the WASH package intervention in South Sudan (Gauthier, 2014); and the case fatality rate 'dropped significantly' after the WASH package intervention in Somalia (ACF, 2007).

Behaviour impacts – Improved hygiene behaviour was self-reported by 90 percent of beneficiaries in outbreak and endemic contexts in Zimbabwe (DeGabriele and Musa, 2009) and DRC (Pennacchia et al., 2011) respectively; although respondents in Zimbabwe acknowledged the improvements were not consistently practised. Improved water collection, handwashing and environmental hygiene practices were also self-reported in an acute watery diarrhoea response in Somalia (Dinku, 2011). Water interventions also reportedly reduced time needed to collect water, with undocumented methods (Dinku, 2011; Pennacchia et al., 2011). A hygiene kit distribution provided 'psychosocial support' to cholera-affected communities (Neseni and Guzha, 2009). Change in people's attitude, especially toward open defecation, was also noted in Sierra Leone (Ngegba, 2002).

Unique to the NGO WASH package evaluations, two practical factors for programme facilitators are consistently identified, including expert staffing (4) and rapid response timing (8).

Expert staffing – Existing country programmes from two different organizations were scaled up in response to the Zimbabwe cholera outbreak; the importance of expert staffing was documented in both evaluations (Simpson et al., 2009; El-Mahmid and Roussy, 2009). Integrating epidemiological experts into response is also noted in a DRC evaluation (Grayel, 2014). Expert staff are identified as offering surge capacity (Gauthier, 2014) to increase the scale and speed of work from non-outbreak times and offering knowledge of interventions not previously used.

Rapid response timing – Pre-positioned hygiene kits were useful for quick initial distributions of hygiene (Lantagne, 2012; Ruiz-Roman, 2009; Neseni and Guzha, 2009; DeGabriele and Musa, 2009; Simpson, 2009), but difficulty in procuring items led to delays thereafter (Neseni and Guzha, 2009). Having flexible emergency funding facilitated response in South Sudan and Haiti (Gauthier, 2014; Condor and Rana, 2011), while securing adequate funding and knowing when to trigger rapid scale up are identified as challenges (Simpson et al., 2009).

WASH package summary

In outbreak response, well rehabilitation, NFI kit distributions and hygiene promotion are the most frequently included individual interventions in these WASH package interventions; meanwhile water trucking is slightly less common and sanitation is rarely present (Figure 3.29). The qualitative field commentaries have high bias but consistent descriptions of anecdotal health impacts and non-health behaviour change impacts. Expert staffing and rapid response timing are consistently identified as critical factors for programme success.

Figure 3.29: WASH package summary

Outcomes	Number of studies	Quality of evidence	Summary
Health	3	Very low	Anecdotal descriptions of disease reductions
Use	-	-	
Barriers and facilitators	13	Low	Anecdotal descriptions of behaviour adjustments and psychosocial support; staffing and timing consistently identified as important factors for programme success

3.7 BEYOND THE SCOPE OF REVIEW

The focus of this review is on population-based WASH interventions implemented for outbreak response. However, the coordination and wide range of activities carried out in outbreak response may crossover between WASH and health. Four interventions considered beyond the scope of the review – hospital-based hygiene promotion, hospital disinfection of contaminated wastewater, dead body management and contact tracing – are briefly described here because they were considered WASH interventions in some WASH package evaluations and are relevant to WASH environmental hygiene.

Hospital-based hygiene – Researchers found that seven consecutive days of hygiene education given to cholera patients and caretakers led to significant disease reduction in an RCT in Bangladesh (George et al., 2016). The intervention, Cholera-Hospital-Based-Intervention-for-7-Days (CHoBI7), was held within the hospital and included equipping families with a hygiene kit to facilitate safe drinking water and handwashing.

Hospital wastewater disinfection – Sozzi et al. (2015) describe a 'duty of care' to protect workers and the local population from potentially very high concentrations of highly infectious diseases in Ebola and cholera patients' fluids and wastes. Two wastewater disinfection methods using pH adjustment and coagulation/flocculation were evaluated in cholera treatment units in Haiti. The first method used hydrated lime to disinfect and separate suspended solids. The second method used hydrochloric acid to disinfect, then aluminum sulfate to coagulate and flocculate the solids. Both methods achieved a more than 90 percent (1 log) removal in chemical oxygen demand, suspended solids and turbidity. There was also a more than 99.9 percent (3 log) removal in thermotolerant coliforms.

Dead body management – The 2014–2015 Ebola outbreak in West Africa highlights the risks of dead body management and unsafe burial practices. The desire for culturally normal burials adds a critical community component to dead body management. Personal protective equipment was used by burial teams in the Ebola response, but there was difficulty in balancing safe protocols with local customs and fears (Nielsen et al., 2015). In Liberia, an assessment of burial practices noted that some staff would 'overprotect' themselves with more personal protective equipment than was recommended, which only increased the overall risk disease transmission (Flachenberg et al., 2015).

Contact tracing – Contact tracing, the identification and diagnosis of people who may have come into contact with an infected person, was described as a WASH activity by some organizations but is normally considered part of health surveillance. One example of a strong contact tracing component was ACF's CLEME that was also considered to be part of community mobilization activities (ACF, 2015).

3.8 ECONOMIC ANALYSIS

Cost-effectiveness and economic outcomes were evaluated in a limited capacity and were not able to be assessed. Cost-related outcomes were commented on, but were too heterogeneous for analysis. These are some examples.

- Acute chlorine HWT interventions cost about US$1/day for a household with confirmed FCR in Nepal and Kenya (Lantagne and Clasen, 2012).
- In a chlorine solution project in Madagascar, a bottle of chlorine solution able to treat 1,000L cost about US$0.46 (Dunston et al., 2001). However, this price did not include promotion or indirect costs and was estimated to have 46 percent cost recovery.
- Cost of a disinfection kit was the only reported cost in an evaluation from Haiti (Gartley et al., 2013), while costs per beneficiary were calculated without the critical hygiene kit values (Gauthier, 2014).
- Vouchers (US$70 for 2,184 households) were used in a special market day, where beneficiaries could negotiate prices and select their own items (Pennacchia et al., 2011).
- There was general uncertainty if reported 'project costs' included: staffing, indirect costs or headquarters costs.

3.9 SUMMARY OF INTERVENTIONS

The variety of WASH interventions is represented in the review, with 10 interventions described and evaluated. While most of these evaluations are poor quality with high bias, the strength of evidence comes from the consistency of reported outcomes (Figure 3.30).

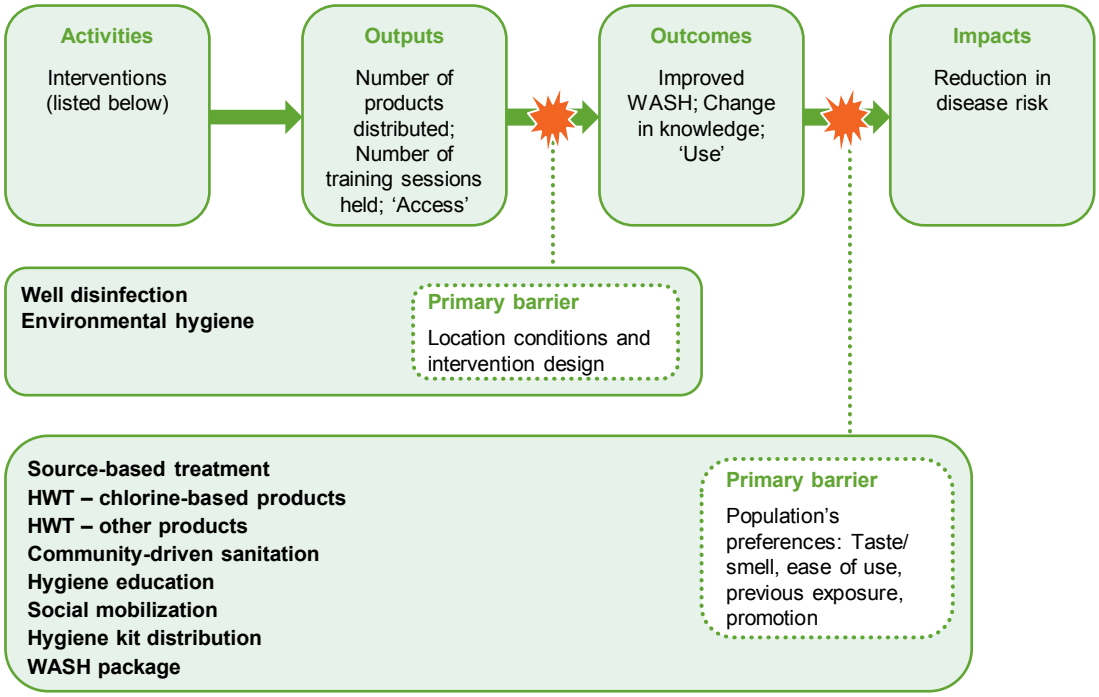
Figure 3.30: Intervention summary

Intervention	Quality of evidence by outcomes			Conclusions	Overall evidence
	Health	Use	Non-health		
Well disinfection	-	-	Moderate	Inconsistent evaluation methods, but consistent results Pot chlorination with pressed chlorine tablets can maintain FCR for 3–4 days in a well; pot chlorination with powdered chlorine also had some success	Moderate
Source-based treatment	-	Moderate	Moderate	Variation in reported, confirmed and effective use – context specific (3 case studies) Speaking with promoter and easy access to dispenser associated with increased use	Moderate
HWT – chlorine Chlorine tablets	-	Moderate	Moderate	Low and wide range of reported and confirmed use with an outlier Taste and smell a hindrance consistently described as a barrier	Moderate
HWT – chlorine Liquid chlorine	-	Low	Low	Low and wide range of reported and confirmed use Links with development and sustainability, including prior exposure and free distribution as factors	Low
HWT – chlorine Flocculant/ disinfectants	Low	Low	Low	Use varied greatly – knowledge of use a factor High potential health impact with high use, but in a controlled experiment with weekly reporting	Low
HWT – other filtration, SODIS, safe storage and boiling	Low	Very low	Low	Limited number of interventions, but higher quality evaluation methods Consistently used in endemic contexts with links to development. Consistent positive health impact	Low
Community-driven sanitation	Low	-	Low	Limited number of interventions, but strong positive health and social aspects from community-led interventions	Low
Hygiene promotion	Low	Very low	Low	Consistently, personal communication and radio are preferred and trusted by the community Use and health reportedly improved	Low
Social mobilization	Low	-	Low	Limited assessments but anecdotal health impact Community trust and ownership important factors	Low
Hygiene kit distribution	-	-	Low	Consistent factor of influence through materials, quantity and timeliness Low quality evaluations, HWT primary investigation of hygiene kits	Low
Environmental hygiene	Very low	Very low	Low	With weak evaluations, jerry can disinfection consistently reported to reduce disease transmission risk Chlorine concentration monitoring is necessary Household spraying consistently not recommended for responders	Very low
WASH package	Very low	-	Low	Weak evaluations had consistent anecdotal descriptions of disease reductions, behaviour adjustments and psychosocial support; staffing and timing also important factors	Low

Theory of change

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 10 WASH interventions and identified common breakages along the causal chain (Figure 3.31). All interventions were efficacious with a positive impact on WASH conditions with the exception of household spraying. Well disinfection and jerry can disinfection evaluations did not have beneficiary involvement, thus the effectiveness is limited to the local conditions and how the intervention was carried out. The remaining interventions were shown to be influenced by beneficiary factors like taste/smell, their knowledge of use, and intervention promotion.

Figure 3.31: Causal chain intervention evidence. Source: The research team



4 DISCUSSION AND CONCLUSIONS

A systematic process was used to identify 51 WASH evaluations in 19 LMICs affected by disease outbreaks. The following sections describe and summarize the research objectives (Section 4.1), limitations (Section 4.2), recommendations (Section 4.3) and conclusions (Section 4.4).

4.1 REVIEW OBJECTIVES

To determine effective WASH interventions in disease outbreaks, we investigated: interventions that reduce the risk of disease via outcomes and/or impacts; design and implementation characteristics associated with more effective programmes; economic outcomes; and barrier and facilitator-related outcomes that require consideration.

Objective 1: WASH interventions that reduce the disease burden in outbreaks

WASH interventions have the potential to reduce disease in outbreaks. Weak evaluation designs and limited studies explain the low quality of evidence, but interventions consistently reduce disease risk and the risk of transmission.

- **Reduced disease risk** – WASH interventions that evaluated health impact through a measured change in disease rates were rarely conducted in outbreaks, as only six health impact evaluations were identified in the review. Five are with less commonly implemented HWT interventions – one with PUR (Doocy and Burnham, 2006), two with simple filters (Colwell et al., 2003; Huq et al., 2010), one with SODIS (Conroy et al., 2001) and two with safe storage (Roberts et al., 2001; Doocy and Burnham, 2006). All five studies reduced disease rates. In the sixth evaluation, a long-running CLTS intervention implemented before and during the Ebola outbreak had a large and significant reduction in disease risk (Meyer Capps and Njiru, 2015).

- **Reduced transmission risk** – More common than disease reduction evaluations, interventions that evaluate the risk of transmission included: well disinfection (Rowe, 1998; Libessart and Hammache, 2000; Garandeau et al., 2006; Guevart et al., 2008; Cavallaro et al., 2011), chlorine dispensers (Yates, Armitage, et al., 2015), HWT (liquid chlorine (Mong et al., 2001; Dunston et al., 2001; Lantagne and Clasen, 2012; ACF 2014b), chlorine tablets (Imanishi et al., 2014; Lantagne and Clasen, 2012; ACF, 2009; Tokplo, 2015; ACF, 2014a) and flocculant/disinfectants (Doocy and Burnham, 2006; Lantagne and Clasen, 2012; ACF 2014a)). Environmental hygiene interventions using chlorine to clean jerry cans also reduced short-term transmission risk (Steele et al., 2008; Walden et al., 2005; Roberts et al., 2001).

WASH interventions consistently reduce both the risk of disease and the risk of transmission in outbreak contexts. Programme design and beneficiary preferences, described in the following sections, are important considerations to ensure WASH interventions reach their potential.

Objective 2: Programme design and implementation characteristics associated with more effective programmes

Four programme design and implementation characteristics, identified through a mixture of research designs and bias, are consistently reported as positive programme characteristics: simplicity, timing, being community driven and having links to development programmes.

- **Simple** – Some of the most basic interventions had a clear positive impact. Interventions requiring little to no promotion led to incremental improvements that reduced the risk of disease (Roberts et al., 2001; Colwell et al., 2003; Huq et al., 2010; Gartley et al., 2013; Lantagne and Clasen, 2012).

- **Timing** – Prepositioned stock, quick release of funds and early triggers for rapid scale up were important facets of a positive response, particularly with hygiene kit and HWT interventions (Simpson et al., 2009; DeGabriele and Musa, 2009; Neseni and Guzha, 2009; Ruiz-Roman, 2009; Lantagne and Clasen, 2012).

- **Community driven** – Engagement in the community empowers and builds trust. Community-driven interventions can increase awareness, trigger behaviour change and identify local solutions (Waterkeyn et al., 2005; Neseni and Guzha, 2009; Rees-Gildea, 2013, Meyer Capps and Njiru, 2015; ACF, 2015; Wall and Chéry, 2011).

- **Linking relief rehabilitation and development** – Linking with pre-existing programming builds on recipient familiarity and having a sustainability plan encourages a better cultural understanding and improved emergency response programmes (Meyer Capps and Njiru, 2015; Dunston et al., 2001; Tokplo, 2015; Imanishi et al., 2014; Lantagne and Clasen, 2012; WHO, no date).

Objective 3: Economic analysis of WASH interventions in outbreaks

Economic outcomes of WASH interventions in outbreaks were not able to be assessed as there were only minimal economic outcomes in the evaluations included in the review.

Objective 4: Barriers and facilitators that affect WASH outbreak interventions

In the review, four community perceptions and preferences that consistently impact the success of WASH outbreak interventions were identified through a mixture of evaluation methods and quality.

- **Taste and smell** – Taste and smell of HWT may hinder use (e.g. chlorine treatments can have an off-putting smell or taste) (ACF, 2009; Lantagne and Clasen, 2012; Imanishi et al., 2014; Ruiz-Roman, 2009) or facilitate use (e.g. filters and flocculant/disinfectants improved taste) (Doocy and Burnham, 2006; Colwell et al., 2003; Huq et al., 2010).

- **Preferred communication** – Radio and face-to-face communication are consistently reported as ‘most trusted’ or ‘most valued’ for hygiene communication (Einarsdóttir et al., 2001; Date et al., 2013; WHO, no date; Contzen and Mosler, 2013; Matemo, 2014; Williams et al., 2015; Wall and Chéry, 2011).

- **Perception of risk** – Community understanding of some interventions overestimate the effectiveness and risk reduction (i.e. household spraying and well disinfection) (Grayel, 2011; Rowe, 1998).

- **Trust/fear** – Social mobilization and open communication between the community and NGOs build trust and greater community cohesion (Wall and Chéry, 2011; Waterkeyn et al., 2005; ACF, 2015).

Summary of objectives

We found that some WASH interventions are successful at reducing the risk of disease via outcomes and impacts, although programme design, implementation characteristics and community preferences are critical to programme success. Overall, the quality of evidence is low; this is attributed to weak study designs that lacked control groups and had high likelihood of spillover effects. We are not able to assess economic outcomes. Based on these results, we recommend the following.

- *Responders* interested in implementing outbreak programmes should: 1) use simple interventions with clear consistent messaging through several communication methods; and 2) engage in open communication with the communities to dispel fears and address local concerns.

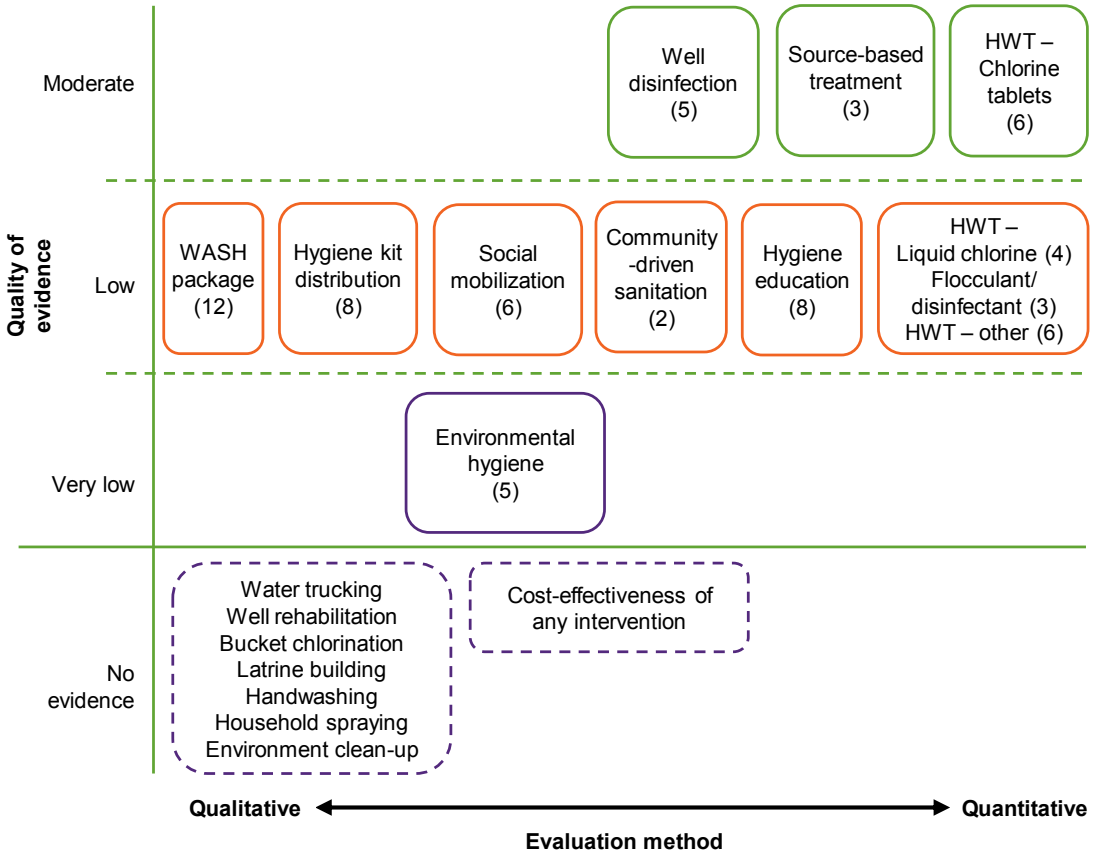
- *Policy makers* should consider: the importance of fast flexible funding, the value of prepositioned hygiene kits and the importance of development/endemic interventions contributing to acute response.

While we need more research on specific WASH interventions that are under-researched (as discussed in Section 4.3 and shown in Figure 4.1), it is anticipated that the implementation and psychosocial aspects of WASH interventions will remain critical to assess, especially for more complex WASH interventions.

Figure 4.1 describes the state of evidence identified in this review. As can be seen, water interventions, source-based treatment and HWT had more evaluations, better evidence and were assessed more quantitatively. Hygiene, sanitation and WASH package interventions were assessed with lower quality and more qualitative studies. No intervention had high quality of evidence.

Lastly, some commonly evaluated WASH interventions were not evaluated in any document included in the review, including: water supply (well rehabilitation, water trucking), latrine building, handwashing, bucket chlorination, household spraying, environmental drainage/clean-up and cost-effectiveness of any intervention.

Figure 4.1: Summary map of evidence. Source: The research team



4.2 LIMITATIONS

This review has several limitations, including the potential for reporting bias, search bias, recall and courtesy bias, the use of proxy indicators, inconsistent outcome reporting and bias inherent in the protocol design.

Reporting bias – Most organizations that submitted documents to the review provided only a select handful of reports. It is possible that provided reports were limited to those with favourable outcomes or innovative approaches, and reports detailing mundane activities or unfavourable results were not provided. One notable exception was the organization ACF, who shared thousands of documents spanning nearly 10 years of work. Additionally, several key organizations in outbreak response did not submit documents, despite multiple efforts to collect information. It is likely that additional information is available, but was not submitted to the review process.

Recall and courtesy bias – Self-reported data (such as diarrhoeal disease incidence or use of HWT products) is subject to both recall and courtesy bias. Recall bias occurs when beneficiaries remember occurrences differently from what actually occurred. Courtesy bias occurs when beneficiaries respond to questions with answers that are acceptable or correct, rather than accurate. These biases would likely over-estimate positive outcomes.

Use of proxy indicators – Diarrhoea incidence and prevalence and *E. coli* microbiological results are limited by the fact they are proxies for the outcomes and impacts of disease outbreaks.

Inconsistent outcome reporting – Outcomes (such as FCR) were reported inconsistently, and this limited the potential for comparison across evaluations. For example, confirmed use of a HWT intervention was the clearest outcome measure identified by measuring FCR; however, reporting thresholds varied by: 'detectable,' >0.0mg/L, >0.1mg/L, ≥0.2mg/L, and ≥0.5mg/L. Additionally, WASH interventions that are intended to prevent or reduce disease transmission may have difficulty showing impact because of the difficulty in proving a negative (i.e. disease reduction) and the uncertainty of knowing future or potential disease rates. While rigorous study designs can account for these issues, they often require a control group and this leads to ethical concerns in emergency contexts.

Bias inherent in protocol design – Some biases were inherent in the search strategy as defined in the protocol (Yates, Vijcic, et al., 2015).

- Database searching was completed in English, French and Spanish. It is likely there is additional information in other languages not searched.
- Keywords searched may not have captured all relevant studies with variations of intervention names or names in local languages.
- The web-based searches were limited by the fact that organization websites were structured differently, and to the authors' knowledge there is no single web repository for research in emergencies.
- Only WASH interventions implemented in outbreak settings were included; as many WASH interventions are derived from other sectors (development, emergency response), it is likely that studies with relevant information were excluded.
- The inclusion criteria permitted a greater quantity of lower quality less technical studies than is traditional to systematic reviews. This increased the knowledge gained, but precluded meta-analysis. Previous systematic review efforts reporting only on health impacts have been limited by small sample size and few lessons learned; the broad inclusion criteria here led to disparate outcomes and impacts that were not possible to directly compare (Taylor et al., 2015; Ramesh et al., 2015).

Challenges in conducting the review – It was more difficult than expected to:

- identify whether an intervention was a WASH intervention, as activities (such as dead body management) can be considered WASH, but also can be health, nutrition and/or community mobilization
- assess whether the WASH intervention was in the same geographic location as the outbreak
- compare interventions conducted at different times in the outbreak, as outbreaks can transition from endemic to acute situations, with different WASH interventions carried out in each stage
- search and extract information from grey literature, as grey literature documents often included information beyond the scope of evaluation and lacked consistency in format, definition, structure and objective.

Despite these limitations, the strength of this review is in its broad inclusion criteria and assessment of intermediary outcomes and final impacts that led to a comprehensive review of available evidence that is policy-relevant and actionable.

4.3 RECOMMENDATIONS AND OPPORTUNITIES FOR FUTURE RESEARCH

There are WASH interventions that are widely implemented, but under-researched, as evidenced by the wide disparity between the types of interventions in grey and published literature. Grey literature proved to be a valuable resource in the review, with 49 percent (25/51) of the included contexts. Water interventions (HWT, source treatments) were well established in the academic literature. On the other hand, grey literature contributed most significantly to sanitation, hygiene and WASH package interventions. The opportunity for synergies in WASH programming is often discussed; yet the WASH package interventions had no published evaluations. WASH package interventions are complex and pose difficult considerations for research; however, the lack of any published WASH package evaluation identifies a disconnect between academic research and field evaluations.

It is clear from the results of the review that some of the most commonly implemented WASH interventions in outbreaks are severely under-researched. We need additional research for: well rehabilitation, bucket chlorination, latrine building, handwashing, household spraying, water trucking, environmental drainage/clean-up and cost-effectiveness of any intervention.

Based on the review, the following recommendations are made for future evaluations of these interventions.

- Clear reporting with consistent evaluation methods could greatly improve the quality and confidence of the interventions. The variety and heterogeneity could be minimized with common and robust methods that are widely applicable.
- Evaluations should include beneficiary input via household surveys, focus group discussions and/or key informant interviews.
- Evaluations should be conducted and reported in a timely manner to ensure lessons learned can be transferred and applied. Publication, while not necessary, does offer transparency and an additional sharing platform for the humanitarian community.
- Economic analysis should be prioritized.
- Natural experiments and comparison groups can be used to increase the quality of research in outbreak settings, for two reasons.
  - Natural experiments, such as occurred with the SODIS health impact study when a cholera outbreak started in the study area (Conroy et al., 2001), leverage research already being conducted to gain knowledge of efficiency and effectiveness of outbreak response.
  - Evaluation designs with control and intervention groups are not often used in outbreak situations because of ethical concerns and practical intervention difficulties with delivering different interventions to similar groups. The design hurdle can be minimized with a stepped-wedge research design where multiple groups are assessed then crossover from control to intervention in a step-by-step progression. This design takes advantage of the time necessary to deliver projects in a large area. Retrospective control groups are also an option, as in the CLTS Ebola response in Liberia (Meyer Capps and Njiru, 2015).
- Evaluations on timely related research issues are needed, such as:
  - interventions in urban areas
  - rapid interventions in areas without water and sanitation infrastructures
  - many of the diseases in this review have, or will soon have, available vaccines. There is an active and ongoing conversation on how to incorporate WASH and vaccine programmes, and which to prioritize (Murray, 1998).

4.4 CONCLUSIONS

A systematic review process was used to identity more than 15,000 documents; ultimately, 51 evaluations of WASH interventions in outbreaks are included in the review. The majority of evaluations focus on water treatment and to a lesser extent hygiene. NGO documents (grey literature) make up nearly half (49%, 25/51) of the included studies, contributing to the overall evidence base. We found that some WASH interventions are successful at reducing the risk of disease via outcomes and impacts, although programme design, implementation characteristics and community psychosocial aspects are critical to programme success. Interventions should be simple with open communication between responders and beneficiaries. The importance of quick and flexible funding, pre-positioned stock and linking development interventions to acute outbreak response are also important considerations. Overall, in outbreak contexts, there is low quality but consistent evidence that WASH interventions can reduce both the risk of disease and risk of disease transmission.

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APPENDIX A – DESCRIPTION OF INCLUDED EVALUATIONS

Intervention	Quantitative	Qualitative	Field commentary	Published or grey literature (P:G)
WATER	**23**	**2**	**1**	**21:5**
Well disinfection	2	2	1	5:0
Source-based treatment	3	0	0	3:0
HWT – chlorine based products – chlorine tablets	6	0	0	3:3
HWT – chlorine based products – liquid chlorine	4	0	0	3:1
HWT –chlorine based products – PUR®	3	0	0	2:1
HWT – other products	5	0	0	5:0
SANITATION	**1**	**0**	**1**	**1:1**
Community-driven sanitation	1	0	1	1:1
HYGIENE	**6**	**5**	**9**	**7:13**
Hygiene education	3	2	3	4:4
Social mobilization	1	1	4	0:6
Hygiene kit distribution	1	0	1	0:2
Environmental hygiene	1	2	1	3:1
WASH (package)	**0**	**3**	**9**	**0:12**
WASH (package)	0	3	9	0:12
Totals	**30**	**10**	**20**	**29:31**

Studies may be included in more than one category.

Note: *Published* refers to studies that have been peer-reviewed and are in the academic literature. *Grey literature* is any study that is not found in the academic literature – often from NGOs involved in outbreak response.

WATER

Well disinfection

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Rowe (1998) Chlorinating well water with liquid bleach was not an effective water disinfection strategy in Guinea-Bissau *Published*	Cholera Guinea-Bissau Endemic	Liquid chlorine ('bleach' sodium hypochlorite) 'shock' dose added to shallow wells to achieve about 30mg/L	Qualitative 10 wells monitored every 24 hours until FCR cessed	40% (4/10 wells) had FCR after 24 hours (median 24 hours; range 0–6 days) Perception of protection in the community after 'well shock' is beyond the protective capabilities of the treatment 'Well shock' may not be effective for disinfecting water	High risk of bias Low sample size, collection procedures questionable
Libessart (2000) Integrated chlorination campaign in Mogadishu *Published*	Cholera Somalia Endemic	Shallow wells treated with 3 different chlorine treatment methods: 1) 1% liquid chlorine 'shock,' 2) Jerry can pot chlorination with powdered chlorine, 3) pot chlorination with immersed pressed tablets (125g HTH)	Quantitative FCR measured at different times over several programming cycles: 1) 1% liquid chlorine: 173 wells over 1 year; 2) Jerry can pot chlorination: 919 tests over 3 month; 3) Pressed tablet pot chlorination: 98 tests (duration not reported)	Liquid chlorine: 69% measured FCR >0.1mg/L (28% >0.6mg/L) Jerry can pot chlorination: 87% measured FCR >0.1mg/L (27% >0.6mg/L) Pressed tablet pot chlorination: 96% measured FCR >0.1mg/L (45% >0.6mg/L) Pressed tablet pot chlorination deemed best option	High risk of bias High number of samples, inconsistent/non-comparable methods of evaluation for each treatment
Garandeau (2006) Chlorination of hand-dug wells in Monrovia *Published*	Cholera Liberia Endemic	4 well chlorination techniques assessed: 1) Floating pot chlorinators; 2) Jerry can pot chlorination- with calcium hypochlorite powder; 3) Liquid chlorine 'bleach' – 5% solution twice per day; 4) Pot chlorination with local pressed calcium hypochlorite tablet 70g in bag of sand	Qualitative 12 wells (3 protected and 9 unprotected) used over 9 weeks with different chlorination techniques, FCR measured	1) Floating pot chlorinators – fairly effective and appropriate but less sustainable 2) Simple pot – appropriate but ineffective as the tablets dissolved too quickly, high spike in FCR 3) Liquid bleach – fairly effective but FCR did not stay above 0.2mg/L all day 4) Pressed tablet pot chlorination with local pressed tablet - effective and appropriate FCR 0.2–1.0mg/L in all wells for 3–6 days, local materials and cheap Locally pressed calcium hypochlorite tablets in bag of sand was most effective with sustained FCR for several days	High risk of bias Unspecified methodology and sampling
Guevart (2008) Handmade devices for continuous delivery of hypochlorite for well disinfection during the cholera outbreak in Douala, Cameroon (2004) *Published*	Cholera Cameroon Outbreak	Pot chlorination with perforated plastic bag, sodium hypochlorite, and sand	Quantitative 18 wells (2 villages – 9 wells each) 36 chlorinations – FCR measured daily	FCR remained above 0.2mg/L for 3 days, after 4 days half of the wells were below 0.2mg/L Maximum concentration occurred after 1 day in 31/36 tests, after 2 days for 5/36	Low risk of bias Clear well selection criteria, clear methods and reporting
Cavallaro (2011) Evaluation of pot-chlorination of wells during a cholera outbreak, Bissau, Guinea-Bissau, 2008 *Published*	Cholera Guinea-Bissau Outbreak	Pot chlorination with 1.5 L plastic bottles, sodium hypochlorite, gravel, and sand	Quantitative 30 wells – FCR and TCR measured daily for 1–3 days after inserting chlorinator	Effectiveness described as sustained FCR above 1.0mg/L (WHO outbreak guideline) After 24 hrs: 15% had FCR >1.0mg/L After 48 hrs: 4% had FCR >1.0mg/L After 72 hrs: 0% had FCR >1.0mg/L	Low risk of bias Clear collection procedures

Source-based treatment

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Yates (2015) Effectiveness of chlorine dispensers in emergencies: Case Study DRC *Published*	Cholera DRC Endemic	Chlorine dispenser installed on paths near river/lake with promotion	Quantitative Mixed-methods 300 HH (initial and sustained); Focus group discussion (FGD); Key informant interview (KII)	52% and 9% reported use (initial and sustained) 34% and 5% confirmed use (initial and sustained) 28% and 0% effective use (initial and sustained)	Low risk of bias Large difference in municipal water supply access between evaluations
Yates (2015) Effectiveness of chlorine dispensers in emergencies: Case Study Sierra Leone *Published*	Cholera Sierra Leone Endemic	Chlorine dispenser installed at community wells with promotion	Quantitative Mixed-methods 300 HH (initial and sustained); FGD; KII	17% and 22% reported use (initial and sustained) 11% and 18% confirmed use (initial and sustained) 10% and 10% effective use (initial and sustained)	Low risk of bias Clear methods and reporting
Yates (2015) Effectiveness of chlorine dispensers in emergencies: Case Study Haiti *Published*	Cholera Haiti Outbreak	Chlorine dispenser installed at high risk sources. Pilot progamme	Quantitative Mixed-methods 298 HH (sustained); FGD; KII	12% reported use (sustained) 9% confirmed use (sustained) 5% effective use (sustained)	Low risk of bias Clear methods and reporting

HWT – chlorine-based products: chlorine tablets

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
ACF (2009) Household NFI monitoring report (PDM) May 2009 *Grey literature*	Cholera Zimbabwe Outbreak	Aquatabs® distributed to HH as part of an NFI kit with bucket and lid (~33,000 kits, other contents not described)	Quantitative Cross-sectional: 218 HH (random)	26% of HH reported use 17% of HH confirmed use (FCR >0.5mg/L) Low Aquatab® use because water was collected from a borehole 'safe water' 75% of HH used the bucket Overdosing, with smell and taste being issues	High risk of bias Inconsistent reporting, self-reported information, FCR was measured but not fully reported
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Nepal *Published*	Cholera Nepal Outbreak	Local NGOs using pre-positioned stock. 1565 HH – received Aquatabs® but also liquid chlorine (Water Guard, Piyush)	Quantitative Cross-sectional: 400 HH	8.3% reported use (Liquid Chlorine: WaterGuard: 6.3% Piyush: 15.8%) 6.8% confirmed use (FCR ≥0.2mg/L) (liquid chlorine: WaterGuard: 3.5%; Piyush: 8.3%)	Low risk of bias Spillover between several similar interventions
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Kenya *Published*	Cholera Kenya Outbreak	Pre-positioned stock. Distribution of Aquatabs® and PUR® Purifier of Water in an NFI kit to 5,592 HH	Quantitative Cross-sectional: 409 HH	12.7% reported use (PUR® Purifier of Water: 5.9%) 7.9% confirmed use (PUR®: 3.7%) (FCR ≥0.2mg/L) 5.3% effective use <1 CFU/100mL (PUR: 2.3%)	Low risk of bias Selection bias not likely, clear and consistent reporting of outcomes
ACF (2014) Hygiene Kits Post Distribution Monitoring Report *Grey literature*	Cholera South Sudan Outbreak	Aquatabs® distributed in NFI kits to 7,348 HH. Kit also included: bucket, PUR® Purifier of Water packets and filter cloth	Quantitative Cluster cross-sectional: 351 HH	87% confirmed use (>0.1mg/L) in HH with Aquatabs® (6% of HH FCR >0.5mg/L) >90% of HH had FCR in Juba (range 83–100%) 78% of HH could demonstrate correct use of PUR HH without FCR said they get water from a treated tanker, or are saving the Aquatabs® for when cholera outbreaks again	High risk of bias Inconsistent reporting, spillover effects likely

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Imanishi (2014) Household Water Treatment Uptake during a Public Health Response to a Large Typhoid Fever Outbreak in Harare, Zimbabwe *Published*	Typhoid Zimbabwe Outbreak	Chlorine tablet distributed to 51,000 HH (3 different doses); 3,500 HH received NFI kits with soap, WaterMaker® (floc/dis), and jerry can in addition to HWT	Quantitative Cross-sectional: 458 HH	31% reported use 22% confirmed use (FCR ≥0.2mg/L) 73% of HH reported using HWT before outbreak, 83% reported using HWT during the outbreak 97% of HH with stored water had covered containers	Medium risk of bias Carried out in worst hit areas, peak of outbreak already declining
ACF – Tokplo (2015) Projet de reprise communautaire de la lutte contre le choléra et les maladies hydriques dans les zones de santé de Minova (Sud Kivu) et de Kirotshe (Nord Kivu), D.R. Congo *Grey literature*	Cholera DRC Endemic	Chloramine tablets with hygiene promotion	Quantitative Before/after: 384 HH	14% reported use of tablets. 26% Reported use of any HWT; 14.5% boiling. 14% confirmed use (FCR 0.3-0.6mg/L)	Low risk of bias Methods, sample selection, and limitations clearly described

HWT – chlorine-based products: liquid chlorine

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Dunston (2001) Collaboration, cholera, and cyclones: A project to improve point-of-use water quality in Madagascar *Published*	Cholera Madagascar Outbreak	Liquid chlorine marketed to community (Safe Water System (SwS) – WaterGuard®). Jerry cans available but not distributed	Quantitative Before/After: 375 HH – 15 communities stratified by mobilization strategy	19.7% reported use (increased from 8.4% baseline, 6 months after mobilization dropped to 11.2%) *No confirmed use* – FCR in HH using SwS 0.23mg/L (median), compared to 0.1mg/L in HH not using (p=0.005)	High risk of bias Selective reporting, incomplete outcomes
Mong (2001) Impact of Safe Water System on Water Quality in Cyclone-Affected Communities in Madagascar *Published*	Cholera Madagascar Outbreak	Liquid chlorine and 5 gallon flexible jerry can distributed to 11,700 HH with some education about use	Quantitative 123 HH (random)	65% reported use (n=123); 'ever used' 85%; SwS already promoted in the area 45% confirmed use (n=40) (FCR ≥0.2mg/L) 76% report receiving jerry can; 76% reported using	High risk of bias Selective reporting and outcomes
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Nepal *Published*	Cholera Nepal Outbreak	Local NGOs using pre-positioned stock. 1565 HH – received liquid chlorine (WaterGuard®, Piyush®) but also Aquatabs®	Quantitative Cross-sectional: 400 HH	22.2% reported use (2 products: WaterGuard®: 6.3% Piyush®: 15.8%) (Aquatabs®: 8.3%) 11.8% confirmed Use (2 products: WaterGuard®: 3.5%; Piyush®: 8.3%) (Aquatabs®: 6.8%) (FCR ≥0.2mg/L)	Low risk of bias Selection bias not likely, clear and consistent reporting of outcomes
ACF (2014) Projet pilote de l'approche de marché pour la promotion du chlore liquide *Grey literature*	Cholera DRC Endemic	Promotion and distribution of liquid chlorine with vouchers to 834 HH	Quantitative Cross-sectional: 32 HH	*No reported use*. Voucher redeemed by 88% of HH 69% confirmed use (FCR ≥0.2mg/L; Average FCR 0.5mg/L) 97% of HH (31/32) reported being satisfied with liquid chlorine as a HWT	Medium risk of bias Potential spillover and selective reporting

HWT – chlorine-based products: PUR® Purifier of Water

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Doocy (2006) Point-of-use water treatment and diarrhoea reduction in the emergency context: an effectiveness trial in Liberia *Published*	Cholera Liberia Endemic	PUR® Purifier of Water sachets (weekly distributions) with 2 10 L buckets compared to HH given just buckets	Quantitative 200 HH intervention and 200 HH control	95.4% confirmed use – "compliant" with FCR and reported use Health impact: Diarrhoea incidence reduced by 67% (absolute risk reduction (adjusted RR) 0.33; 95% CI 0.30–0.37); diarrhoea prevalence reduced by 77% (adjusted RR 0.23; 95% CI 0.21–0.25). Covered stored water alone was also protective for diarrhoea incidence (adjusted RR 0.84; 95% CI 0.82–0.86)	Medium risk of bias Weekly visits for 12 weeks prone to courtesy bias; rainy season over – less diarrhoea
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Kenya *Published*	Cholera Kenya Outbreak	Pre-positioned stock. Distribution of Aquatabs® and PUR® Purifier of Water in an NFI kit to 5,592 HH	Quantitative Cross-sectional: 409 HH	12.7% reported use (PUR® Purifier of Water: 5.9%) 7.9% confirmed use (PUR: 3.7%) (FCR ≥0.2mg/L) 5.3% effective use <1 CFU/100mL (PUR: 2.3%)	Low risk of bias Selection bias not likely, consistent reporting of outcomes
ACF (2014) Hygiene Kits Post Distribution Monitoring Report *Grey literature*	Cholera South Sudan Outbreak	Aquatabs® distributed in NFI kits to 7,348 HH. Kit also included: bucket, PUR® Purifier of Water packets and filter cloth	Quantitative Cluster cross-sectional: 351 HH	87% confirmed use (>0.1mg/L) in HH with Aquatabs® (6% of HH FCR >0.5mg/L) >90% of HH had FCR in Juba (range 83–100%) 78% of HH could demonstrate correct use of PUR® HH without FCR said they get water from a treated tanker, or are saving the Aquatabs® for when cholera outbreaks again	High risk of bias Inconsistent reporting, spillover effects likely

HWT – other products: filtrations, SODIS, safe storage

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Conroy (2001) Solar disinfection of drinking water protects against cholera in children under 6 years of age *Published*	Cholera Kenya Outbreak	1.5L clear plastic bottle distributed with instructions (SODIS project) – targeted children under <5	Quantitative 67 HH intervention and 64 control; HH had child under 5 years for original study then monitored a year after (case-control out of an RCT)	*No reported use.* (67/131 used SODIS) Health impact: Self-reported cases of cholera: <6 yr: (RR 0.12; 0.02-0.65; p=0.014); 6-15 yr: (RR 1.09; 0.58-2.05); Adults: (RR 1.2; 0.59-2.5)	High risk of bias Inconsistent results, unclear intervention impact
Colwell (2003) Reduction of cholera in Bangladeshi villages by simple filtration *Published*	Cholera Bangladesh Endemic	Simple filter intervention group compared to control. Intervention groups: 1) Nylon mesh water filter 150µm mesh size and 2) folded sari cloth as a filter.	Quantitative 65 villages: 27 villages using Sari; 25 villages using filter screen; 13 villages control. ~44,000 in each group.	90% reported use of filters Health impact: 38% reduction in cholera cases by filter use, hospital confirmed cases. (Nylon filter: control OR: 0.59; p<0.05) (Cloth filter: control OR: 0.52 Sari (8 folds); p<0.05)	Low risk of bias Pilot intervention had strong consistent results, but increased for power
Huq (2010) Simple sari cloth filtration of water is sustainable and continues to protect villagers from cholera in Matlab, Bangladesh *Published*	Cholera Bangladesh Endemic	5 years after Colwell, revisit same HH to see use of HWT	Quantitative 7,233 HH, 5 years after Colwell (2003); 2,251 nylon filter, 2,556 cloth group, and 2,426 control group intervention	31% reported use of a filter (2,207 of 7,233 HH); Sari group (35%), nylon filter (26%), control group (23%) Confirmed use 38% of reported rates (19/50) (through 11 hour observation period)	Medium risk of bias Spillover effects likely

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Roberts (2001) Keeping clean water clean in a Malawi refugee camp: a randomized intervention trial *Published*	Cholera Malawi Endemic	Improved bucket distribution to intervention group, only told not to put hands in the buckets. Compared to standard buckets	Quantitative RCT: 100 intervention HH and 300 control HH	*No reported use.* Health impact: 8.4% lower diarrhoea attack rate with improved buckets (p=0.26); children <5, 31.1% lower diarrhoea attack rate with improved buckets in children (p=0.06) Non-health impact: 53.3% lower (69% lower with geometric mean) faecal coliforms in improved vs. control buckets over several hours (measured at 6 time steps) n=604	Low risk of bias HH visited 2x per week for diarrhoea rates; loss to follow-up significantly different
Einarsdbttir (2001) Health Education and Cholera in Rural Guinea-Bissau *Published*	Cholera Guinea-Bissau Endemic	Hygiene promotion to support treating water (and other hygiene practices). Radio, TV, health staff, poster, word of mouth, song, theatre group	Quantitative 53 HH (random)	66% reported use with lemon to treat water; 40% reported boiling water; no one reported only drinking treated (boiled /lemon) water. Not consistent use of treated water	High risk of bias Small sample size, open-ended questions, self-reported results

SANITATION

Community-driven sanitation

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Meyer Capps (2015) Open Defecation Status, Community-Led Total Sanitation and Ebola Virus Disease (EVD) in Voinjama and Kolahun Health Districts, Lofa County, Liberia (2014) *Grey literature*	Ebola Liberia Outbreak	CLTS project (running for 5 years – carried on through Ebola outbreak) in 6,865 HH	Quantitative Mixed-methods; Matched controls: 239 Project HH: 312 non-Project HH, 16 FGD, KII	HH in CLTS communities 17 times less likely to have cases of Ebola than non-CLTS communities (OR=0.06, p<0.001) Beneficiaries trusted: 1) Health workers, 2) radio, then 3) NGOs for sources of info by both CLTS and non-CLTS communities	Medium risk of bias Spillover effects unclear
Waterkeyn (2005) Rapid sanitation uptake in the internally displaced people camps of northern Uganda through community health clubs *Published*	Cholera Uganda Outbreak	Community mobilization through community health club and PHAST approaches: community trainers, drama presentations, 20 hygiene topics, delivered in groups, peer pressure to keep them. Certificate if attended 20 sessions. Community provided own materials but would receive a concrete 'sanplat' (latrine floor)	Field commentary Case study	Group cohesion and peer pressure adjusted hygiene behaviour and improve hygiene practices Motivation of >15,000 beneficiaries; built 8,500 latrines, 6,000 bath shelters, 3,400 drying racks, and 1,550 handwashing stations in a 4 month timeframe Rapid, scalable, and cost-effective	High risk of bias Case study description

HYGIENE

Hygiene education

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Einarsdbttir (2001) Health Education and Cholera in Rural Guinea-Bissau *Published*	Cholera Guinea-Bissau Endemic	Hygiene promotion to support treating water (and other hygiene practices). Radio, TV, health staff, poster, word-of-mouth, song, theatre group	Quantitative 53 HH (Random)	Radio and word-of-mouth were most received and best understood 66% reported use with lemon to treat water; 40% reported boiling water boiling water; no one reported only drinking treated (boiled/lemon) water. Not consistent use of treated water	High risk of bias Small sample size, open-ended questions, self-reported results
Meyer Capps (2015) Open Defecation Status, Community-Led Total Sanitation and Ebola Virus Disease (EVD) in Voinjama and Kolahun Health Districts, Lofa County, Liberia (2014) *Grey literature*	Ebola Liberia Outbreak	CLTS project (running for 5 years – carried on through Ebola outbreak) in 6,865 HH	Quantitative Matched controls. 239 Project HH: 312 non-Project HH	Beneficiaries trusted: 1) Health workers, 2) radio, then 3) NGOs for sources of information by both CLTS and non-CLTS communities HH in CLTS communities 17 times less likely to have cases of Ebola than non-CLTS communities (OR=0.06, p<0.001)	Medium risk of bias Spillover effects likely
Williams (2015) Perceptions of health Communication, Water Treatment and Sanitation in Artibonite Department, Haiti, March–April 2012 *Published*	Cholera Haiti Outbreak	Evaluation of WASH preferences in regional cholera response	Qualitative 18 FGD	Most valuable source of information – community health worker (CHW) and megaphone going house to house was the best way to reach the communities Most 'trusted' vender of HWT products – pharmacies Increase in handwashing as a result from messaging Perceived reduction in diarrhoea	Medium risk of bias Inconsistent language definitions, self-reporting
Date (2013) Evaluation of a Rapid Cholera Response Activity – Nyanza Province, Kenya, 2008 *Published*	Cholera Kenya Endemic	Distribution of HWT and hygiene kits (not described); environmental investigations, cholera case management	Quantitative Cross-sectional: 358 intervention HH and 365 control HH	Social contacts (friends, family, and neighbours), which suggests that social networks can be a valuable resource *No reported use* (Reported any water treatment: Intervention: Control 56%: 37%; p<0.001) *No confirmed use* ('Detectable' FCR 17% in intervention and 14% in control groups; NS)	High risk of bias Intervention overlap, intervention loosely described, convenience sample, 3 month recall time
WHO (no date) guidance on communication with respect to safe drinking water and household hygiene literature review, interviews and case studies; case study – South Africa *Grey Literature*	Cholera South Africa Outbreak	Hygiene campaign: Messages: Water storage, personal hygiene, safe refuse disposal, food handling, use of HWT Mode: health workers, schools, religious leaders; some religious services use to recruit volunteers	Field commentary Case study	Red Cross (working in specific areas) observed a sharp decline in mortality rates following education progamme. Hygiene messages were known beforehand	High risk of bias Case study commentary
WHO (No Date) Guidance on communication with respect to safe drinking water and household hygiene Literature review, interviews and case studies; case study – Zimbabwe *Grey literature*	Cholera Zimbabwe Outbreak	Cholera prevention, control, food prep, hand washing, use of HWT (tablets/sachets) Mode: T-shirts and dramas used, 310,000 flyers, 14,000 posters in 3 languages distributed to 250,000 people	Field commentary Case study	Change in behaviour – not attending funerals, reducing physical contact (hugs, shaking hands) Response built on existing organizations Unwillingness to drink chlorinated water Lack of resources and worthless currency	High risk of bias Case study commentary

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
ACF – Matemo (2014) Use Of H2S To Support Hygiene Promotion *Grey literature*	Cholera/ hepatitis Kenya Spike in cases	H_2S used as part of hygiene promotion	Field commentary 2,820 HH tests – methods unclear	Use of H_2S used a visual aid to assist hygiene messaging as well as test water samples. Proof to community that 'clear doesn't mean safe'	High risk of bias Unclear methods and reporting
Wall (2011) Ann Kite Yo Pale (let them speak) Best Practice and Lessons Learned in Communication with Disaster Affected Communities: Haiti 2010 *Grey literature*	Cholera Haiti Outbreak	Various communication strategies from many organizations	Qualitative 15 FGD, KII (not described)	Communication was effective at improving trust, mitigating conflict, developing relationships, and gaining insights to community perceptions and values 2-way communication was key – asking a question, sharing stories, discuss an issue (face-to-face was key); technical and medical messages did not address fears and perceptions of the disease Cholera treatment centres were initially rejected due to fears about the origin and response to the disease The assessments of overall effect on communication efforts on cholera, as "too many organizations were involved and too many techniques used" (p. 28)	Medium risk of bias Unclear methodology and selective reporting
Contzen-Mosler (2013) Impact of different promotional channels on handwashing behaviour in an emergency context: Haiti post-earthquake public health promotions and cholera response *Published*	Cholera Haiti Outbreak	Various communication strategies from many organizations	Quantitative 811 HH across several regions	For both faeces and food related handwashing, the most effective were material distributions with demonstrations, and radio spots Spontaneous/unplanned promotions by friends and neighbours also influential For food related handwashing, community clubs and theatres were also relevant Better targeting of messages could be done - washing prevents diarrhoea; severity of cholera Focus groups, hygiene days, and stickers/posters/paintings were rated at less likeable, less convincing, and less trustworthy than other methods	Medium risk of bias Large sample size, but possibility of courtesy bias

Social mobilization

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Meyer Capps (2015) Open Defecation Status, Community-Led Total Sanitation and Ebola Virus Disease (EVD) in Voinjama and Kolahun Health Districts, Lofa County, Liberia (2014) *Grey literature*	Ebola Liberia Outbreak	CLTS project (running for 5 years – carried on through Ebola outbreak) in 6,865 HH	Quantitative Matched controls. 239 Project HH: 312 non-Project HH	HH in CLTS communities 17 times less likely to have cases of Ebola than non-CLTS communities (OR=0.06, p<0.001) Beneficiaries trusted: 1) Health workers, 2) radio, then 3) NGOs for sources of info by both CLTS and non-CLTS communities	Medium risk of bias Spillover effects likely
Waterkeyn (2005) Rapid sanitation uptake in the internally displaced people camps of northern Uganda through community health clubs *Published*	Cholera Uganda Outbreak	Community mobilization through community health club and PHAST approaches: community trainers, drama presentations, 20 hygiene topics, delivered in groups, peer pressure to keep them. Certificate if attended 20 sessions. Community provided own materials but would receive a concrete 'sanplat' (latrine floor)	Field commentary Case study	Group cohesion and peer pressure adjusted hygiene behaviour and improve hygiene practices Motivation of >15,000 beneficiaries; built 8,500 latrines, 6,000 bath shelters, 3,400 drying racks, and 1,550 handwashing stations in a 4 month timeframe Rapid, scalable, and cost-effective	High risk of bias Case study description

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
ACF (2015) Trigger Behavioural Change to strengthen community's resilience to Ebola Outbreaks *Grey literature*	Ebola Sierra Leone Outbreak	Community Led Ebola Management and Eradication (CLEME), as modified CLTS approach with community driven action. ACF also involved in other aspects of the response	Field commentary Case study	CLEME approach and 'triggering' deemed successful in many aspects: 80% of communities planned isolation rooms; tippy tap handwashing widely promoted; and community ownership and trust were shown to be very important project results Time, staff requirements, and prerequisites limit wider applicability	High risk of bias Case study description
IFRC – Rees-Gildea (2013) Sierra Leone Cholera ERU Operation Review *Grey literature*	Cholera Sierra Leone Outbreak	Sensitisation progamme to 350,000 Mode: radio, texts, cinema progamme, community volunteers, school club progamme Messages: 'key cholera messages' 419 oral rehydration points with ORS; 500 wind up radios	Field commentary Case study (limited evaluation)	Decrease in CFR deemed to be more influenced by social mobilization promoting early presentation and access to ORP (mobilization more important that case management) Scalable networks with long-running progammes Not cost effective - planned for worst case scenario (over staffed with emergency and development programming running simultaneously)	High risk of bias Organization review; case study commentary
IWSD – Neseni (2009) Evaluation of the WASH Response to the 2008–2009 Zimbabwe Cholera Epidemic and Preparedness Planning for Future Outbreaks *Grey literature*	Cholera Zimbabwe Outbreak	Water trucking, drilling boreholes, rehabilitation of wells, HWT, water quality monitoring Latrine construction was limited, rehab of latrines, sewer decongestion, rehab sewer pipes Hygiene: door to door, dramas, traveller information, print and electronic media, 'revitalization of volunteers and health workers, NFI distribution HH spraying done by government	Field commentary Case study	Social mobilization considered most impactful to reduce disease transmission NFI gave 'psychosocial support'; blanket distribution late; prepositioned stocks were helpful Errors in IEC materials; soap was scarce	High risk of bias Case study – commentary, limited methods
Wall (2011) Ann Kite Yo Pale (let them speak) Best Practice and Lessons Learned in Communication with Disaster Affected Communities: Haiti 2010 *Grey literature*	Cholera Haiti Outbreak	Various communication strategies from many organizations	Qualitative 15 FGD, KII (not described)	Communication was effective at improving trust, mitigating conflict, developing relationships, and gaining insights to community perceptions and values 2-way communication was key – asking a question, sharing stories, discuss an issue (face-to-face was key); technical and medical messages did not address fears and perceptions of the disease Cholera treatment centres were initially rejected due to fears about the origin and response to the disease The assessments of overall effect on communication efforts on cholera, as "too many organizations were involved and too many techniques used" (p. 28)	Medium risk of bias Unclear methodology and selective reporting

Hygiene kit distribution

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Unicef – Ruiz-Roman (2009) Evaluation of the blanket distribution of non-food items as part of the cholera response in Zimbabwe *Grey literature*	Cholera Zimbabwe Outbreak	~200,000 HH NFI distribution (1 20L bucket, 1 20L bucket with tap, 30 water purification tablets, 3 ORS sachets and 1 pack of information, education and communication (IEC) materials)	Quantitative Evaluation: 307 HH	87% of 307 surveyed HH reported receiving a hygiene kit; only 33% reported receiving all 5 recommended items (differences in kits) 59% of HH requested additional quantities – mostly from families of 6 or more Soap was most used item	High risk of bias Spillover effects likely, selective reporting
CRS – Pennacchia (2011) Bridging the Gap: Providing Water and Sanitation and Non-Food Item Assistance to Returnees, IDPs and Host Communities in North Kivu *Grey literature*	Cholera DRC Endemic	NFI vouchers – US$70 for 2,184 beneficiaries (HH) – set a market day Also WASH activities, including construction/rehabilitation of water sources and hygiene stations and hygiene promotion	Field commentary 332 HH survey 3 months after case study	3 months after voucher market, vulnerability score dropped from 3.2 to 1.6 (3.0 is the threshold for emergency intervention) Voucher – beneficiaries 'empowered' to choose their own needs More than US$150,000 pumped into local economy Beneficiaries thought prices (via voucher market) were competitive, 80% thought prices were at or below market 85% of vendors said they reduced prices out of negotiation	High risk of bias Commentary – limited methods

Environmental hygiene

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Steele (2008) Impact of jerry can disinfection in a camp environment – experiences in an IDP camp in Northern Uganda *Published*	Cholera Uganda Endemic	Disinfecting jerry cans with 3% chlorine solution using 2 methods of cleaning	Qualitative Jerry cans from 13 HH barrowed then revisited 3–5 days after cleaning	92% (11/12) had reduced *E. coli* after cleaning; 75% (9/12) had <5 *E. coli* after cleaning; 42% (5/12) had 0 *E. coli* after cleaning Either method of cleaning with high strength chlorine solution was considered efficient at a one-time disinfection One-time disinfection did not affect the recontamination after 3–5 days	High risk of bias Small sample and inconsistent results
Walden (2005) Container contamination as a possible source of a diarrhoea outbreak in Abou Shouk camp, Darfur province, Sudan *Published*	Shigellosis Sudan Outbreak	Disinfecting jerry cans with 5% chlorine solution. 13,224 over 5 days for about 88% IDP camp coverage Loudspeaker and door to door	Qualitative Case study – observation	Number of watery and bloody cases of diarrhea *continued to decline* after the disinfection (according to clinic records) Response deemed more important than random water testing to determine the source of contamination 1 week later, observations were that people were keeping containers clean	High risk of bias Case study description
Roberts (2001) Keeping clean water clean in a Malawi refugee camp: a randomized intervention trial *Published*	Cholera Malawi Endemic	Buckets were chlorinated with 2.5mg/L solution 8 times over 2 months	Quantitative Cross-sectional 24 buckets	Faecal coliform virtually eliminated for 4 hours, but increased after 6 hours Stock solution concentrations were considerably lower than intended on several occasions, leading to inadequate chlorination *Note: the chlorine concentration of 2.5 mg/L is typically a drinking water level and 4 magnitudes weaker than the concentrations of Steele et al. and Walden et al. described above to disinfect inanimate objects.*	High risk of bias Weak evaluation methods outside the larger RCT

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Gartley (2013) Uptake of household disinfection kits as an additional measure in response to a cholera outbreak in urban areas of Haiti *Published*	Cholera Haiti Outbreak	1,220 NFI/household disinfection kits given to cholera patients or caregivers (0.5–1kg soap, 14L bucket, 10L jerry can, 3.8L bleach, cloth, scrubbing brush, instruction book)	Quantitative 208 HH in sequence	98% of HH reported using contents at time of survey Training changed 1/3 way through programme – there was a significant $p<0.05$ difference in use of materials with increased training focusing on using all items in the kit together and sharing with family members and neighbours Kit – US$14 USD 94% of HH said instructions were clear and simple	High risk of bias Sequential sampling, likely courtesy bias

WASH PACKAGE

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
ACF – Dinku (2011) Emergency Water, Sanitation, and Hygiene Interventions for AWD and Drought Affected Pastorial Communities in Borana Zone, Ethiopia *Grey literature*	Acute Watery Diarrhoea (AWD) Ethiopia Endemic	Rehabilitation of wells, sanitation promotion, NFI kits (with WaterGuard®) to 10,059 HH	Field commentary Case study	"Reduced risk of water and sanitation related morbidity and mortality among AWD and drought affected pastoral communities" Reported improvements in time to collect water, water collection practices, handwashing, latrine use, garbage practices	High risk of bias Case study description
DeGabriele (2009) An emergency response to humanitarian WASH- related emergencies in Zimbabwe *Grey literature*	Cholera Zimbabwe Outbreak	Hygiene kit distribution (8,000 HH), Aquatabs® to 3,300 HH for 3 weeks, 'cat litter' method promoted, well rehabilitation and water trucking	Qualitative 34 KII, FGD (not described)	90% of respondent claimed to have changed hygiene behaviour as a result of promotion, but may not be practiced consistently Aquatabs® inconsistent but accepted by community; Leaflet not enough to educate on Aquatab® use	High risk of bias Inconsistent methods
IWSD – Neseni (2009) Evaluation of the WASH Response to the 2008–2009 Zimbabwe Cholera Epidemic and Preparedness Planning for Future Outbreaks *Grey literature*	Cholera Zimbabwe Outbreak	Water trucking, drilling boreholes, rehabilitation of wells, HWT, water quality monitoring Latrine construction was limited, rehab of latrines, sewer decongestion, rehab sewer pipes Hygiene: door to door, dramas, traveller information, print and electronic media, 'revitalization of volunteers and health workers, NFI distribution HH spraying done by government	Field commentary Case study	Social mobilization considered most impactful to reduce disease transmission NFI gave 'psychosocial support'; blanket distribution late; prepositioned stocks were helpful Errors in IEC materials; soap was scarce	High risk of bias Case study – commentary, limited methods
IOM – Condor (2011) Evaluation of the International Organization for Migration's Ongoing Activities on Support to the Flash Appeal for the Haiti Earthquake and Cholera Outbreak (Sida/IOM Agreement January 2010 – May 2011) *Grey literature*	Cholera Haiti Outbreak	Improvement of 250 sites through hygiene promotion (Community Action Groups), Radio Tap Taps, and cartoon newspaper WASH facility construction/rehabilitation/cleaning (including hand washing stations, water tanks and latrines) to support efforts of ORS focal points	Field commentary Case study	"Two-way communications with affected populations and the general public is a critical factor in achieving scale in cholera prevention health messages" Low staff turnover Quick and flexible funding – realistic approach built on experience with 'no false expectations' 'High value for money' with Community Action Groups (paid hygiene promoters for 12 months); other NGOs did not appreciate paying for a 'volunteer' job	High risk of bias Limited methods

Author (year) title ***Type***	**Context**	**Description of activities**	**Evaluation**	**Key impacts**	**Bias** **Comments**
ACF – Gauthier (2014) A Real-time Evaluation of ACF's Response to Cholera in Juba, South Sudan *Grey literature*	Cholera South Sudan Outbreak	Borehole rehabilitation; 'Support' community building latrines; Hygiene promotion – megaphone, house to house, groups; NFI kit; HH/environmental disinfection	Field commentary 28 staff KII	Weekly attack rate has been decreasing (even prior to intervention) NFIs not aligned with Sphere or South Sudan and size not adequate for large families, rapidly used Surge capacity and 'kick off' funds were effective HH disinfection actually spraying community latrines and high risk areas – but not a priority by cluster	High risk of bias Lack of consistent data
CRS – Pennacchia (2011) Bridging the Gap: Providing Water and Sanitation and Non-Food Item Assistance to Returnees, IDPs and Host Communities in North Kivu *Grey literature*	Cholera DRC Endemic	Water: 25 spring rehabilitations; 3 new spring construction Sanitation: 20 shower blocks; 20 laundry stations; 2,509m of drainage; 20–15m^3 solid waste areas Hygiene: 20 hygiene promoters; 28 Water Committees formed (1 for each water system); Promotion via: HH, schools, markets, churches, radio, drama, IEC book; topics: handwashing, boiling of water, proper latrine usage NFI vouchers – US$70 for 2,184 beneficiaries (HH)	Field commentary Unclear evaluation	90% of HH thought personal hygiene improved (no sample mentioned) 74% decrease in diarrhoea cases in 5 months (35 cases in September: 9 cases in January); clinic records Time savings to collect water: average 322m before to 92m after (also less time in insecure environment)	High risk of bias Commentary – limited methods
Tearfund – Ngegba (2002) Water and Sanitation Programme February-December 2002 Jaluahun Chiefdom, Kailahun District Eastern Province, Sierra Leone *Grey literature*	Bloody diarrhoea Sierra Leone Outbreak	Water: 8 new wells dug, 6 rehabilitated, 10 spring boxes Sanitation: 652 pit latrines Hygiene: 8 laundry areas, developed community management committees and community health volunteers	Field commentary	Social cohesion observed. Community management committees and training; community health visitors engage in communal activities and help one another in times of need 50% of interviewed demonstrated knowledge of diarrhoea transmission routes There have been considerable changes in people's attitudes, especially toward open defecation Clinic and Ministry of Health data shows diarrhoea reduction from 50% to 5% in intervention villages	High risk of bias Commentary – limited methods
Grayel (2014) Programme d'intervention pour limiter et prévenir la propagation de l'épidémie de choléra en République Démocratique du Congo *Grey literature*	Cholera DRC Endemic	Water: Rehabilitation of water 10 sources and 3 networks, chlorination in 3 water networks and 15 high risk water points, pilot promotion of HWT with chlorine Sanitation: Improvement of access to sanitation for 2,500 HH Hygiene: Soap distributed (not described), disinfection of households (spraying), hygiene promotion and epidemiological surveillance/control	Qualitative 7 FGD; 34 KII	Local volunteers for hygiene promotion and disinfection The influence of the project on cholera prevalence is not as strong as hoped; "little change from 2012 to 2013" In the future, integrate epidemiological experts to better understand cholera transmission pathways and dynamics; work on longer term (3–5 years)	Medium risk of bias High likelihood of spillover bias and reliance on expert opinion

Author (year) title ***Type***	**Context**	**Description of activities**	**Evaluation**	**Key impacts**	**Bias** **Comments**
ACF – El-Mahmid Zimbabwe Emergency Response 01/05/2008 – 30/06/2009 Capitalization Report *Grey literature*	Cholera Zimbabwe Outbreak	Water: 13 bladders and 3 rigid tanks at cholera treatment units (CTUs) with some taps; Water trucking to supply bladders/tanks at CTUs; 18 water points repaired and disinfected with 2% HTH; Repaired 5 springs; 81 boreholes repaired (19 in schools) – water committees and spare parts too 5 new boreholes in health clinics Hygiene: Hygiene promotion to 29,000; Training on chlorine solution for health volunteers; 4000 hygiene kits (1 water container 30L with lid and cap, 1 plastic bucket 15 L with lid, 1 kg of green soap, 2 stripes of Aquatabs® with leaflets)	Field commentary	Emergency experts in the field were main added value Bladder used to establish safe drinking water for 34,912 people (4L/p/d) Distribution point: FCR 0.1-1.3mg/L; turbidity <5 NTU HH (54 samples) Average: 0.25mg/L; NTU <5; 84 samples 0.1-0.6mg/L	High risk of bias Commentary – limited methods
ACF (2007) – UNOCHA Emergency Funding Water and Sanitation Program in Kebri Dehar District, Somali Region *Grey literature*	Diarrhoea Somalia Outbreak	Water: 6 community wells rehabilitated (7095 people); 120 m3/day for 3 weeks for 3500 people with water trucking; Widespread well chlorination, 150 surface water storage structures (birkhats); 1,554 bottles of WaterGuard® given to families with birkhats (259 HH); 45 bottles given to schools; 1 bottle treats 1,000L NFI kits: 500 kits: (4 pieces of soap, water container (no size), cup with handle, 4–6 bottles of WaterGuard® Hygiene: 4809 people, including 424 community people; Mostly women, children and 'community people'; Topics: Disinfection, storage, handling	Field commentary Case study	Case management improved, and the case fatality rate dropped significantly after the NGO's intervention, bringing it to an acceptable standard of < 5% (from 11.7% to 4.9% and 2.8%) Microbiological testing not sufficiently carried out on rehabilitated/disinfected water sources; 7 were tested – all had 12-30 faecal coliform/100mL Hygiene kits had logistic delays; contract delays	High risk of bias Case study description
ACF Grayel (2011) Evaluation externe – Réponse d'urgence à l'épidémie de choléra en Haïti *Grey literature*	Cholera Haiti Outbreak	Water - Distribution of HHWT kits/ceramic filters for turbid waters; mobile drinking water station; Antenna WATA. 260 water supply points Sanitation – construction of 20 public latrines Hygiene - Sensitization/education ~250,000 people; distribution of hygiene kits (soap, Aquatabs® for 15 days); chlorination of water buckets; disinfection of meeting/public spaces (spraying)	Qualitative Informal interviews with local stakeholders and beneficiaries	Decrease of attack rate (not quantified and could be natural trend) Improved water quality (no systematic assessment) Legal/political difficulties HH/public chlorine spraying planned but stopped.	High risk of bias Expert opinion. "informal conversations", limited number of site visits
Simpson – Real Time Evaluation of the Cholera Response in Zimbabwe 09 February – 19 February 2009 *Grey literature*	Cholera Zimbabwe Outbreak	Water: Aquatabs® in hygiene kit; water tankering; rehabilitation of wells; new boreholes Hygiene: Hygiene promotion – volunteers used (but other NGOs paid causing issues) 29,000 HH receive hygiene kits (not described further)	Field commentary 100 KII (some beneficiaries)	Prepositioned stock key (with response scenarios) Existing public health progamme; decision to scale up to response difficult to assess – trigger needed NFIs materials lacking, quantity (quality ok), beneficiaries appreciated Emergency staff available	High risk of bias Commentary – limited methods

APPENDIX B – SEARCHING SUMMARY

Database		Date	Results
Scopus	WASH intervention string (9 sets) AND context group AND LMIC country string AND 1995 – present	11–12 November 2015	666
Web of Science	WASH intervention string (9 sets) AND context string AND 1995 – present (topic search)	16 November 2015	4,163
Ovid Medline Ovide Medline In-Process and other non-index citations; Evidence Based Medicine Reviews full text – Cochrane Database of Systematic Reviews (DSR), ACP Journal Club and (Database of Abstracts of Reviews of Effects) DARE	WASH intervention strings (9 sets) AND context string AND 1995 – present (abstract, title)	23 November 2015	2,315
Google Scholar	48 – 2 and 3 word searches: WASH intervention AND emergency or disaster; first 2 pages	25 November 2015	756
LILACS (Spanish/English)	WASH intervention strings (4 sets – water, sanitation, hygiene, WASH) AND context string (abstract words)	25 November 2015	756
IDEAS	WASH intervention strings (4 sets – water, sanitation, hygiene, WASH) AND context string (all record types; abstract, 1995-2015)	27 November 2015	328
ArticleFirst – WorldCat (French)	water/sanitation/hygiene AND context key words AND 1995-2015; keyword	11 December 2015	83
Academic Search Premier	15 – 2 word searches; water/sanitation/hygiene; disaster/outbreak	11 December 2015	625
Academic Search Premier (French)	9 – 2 word searches; water/sanitation/hygiene; context	11 December 2015	634
		Total	**10,326**

Source	Description	Date	Results
Web searching	NGO websites UN (Unicef, WHO, UNHCR) Government agencies Information hubs (ALNAP, ReliefWeb) Development banks Grey literature repositories	September 2015–March 2016	2,676
Direct communication	Mass emails to WASH cluster Targeted (individual) emails Web postings Personal contacts Conference presentations	September 2015–February 2016	2,024

Summary

Source	Results
Academic databases	10,326
Internet searching	2,676
Direct communication	2,024
Total	15,026

Search update

In September 2016, the search strings were re-run to check for updated studies. Dates were restricted to 2015–2016. Additionally, local names for some products were searched to ensure searching was comprehensive. For example, 'gadyen dlo' is a Haitian word for WaterGuard or the Safe Water System that has been promoted in several countries.

Database		Date	Results
Scopus	WASH intervention string (9 sets) AND context group AND LMIC country string AND 2015–2016	September 2016	58
Web of Science	WASH intervention string (9 sets) AND context string AND 2015–2016 (topic search)	September 2016	2,180
Ovid Medline	WASH intervention strings (9 sets) AND context string AND 2015–2016 (abstract, title)	September 2016	2,368
Cochrane	WASH intervention strings (9 sets) AND context string AND 2015–2016 (abstract, title)	September 2016	610
Google Scholar	48 – 2 and 3 word searches: WASH intervention AND emergency or disaster; first 2 pages	September 2016	480
LILACS (Spanish/English)	WASH intervention strings (4 sets – water, sanitation, hygiene, WASH) AND context string (abstract words)	September 2016	99
IDEAS	WASH intervention strings (4 sets – water, sanitation, hygiene, WASH) AND context string (all record types; abstract, 2015–2016)	September 2016	230
ArticleFirst – WorldCat (French)	Water/sanitation/hygiene AND context key words AND 2015–2016; keyword	September 2016	46
Academic Search Premier	15 – 2 word searches; water/sanitation/hygiene; disaster/outbreak; 2015–2016	September 2016	571
Academic Search Premier (French)	9 – 2 word searches; water/sanitation/hygiene; context; 2015–2016	September 2016	42
		Total	**6,684**

Example search string for databases

Keyword strings were used to search databases. Keyword strings for the eight WASH interventions (in addition to a 'WASH' intervention) were searched with other strings for emergency contexts, low and middle-income countries, outcomes and included dates. Search strings were combined using the 'AND' operator; example strings are described below.

Keyword string	Keyword string
Intervention (example: water access)	("water access" OR "source rehabilitation" OR "source cleaning" OR "water source" OR "protected source" OR "unprotected source" OR "improved source" OR "unimproved source" OR "contaminated source" OR "water quality" OR "water quantity" OR "tanker*" OR "water truck*" OR "well rehabilitation" OR "well cleaning" OR "dug well" OR "tube well" OR "point source" OR "non-point source" OR river OR stream OR canal OR "drinking water")
Year	1995–present
Context	(emergency OR emergencies OR crisis OR "emergency response" OR "complex emergenc*" OR disaster OR flood OR tsunami OR outbreak* OR earthquake OR drought* OR endemic OR pandemic OR hurricane OR typhoon OR "failed state" OR conflict OR war OR refugee OR "IDP" OR "internally displaced" OR entrapped or humanitarian)
Outcomes	(diarrhea OR diarrhoea OR outbreak OR "waterborne diseases" OR "disease burden" OR "disease risk" OR "disease reduction" OR "DALY" OR mortality OR morbidity OR prevalence OR evidence OR effectiveness OR "cost effectiveness" OR cost-effectiveness OR economic OR efficacy OR "quality of life" OR "QOL" OR psycosocial OR ebola OR cholera OR "hepatitis E" OR "hep e" OR "use of service" OR use-of-service OR "effective use" OR "sustained use" OR uptake OR up-take OR "up take" OR "EVD")
Low and middle-income countries	("LMIC" OR "low and middle income countr*" OR "low-and-middle-income" OR "low income country" OR "low-income-country" OR "middle income country" OR "middle-income-country" OR afghanistan OR libya OR albania OR macedonia OR algeria OR madagascar OR "American Samoa" OR malawi OR angola OR malaysia OR armenia OR maldives OR azerbaijan OR mali OR bangladesh OR "Marshall Islands" OR belarus OR mauritania OR belize OR mauritius OR benin OR mexico OR bhutan OR micronesia OR bolivia OR moldova OR bosnia OR herzegovina OR mongolia OR botswana OR montenegro OR brazil OR morocco OR bulgaria OR mozambique OR "Burkina Faso" OR myanmar OR burundi OR namibia OR "Cabo Verde" OR nepal OR cambodia OR nicaragua OR cameroon OR niger OR "Central African Republic" OR "CAR" OR nigeria OR chad OR pakistan OR china OR palau OR colombia OR panama comoros OR "Papua New Guinea" OR congo OR paraguay OR congo OR peru OR "Costa Rica" OR philippines OR "Ivory Coast" OR "Cote d'Ivoire" OR romania OR cuba OR rwanda OR djibouti OR samoa OR dominica OR "Sao Tome" OR principe OR "Dominican Republic" OR senegal OR ecuador OR serbia OR egypt OR "Sierra Leone" OR "El Salvador" OR "Solomon Islands" OR eritrea OR somalia OR ethiopia OR "South Africa" OR fiji OR "South Sudan" OR gabon OR "Sri Lanka" OR gambia OR "St. Lucia" OR "Saint Lucia" OR georgia OR "St. Vincent" OR "Saint Vincent" OR grenadines OR ghana OR sudan OR grenada OR suriname OR guatemala OR swaziland OR guinea OR syrian OR syria OR guinea-bissau OR tajikistan OR guyana OR tanzania OR haiti OR thailand OR honduras OR timor-leste OR "Timor Leste" OR india OR togo OR indonesia OR tonga OR iran OR tunisia OR iraq OR turkey OR jamaica OR turkmenistan OR jordan OR tuvalu OR kazakhstan OR uganda OR kenya OR ukraine OR kiribati OR uzbekistan OR korea OR vanuatu OR kosovo OR vietnam OR "Kyrgyz Republic" OR kyrgyzstan OR "West Bank" OR gaza OR lao OR laos OR yemen OR lebanon OR zambia OR lesotho OR zimbabwe OR liberia OR "middle-east" OR "middle east" OR "Africa" OR "Sub-Saharan Africa" OR "Central America" OR "Latin America" OR "Caribbean" OR "South America" OR "Central Asia" OR "East Asia" OR pacific OR "South Asia" OR "Asia" OR "South-east Asia" OR "southeast Asia" OR "South east Asia")

Example website searches with keywords

For websites that were not equipped to handle complex search strings, basic keywords within the scope of WASH were used in combination. Example keyword searches include:

- outbreak and water
- emergency and latrine
- cholera and hygiene.

APPENDIX C – SUMMARY OF EVIDENCE

To establish the summary of evidence from multiple studies of varying qualities and study designs, a protocol was developed to clearly communicate the overall evidence for outcomes and interventions. The summary of evidence protocol is based on Grading of Recommendations Assessment, Development and Evaluation (GRADE) assessment of evidence outlined in Cochrane Review. However, some modifications were made so there would be less emphasis on randomized control trials (RCT), which are known to be rarely carried out in humanitarian research. The summary of evidence is described through four categories to give the reader levels of confidence in the quality of the outcomes and interventions. The four hierarchal categories are taken directly from GRADE and Cochrane.

- **High –** further research is very unlikely to change our confidence in the estimate of effect or accuracy.
- **Moderate** – further research is likely to have an important impact on our confidence in the estimate of effect or accuracy and may change the estimate.
- **Low** – further research is very likely to have an important impact on our confidence in the estimate of effect or accuracy and is likely to change the estimate.
- **Very low** – any estimate of effect or accuracy is very uncertain.

A three-step evaluation process is used to determine the level of evidence with transparency. Each outcome (health, use, and barrier/facilitator) is assessed individually. The baseline of evidence (Step 1) is determined by the study designs. Steps 2 and 3 downgrade or upgrade the baseline evidence considering biases, effect size, consistency and generalizability (Figure C.1). Definitions for upgrading and downgrading are below the figure.

The overall evidence for the intervention is then balanced between the outcomes assessed. Outcomes with the most studies are weighted heavier; however, judgement and group discussions should be used to appreciate the definitions of 'high,' 'moderate,' 'low,' and 'very low'.

Figure C.1: Level of evidence assessment. Source: The research team

Step 1: Evidence baseline established from study designs

Study design		Summary of evidence
RCT	→	4 – High
Control groups	→	3 – Moderate
Cross-sectional, observation, qualitative	→	2 – Low
Field observation	→	1 – Very low

Step 2: Factors that reduce the evidence baseline (1 step per point if applicable)

- High bias in half or more of the studies included in the outcome
- Unexplained heterogeneity
- Imprecision – small sample sizes

Step 3: Factors that *increase* the evidence baseline (1 step per point if applicable, maximum 2-step increase)

- Large magnitude of effect
- Evidence of dose-response relationship
- Confidence in effect (confidence intervals)
- Generalizability (multiple studies across different contexts with consistent results)

Step 1: Start with the study design evaluating the outcome. In situations with a mixture of research designs, the most frequent study design controls. When the same number of studies is in each category, start with 'low.'

Step 2: The quality of studies is downgraded. One step down for each of the criteria identified. Level 1 is the lowest possible.

- **High bias**: Half or more of the studies are high bias. Confidence in the results and conclusions lessens with high bias evaluations and can be a major limitation to the intervention effect.
- **Inconsistency of results**: Studies have a wide range of effects or estimates. Contradictory conclusions or factors that do not explain variation/heterogeneity.
- **Imprecision of results**: Studies have limited sample sizes, so application and implication of conclusions are doubted.

Step 3: Factors that upgrade studies include:

- **Large magnitude of effect:** Studies with low and medium bias that conclude a 'large effect size' (e.g. RR >2 or RR <0.5) that is in agreement with other studies.
- **Dose-response:** Evidence that outcomes change with a dose-response relationship.
- **Confidence in effect:** Narrow range of rates or calculated effect size and confidence intervals. Consistency of impact and factors.
- **Generalizability:** Multiple studies across different contexts with consistent results.

  Note: the maximum upgrade is 2 and should be justified.

APPENDIX D – RISK OF BIAS FOR INDIVIDUAL STUDIES

Risk of bias was separate between quantitative and qualitative studies (including field commentary). Additional procedures are found in the review protocol (Yates, Vijcic et al., 2015).

QUANITATIVE STUDIES

To determine the risk of bias in quantitative studies (experimental, quasi-experimental, and non-experimental), an assessment tool was developed, based on the *Cochrane Handbook* 'risk of bias' tool while also drawing heavily on the structuring and description by Baird et al (2013). We assessed the risk of bias through five categories: 1) selection and confounding; 2) spillover effects and contamination; 3) incomplete outcome; 4) selective reporting; and 5) other bias. Similarly described by Baird et al (2013):

- **Selection and confounding:** addresses the issue of evaluation design. Allocations, selection of beneficiaries, targeting, and matching concerns are represented in this category.

- **Spillover effects and contamination –** Addresses the issue of spillovers from the treatment to the control group. Not controlling for outside factors or for additional interventions in the area also has spillover effects.

- **Incomplete outcome –** Addresses the issue of whether analysis of all relevant outcomes was reported or whether there appears to be selection in reporting. Loss to follow-up or missing data can reduce the power of the research design as well as potentially introduce bias with unequal loss of sample between groups.

- **Selective reporting** – Authors use a credible analysis method and report on all intended outcomes. Some research is funded by manufacturers of products, which can lead to selective reporting of only favourable outcomes.

- **Other risks of bias –** This category is for any number of other risks of bias present in the report. Self-reported data is of particular concern for our analysis. Also, retrospective baseline data, data using inappropriate methods, and changing follow-up methods or procedures are examples of other potential biases. This is the most subjective of the five categories.

Each study is scored across the five categories as 'low risk,' 'medium risk,' 'high risk' or 'unclear.' The overall determination for the risk of bias for that study is assessed with Figure D.1, summarizing the five categories into a single quality assessment for each qualitative study.

Figure D.1: Quantitative risk of bias summary

Risk of bias	'Low risk' assessed in categories
Low risk	4–5 'low risk' scores
Medium risk	3 'low risk' scores
High risk	1–2 'low risk' scores

Figure D.2: Summary risk of bias for quantitative studies

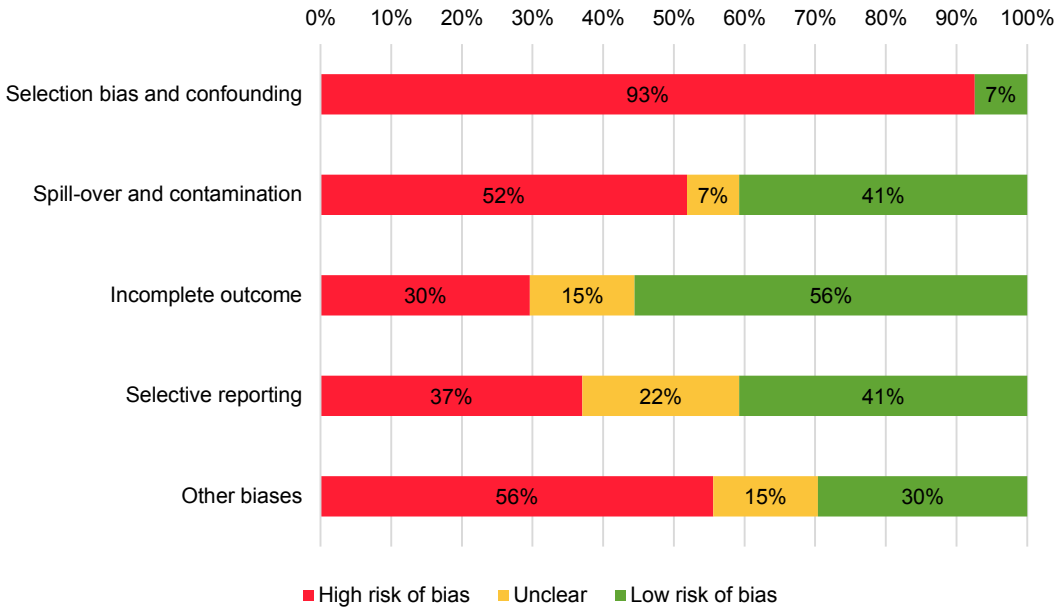

Figure D.3: Overall risk of bias score for quantitative studies

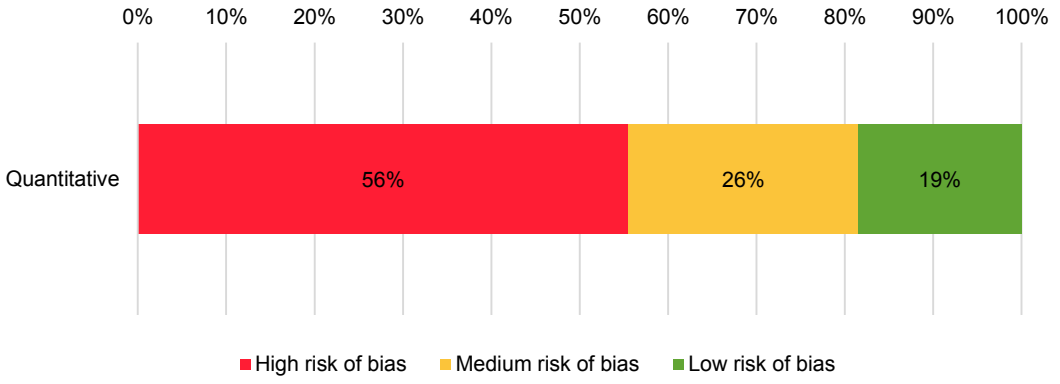

Figure D.4: Individual assessment of quantitative studies

	Selection bias and confounding	Spillover and contamination	Incomplete outcome	Selective reporting	Other biases	Overall
Contzen and Mosler, 2013	High	Low	Low	Low	High	Medium
Mong, Kaiser et al., 2001	High	High	High	High	High	High
Ruiz-Roman, 2009	High	High	Unclear	High	High	High
Date, Person et al., 2013	High	High	Low	Unclear	Unclear	High
ACF, 2009	High	High	High	High	High	High
Colwell, Huq et al., 2003	High	High	Low	Low	Low	Medium
Conroy, Meegan et al., 2001	High	Low	High	High	High	High
Doocy and Burnham, 2006	Low	Low	Low	Low	Unclear	Low
Huq, Yunus et al., 2010	High	Low	Low	Low	High	Medium
Imanishi, Kweza et al., 2014	High	Low	Low	Low	High	Medium
Dunston, McAfee et al., 2001	High	High	Low	High	High	High
Roberts, Chartier et al., 2001	Low	Low	Unclear	Low	High	Low
Meyer Capps and Njiru, 2015	High	Low	Low	Low	High	Medium
Dinku, 2011, ACF, 2014	High	High	High	High	Unclear	High
Dinku, 2011	High	Low	High	High	High	High
Lantagne and Clasen, 2012 – Nepal	High	Unclear	Low	Low	Low	Medium
Lantagne and Clasen, 2012 – Kenya	High	Low	Low	Low	Low	Low
Libessart and Hammache, 2000	High	Low	High	Unclear	High	High
Gartley, Valeh et al., 2013	High	High	Unclear	High	High	High
Yates, Armitage et al., 2015 – DRC	High	High	Low	Low	Low	Medium
Yates, Armitage et al., 2015 – Sierra Leone	High	Low	Low	Low	Low	Low
Yates, Armitage et al., 2015 – Haiti	High	Low	Low	Low	Low	Low
Einarsdbttir, Passa et al., 2001	High	High	High	High	High	High
ACF, 2014	High	High	Low	High	Low	High
Grayel, 2014	High	High	High	Low	Unclear	High
Tokplo, 2015	High	High	Low	Unclear	High	High
Cavallaro, Harris et al., 2011	High	Low	Unclear	Unclear	Low	High

QUALITATIVE AND FIELD COMMENTARY STUDIES

The qualitative assessment has been adapted from Spencer et al. (2003) *Quality in Qualitative Evaluation: A Framework for assessing research evidence*. The quality assessment is evaluated on four appraisal questions. Each study was scored across the four appraisal questions categories: 1) design, 2) bias, 3) data collection, and 4) clarity of finding as 'low risk,' 'medium risk' 'high risk,' or 'unclear.' The overall determination for the risk of bias for that study is assessed with the table below.

- **Design:** The overall design of the research is considered, especially the targeting of the research population.
- **Bias:** How representative is the research population and are there obvious biases that affect the findings?
- **Data collection:** How was the data collected, recorded (audio, video, transcribed)? Who collected the information?
- **Clarity of findings:** Do the conclusions match what could be achieved from the study design? Is there an inherent logic to the conclusions?

Figure D.5: Risk of bias summary

Risk of bias	'Low risk' assessed in categories
Low risk	3 or more 'low risk' score
Medium risk	2 'low risk' scores
High risk	1 or less 'low risk' score

Figure D.6: Risk of bias for qualitative and field commentary studies by category

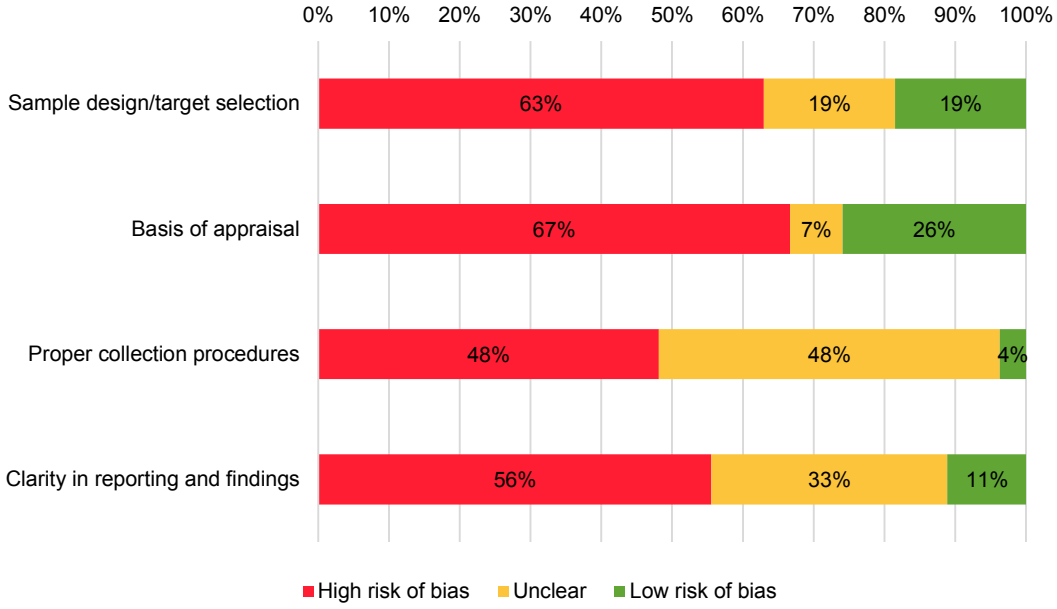

Figure D.7: Summary risk of bias for qualitative and field commentary studies

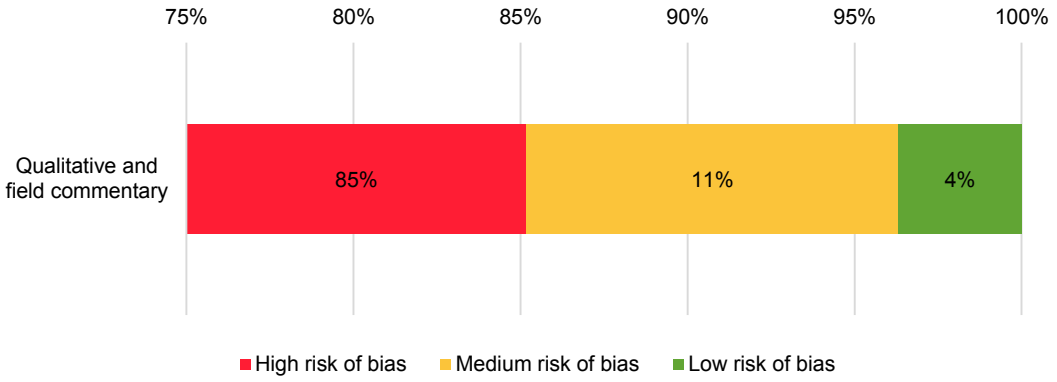

Figure D.8: Qualitative and field commentary risk of bias by category

	Sample design/target selection	Basis of appraisal	Proper collection procedures	Clarity in reporting and findings	Overall
Williams, Gaines et al. 2015	Low	Low	Low	Unclear	Low
Wall and Chéry, 2011	Low	Low	Unclear	Unclear	Medium
Steele, Clarke et al., 2008	High	High	High	High	High
Simpson, Bazezew Legesse et al., 2009	Unclear	Unclear	High	High	High
Rowe, 1998	High	Low	High	High	High
Garandeau, Trevett et al., 2006	High	Low	High	Unclear	High
DeGabriele and Musa, 2009	High	High	Unclear	Low	High
Walden, Lamond et al., 2005	High	High	High	High	High
Grayel, 2011	High	High	High	High	High
Waterkeyn, Okot et al., 2005	High	High	High	High	High
WHO, no date – South Africa	High	High	Unclear	Unclear	High
WHO, no date – Zimbabwe	High	High	Unclear	Unclear	High
Pennacchia, Poidatz et al., 2011	High	High	Unclear	High	High
Dunoyer and Sudre, 2012	High	High	High	Unclear	High
Condor and Rana, 2011	High	High	Unclear	High	High
Rees-Gildea, 2013	Unclear	Low	High	High	High
Neseni and Guzha, 2009	Unclear	Unclear	Unclear	Low	High
Matemo, 2014	Unclear	High	Unclear	High	High
El-Mahmid and Roussy, 2009	High	High	High	High	High
ACF, 2007	High	High	High	High	High
Guevart, Van Hecke et al., 2008	Low	Low	Unclear	Unclear	Medium
ACF, 2015	High	High	Unclear	Unclear	High
Flachenberg, 2014	High	High	High	High	High

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