Emergency Water, Sanitation, and Hygiene Interventions in Low and Middle-income Countries

A dissertation submitted by

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Abstract

Water, sanitation, and hygiene (WASH) interventions are used in low and middle-income countries to help reduce the risk of disease by providing safe water, reducing open defecation, and promoting hygiene practices. Specifically, in emergencies WASH interventions are used in nearly all contexts ranging from natural disasters, to disease outbreaks, and conflicts. Over the last several years, the number of people affected by emergencies is increasing while the gap between needs and funding is widening. To address these growing needs, emergency responders need confidence in choosing effective WASH interventions and increased understanding to improve impact and cost-effectiveness. Unfortunately, there is a lack of robust evidence on the efficacy and effectiveness of these interventions because of the difficulty in conducting high-quality research in emergency contexts. Herein, I present four projects which increase the evidence of emergency WASH interventions: 1) a systematic review of WASH and the impact on people living with HIV and AIDS, 2) an evaluation of a chlorine Dispenser project through four case studies in emergencies, 3) a systematic review of WASH interventions in disease outbreaks, and finally 4) a systematic review of short-term WASH interventions in emergency response. The impact of emergency WASH interventions was identified through primary evaluations (Dispensers) and secondary data analysis (three different systematic reviews, two of which included grey literature). Across all four projects, seven common themes were identified: 1) weak overall evidence, despite inclusion of non-experimental studies and grey literature; 2) impact of WASH on disease reduction is assumed, rather than consistently documented; 3) most evaluated WASH interventions focus on the water component; 4) significance of grey

literature contributing to the evidence base; 5) sustainability of emergency interventions; 6) how and when interventions are carried out influences the success of interventions; and lastly, 7) social aspects like taste and smell preferences or community trust are important considerations for emergency WASH interventions. Overwhelmingly, WASH interventions benefit affected populations; however, the manner of implementation and depth of community engagement of affected populations greatly influence the effectiveness of the response.

Dedication

This work is dedicated to my father, Steve K. Yates. My Dad passed away in to January 2015 and was the perfect example that knowledge is not held in a piece of paper, but the ability and drive to solve problems and the importance to communicate solutions to others. Thank you for your love, grace, and pride in who I am. You are missed.

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Emergency Water, Sanitation, and Hygiene Interventions in Low and Middle-Income Countries

Chapter 1: Introduction

1.1 Emergency WASH Interventions

In almost all emergency contexts, such as natural disasters, conflicts, and disease outbreaks, there is a basic need to create or re-establish access to water, sanitation, and hygiene (WASH) (Connolly et al., 2004, Toole, 1995, Toole, 1996). WASH interventions in emergency 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). According to the *Humanitarian Charter and Minimum Standards in Humanitarian Response (Sphere Project, 2011):*

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

Emergency WASH interventions should provide access to safe water and sanitation and promote good hygiene practices with dignity, comfort, and security (Sphere Project, 2011). The overall aim of all emergency WASH interventions is to promote safe practices that reduce preventable waterborne and communicable diseases (Sphere Project, 2011). WASH responses represent a wide range of possible interventions that are carried out as stand-alone interventions or combined water, sanitation, and hygiene interventions; more specifically:

Water. Water interventions are intended to increase water quantity and/or water quality. Securing access to sufficient quantities of water is a necessary step in providing potable water, and also enables hygiene and sanitation practices. Improving water quality to ensure no microbial contamination is also critical to maintain health of the emergency-affected population. Improving water quality can occur at the water source

or in the household, and should also reduce turbidity and increase taste and smell acceptance. Example water interventions include: well rehabilitation, water trucking, large water treatment systems, treating water with chlorine, or water filters.

Sanitation. Sanitation interventions are intended to isolate human feces from the environment. As a fundamental disease transmission route, minimizing open defecation and ensuring proper management of feces reduces exposure to potentially infectious waste and can reduce ongoing disease transmission. Examples of sanitation interventions include: latrine building, temporary port-a-johns, Peepoo® bags, trench latrines, or using the community approach for total sanitation which is a sanitation strategy that focuses on hygiene education and community mobilization to stop open defecation.

Hygiene. Hygiene interventions are intended to promote awareness among affected or at risk populations on disease transmission routes. Instructions encouraging the population to use effective, safe practices may require a sudden change in behavior. The distribution of hygiene kits equip affected or at-risk populations to act on hygiene messages by often providing soap, water containers, and chlorine tablets. Environmental hygiene interventions reduce risks by reducing the impact of disease vectors (e.g. flies, rats), and environmental conditions. Example hygiene interventions include: handwashing promotion, encouraging safe water storage, disinfecting household objects, managing garbage, and encouraging land drainage.

A visual depiction of how WASH interventions can interrupt primary disease transmission routes is shown through the F-Diagram (Figure 1).

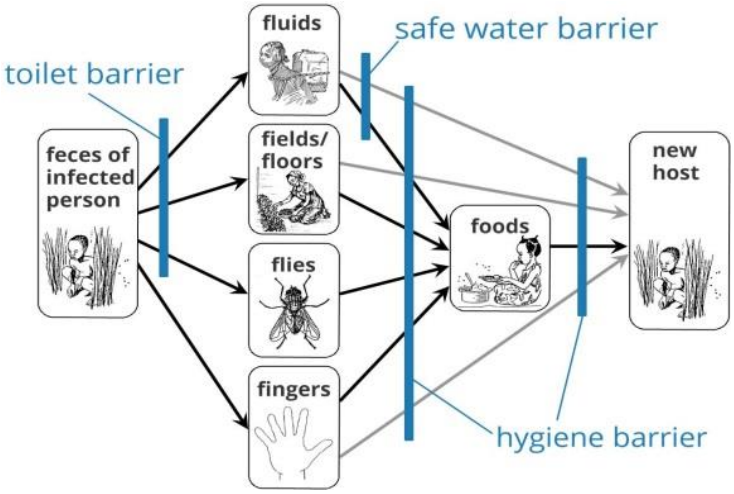


Figure 1: F-Diagram (Water1st International, 2015)

In the following sections, I discuss: the theory of change for WASH interventions and the connection with Water Diplomacy principles (Section 1.2), the increasing need for emergency WASH interventions (Section 1.3), call for improving evidence in emergencies (Section 1.4), and research objectives (Section 1.5).

1.2 WASH Theory of Change and Water Diplomacy

The goal of all WASH interventions is to reduce the risk of disease transmission. The extent to which WASH interventions are successful in interrupting transmission is dependent on their efficacy and effectiveness. *Efficacy* is the theoretical potential for interrupting transmission routes, and answers the question "Could the intervention work?" Efficacy is often established through laboratory testing, such as establishing that various chlorine concentrations kill bacteria in controlled conditions. *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?"

The efficacy of a WASH intervention may not translate to effectiveness in an emergency setting (Parkinson, 2009). To better understand the theoretical transition between efficacious interventions and effective interventions, a theory of change model is used to describe the theoretical route from intervention activities to outputs, outcomes, and ultimately, impacts (disease reduction). Identifying influencing factors and assumptions is critical to understand potential breakdowns between intervention efficacy and effectiveness. A theory of change template for WASH interventions is presented in Figure 2.

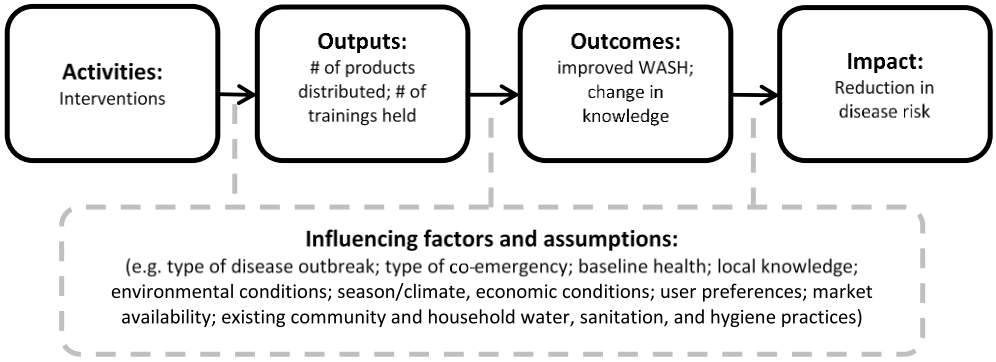


Figure 2: Theory of Change Template (WHO, 2014)

A specific theory of change model is depicted for a combined household water treatment intervention and hygiene education intervention in Figure 3. In this example, a water filter and hygiene education is distributed to households; both are known to be efficacious from previous laboratory and field studies. The assumptions detailed at each stage of the model show the steps necessary to achieve correct and consistent use in the target population, i.e. effectiveness.

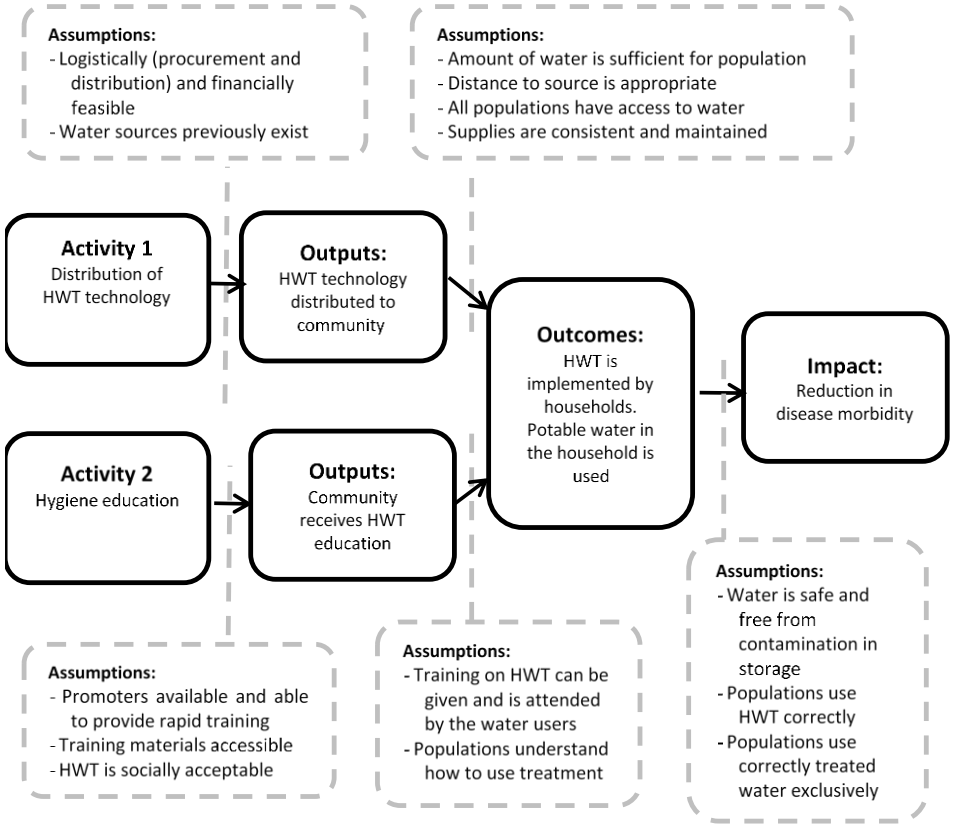


Figure 3: Theory of Change Example – HWT (Yates)

As seen above, emergency WASH interventions are complex with many external factors and include a wide range of disciplines, from public health to anthropology, conflict studies to engineering, and even international law (Hilhorst et al., 2010, Dijkzeul et al., 2013). The influencing factors and assumptions are often not related to the technical efficacy of an intervention but highlight the complexity and the interconnected relationship of the many facets of an emergency WASH intervention. The pillars of Water Diplomacy, described by Susskind and Islam, aim to address the complexities across multiple disciplines, as is present in WASH emergencies (Susskind and Islam, 2012). Specifically, Water Diplomacy is a framework intended to bridge technical and social disciplines to find amenable negotiated solutions with all the relevant stakeholders.

Understanding and negotiating stakeholder values, is a core principle in Water Diplomacy and is also critical for an effective response. Assisting disaster-affected populations is the primary goal, but there are many stakeholders in emergency response (Table 1) and each stakeholder often has different priorities, responsibilities, and aims. Considerations for who, how, and when stakeholders are involved is in constant debate. There are also further considerations for scope of response, sustainability, and equality. Identifying the decision makers is another critical and often negotiated; deciding factors are balanced between international funding objectives, Non-Governmental Organizations (NGO) constraints, and the wants/needs of a population.

Table 1: Description of Responding Organizations (Yates)

Stakeholder	Description
Government Donors	Institutional donors, like USAID, ECHO, and DFID, donate billions of dollars annually to emergencies around the world. Money is allocated from taxes in donor countries and may be tied to specific interests determined by government policy.
Private Donors	Private donors, like the Bill and Melinda Gates Foundation or the Clinton Foundation, contribute or raise funds to give toward interantional needs. Private individuals may also contribute toward NGOs to fund assistence.
United Nations (UN)	(UN) agencies lead emergency 'clusters' that cover the range of humanitarian needs in an emergency (e.g. WASH, shelter, health). United Nations Children's Fund (Unicef) typically leads and coordinates the WASH response, with substantial coordination with other sectors and respective UN agencies. For example, the health sector is led by the World Health Organization (WHO) and refugee management is led by United Nations High Commissioner for Refugees (UNHCR).
Local Governments	Local governments may be involved in all on-the-ground aspects of emergency response, from agency coordination to municipal services.
Non-governmental Organizations (NGOs)	NGOs play a key role working directly with the communities to implement interventions, often in coordination with other actors. Some NGOs specialize in emergency response (e.g. Action Contre la Faim (ACF), Oxfam, or International Rescue Committee (IRC)).

Stakeholder	Description
Community Leaders	Community leaders, local elders, spiritual leaders, or local councils often have significant influence in LMIC.
Affected Population	The general population affected by the disaster or emergency.

The Water Diplomacy framework, like the theory of change models, is useful to highlight some of the complexity of emergency WASH response, as effective interventions require practitioners and researchers to embrace the dynamic relationship of the political, natural, and societal spheres of WASH interventions.

Political Sphere. Emergency WASH interventions, like all humanitarian activities, are entrenched in international and local politics (Hilhorst et al., 2010). The United Nations is the primary international response mechanism funded from donor nations like the United States, Canada, Japan, as well as, the European Union, and others. These funds often have allocated interests, which may change with the current political environment. In fact, donor giving is balanced between humanitarian needs and other factors like: geographic proximity, oil rich, or political likeness, but donor 'bandwagoning' can also influence where and who is receiving funds (Fink and Redaelli, 2011). Additionally, politics often directly influence the timing, delivery, and coverage of interventions (Lautze et al., 2004). An emergency can overwhelm national or local government systems, further compounding the impact of international interests and funds. Moreover, local interests may not align with national or international interests, straining political relationships. While most responder agencies claim full neutrality, they operate in the middle of multiple stakeholders with different interests.

Natural Sphere. The natural sphere describes the physical environment, the technical constraints to providing access to water, sanitation, and hygiene services. The Sphere

Guidelines are the minimum standards that responders aim to achieve during a response. For instance, the minimum water needed per person per day is 15 liters, while one latrine is needed for no more than 20 persons (Sphere Project, 2011). The natural sphere may be the least complex; however, the overwhelming scope of need, procurement constraints, and gaining consistent access to remote locations require negotiation of priorities and expectations.

Societal Sphere. The societal sphere has long been underappreciated in emergency response. The notion that beneficiaries' tastes, preferences, and culture would impact the provision of basic human needs was generally not considered. Little effort was done to adjust programming to a specific context; thus, there are many examples of efficacious interventions having little to no impact. Taste, smell, beneficiary participation, and cultural understanding are just some of the societal factors necessary to appreciate the full context of emergency WASH interventions. Affected populations may also be in 'value-driven' societies that prioritize political or religious values that are less likely to be influenced by an analytical evidence-based approach (Dijkzeul et al., 2013). Identifying the relevant stakeholders is not sufficient, but also understanding their values is an important consideration for emergency response.

Effectiveness of emergency WASH interventions is a function of complex relationships between stakeholders and physical parameters. In the midst of this complexity, the importance of emergency WASH research is apparent with the increasing needs (Section 1.3) and defining evidence in emergencies (Section 1.4).

1.3 Increasing Needs

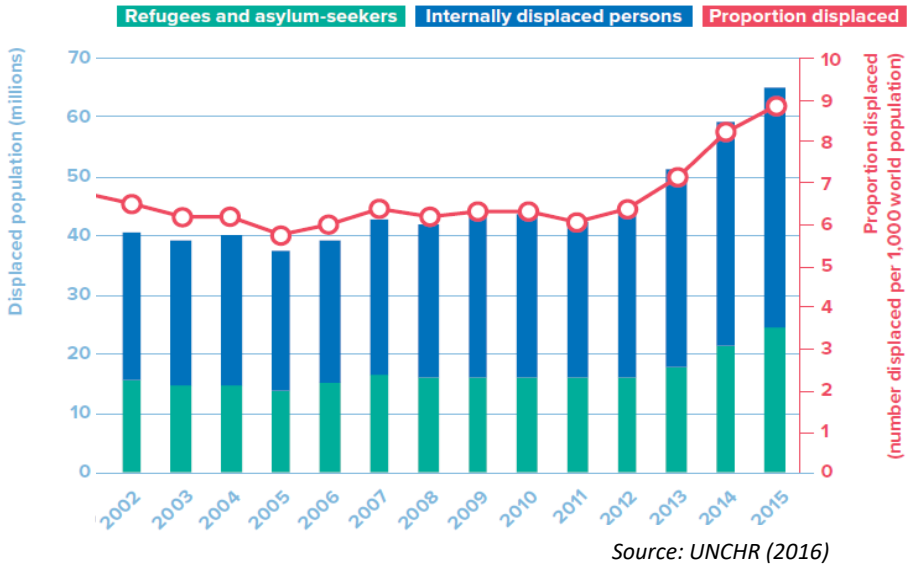
Emergency events where WASH interventions are needed are occurring at increasing rates and affecting a larger number of people, especially considering the impacts of natural disasters, disease outbreaks, and conflict.

Natural Disasters. Natural disasters (i.e. earthquakes, hurricanes, flooding events, disease outbreaks or droughts) affect more than 200 million people annually (EM-DAT, 2014). Climate change is expected to increase the scale and frequency of natural disasters, and the rapidly increasing urban and slum populations in disaster prone regions are expected to increase the number of people impacted (Walker et al., 2012).

Disease Burden and Outbreaks. Annually, there are 4 billion cases of diarrhea caused by waterborne diseases, resulting in 61 million disability adjusted life-years (DALYs) lost (Hutton, 2012). Furthermore, there is a sharp increase in vulnerability to waterborne diseases during emergencies from flooding events or events that result in population displacement, as some refugee situations have recorded mortality rates 20-30 times baseline rates in the acute phase of emergencies (Toole and Waldman, 1997, Toole, 1995, Connolly et al., 2004, Moss et al., 2006). For example, an estimated 50,000 Rwandan refugees died from cholera over a four-week period during the 1994 refugee influx into what is now the Democratic Republic of the Congo (DRC) (Goma Epidemiology Group, 1995). Specifically, a disease outbreak exists 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 greater than 44 million cases, were reported into the Global Infectious Disease and Epidemiology Online

Network from 219 nations (Smith et al., 2014). The total number of outbreaks and the diversity of causal diseases (the number of diseases causing outbreaks) have both increased over time ($p<0.0001$).

Conflict and Displacement. Currently, 1.5 billion people are potentially threatened by conflict and violence (Institute for Economics and Peace, 2014, IISS, 2015). As a result, in 2015 there were more than 60 million displaced persons (refugees and internally displaced persons (IDPs)) worldwide (Figure 4), the highest number ever recorded (UNHCR, 2015). *Note: refugees reside in a country not their own, while IDPs are similarly displaced but within their own country's borders.* This large number causes enormous strain on limited funds and resources (UNHRC, 2016).



Source: UNCHR (2016)

Figure 4: Displacement by Year

Funding Gaps

As there is a growing number of people at risk and in need, there has also been a corresponding increase in international funding (Lattimer, 2016). Each of the last three

years, there has been an increase in international funding, with the record highest amount of $28 billion USD in 2015 (Figure 5).

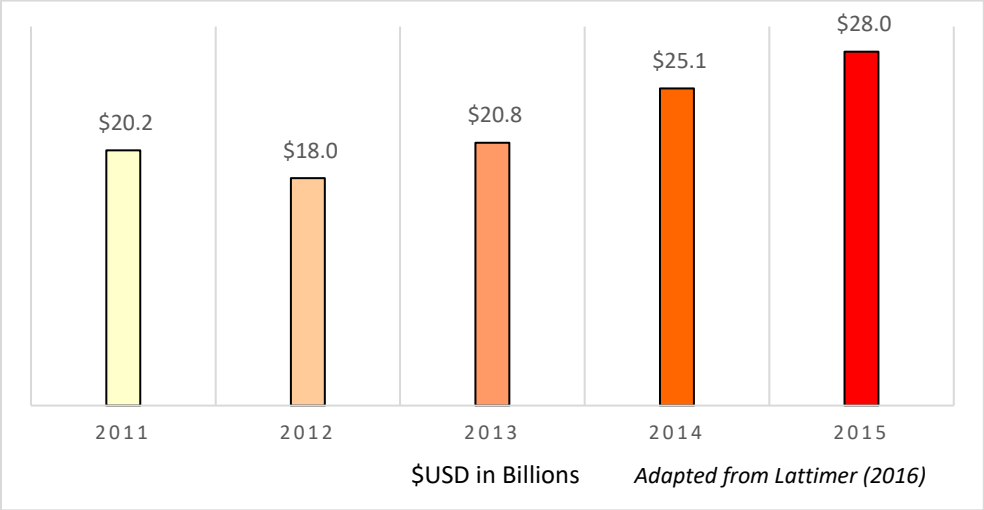


Figure 5:Total Humanitarian Assistance Directed by International Donors

Despite the highest ever levels of giving, the increased number of people in need are exceeding the funding increases, as 2015 also had the highest ever funding gap, with 45% of the appeals going unfunded. This funding gap could be described as requiring $51 billion per year but only raising $28 billion, leaving tens of millions of people without assistance.

1.4 Evidence in Emergencies

Considering the increase of persons in need of emergency assistance and the growing gap in available funding, decision-makers increasingly need to rely on interventions with known and proven impact (Parkinson, 2009, Darcy et al., 2013a). Essentially, responders must deliver “more for less” in difficult and changing contexts (Nutley et al., 2013). However, in emergency WASH interventions - and emergencies in general - there is an overwhelming lack of evidence (Ager et al., 2014, Clarke et al., 2014, Brown et al., 2012), which is often attributed to the divergent priorities of responders. Thorough evaluations

of emergency interventions were not carried out until the 1990s as it was considered inappropriate to evaluate 'life-saving action'(Frerks and Hilhorst, 2002, Dijkzeul et al., 2013). The ethics of piloting new interventions and carrying out randomized control trials in emergencies remains controversial; however, conducting interventions for vulnerable population without evidence is also considered unethical and highlights the critical need for evidence (Ager et al., 2014).

In the absence of evidence, Dijkzeul et al. (2013) describe emergency interventions as "normative and agencies derive their legitimacy and credibility by making reference to their principles rather than to their evidence-based approaches." WASH interventions currently used in emergency response are often ones shown to be efficacious and effective in development contexts, not 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" (Darcy et al., 2013a, Loo et al., 2012, Steele and Clarke, 2008). As the effectiveness of WASH interventions depends on contextual factors unique to each emergency (Bastable & Russell, 2013; Loo et al., 2012; Parkinson, 2009), these unjustified assumptions has led to the use of interventions in inappropriate situations (Dorea, 2012; Loo et al., 2012). For example, in northern Uganda there were cultural beliefs that a disease outbreak was caused by "bad spirits," not water, thus responders must understand the local beliefs to adapt and appropriately respond (de Vries et al., 2016). Contextually appropriate information on WASH intervention effectiveness may provide more relevant and effective guidance for responders and lead to better WASH interventions in emergencies.

Defining Evidence

There are a variety of definitions for evidence*;* acknowledging the differences in defining evidence is important before establishing there 'is no evidence.' For example, some analysts focus on statistically high-quality research while others place a high value on key informants or word-of-mouth. Currently in the medical field, and in some development contexts, evidence is established through a methodological hierarchy which prioritizes randomized control trials (RCTs) and meta-analyses (Figure 6).

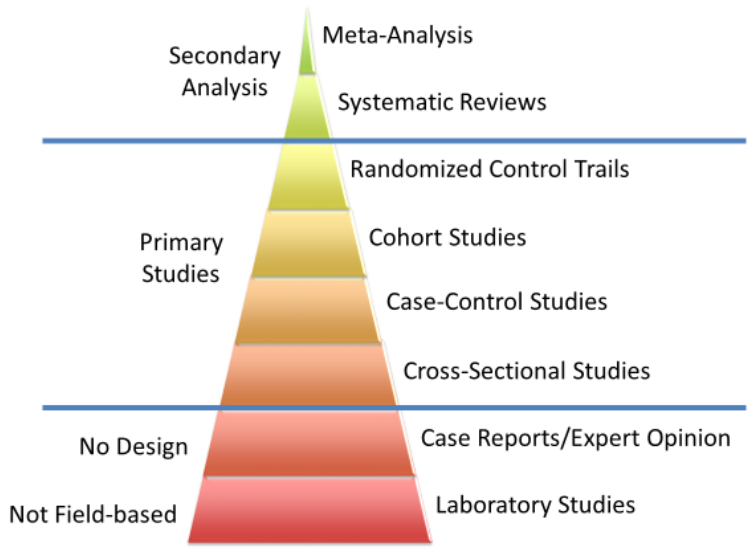


Figure 6: Methodology Hierarchy

RCTs are regularly designed to determine a single 'yes or no' under controlled conditions or to evaluate causation by investigating a very specific outcome between an intervention and control group while controlling as many outside influencing factors as possible (e.g. age, gender). RCTs are often very rigorous, so it is not surprising that promoting 'evidence based-research' is often synonymous to conducting RCTs (Mayne, 2011).

Practical Evidence in Emergencies

RCTs are not often used in emergencies. Responders have prioritized action over research, which has justified 'quick and dirty' lower quality evaluations to justify interventions and not evaluate impact (Levine et al., 2004, Garfield, 2010, Dijkzeul et al., 2013). Furthermore, short project cycles, competition between responding agencies, and lack of coordination work against the sharing of systematic approaches to research (Darcy et al., 2013a, Garfi and Ferrer-Marti, 2011, Dijkzeul et al., 2013). Fundamentally, interventions with long causal chains, multiple modes of potential failure or outside influences, like the aftermath of an emergency, are also not well suited for RCT evaluations (Victora et al., 2004). Publishing findings is also, generally, not a priority for responders. Overall, there is a distinct gap between evaluations conducted in emergencies and would be desirable from an evidence standpoint (Figure 7).

	Design	Published	Grey Literature
Desirable	RCT	✓	
	Cohort	✓	
	Case-Control	✓	
Actual	Cross-Sectional		✓
	Expert Opinion		✓
	Case Reports		✓
	Qualitative		✓

Figure 7: Desirable Verses Actual Research Methods in Emergencies

The expectation of generating rigorous quasi-experimental evaluations as a minimum bar to define evidence is incongruent with the practical realities imposed by emergency WASH interventions - however such thinking persists. As a result, there are very few experimental evaluations of emergency WASH interventions, and therefore there is little

formal evidence for emergency WASH interventions. There are, however, other metrics of evidence that could be applied to emergency interventions, from 'empirical data' to 'information we can trust' (Leeuw, 2012) or simply information which we can then base a conclusion (Bradt, 2009, Dijkzeul et al., 2013). In Table 2, an example of an evidence scheme is described that may be better suited for assessing emergency response interventions. Furthermore, there are many additional evidence frameworks that can be used outside of the traditional methodological hierarchy, for example Nutley et al. (2013) identified 16 different types of evidence schemes, while Dijk et al. identified 23 tools and methods for evidence evaluation. Utilizing an evidence scheme that more adequately considers the information gathered in emergency WASH could better calibrate and perhaps fill the evidence gap.

Table 2: Example of an Evidence Scheme

Type	Description
Good Practice	'we've done it, we like it, and it feels like we make an impact'
Promising Approaches	Some positive findings but the evaluations are not consistent or rigorous enough to be sure
Research-based	The programme or practice is based on sound theory informed by a growing body of empirical research
Evidence-based	The programme or practice has been rigorously evaluated and has consistently been shown to work

(Perkins, 2010)

Information and data from emergencies does exist, but it primarily consists of qualitative case reports, needs assessments, evaluation reports, expert opinions, and cross-sectional surveys which are generally inconsistent with low quality methodology (Dijkzeul et al., 2013). Additionally, this information is often contained in non-published grey literature and is not peer-reviewed. Sometimes, grey literature is critiqued by

peers; however, not quite the same as a technical journal. Responding organizations, like the United Nations (UN) or non-governmental organizations (i.e. Oxfam, Action Against Hunger) hold much of the information from emergencies, but it is not often widely shared and difficult to access outside the organization. As a result, the evidence hidden in these reports is difficult for researchers to access or even acknowledge. Also, low-quality research methods have inherent potential for bias and restrict the potential for wider application and secondary synthesis. A systematic review process is useful regardless of the methodological quality of included reviews, but may be limited in the definitive conclusions desired for a strong evidence base.

Recently, two reviews of published literature on WASH interventions for cholera response (Taylor et al., 2015) and the health impact of WASH interventions in emergencies (Ramesh et al., 2015) concluded there was a lack of evidence to support implementing WASH interventions in outbreaks and emergencies. Neither review included both grey literature and other less robust evaluations; thus, the quality of evidence was found to be low and limited to only a small portion of interventions, primarily focused on household water treatment.

Evidence should be based, not on a narrow-scoped hierarchy or limited to one source of studies, but on the most appropriate and relevant information available (Nutley et al., 2013). Therefore, summaries and systematic reviews should accept data from a variety of research methods (experimental, non-experimental, qualitative) and sources (published and grey literature (Dijkzeul et al., 2013, Gerdin et al., 2014, Victora et al., 2004, Nutley et al., 2013, Brown et al., 2012).

1.5 Research Objectives

The thesis presented here is unique in identifying and defining evidence in emergency WASH. It also responds to the call for evidence to be derived from both the published and grey literature, as well as, considering lower less resource intensive evaluations. The overarching research objective is to increase the evidence of emergency WASH interventions carried out in low and middle-income countries. To achieve the research objective, four separate and complete projects, presented below, were conducted with the adherence of each project to the overall theme:

Chapter 2: The Impact of Water, Sanitation, and Hygiene Interventions on the Health and Well-being of People Living with HIV (PLHIV): A Systematic Review

Chapter 3: Effectiveness of Chlorine Dispensers in Emergencies: Case Study Results from Haiti, Sierra Leone, DRC, and Senegal

Chapter 4: WASH Interventions in Outbreak Response: Evidence Synthesis

Chapter 5: Short-term WASH Interventions in Emergency Response: A Systematic Review

Chapter 2: WASH and Persons Living with HIV and AIDS (PLHIV). This project was a systematic review of impact from WASH interventions specifically on PLHIV in low and middle-income countries. Through the 1990s and early 2000s, HIV and AIDS was a global pandemic of utmost concern with specific government and international agencies being established to control the spread of disease and improve care for those affected. Evidence for the impact of WASH interventions on PLHIV was evaluated for each individual study and summarized by outcomes (i.e. morbidity, mortality, quality of life, retention in HIV care, prevention of ongoing HIV transmission, and cost-effectiveness). The learned procedures to systematically identify, review, and evaluate published

manuscripts were critical for future projects. This project was supported by the Office for Global Aids Coordinator and the Centers for Disease Control and Prevention (CDC). Personal stipend support was provided by the National Science Foundation Water Diplomacy Grant (0966093) during this project.

Chapter 3: Chlorine Dispensers in Emergencies. Chlorine Dispensers were a proven water treatment technology in the development setting. With that success, Dispensers were assessed in four emergency contexts, three cholera responses and one food security crisis. Similar mixed-method research was used in each of the four emergency-affected countries including: Dispenser sites visits, water point observations, household surveys, focus group discussions, and key informant interviews. Combined, the multi-country field results provided evidence of use and potential impact, which was then openly discussed with the responders who carried out the projects to make further recommendations for the global responder community. This project was funded by the Bill and Melinda Gates Foundation.

Chapter 4: WASH Intervention in Outbreak Response. Responders requested a systematic review of the impact of WASH interventions in disease outbreaks. Outbreaks of greatest concern for emergency contexts were a focus, including: cholera, hepatitis E, Ebola, hepatitis A, acute-watery diarrhea, shigella (dysentery), and typhoid. To better appreciate the information present in the emergency sector, as described above, grey literature from responders was specifically targeted for inclusions alongside published literature. Evidence was assessed through health outcomes (morbidity and mortality), use, influencing factors along the theory of change, and cost-effectiveness. This project was funded by the Humanitarian Evidence Programme.

Chapter 5: Short-term WASH Interventions in Emergencies. Another systematic review was conducted like the review on disease outbreaks, albeit with a broader definition of emergency to include natural disasters and complex emergencies with war and large population movements. The application of grey literature and evaluation of evidence was the same as the review of disease outbreaks. This project was supported by the International Initiative for Impact Evaluation (3ie).

The first two projects (Chapters 2 and 3) were necessary stepping stones to gain research expertise for the culmination of evidence gathered in the final two projects (Chapters 4 and 5). Contributions to the evidence base (Chapter 6), General Conclusions (Chapter 7), Supplemental Information (Chapter 8), and References (Chapter 9) follow the core research chapters.

Chapter 2: The Impact of Water, Sanitation, and Hygiene Interventions on the Health and Well-being of People Living with HIV: A Systematic Review

2.1 Abstract

Background: Access to improved water supply and sanitation is poor in low-income and middle-income countries. Persons living with HIV/AIDS (PLHIV) experience more severe diarrhea, hospitalizations, and deaths from diarrhea because of waterborne pathogens than immunocompetent populations, even when on antiretroviral therapy (ART).

Methods: We examined the existing literature on the impact of water, sanitation, and hygiene (WASH) interventions on PLHIV for these outcomes: (1) mortality, (2) morbidity, (3) retention in HIV care, (4) quality of life, and (5) prevention of ongoing HIV transmission. Cost-effectiveness was also assessed. Relevant abstracts and articles were gathered, reviewed, and prioritized by thematic outcomes of interest. Articles meeting inclusion criteria were summarized in a grid for comparison. **Results:** We reviewed 3355 citations, evaluated 132 abstracts, and read 33 articles. The majority of the 16 included articles focused on morbidity, with less emphasis on mortality. Contaminated water, lack of sanitation, and poor hygienic practices in homes of PLHIV increase the risk of diarrhea, which can result in increased viral load, decreased CD4 counts, and reduced absorption of nutrients and antiretroviral medication. We found WASH programming, particularly water supply, household water treatment, and hygiene interventions, reduced morbidity. Data were inconclusive on mortality. Research gaps remain in retention in care, quality of life, and prevention of ongoing HIV transmission. Compared with the standard threshold of 3 times GDP per capita, WASH interventions were cost-effective, particularly when incorporated into complementary programs. **Conclusions:** Although research is required to address behavioral aspects, evidence supports that WASH programming is beneficial for PLHIV.

2.2 Introduction

Worldwide, 748 million people do not have access to improved drinking water sources and 2.5 billion people are without improved sanitation (United Nations Statistics Division, 2014). Each year, 61 million disability adjusted life-years (DALYs) are lost due to the estimated 4 billion cases of diarrhea caused by unsafe drinking water and sanitation (Hutton, 2012, WHO, 2012). The Millennium Development Goals for water and sanitation are to reduce by half the proportion of the population without access to "improved" water sources (such as protected wells or piped water supplies) and sanitation facilities [such as ventilated improved pit (VIP) latrines and sewerage]. Access to improved water supply and sanitation facilities are particularly poor in low- and middle-income countries (LMIC). In several LMIC formerly considered President's Emergency Plan for AIDS Relief (PEPFAR) focus countries only 40% (six of 15 countries) met the safe drinking water goal and 7% (one of 15 countries) met the sanitation goal in 2012, according to the World Health Organization (WHO) and UNICEF Joint Monitoring Report (Table 1) (Joint Monitoring Program, 2014). Furthermore, a substantial proportion of improved water supplies are not considered safe, more than doubling the population at risk (Onda et al., 2012, Bain et al., 2012).

Persons living with HIV/AIDS (PLHIV) are at increased risk of enteric infections from waterborne pathogens that cause diarrhea (WHO, 2012, Katabira, 1999, Dwivedi et al., 2007, Nkenfou et al., 2013), and experience more severe diarrhea, hospitalizations, and diarrheal-related deaths compared to immunocompetent populations (Lule et al., 2005, Villamor et al., 2005). These risks persist even for patients on antiretroviral therapy (ART) (Colford et al., 2005, Pavlinac et al., 2014, Abebe et al., 2014).

Table 3: Access to Water and Sanitation of Former PEPFAR Focus Countries

Percentage of population in 15 former PEPFAR focus countries with access to improved drinking water and sanitation in 1990 and 2012, with indication of whether Millennium Development Goal for each indicator was met.

PEPFAR Focus Country	Drinking Water			Sanitation		
	% of Total Population		MDG Progress (Met/Not Met)*	% of Total Population		MDG Progress (Met/Not Met)*
	1990	2012		1990	2012	
Botswana	91.9	96.8	Met	38.6	64.3	Not Met
Côte d'Ivoire	76.0	80.2	Not Met	14.9	21.9	Not Met
Ethiopia	13.2	51.5	Not Met	2.4	23.6	Not Met
Guyana	77.1	97.6	Met	75.7	83.6	Not Met
Haiti	60.8	62.4	Not Met	18.8	24.4	Not Met
Kenya	42.7	61.7	Not Met	24.6	29.6	Not Met
Mozambique	33.6	49.2	Not Met	8.5	21.0	Not Met
Namibia	67.2	91.7	Met	23.6	32.2	Not Met
Nigeria	45.6	64.0	Not Met	36.9	27.8	Not Met
Rwanda	60.3	70.7	Not Met	30.2	63.8	Not Met
South Africa	81.3	95.1	Met	58.0	74.4	Not Met
Tanzania	55.0	53.2	Not Met	6.6	12.2	Not Met
Uganda	41.6	74.8	Met	26.2	33.9	Not Met
Vietnam	61.6	95.0	Met	37.4	75.0	Met
Zambia	49.1	63.3	Not Met	41.3	42.8	Not Met

*Halve the proportion of people without sustainable access to safe drinking water and basic sanitation, by 2015 Source: JMP Database: http://www.wssinfo.org/data-estimates/tables/

Waterborne pathogens can be bacterial, viral, or parasitic and include *Vibrio cholerae* (cholera), pathogenic *E. coli*, *Cryptosporidium parvum*, *Giardia lamblia*, *Salmonella Typhi* (typhoid fever), *Shigella*, and helminthes. Water, sanitation, and hygiene (WASH) interventions–such as installing a protected well (water supply), distributing chlorine tablets (water quality), latrine construction (sanitation), or hand-washing promotion (hygiene)—aim to break the fecal-oral transmission route and provide a foundation for health, nutrition, a safe living environment, and improved quality of life. WASH

programming that targets PLHIV also benefits their families and communities by reducing exposure to, and transmission of, disease-causing organisms.

The two most common indicators for assessing the impact of WASH interventions are diarrhea rates and prevalence of waterborne pathogens among people presenting with diarrhea. The WHO defines a case of diarrhea as "three or more loose watery stools in a 24-hour period"; this indicator is evaluated by self-reported recall of the beneficiary/patient or through a review of clinical records. For programs targeting PLHIV, diarrhea cases are reported for PLHIV and sometimes also for family members (e.g., diarrhea for children <2 with an HIV+ mother). The prevalence of waterborne pathogens is evaluated through stool samples that are collected and analyzed, which is costly, time consuming, and requires laboratory equipment and trained personnel. Both indicators are usually expressed using a relative ratio of risk or exposure [i.e., risk ratio (RR), odds ratio (OR), or hazard ratio (HR)].

WHO guidance from "Essential Prevention and Care Interventions for Adults and Adolescents Living with HIV in Resource-limited Settings" (2008) states that simple, accessible and affordable WASH interventions have been effective in reducing the risk of diarrheal diseases (WHO, 2008). Household water treatment, sanitation, and personal hygiene interventions have been found to be cost-beneficial and (for patients on ART) reduce the risk of contracting diarrheal diseases that reduce drug absorption (Bushen et al., 2004).

The objective of this review was to examine the existing literature on the impact of WASH interventions on PLHIV, including: water supply, water treatment, sanitation, and hygiene. WASH strategies and conclusions that are widely applicable regionally or

globally were of particular interest. In this review, we assess the quality of published studies and describe the impact of WASH interventions on the following outcomes: 1) mortality, 2) morbidity, 3) retention in HIV care, 4) quality of life, and 5) prevention of ongoing HIV transmission. Cost-effectiveness of WASH interventions was also assessed.

2.3 Methods

A literature review was conducted by accessing six databases: 1) African Index Medicus, 2) CINAHL, 3) Embase, 4) Global Health, 5) Medline, and 6) Sociological Abstract. Articles from January 1995 to June 2014 were reviewed for: 1) PLHIV (adult and adolescent populations); 2) focused or applied to resource limited countries; 3) focused on one or more outcome of interest (mortality, morbidity, retention in HIV care, quality of life, prevention of ongoing HIV transmission) and 4) related to WASH program objectives and interventions designed to reduce the risk of diarrhea or prevalence of waterborne pathogens. The key terms that are uniquely relevant to the WASH review search strategy are presented in Table 4.

After all relevant abstracts were gathered and duplicates were eliminated, an initial screening was carried out to focus the wide variety of searches to WASH and PLHIV. This systematic screening of the abstracts eliminated those not specific to WASH or PLHIV, including: 1) small clinical trials limited to the laboratory or hospital that did not approach WASH as a programmatic initiative; 2) manuscripts focused only on the prevalence of waterborne diseases without a connection to WASH programming; and, 3) studies focused on male and female circumcision, douching, breastfeeding, and nutrition (unless a direct connection to WASH programming was established).

Table 4: WASH-Specific Search Terms

Water	Disinfection
Sanitation	DALY (Disability Adjusted Life Year)
Hygiene	WASH in Home Based Care
Hand-Washing	Transmission
WASH	Waterborne Diseases
Water Treatment	Water Microbiology
Water Quality/Clean Water/Safe Water/ Water Pollution	Water Source/Springs/Wells/Surface Water/ Water Supply
Washing	Water Container
WASH in Facility Based Care	Water Purification

Abstracts that passed the initial screening were reviewed independently by the research team and collaboratively discussed to determine whether to include for full manuscript review. Manuscripts that met the selection criteria were reviewed by all team members and sorted by thematic outcomes of interest. The strength of association between WASH and PLHIV was also specifically considered. Consensus was required among the researchers for inclusion of manuscripts in the review.

For each included manuscript, the overall quality of evidence was rated as “strong”, “medium”, or ”weak” considering quality of the study design, cohort population, and sample size, Impact was assessed through key outcomes considering the magnitude of effect (e.g. risk ratios, hazard ratios) on the target population. This approach allowed the research team to assess the internal/external validity and the application for broader contexts. For each outcome of interest, the overall quality of evidence in the articles that addressed that outcome was rated as ”good”, “fair”, or ”poor”; the expected impact, based on existing published evidence, of WASH programming on that

outcome was rated as “high,” “moderate,” “low,” or “uncertain.” Cost-effectiveness was separately but similarly assessed by a health economist at the Centers for Disease Control and Prevention. More details of the assessment are described in “The Impact of HIV Care and Support Interventions on Key Outcomes in Low and Middle-Income Countries: A Literature Review. Introduction” (Kaplan et al., 2015).

2.4 Results

For this literature review, we screened 3,355 citations, closely read 132 abstracts, evaluated 33 manuscripts, and included 16 manuscripts in the final review (Figure 8). The majority of the evaluated manuscripts focused on morbidity (16), with a lesser emphasis on mortality (2). Two manuscripts were included in both the morbidity and mortality outcomes. Within the morbidity and mortality outcomes, cost-effectiveness was evaluated in three (3) manuscripts. No manuscript addressed the relationship between WASH and the other three outcomes (retention in HIV care, quality of life outcomes, or HIV transmission). The methods, study populations, and key findings of the 16 articles meeting the final inclusion criteria are summarized in Appendix 1.

2.4.1 Mortality

One study with mortality as an outcome met the evaluation criteria. A prospective cohort study in Kenya evaluating long lasting bed nets (LLBN) and household water filters did not find a difference in mortality between intervention and control groups over a two-year period (1.5 compared to 1.4 deaths per 100 person-years, respectively) (Walson et al., 2013). The overall quality of evidence of studies examining mortality was determined to be ‘poor’, with ‘uncertain’ impact because of the limited number of studies and inconclusive results.

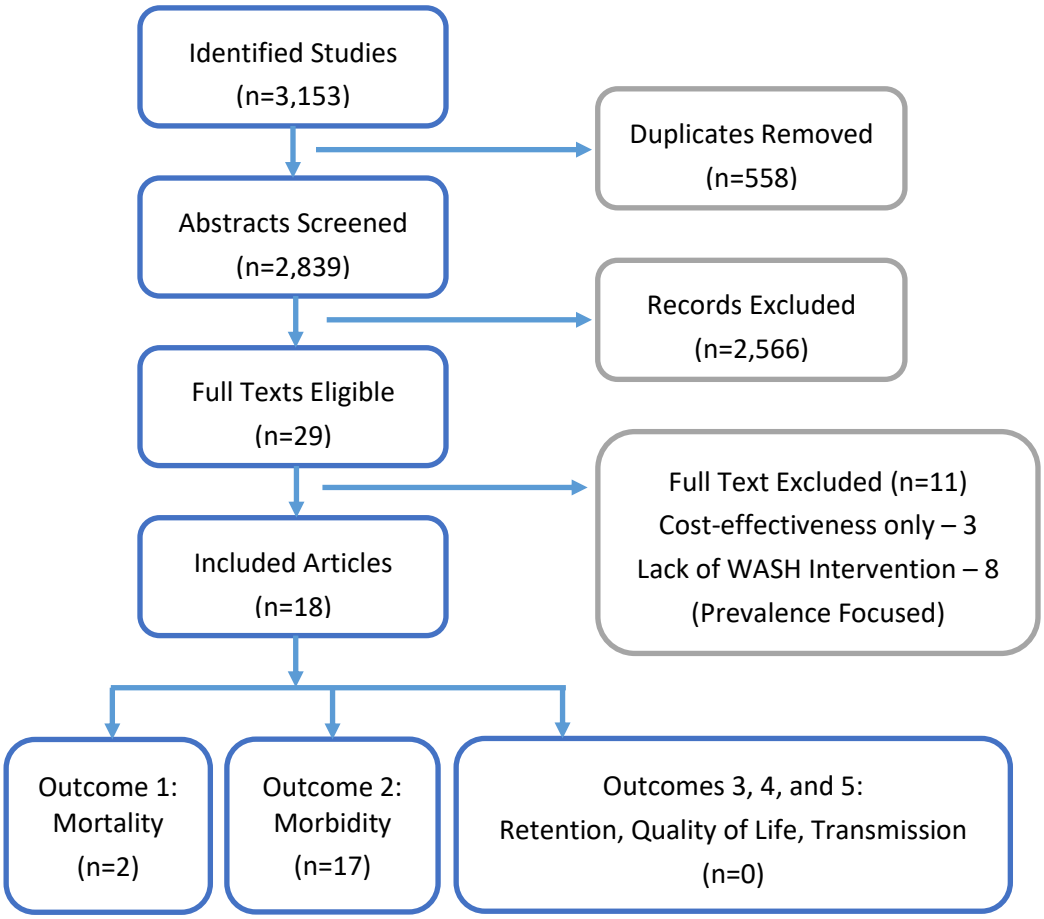


Figure 8: WASH Studies Flow Diagram

2.4.2 Morbidity

The results relating to morbidity included all major aspects of WASH programming: 1) household water treatment and safe storage (HWTS); 2) water supply; 3) sanitation (including the local environment); and 4) hand-washing. The effect on morbidity was most often described through diarrhea rates or prevalence of waterborne disease causing agents.

HWTS. The impact of HWTS on PLHIV has been widely studied. Peletz et al (2013) conducted a meta-analysis evaluating the health impact of HWTS options on PLHIV. The meta-analysis included seven studies evaluating four different HWTS interventions (including chlorination, hollow fiber filters, ceramic filters, and filters plus UV radiation),

diarrhea was reduced in PLHIV or their family members by 43% (pooled risk ratio = 0.57; 95% CI 0.38 - 0.86)(Peletz et al., 2013). Several of the studies in Peletz et al (2013) are also detailed in this analysis, alongside additional studies.

In an RCT, distribution of sodium hypochlorite solution and safe storage in Uganda led to 25% fewer episodes of diarrhea [Adjusted Incidence Rate Ratio (IRR) = 0.75; 95% CI 0.59-0.94; p=0.015] and an even greater diarrheal reduction of 67% among PLHIV when sodium hypochlorite was used in conjunction with cortrimoxazole prophylaxis (IRR = 0.33; 95% CI 0.24-0.46; p<0.001) (Lule et al., 2005). Additionally, there was also a 44% reduction in viral load for PLHIV in the intervention group compared with the control group (0.71 $\log_{10}$ to 0.4 $\log_{10}$ per person-year: adjusted mean pairwise difference = -0.14 $\log_{10}$ per person year; 95% CI -0.55 – 0.27, p=0.510) (Lule et al., 2005). In a prospective cohort study in Nigeria, PLHIV using sodium hypochlorite solution with a safe storage container had 36% fewer diarrhea episodes (p=0.04); frequent chlorinators were three times less likely to report diarrhea than infrequent chlorinators (15% compared to 46%) (Barzilay et al., 2011).

In a prospective cohort study, PLHIV in Kenya given a hollow-fiber household water filter and an LLBN were found to have a slower CD4 decline (p=0.03), did not fall below the <350 cells/mm^3 threshold as often (HR = 0.73; 95% CI 0.57-0.95); and reported less diarrhea (RR = 0.65; 95% CI 0.45-0.93) (Walson et al., 2013). In further analysis from the same study, filter provision reduced diarrhea by 61% (OR = 0.39; 95% CI 0.23-0.66; p<0.001) and was effective when filter users were also taking cotrimoxazole prophylaxis (OR=0.47; 95% CI 0.25-0.88; p=0.02) (Pavlinac et al., 2014).

In an RCT with an ART targeted population in South Africa, PLHIV households using a silver-impregnated ceramic water filter had a 25% lower prevalence of *Cryptosporidium* (p=0.02) and 79% lower diarrhea rates than the control group [Adjusted Odds Ratio (AOR) = 0.21; 95% CI 0.18-0.26; p=0.0001] (Abebe et al., 2014). In a cross-sectional study in Kenya, consumption of boiled or household-treated water was associated with less diarrhea than those using untreated water (AOR) = 0.23; 95% CI 0.13-0.83) (Missaye et al., 2013).

Water Supply. Access to improved water sources was associated with a lower prevalence of intestinal parasites and diarrhea among PLHIV and their household members. In a cross-sectional study among PLHIV in Kenya, piped water, treated water, and a reliable water source were protective against intestinal parasites (p=0.0001; p=0.0001; and p=0.04, respectively) (Yallew et al., 2012). In a cross-sectional study in Cameroon, use of protected water sources was associated with reduced intestinal parasite prevalence among PLHIV (AOR = 2.4; 95% CI 1.2 – 5.2) (Nkenfou et al., 2013). Conversely, an increased risk of intestinal parasites for households without access to improved water sources was found in separate cross-sectional studies in Ethiopia (AOR = 6.03; 95% CI 1.1 – 32.0) (Missaye et al., 2013) and Zimbabwe (RR = 1.9; 95% CI 1.1 – 3.1) (Gumbo et al., 1999). In another cross-sectional study in Ethiopia, PLHIV using unimproved sources were more likely to have diarrhea than those using protected sources (AOR = 6.1; 95% CI 1.2 – 30.6) (Yallew et al., 2012).

Sanitation. In a cross-sectional study in Ethiopia, access to a sanitation facility (e.g. latrine) reduced the risk of intestinal parasites in PLHIV (controlling for ART, AOR=7.57; 95% CI 1.3-44.2) (Yallew et al., 2012). In a case control study in India, the prevalence of intestinal parasites (IP) among individuals practicing open defecation (12%) and relying

on public toilets (47%) was significantly greater than household toilet users (7%; p<0.01) (Wanyiri et al., 2013). Lack of household latrine availability was a significant risk factor for diarrhea in a cross-sectional study from Ethiopia (AOR 10.39; 95% CI 5.13-21.03; p<0.05) (Kipyegen et al., 2012) and in an RCT in Uganda [Incidence Rate Ratio (IRR) = 0.69; 95% CI 0.53-0.91; p=0.009] (Lule et al., 2005).

In a cross-sectional study in Kenya, contact with cows (OR = 3.2; 95% CI 1.26–8.13) and pigs (OR = 11.2; 95% CI 3.8–43.6) were significant risk factors for diarrhea in PLHIV (Missaye et al., 2013). Exposure to animal dung was a significant risk factor for intestinal parasites in PLHIV in cross-sectional studies from Zimbabwe (RR = 2.2; 95% CI 1.6-2.9) (Gumbo et al., 1999) and Ethiopia (Crude Odds Ratio = 3.56; 95% CI 1.3-9.9) (Yallew et al., 2012). In a case control study in India, pets and animals were also significantly associated with intestinal parasite prevalence in PLHIV (p<0.05) (Ram Mohan et al., 2013).

Hand-washing. In an RCT in Uganda, the presence of soap in the home corresponded with a reduction in days ill with diarrhea among PLHIV (IRR = 0.58, 95% CI = 0.35 – 0.97; p=0.038) (Lule et al., 2005). In an RCT, active and targeted hand-washing promotion for PLHIV in the United States decreased diarrheal incidence from 2.9 to 1.2 episodes per year (p<0.001) with a marked increase in the frequency of hand-washing from four to seven times per day; this was outside the scope of this research because it is based in the United States, but remains applicable to resource limited countries (Huang and Zhou, 2007).

The overall quality of evidence of studies examining the impact of WASH programming on morbidity was determined to be ‘good’, with ‘high’ expected impact.

2.4.3 Cost Analysis

WASH programs are cost-effective in many development contexts (Hutton, 2012); this review found that this remains true for WASH interventions targeting PLHIV. Related studies with water filters and LLBN for PLHIV delayed the entry of HIV+ individuals into ART by slowing the rate of decrease of CD4 counts in Kenya (Kern et al., 2013, Kahn et al., 2012). The program resulted in significant benefits compared to costs; the costs per DALY averted were <$20 in 93% of simulations in one study (Kahn et al., 2011) and $99 in another (Kern et al., 2013).[30] However, outcomes were not presented separately for water filters and LLBN in either study. In an HWTS program in Uganda using sodium hypochlorite solution and improved storage, the cost per diarrhea episode averted was $5.21 but the cost per DALY averted was $1,252, above standard thresholds for cost-effective interventions in low income countries, such as 3 times GDP per capita (reported by the World Bank as $236 for Uganda in 2002) (Shrestha et al., 2006). Because this program involved intensive treatment of ill persons and was not designed to detect mortality, the authors conducted a sensitivity analysis incorporating mortality data from a trial of a similar HWTS intervention in the region, which reduced the estimated cost to $11 per DALY averted (Bartram et al., 2005). Results of these studies suggest that WASH interventions for PLHIV are cost-effective because they slow HIV progression and avert the cost of diarrhea treatment. The overall quality of evidence of studies examining the cost-effectiveness of WASH programming was determined to be 'good,' because cost per DALY averted was favorable and within the accepted threshold of cost-effectiveness for most studies.

2.5 Discussion

We identified 16 peer-reviewed manuscripts focused on WASH interventions for PLHIV adults in resource-limited countries. Manuscripts spanned 15 years (1999-2014) and represented eight countries, including countries in East, West, and Southern Africa, as well as India. For the five outcomes of interest in this systematic review, we conclude that WASH programming reduced morbidity, was inconclusive for mortality, and did not address retention in HIV care, quality of life outcomes, or HIV transmission. Compared to the standard threshold of 3 times GDP per capita, some WASH interventions were found to be cost-effective, particularly when incorporated into complementary programs. General conclusions for each thematic outcome of interest are summarized in Annex 1.

2.5.1 Limitations

The manuscripts we reviewed had several important methodological limitations. Many evaluations used self-reported diarrhea rates as the outcome, which is subject to survey bias. Several studies were funded by water treatment product manufacturers, which raised the possibility of conflict of interest. It can be difficult to compare results from studies that included all members of HIV-infected households instead of only PLHIV. Lastly, researching WASH interventions alongside other disease prevention measures (such as LLBN or use of cotrimoxazole) without a study design that allows researchers to separate the impacts leads to unclear results.

2.5.2 Knowledge Gaps

While the spectrum of WASH interventions is broad, the majority of the research effort has been focused on water supply and water treatment. Research has shown that improved sanitation and hygiene education are effective, sustainable, and cost-efficient ways to reduce diarrhea, but they are often overlooked (Hutton et al., 2007, Bartram et al., 2005, Evans et al., 2004). Our review of WASH interventions related to PLHIV also focused on water, as all 16 reviewed papers evaluated water supply, water treatment, or general risk factors. Sanitation and hygiene were often only secondary results in these papers. Additional research is required on the impact of improved sanitation and hygiene on the health of PLHIV and on the value of approaching WASH from a holistic water, sanitation, and hygiene approach.

The use of ART for PLHIV, regardless of CD4 count, is now widespread. However, research targeting the incremental benefit from WASH interventions with ART is lacking. Only one study targeted PLHIV on ART (Abebe et al., 2014) and two other studies combined cotrimoxazole prophylaxis with WASH (Lule et al., 2005, Pavlinac et al., 2014). The results of these studies had incremental, yet significant, impacts from WASH interventions targeted to PLHIV on ART or cotrimoxazole prophylaxis.

Only two of the five reviewed thematic outcomes of interest (morbidity and mortality) were specifically addressed in the literature that met criteria for inclusion in this review. The majority of the selected papers and the body of research were dedicated to one outcome (morbidity), and the research methodology quality varied widely. Three other thematic outcomes of interest (retention in care, quality of life, and HIV transmission) are beyond the traditional scope of WASH programming and evaluation. As one

example, a theoretical cost-analysis was conducted to evaluate prevention of female genital lesions due to schistosomiasis, which could potentially reduce the risk of HIV transmission; however, the paper did not meet the inclusion criteria for the review as there was no program implementation (Ndeffo Mbah et al., 2013). Behavior change research on community-based WASH interventions could specifically address these less-traditional WASH outcomes. Additional research is also needed for mortality.

Specific scenarios are unique and no WASH intervention has been shown to be a "silver bullet" applicable in all circumstances (Clarke and Steele, 2009). For example, chlorine is an effective water treatment strategy in many scenarios but is not effective at inactivating *Cryptosporidium parvum* (Lantagne et al., 2006). Progress has been made to incorporate WASH into the multifaceted needs of PLHIV, though conflicting PLHIV program priorities remain barriers (Mahmoudi et al., 2014). Further research is needed to examine the wider societal impact of WASH interventions and the nexus of WASH with health and nutrition.

2.5.3 Programmatic Considerations for Implementation

Contaminated water, lack of sanitation, and poor hygienic practices in homes of PLHIV increase the risk of diarrhea, which can result in increased viral load, decreased CD4 counts, and reduced absorption of nutrients and ARVs (Lule et al., 2005, Boschi-Pinto, 2008). Programs can mitigate or eliminate these effects by ensuring access to safe drinking water, sanitation, and hygiene through measures including: 1) installation of improved water sources or piped water into the home; 2) distribution of HWTS options such as water filters or chlorine; 3) proper disposal of human feces in an improved sanitation facility and isolation from animal feces; and, 4) distribution of soap and

promotion of hand-washing with soap after defecation, handling of human or animal feces, and before food preparation and eating. Targeting the entire household, not only PLHIV, reduces exposure risk for PLHIV living within the household and for the rest of the community. In addition, although stigma and discrimination towards PLHIV have been identified as barriers to individuals accessing WASH interventions (Yallew et al., 2012, Mugambe et al., 2013, Datta and Bandyopadhyay, 1997, Ouedraogo et al., 2005, Dlamini et al., 2007), community-based and social marketing interventions that address this barrier have been effective and should be considered (Barzilay et al., 2011, O'Reilly et al., 2014).

WASH interventions can also be integrated into community structures, such as health facilities (Loharikar et al., 2013, Parker et al., 2006) and schools (WHO, 2009, Jasper et al., 2012). In health facilities that treat PLHIV, patients and staff should have access to safe drinking water, adequate sanitation, and hand-washing facilities with soap to reduce the risk of health facility-acquired infections. Providing water treatment products or soap can also serve as an incentive for patients to increase use of health services and improve health outcomes (Lule et al., 2005, Loharikar et al., 2013, Xue et al., 2010, Colindres et al., 2008).

The scope of this review did not include children or infants living with HIV/AIDS. However, as WASH is critical to prevent childhood deaths from diarrhea, some discussion on the research on WASH and children and infants living with HIV is warranted. Safe water is necessary to protect the health of infants during formula feeding or early weaning from HIV-infected mothers (WHO, 2008). Water access within the compound, as compared to at public sources, significantly reduced the risk of death in HIV+ children in Tanzania [Adjusted Hazard Ratio (AHR) 2.92, 1.03-8.30; $p<0.04$]

(Villamor et al., 2005). Parental handwashing practices and the presence of soap in the house were protective against diarrhea in HIV+ children in Botswana and Zambia (AOR 4.2; 95% CI 1.1-20.4) and (OR=1.89; 95% CI 1.02-3.45; p=0.04), respectively (Arvelo et al., 2010, Peletz et al., 2011). The use of household water treatment significantly reduced diarrhea in infants with HIV+ mothers (longitudinal prevalence ratio (LPR) 0.47; 95%CI 0.30-0.73; p=0.001) in Zambia; and also reduced diarrhea in other household members (LPR 0.46; 95%CI 0.3-0.7; p<0.001) (Peletz et al., 2012). Thus, targeting the entire HIV-affected household with WASH interventions has been shown to be beneficial for PLHIV, HIV+ children, and other family members.

Compared to the standard threshold of 3 times GDP per capita, WASH programs are cost-effective stand-alone projects (Hutton, 2012, Clasen et al., 2007), but, by leveraging infrastructure and resources among partner organizations, WASH interventions can be even more effective through integrated programs in health, nutrition, food security, or other community-based interventions (O'Reilly et al., 2014, Confalonieri and Schuster-Wallace, 2011). Integrated WASH programs can maximize efficient use of funds, personnel, and other resources(Montgomery and Elimelech, 2007).

2.6 Conclusions

Waterborne diseases are a primary burden to PLHIV, and WASH interventions are effective in reducing this burden on individuals and their households. Morbidity was the only thematic outcome of interest within this WASH review with sufficient research to generate firm conclusions. Access to an improved water supply, household water treatment, and hand-washing with soap consistently reduced the prevalence of waterborne pathogens and the risk of diarrheal diseases in PLHIV. Sanitation

interventions were also protective, though with less robust evidence. The reduction in diarrheal disease associated with these WASH interventions has been shown to slow the decrease in CD4 counts in PLHIV and to show positive impacts in those concurrently on ARV treatment. Compared to the standard threshold of 3 times per capita GDP, WASH interventions were also cost-effective for PLHIV, HIV-affected households, and the greater community. Although additional research is required to address the behavioral aspects of sanitation and hygiene and further strengthen the nexus between WASH and other sectors, the evidence is clear that WASH interventions are incrementally beneficial to PLHIV and their families.

2.7 Acknowledgements

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2.8 Citation

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Chapter 3: Effectiveness of Chlorine Dispensers in Emergencies: Case Study Results from Haiti, Sierra Leone, DRC, and Senegal

3.1 Abstract

Dispensers are a source-based water quality intervention with promising uptake results in development contexts. Dispenser programs include a tank of chlorine with a dosing valve that is installed next to a water source, a local Promoter who conducts community education and refills the Dispenser, and chlorine refills. In collaboration with response organizations, we assessed the effectiveness of Dispensers in four emergency situations. In the three initial and four sustained response phase evaluations, 70 Dispenser sites were visited, 2057 household surveys were conducted, and 1676 water samples were analyzed. Across the evaluations, reported Dispenser use ranged from 9 to 97%, confirmed Dispenser use (as measured by free chlorine residual) ranged from 5 to 87%, and effective use (as measured by improvement in household water quality to meet international standards) ranged from 0 to 81%. More effective Dispenser interventions installed Dispensers at point-sources, maintained a high-quality chlorine solution manufacturing and distribution chain, maintained Dispenser hardware, integrated Dispensers projects within larger water programs, remunerated Promoters, had experienced project staff, worked with local partners to implement the project, conducted ongoing monitoring, and had a project sustainability plan. Our results indicate that Dispensers can be, but are not always, an appropriate strategy to reduce the risk of waterborne diseases in emergencies.

3.2 Introduction

An estimated 748 million people lack access to improved water supplies (Joint Monitoring Program, 2014), and an estimated 1.2 billion more consume drinking water from improved sources with an elevated risk of contamination at the source, or during

collection, transport, or storage (Onda et al., 2012). Unsafe drinking water is estimated to cause 502,000 deaths from diarrhea annually, mainly among young children (Prüss-Üstün et al.). The addition of chlorine to stored household drinking water has been shown to improve the microbiological quality of water and reduce the burden of diarrheal disease in users (Crump et al., 2004, Arnold and Colford, 2007). While there is active debate about the magnitude of this effect (Hunter, 2009), chlorine inactivates most diarrhea-causing bacteria and viruses (CDC, 2008), provides residual protection in stored household water, and effectively reduces disease in contexts where drinking water is a pathogen transmission route (Harshfield et al., 2012). However, outside some exemplary programs (Harshfield et al., 2012, Lantagne and Clasen, 2012b), adoption of chlorine-based household water treatment (HWT) products have been low (Rosa and Clasen, 2010).

In 2006, researchers from Harvard University and the University of California Berkeley found that a spring protection intervention was less efficacious at reducing diarrheal disease than anticipated, because spring water was recontaminated during water collection and storage in the home (Kremer et al., 2011). To address this, the researchers worked in collaboration with Innovations for Poverty Action (IPA) to develop the Chlorine Dispenser System (Dispensers). A Dispensers program includes three elements: (1) hardware installed next to a water source that dispenses chlorine solution, (2) a local Promoter who refills the Dispenser and conducts community education, and (3) a supply chain of chlorine refills.

When Dispensers were installed at no cost at the water source, 50−61% of households with stored water who used the Dispenser source had total chlorine residual (TCR) in household water up to 2.5 years after Dispenser installation (Null et al., 2011). This is

compared to 6−14% TCR in control households who purchased chlorine bottles from local vendors. Based on these adoption numbers, Dispenser programs have been scaled-up in east Africa, with 6050 Dispensers installed at the end of 2013 (average 43% adoption rate) (IPA, 2014a), and >10 000 total Dispensers installed as of end-2014 (Evidence Action, 2014).

With this documented success in the development context, there was interest in whether Dispenser interventions would be appropriate in emergency response. Drinking water is an immediate priority in most emergency situations, including natural disasters, complex political emergencies, and outbreaks (Sphere Project, 2011). When normal water supplies are interrupted or compromised due to natural disasters, complex emergencies, or outbreaks, responders have often encouraged affected populations to treat their drinking water to ensure its microbiological integrity.

The goal of the work presented herein was to assess the effectiveness of Dispenser installations in emergencies, and to make recommendations on if, and if so how, to implement Dispensers in emergencies.

3.3 Methods

Study Design. We worked in collaboration with Oxfam America (OA), Oxfam Great Britain (OGB), International Federation of Red Cross and Red Crescent Societies (IFRC), and International Rescue Committee (IRC) to complete three main activities: (1) evaluate the existing cholera-response Dispenser program in Haiti, (2) implement Dispensers in four to-be-determined new emergencies in any developing country based on lessons learned from Haiti, and (3) evaluate reported, confirmed, confirmed correct,

and effective use of Dispensers in each of these four new emergencies in both the initial and sustained response phases.

A mixed-methods protocol, approved by the IPA institutional review board, included (1) Dispenser site visits, (2) household surveys, (3) water quality testing, (4) structured observations at the Dispenser, (5) key informant interviews (KII), (6) focus group discussions (FGD), and (7) partner monitoring data review. Please note structured observation, KII, FGD, and partner data review results are not presented herein.

Dispenser Site Visits. In each evaluation, 10 Dispensers were randomly selected for a site visit. At each Dispenser site visit, a community map was drawn in collaboration with local residents, the Dispenser location was collected using a Garmin (Olathe, KS, USA) eTrex hand-held GPS meter, the physical condition of the Dispenser and signposting was assessed, and a chlorine solution sample (if available) was collected. The concentration and pH of the chlorine solution was tested by IPA staff within 8 h of collection using Hach (Loveland, CO, USA) iodimetric titration method 8209 and ColorpHast pH test strips (0−14 range). A 10% variation from the target chlorine solution concentration was considered acceptable. The chlorine solution was considered stabilized at pH > 11.

Household Surveys. Thirty households at each of the 10 Dispenser sites were surveyed, for a total sample size of 300 households per evaluation. This sample size calculation was based on a 95% confidence interval to measure a difference of 5% in effective use of Dispensers, and adjusted for clustering at the source level with a 0.1 correlation coefficient.

The 44-question survey included questions on water collection, treatment, storage, and Dispenser use. The survey was translated into the local language and pretested. Local

enumerators participated in a two-day training to learn how to select households, obtain consent, deliver questions without bias, and record answers. Informed consent was obtained before administering each 15−20 min survey. Enumerators selected houses by skipping houses while walking along an assigned path that was determined using the community map from the Dispenser site visit.

Water Sampling and Analysis. During the household survey, the respondent was asked,"Can you give us a cup of water as you would give your child?" A 125-mL sample of this water was then collected aseptically from the drinking cup into a Whirl-Pak (Nasco, Ft. Atkinson, WI, USA) bag with sodium thiosulfate. The respondent was then asked if that water had been treated; if the response was yes, an untreated water sample from the household was also collected. Samples were stored on ice at <4 °C for <8 h before analysis. Treated and untreated water sample pairs were analyzed using membrane filtration on a Millipore (Billerica, MA, USA) portable filtration stand. Samples were diluted appropriately with sterile buffered water, filtered aseptically through a 45-µm Millipore filter, placed in a plastic Petri dish with a pad soaked with mColiBlue24 media specific for total coliforms and E. coli, and incubated at 35−37 °C. Negative controls of boiled water were sampled every 20 plates and 10% of samples were duplicated.

Enumerators used Hach ColorWheel test kits and DPD-1 tablets to measure free chlorine residual (FCR) of reported treated and untreated drinking water at the household during the survey. Turbidity samples were measured by IPA staff with a calibrated Lamotte 2020 Turbidimeter (Chestertown, MD, USA) within 24 h of collection. Turbidity sample water was obtained from the excess water in the Whirl-Pak bags following microbiological testing.

Data Analysis. Whereas direct assessments of health impact (such as diarrheal disease reduction) are rarely possible in emergencies, risk reduction can be measured. In this evaluation, we used four metrics to assess risk reduction: reported use, confirmed use, confirmed correct use, and effective use. Reported use is the percentage of the total surveyed population who self-reported having stored household drinking water at the time of the unannounced survey and self-reported that water was currently treated with the Dispenser. Confirmed use is the percentage of the total surveyed population who met the criteria for reported use and whom enumerators confirmed had ≥0.2 mg/L FCR in their stored household drinking water. Confirmed correct use is those who met the criteria for reported use and whom enumerators confirmed had 0.2−2.0 mg/L FCR in their stored household drinking water (indicating they had used the Dispenser to dose their water correctly). Effective use is the percentage of the total surveyed population who met the criteria for reported use and who used a Dispenser to improve their household water quality to internationally accepted standards (as measured by their untreated stored household drinking water having ≥1 CFU/100 mL E. coli and their treated stored household drinking water having ≥1 CFU/100 mL E. coli and their treated stored household drinking water having <1 CFU/100 mL E. coli) (WHO, 2011).

Data from the Dispenser site visits, household surveys, and water quality testing were recorded on paper worksheets and entered into Microsoft Excel (Redmond, WA, USA). Statistical analysis including chi-squared tests and logistic regression were conducted to study correlations using Stata 13.0 (College Station, TX, USA). Backward stepwise logistic regression stratified by implementation site and evaluation phase (and with outliers removed based on influential statistics) was completed using programmatic and behavioral input variables from the survey and two outcome variables: (1) reported use

of Dispenser in current stored household water, and (2) confirmed use of Dispenser (≥0.2 mg/L FCR in current stored household water reportedly treated with the Dispenser). Models controlled for demographics, as well as clustering by Dispenser source. Model fit was assessed.

At project end, a meeting with all project partners was held to review collected data and glean best practices for implementing Dispensers in emergencies.

3.4 Results

Characteristics of Emergencies Investigated. The Haiti Dispensers were installed by OA in June 2011, and evaluated in November 2011. Results were discussed by project partners in a December 2011 meeting. On the basis of Haiti results, project partners recommended the following characteristics for subsequent Dispensers implementations: (1) install Dispensers in an area with homogeneous point sources, (2) have sufficient population density per source, (3) have a sufficient density of point sources in the intervention area (50−100 sources), (4) have at least a minimum number of affected population, (5) install where Dispensers are the most appropriate option, (6) have a minimum chlorine acceptability in the target population, (7) have access for evaluators, (8) be in a developing country, and (9) install in an emergency with diarrheal disease risk.

Dispenser implementation sites, chosen by the partners, began 11−14 months after the December 2011 meeting. Partners implemented Dispensers in response to (1) a cholera outbreak in Kenema, Sierra Leone (IRC), (2) endemic cholera in Uvira, Democratic Republic of Congo (DRC) (OGB), and (3) a food crisis in Kolda, Senegal (OA). IFRC was ultimately unable to implement Dispensers due to (1) the difficulty coordinating

research funding for an emergency that had not yet occurred, and (2) the decentralized relationship between the Federation and National Societies.

The initial and sustained evaluations of these programs occurred between January and December 2013, with the initial evaluations conducted <2−6 weeks after program initiation and the sustained evaluations occurring 4−7 months after program initiation.

In Haiti, Dispensers were installed only at the most microbiologically contaminated sources in peri-urban and rural communities (Table 5). Two Dispensers were installed at each source for large (20 L) and small (5 L) collection containers. Dispensers were installed as an alternative to chlorine tablet distribution because it was felt Dispensers were more sustainable as they could be managed by the community. Promoters were remunerated and used nonstabilized chlorine solution they manufactured in their communities to refill the Dispenser.

Table 5: Characteristics of Emergencies Investigated

	Haiti	Sierra Leone		DRC		Senegal	
Type of Evaluation	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
Date Evaluated	Nov. 2011	Mar. 2013	Sept. 2013	May 2013	Dec. 2013	Jan. 2013	April 2013
Time from start to evaluation	6 months	<2 weeks	7 months	4 weeks	7 months	6 weeks	4.5 months
Emergency type	Cholera outbreak	Cholera outbreak		Endemic cholera		Food crisis	
Setting	Rural	Peri-urban		Rural and Peri-urban		Rural	
# Dispensers sites	60	50		100		100	
# Dispensers per site	2 (20L and 5L)	1 (20L)		2 (each 20L)		2 (20L and 5L)	
Worked with local partner	No	Yes		No		Yes	
Promoter:Dispenser ratio	1:1	32:50		1:1		1:1	
Compensation for Promoter	No	Yes		No		Yes	
Chlorine source	HTH	HTH		HTH		HTH	
Solution stabilized	No	Yes		No (replaced daily)		Yes	
Chlorine manufacture	Central office	Central office		Promoter homes		Central office	
How chlorine delivered	n/a	Promoters collect		n/a		Delivered to Promoters	
Complementary programming	Area with chlorine tablet distribution	None		Replaced bucket chlorination		Followed well rehabilitation and food security programs	
Sustainability plan	Handover to local government	Handover to local health office		Transfer ownership to community		Handover to local involved partner	

In Sierra Leone, Dispensers were installed in peri-urban communities with many water points in close proximity and few users per source (Table 5). Dispensers were installed at only some of these sources. One Dispenser for 20-L collection containers was installed at each source. Promoters were remunerated and picked up chlorine solution refills from local health office staff trained to manufacture stabilized chlorine solution. A local partner assisted in the project.

In DRC, Dispensers were installed on pathways to the river and lake water sources in communities where cholera recurs each rainy season and households use a mix of piped water and surface water (Table 5). Dispensers replaced an ongoing bucket chlorination project because Dispensers were viewed as more sustainable and cost-effective. To reduce wait time, two Dispensers with a 20-L chlorine solution concentration were installed at each site. Promoters manufactured non-stabilized chlorine solution in the community, refilled the Dispenser daily, and were not remunerated.

In Senegal, Dispensers were installed in villages affected by the food shortage at protected wells that were part of a well rehabilitation program (Table 5). Two sizes of Dispensers were installed: one for small collection containers (10−15 L), and one for large collection containers (20−30 L). Promoters were remunerated and refilled the Dispenser with a stabilized chlorine solution centrally prepared and delivered via motorcycle to Promoters every 2−3 weeks. Experienced staff from the Haiti Dispenser project traveled to Senegal to implement the project, and a local partner assisted with the project.

There was one Promoter per Dispenser in all emergencies except Sierra Leone (Table 5). Please note that Promoters completed community education and refilled the Dispenser

with chlorine, but were not stationed at the water source, and did not dispense the chlorine solution for users. Overall, 5−9 of the nine Dispenser implementation criteria were met in the emergencies selected by the partner organizations (Table 6).

Table 6: Relationship between Emergency Context and Implementation Criteria

	Haiti	Sierra Leone	DRC	Senegal
Use only homogenous point sources	✗	?	✗	✓
Sufficient population density to number of sources	✗	✗	✓	✓
Source density (50-100) in intervention area	✗	✗	?	✓
At least a minimum number of affected population	✓	✓	✓	✓
Dispensers are appropriate	✗	?	?	✓
Minimum chlorine acceptability	✓	✓	✓	✓
Access for evaluators	✓	✓	✓	✓
Developing country	✓	✓	✓	✓
Diarrheal disease risk	✓	✓	✓	✓

Legend: (✓) Criterion met (?) Criterion questionable (✗) Criterion not met

All partner organizations intended the Dispenser programs to be sustained. In Haiti and Sierra Leone, the sustainability plans were to hand over Dispensers to local government officials. In DRC and Senegal, the sustainability plans were to hand over the program to the local community and local partner, respectively. Partner organizations had ~$94,000 each to implement the Dispenser program. Staff salaries were the largest expense across all programs, followed by transport and travel costs.

Dispenser Site Visits. In the initial evaluations, 87−100% of Dispensers were in good overall condition (well installed with chlorine solution and clear signposting). This dropped in the sustained evaluation to 61−91%, due to (1) blocked valves and empty Dispensers in Sierra Leone, and (2) blocked valves that led to removing the second

Dispenser at sites in DRC to replace broken Dispensers at other sites. Valves were blocking because the chlorine solution was not decanted before refilling the Dispenser tank, and the precipitate formed when mixing HTH and water clogged the valves.

Across all programs, chlorine solution was >10% below the targeted concentration (minimum below 14%, maximum below 64%, average below 32%).

Household Surveys. Across the seven evaluations, 2,057 household surveys were completed (Table 7).Overall, 56−94% of respondents were female, the average age of respondents was 31−47 years old, and 14−61% of female respondents had attended school. Respondents self-reported having a cholera sufferer in their home in 1−20% of households (highest DRC and Haiti, lowest Senegal). Self-reported water sources varied in Haiti, Sierra Leone, and DRC, and were majority protected wells (96−99%) in Senegal.

Between 76 and 100% of respondents considered their water safe, with the main reason for safety that it was “clear” in Sierra Leone and DRC or “treated” in Haiti and Senegal (Table 7). Overall, 33−100% of respondents reported receiving Dispenser training, including community trainings and household visits. Reported training percentages doubled between the initial and sustained evaluations in Sierra Leone, which was attributed to programmatic improvements after the initial evaluation. Trainings appeared to improve knowledge, as the percentage of respondents who listed the reason “has bacteria” for being unsafe increased in Sierra Leone and Senegal between initial and sustained evaluations.

The most common reasons for using the Dispenser was that it “makes water safe”, “prevents disease”, and ensures “clean water” (Table 7). The main reason for not using

the Dispenser in the Sierra Leone and DRC sustained evaluations was “empty”, indicating a lack of sustainable chlorine resupply.

Reported Knowledge and Treatment. Across the seven evaluations, 31−99% of respondents reported knowing their Promoter by name, 37−99% reported seeing their Promoter in the last month, and 28−99% reported speaking with their Promoter in the last month (Figure 1c). The percentage of respondents who knew “how to correctly use the Dispenser” ranged from 33 to 99% and who knew “to wait 30 min after treatment before drinking” ranged from 37 to 99% (Figure 1b). These indicators increased in Sierra Leone from the initial to the sustained evaluation, decreased from the initial to sustained evaluation in DRC, and remained stable and high in Senegal.

The number of households who used a source with a Dispenser (or in DRC passed a Dispenser on way to source) ranged from 26 to 98% (Table 4). Across the seven evaluations, 39−99% of respondents reported ever using the Dispenser, 33−98% reported using the Dispenser in the last week, and 26−99% reported using the Dispenser the last time they collected water (Figure 1a).

Reported, Confirmed, and Confirmed Correct Use. Across the seven evaluations, 9−97% households reported their current household stored water was treated with a Dispenser, 5−87% were confirmed to have FCR ≥0.2 mg/L, and 4−70% had confirmed correct FCR of 0.2−2.0 mg/L (Figure 9, Table 8). Reported use was low in Sierra Leone but increased slightly from the initial to the sustained evaluation, medium in DRC but decreased significantly for the sustained evaluation, and remained high and stable across evaluations in Senegal.

Table 7: Evaluation Assessment with Household Demographics, Beliefs, and Training Reported

	Haiti	Sierra Leone		DRC		Senegal	
	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
Dispenser site visits	10	10	10	10	10	10	10
Individual Dispensers assessed	20	36	36	19	10	20	20
Water point observations	--	--	--	--	--	9	--
Focus group discussions	--	3	--	3	--	4	3
Key information interviews	1	3	--	2	--	2	--
Household surveys	298	300	300	300	300	277	282
Female respondents	73%	94%	80%	85%	80%	56%	85%
Average age respondents	47	35	34	32	31	40	36
Female respondents attend school	51%	56%	61%	57%	59%	21%	14%
Households with cholera sufferers	16%	7%	8%	16%	20%	1%	1%
Source of household water (most common)	Spring (43%) Tap (17%) Captage (15%)	Prot. well (48%) Tap (25%) Borehole (16%)	Open well (43%) Prot. well (29%) Tap (28%)	River (41%) Tap (34%) Lake (22%)	Tap (60%) River (23%) Lake (14%)	Prot. well (99%)	Prot. well (96%)
Considered stored household water safe	76%	100%	98%	94%	86%	100%	>99%
Most common reason water safe	Treated (93%)	Clear (82%)	Clear (86%)	Clear (53%)	Clear (54%)	Treated (55%)	Treated (62%)
Most common reason water unsafe	Not treated (63%)	Dirty (88%)	Dirty (84%)	Dirty (64%)	Dirty (58%)	Not treated (44%)	Not treated (49%)
Report receive training on Dispensers	--	33%	70%	62%	69%	99%	100%
Most common reason use Dispenser	Makes water safe (73%)	Makes water safe (86%)	Prevents disease (84%)	Prevents disease (80%)	Prevents disease (68%)	Ensures clean water (73%)	Ensures clean water (78%)
Most common reason not use Dispenser	Use other treatment (32%)	Don't know about it / how (59%)	Empty (25%)	Too far (19%)	Empty (51%)	Forgot (3 people)	Too far (5 people)

Table 8: Reported, Confirmed, Correct, and Effective Use by Implementation Site and Stage

		Report having stored HH water	Report HH water treated	Confirmed use, any treatment	Report using source w/ Dispenser	Report use treated w/ Dispenser	Untreated samples with E. coli ≥1 CFU/100 mL	Confirmed use[b] Dispenser	Correct use[c] of Dispenser	Effective use[d] of Dispensers
Haiti	Sustained	79%	55%	20%	55%	12%	59%	9%	7%	5%
Sierra Leone	Initial	94%	42%	18%	26%	17%	76%	11%	10%	10%
	Sustained	78%	47%	21%	31%	22%	83%	18%	15%	10%
DRC	Initial	85%	59%	37%	76%[a]	52%	100%	34%	32%	28%
	Sustained	59%	38%	6%	75%[a]	9%	100%	5%	4%	0%
Senegal	Initial	99%	100%	84%	97%	92%	75%	79%	60%	63%
	Sustained	98%	98%	87%	98%	97%	86%	87%	70%	81%

a. Percent of households with stored water who passed by a Dispenser on route to collecting water

b. Confirmed use is defined as a measured FCR > 0.2 mg/L

c. Correct use is defined as a measured FCR 0.2-2.0 mg/L

d. Effective Use is defined as the population reporting Dispenser use * % of samples improved due to Dispenser treatment

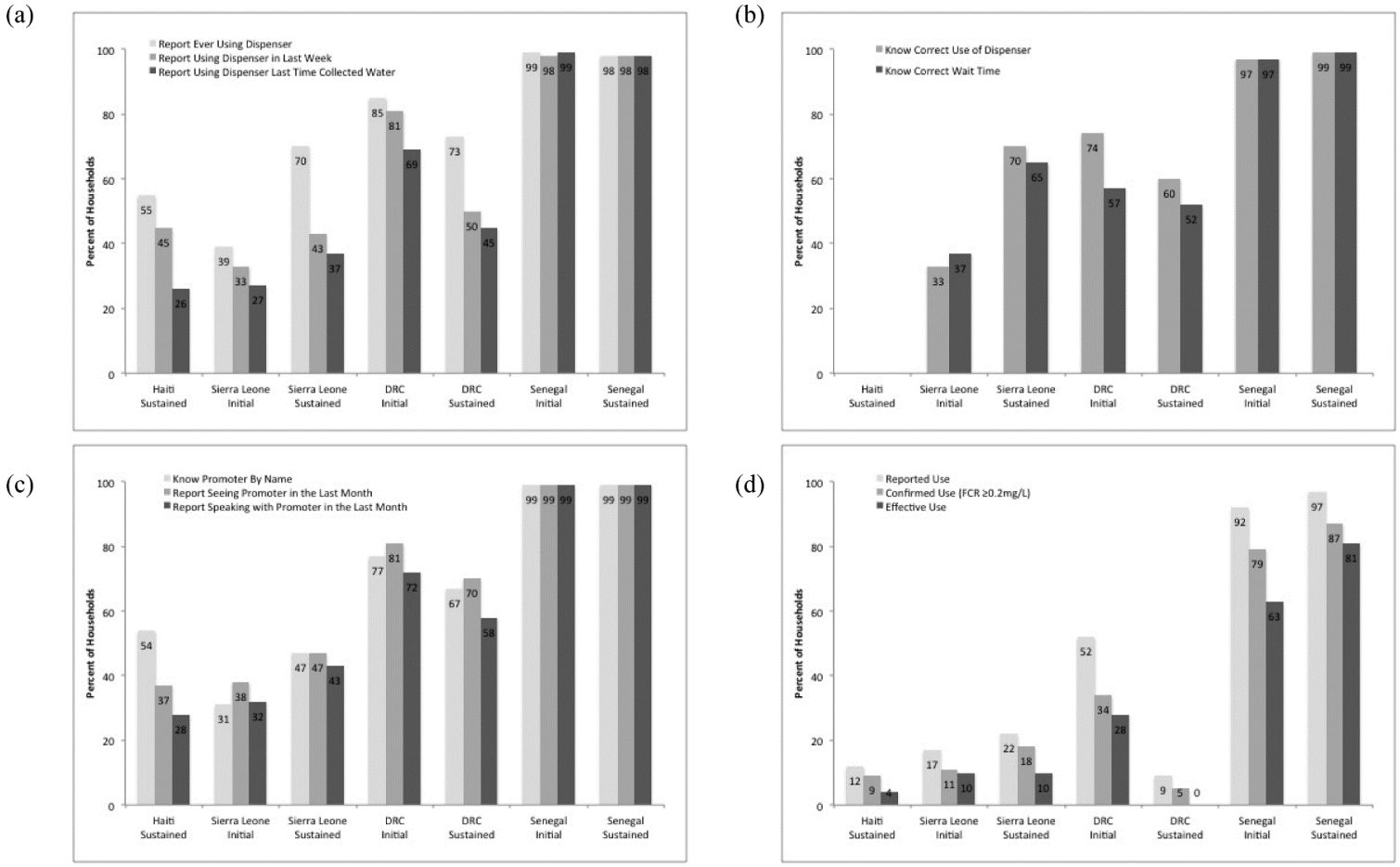

Figure 9: Use and Knowledge of Dispensers and Promotors

(a) Reported use of Dispenser, (b) Reported knowledge on Dispenser use, (c) Reported knowledge of Promoter, and (d) Reported use, confirmed use, and effective use of Dispensers in current stored household water. By implementation and stage.

Overall, 36% of Haitian households surveyed reported using another water treatment option, the widely available Aquatabs. Additionally, 4−25% of DRC respondents reported their water was treated because it was from the municipal system. In Senegal and Sierra Leone, the initial evaluation rates of cloth filtration and other water treatment ranged from 3 to 24%, but dropped to 0−2% in the sustained evaluation, indicating greater acceptance of Dispensers over time.

Water Quality and Effective Use. Stored household drinking water was collected from 59−99% of households during the unannounced survey. Turbidity was measured in 907 treated and 769 untreated household water samples. In DRC, where many families used unimproved sources, turbidity was above the threshold requiring a double dose of chlorine (10 NTU) in 7−26% of the samples (Lantagne, 2008); in all other emergencies <4% of samples were >10 NTU. E. coli testing was completed on 322 paired treated−untreated household drinking water samples. Overall, 59−100% of untreated samples had E. coli ≥ 1 CFU/100 mL, and 0−81% of surveyed households used the Dispenser to improve their water quality from contaminated (E. coli ≥ 1 CFU/100 mL) to uncontaminated (E. coli < 1 CFU/100 mL) (Figure 9, Table 8).

Associations between Input Variables and Dispenser Use. Model development was limited by the number of households without stored household drinking water (1−41% of households, Table 8), demographic differences between populations with and without stored household water, the small number of Dispenser users in Sierra Leone and DRC, and the small number of Dispenser nonusers in Senegal. These limitations violated model assumptions of variable separation and zero cell count of several evaluations; therefore, model development was restricted to initial evaluations in Sierra Leone and DRC, and the sustained evaluation in Haiti. In all models, there were

demographic differences between the populations with and without stored household water.

For the 94% of respondents (n = 283) in Sierra Leone with stored household water in the initial evaluation, two variables were significantly associated with reported Dispenser use in current household stored water: (1) reporting collecting water from a source with the Dispenser (OR: 7.3, 95% CI: 2.3−22.9, p= 0.001), and (2) seeing a Promoter in the last month (OR: 42.2, 95% CI: 4.5−393, p = 0.001). Respondents without stored water all reported using unimproved sources.

For the 85% of respondents (n = 254) in the initial DRC evaluation with stored household water, four variables were associated with reported Dispenser use in current household stored water: (1) reported walking by a Dispenser on the way to the source (OR: 57.0, 95% CI: 7.5−434, p < 0.001), (2) knowing how to correctly use the Dispenser (OR: 6.5, 95% CI: 2.7−15.7, p < 0.001), (3) knowing, seeing, or talking with the Promoter (OR: 2.78, 95% CI: 1.2−6.6, p = 0.020), and (4) not using an improved source (OR: 0.07, 95% CI: 0.02−0.21, p < 0.001). Compared with respondents without stored household water, those with stored household water were more likely to report thinking their drinking water was safe, having received Dispenser training, knowing/seeing/talking with their Promoters, and knowing how to use Dispensers correctly (all p < 0.05).

In the sustained Haiti evaluation, for the 79% of respondents (n = 236) with stored household water, three variables were associated with reported Dispenser use in current household stored water: (1) using the source where the Dispenser was located (OR: 14.1, 95% CI: 1.7−116, p = 0.014), (2) knowing the Promoter (OR: 2.9, 95% CI: 1.2−7.0, p = 0.016), and (3) knowing how to use the Dispenser correctly (OR: 4.5, 95%

CI:1.7−12.0, p = 0.002). Using the source where the Dispenser was located (OR: 18.7, 95% CI: 2.2−158, p = 0.007) and knowing how to use the Dispenser correctly (OR: 6.0, 95% CI: 2.1−16.9, p = 0.001) were associated with confirmed use of Dispensers. Compared to respondents without stored household water, those with stored household water were more likely to report going to school, literate male head-of-household, safe drinking water, their family was not affected by cholera, and that they talked to the Promoter (all $p < 0.05$).

3.5 Discussion

Dispensers were evaluated in four emergencies that represented a diverse range of emergency situations, geographical settings, and implementation strategies. Only one implementation met all partner recommended implementation criteria. Program metrics varied significantly across these contexts, with reported use ranging from 9 to 97%, confirmed use ranging from 5 to 87%, confirmed correct use ranging from 4 to 70%, and effective use ranging from 0 to 81%. Programs where a greater number of the implementation criteria were met were more successful than programs that only partially met the criteria. The most successful program (Senegal) was the only program that met all three source-related criteria (including the use of homogeneous point sources, sufficient population density per source, and source density in intervention area). These results indicate that Dispensers can be, but are not always, an effective emergency response tool.

The strongest predictors of program success were the criteria related to source selection. There was limited success in the DRC program that installed Dispensers on pathways to the source, and very low success in Sierra Leone and Haiti, where

Dispensers were installed in only some sources in the community. It is thus recommended that Dispensers be installed in all point sources (such as wells or springs) in a geographical area with sufficient population per source (approximately 50−100 families) and where Dispensers can be cost-effectively installed at all sources in the area. We found that respondents, generally, did not switch sources to walk to a source with a Dispenser. An additional benefit of focusing Dispenser installations at improved point sources is that improved sources are less likely to have Cryptosporidium, which is a chlorine-resistant protozoa important in the development of malnutrition and in immunocompromised populations (Medema et al., 2006). However, focusing installations at already improved sources may be in conflict with the emergency response ethic of "humanitarianism", which encourages emergency responders to respond first to those most in need (i.e., those without access to improved sources) (Sphere Project, 2011).

Chlorine supply and hardware maintenance were also critical to program success. Partner organizations experienced more difficulty than anticipated to source, manufacture, and distribute the chlorine solution. Concentrations of the chlorine solution were >10% lower than recommended in all programs. Promoters were unable to obtain chlorine solution, leading to empty Dispensers, particularly during the sustained evaluations. There were also issues with HTH precipitate clogging valves, leading to maintenance difficulty and decommissioning of Dispensers, particularly in DRC where removal of Dispensers led to a precipitous drop in use in the sustained evaluation. It is recommended future programs manufacture and stabilize the chlorine solution centrally (including allowing HTH solutions to settle for 24 hours before decanting) and deliver the chlorine solution directly to Promoters.

As seen in the regression models, Promoters were critical to program outcomes, particularly in less strong programs. It is recommended that the Promoter's role be clear from the outset, involve manageable tasks, and that Promoters be remunerated. Additionally, experienced project staff were better able to communicate and navigate the complexities of a pilot program that blended emergency response, research, relationships with local partners, and sustainability plans.

Programs that worked with local partners, conducted ongoing monitoring, integrated into larger WASH programming, and established a realistic sustainability plan were more successful. However, these characteristics, and the fact Dispensers are installed in the ground with concrete, lead to the question of whether successful emergency Dispenser programs were actually programs implemented like development programs. There was active discussion at the project-end meeting about the role of research in emergency response, and the potential for trialing, and implementing, unfamiliar new interventions in emergencies. Research projects do have the potential to increase responder confidence in using the most appropriate interventions for an individual emergency context, rather than defaulting to familiar–but not as appropriate–interventions.

At the end-of-project meeting, project partners identified nine implementation factors leading to program success: (1) source selection, (2) chlorine solution quality and supply chain, (3) hardware maintenance, (4) Promoter remuneration, (5) experienced program staff, (6) working with local partners, (7) regular monitoring, (8) integration into larger WASH programming, and (9) establishing a sustainability plan (Table 9). On the basis of our research results, a handbook for implementing Dispensers in emergencies was developed providing detail on recommended implementation strategies (IPA, 2014b). Lessons learned from these emergency response programs can also inform future

installation of Dispensers in development programs. One important lesson from this work is that there are differences in populations with and without stored household water at the time of the unannounced survey visit.

Table 9: Relationship between Emergency Context and Post-Project Recommended Implementation Criteria

	Haiti	Sierra Leone	DRC	Senegal
Source selection	✗	✗	?	✓
Chlorine solution quality and supply chain	✗	✗	✗	✓
Hardware maintenance	?	?	✗	✓
Promoter remuneration	✗	✓	✗	✓
Dispenser experienced program staff	✗	✗	✗	✓
Working with local partners	✗	✓	✗	✓
Regular monitoring	✗	✓	✓	✓
Integration into larger WASH programming	✗	✗	✗	✓
Establishing a sustainability plan	✓	✓	✓	✓

Legend: (✓) Criterion met (?) Criterion questionable (✗) Criterion not met

3.5.1 Limitations

Our work was limited by conducting research in emergency contexts with short timeframes and logistical challenges. Project partners found it challenging to implement Dispensers in an appropriate context from their portfolio and within the scope and timeframe of the project. Effective use with water treatment was used as a proxy indicator for diarrheal disease risk and did not consider the multitude of pathways of fecal contamination, chemical contaminants, or health outcomes. Sustained use was measured only over the course of 4−7 months. As evidenced by the inability of IFRC to implement a research Dispensers project, these research evaluations might not be representative of real-world programs.

IPA supported the initial research to design Dispensers, previously supported the Dispensers scale-up work (although scale-up work has now been transferred to sister organization Evidence Action), and supported this research. The PI on this project was not a PI on the other IPA Dispensers projects, although three of the authors on this manuscript previously supported Dispenser scale-up work. Thus, there is the potential for the perception of conflict of interest. The authors state (and we feel our results support our statement) that we conducted a rigorous and unbiased analysis of the potential for Dispensers in emergencies. However, external evaluations would be a valuable addition to the knowledge base on Dispensers. Additionally, further research on the cost-effectiveness of Dispensers in various contexts-particularly in relation to other common emergency response chlorine interventions such as chlorine tablets and bucket chlorination — is recommended.

3.6 Conclusion

The success of Dispensers at reducing the risk of waterborne disease in the recipient population varied dramatically in the four emergencies evaluated. Results indicate that Dispensers can be an appropriate and effective tool for responding in some emergencies, but should be considered as one of many tools available to an organization planning a WASH emergency response. At the project-end meeting, partners concluded that Dispensers might be most appropriate for longer-term (as opposed to acute) emergency response.

3.7 Acknowledgements

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Chapter 4: WASH Interventions in Outbreak Response: Evidence Synthesis

4.1 Abstract

Water, sanitation, and hygiene (WASH) interventions are key to reducing the burden of disease associated with outbreaks, and commonly implemented in emergency response. However, there is a lack of summarized evidence on the efficacy and effectiveness of these interventions. We conducted a systematic review of published and grey literature by developing theory of change models, developing inclusion criteria, conducting the search, selecting evaluations for inclusion, assessing the quality of the evidence and analyzing the included evaluations. Overall, 15,026 documents were identified and 47 studies describing 51 evaluations met inclusion criteria. Interventions from 19 countries were included, primarily in response to cholera (86%). Most included evaluations (70%) were high risk of bias and nearly half were from grey literature (49%). We found that WASH interventions consistently reduced both the risk of disease and the risk of transmission in outbreak contexts; however, program design and beneficiary preferences were important considerations to ensure WASH intervention effectiveness. Critical program design characteristics included simple interventions that were appropriate timed, community driven and had linkages between relief and development. Beneficiary preferences, barriers, and facilitators to WASH interventions in outbreak response were taste and smell of water treatment, communication methods, inaccurate perception of efficacy and trust/fear. Research on commonly implemented but severely under-researched WASH interventions is recommended. It is also recommended that responders implement efficacious, simple interventions that are appropriately timed, community-driven and have linkages between relief, and development in collaboration with the recipient communities to address barriers and facilitators to use.

4.2 Introduction

An outbreak occurs when disease cases increase above expected levels in a defined community, geographical area or season (GIDEON, 2016). Between 1980 and 2013, the number and diversity of disease outbreaks globally increased significantly (Smith et al., 2014). These increases are attributed to microbial adaption of pathogens, changing human susceptibility, climate change, changing human demographics, economic development, breakdowns in public health, war, famine, poverty, and social inequality.

In low and middle-income countries (LMIC), cholera, Ebola Virus Disease (Ebola) and hepatitis E are outbreaks of current concern. The number of cholera cases is increasing globally, and currently there are more than 2.8 million cholera cases that lead to more than 90,000 deaths worldwide (Ali et al., 2012, WHO, 2016a, Gaffga et al., 2007). The West African Ebola outbreak that began in 2014 was unprecedented in scale, impacting the entire global community with 28,626 cases and 11,323 deaths(WHO, 2016c). Hepatitis E can cause acute liver failure, particularly in pregnant women, and currently causes 70,000 deaths and 3,000 stillbirths annually (Rein et al., 2012) and have recently become more common in displacement camps (Boccia et al., 2006, Hakim et al., 2016).

Water, sanitation, and hygiene (WASH) interventions play a critical role in preventing disease outbreaks by breaking transmission routes (Figure 10). More specifically, WASH interventions can prevent and control outbreaks of waterborne diseases, diseases transmitted through the fecal-oral route (i.e. cholera and Hepatitis E) and diseases transmitted by direct contact (i.e. Ebola) (Sphere Project, 2011, 2014, Watson et al., 2007). *Water* interventions aim to increase water quantity and/or improve water quality; *sanitation* interventions aim to isolate feces from the environment; *hygiene*

interventions aim to prevent transmission through hands, and more broadly, promote awareness among affected populations on the disease and equip these populations to act; and *environmental hygiene* interventions reduce risks by disinfecting household objects and managing rubbish. WASH interventions in outbreaks 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). In addition to the three diseases detailed above, hepatitis A, acute (watery) diarrhea, typhoid and dysentery (shigellosis) are also diseases of current concern that can be prevented or controlled by WASH interventions.

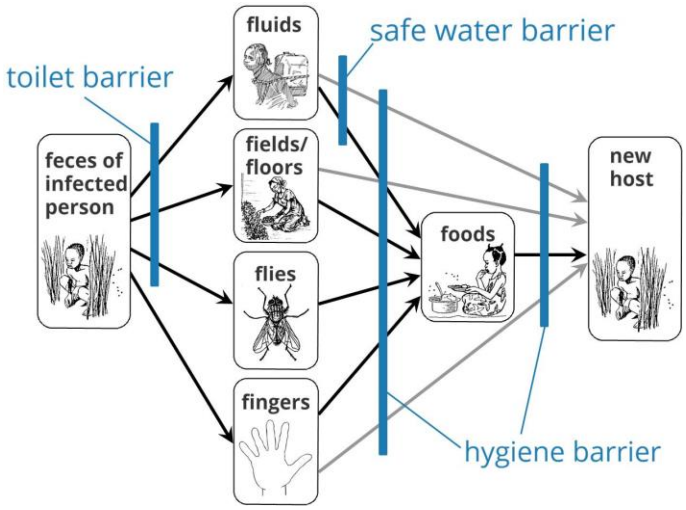

Figure 10: F-Diagram (Water 1st International, 2015)

WASH interventions are commonly implemented as part of outbreak response activities by United Nations (UN) agencies, local governments, and emergency responders. While the ability of WASH interventions to disrupt disease transmission is well established through laboratory experiments and development contexts, there is little evidence on the effectiveness in outbreak and humanitarian emergency situations (Blanchet et al., 2013, Ramesh et al., 2015, Brown et al., 2012, Taylor et al., 2015). Establishing an

evidence-base is challenging in outbreak and emergency situations because responders prioritize response activities over research and the inherent difficulty of using vigorous research methods in the unstable settings (Spiegel et al., 2007). Responders also note that there is a lack of technical knowledge related to data collection, lack of personnel to collect data, and lack of clear goals for how to use the information (Vujcic et al., 2015). While randomized control trials (RCTs) are robust evaluation designs and considered the 'gold standard' for health research, conducting RCTs in emergencies is hindered by the complex and dynamic conditions of emergencies (Mayne, 2011, Victora et al., 2004). Less robust, higher bias and more flexible evaluation designs, like cross-sectional evaluations, are more often used in emergencies.

In 2015, a systematic review on the efficacy of WASH interventions for cholera response (Taylor et al. 2015) and another on the health impact of WASH interventions in emergencies (Ramesh et al. 2015) concluded there is a lack of data to establish firm evidence for implementing WASH interventions in outbreaks and emergencies. As Taylor et al. (2015) only included published studies of a certain quality and Ramesh et al. (2015) only included manuscripts documenting health impacts, neither review included the most prominent information sources or variety of evaluation methods and outcomes available in outbreak contexts. Ideally, a synthesis of evidence would include both published and grey literature, as well as quantitative and qualitative information on outcomes, impacts and influencing contextual factors that contribute to program effectiveness in order to fully encompass the evidence base (Brown et al., 2012).

4.2.1 Objectives

The objective of this systematic review was to assess the outcomes and impacts of WASH interventions during disease outbreaks in LMIC, including both published and grey literature, with the aim of including a broader set of contextual factors that may shape intervention effectiveness. We specifically intended to address four research questions in WASH interventions during outbreak response, including:

1. What are the health impacts of WASH interventions in disease outbreaks?
2. What are important WASH program design and implementation characteristics in disease outbreaks?
3. What is the cost-effectiveness of WASH interventions in emergency outbreak situations?
4. What are the population-related barriers and facilitators that affect WASH interventions in disease outbreaks?

4.3 Methods

To address these research questions, we conducted a systematic review of published and grey literature, including development of: 1) theory of change models; 2) search strategy; 3) inclusion criteria; 4) selection and processing strategy; 5) quality of evidence appraisal; and 6) analysis plan. Please note the full systematic review protocol was peer-reviewed and made publicly available before conducting the review (Yates et al., 2015a). Each step of the systematic review process is summarized below.

4.3.1 Theory of Change Model Development

A theory of change model was developed for each WASH intervention to describe the theoretical route from intervention activities to outputs, outcomes, and impacts, while

also identifying influencing factors and assumptions (Figure 11). We developed a model for each of the eight WASH activities anticipated in the review: increasing access to water, source-based water treatment, household water treatment (HWT), temporary or permanent latrines, latrine alternatives, hygiene promotion (including handwashing), distribution of soap and/or hygiene materials/kits, and environmental hygiene.

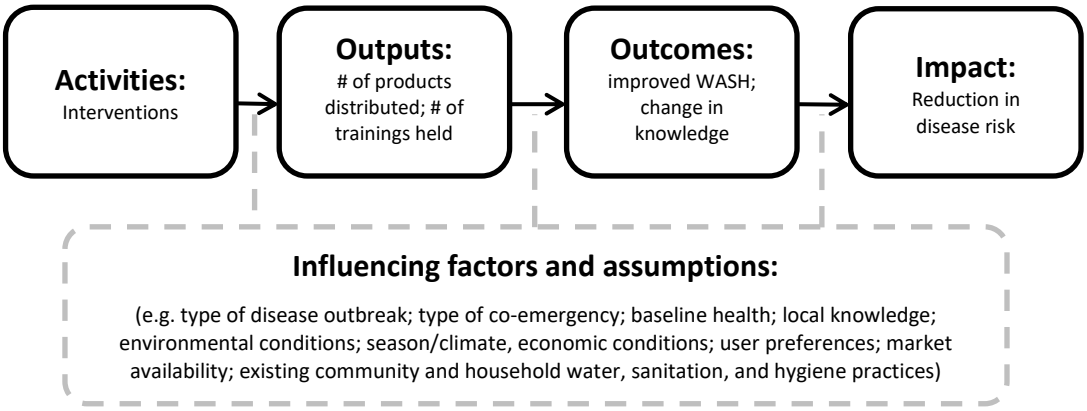

Figure 11: Theory of Change Template Adapted from (WHO, 2014)

4.3.2 Search Strategy

A search strategy was developed to identify published and unpublished grey literature. Individualized search terms and strings were developed for each of the eight WASH interventions from their associated theory of change, and included keywords and outcome and impact measures specific to that intervention. The search strings were used in a total of nine peer-reviewed databases and 10 searches, 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. Searching took place in November and December 2015, and was re-run in September 2016. Six journals identified as most likely to have relevant

research and reference lists of included evaluations and reviews identified in the searchers were screened by hand. Responder websites were also searched with keywords, including: non-governmental organizations (NGO), UN, and other relevant websites.

Additionally, solicitation for relevant documents was carried out through email and personal contacts. Requests for information were sent to the international community via the Global WASH Cluster in September 2015 and February 2016, and to the International Network on Household Water Treatment and Safe Storage in September 2015. Overall, more than 75 organizations were contacted through email. Lastly, personal solicitations, online posts and international conferences were also used to collect relevant information.

4.3.3 Inclusion Criteria

Inclusion criteria were established according to the populations, interventions, comparisons, outcomes and study types (PICOS) framework (Yates et al., 2015a).

Populations. All age, gender, and socioeconomic populations in LMIC were eligible for inclusion. Populations must have also been affected by an outbreak of: cholera, Ebola, hepatitis E, hepatitis A, acute (watery) diarrhea, typhoid or dysentery (shigellosis). An outbreak was defined in accordance with WHO definitions (WHO, 2016b).

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. Interventions must have been field-based. Laboratory research and health focused interventions (i.e. clinic or hospital interventions) were excluded.

Comparisons. No specific comparisons were required for inclusion.

Outcomes. Evaluations were included if at least one intermediate outcome (use of service or non-health outcomes) or final impact (disease reduction or cost-effectiveness) were reported. Use of service includes three specific indicators: self-reported use, confirmed use, and effective use. Self-reported use is beneficiary reported use without additional verification. Confirmed use is when an evaluator tests or observes the use or service in some way (i.e. testing free chlorine residual (FCR) in chlorine-based water treatment programs). Effective use is a measure of improving quality of contaminated water requiring confirmed use and microbiological testing. Cost-effectiveness included economic analyses investigating cost-benefit, cost-utility, cost per beneficiary and cost per disability adjusted life-year averted. Disease reduction data were included if beneficiary morbidity and mortality impact were self-reported or clinically measured. Non-health outcomes 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 were included.

Study Types. Experimental, quasi-experimental, non-experimental, mixed-methods and qualitative methodological study type designs were eligible for review.

Dates for inclusion were 1995-2016. Both peer-reviewed and unpublished grey literature documents were eligible. Personal blogs, diaries, newspapers articles, magazine articles, website postings, poster abstracts, and legal proceedings/court documents were not included. Review documents were not included, but individual references in review documents were screened for inclusion.

4.3.4 Selection and Processing

Identified studies were screened first by titles, then by abstracts, and full texts. From abstract to final inclusion, studies were independently double screened by two of the authors. Any discrepancies were discussed with a third author for 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 was completed with a detailed coding sheet using Microsoft Excel 2010, and included author and publication details, type of intervention, context of the intervention, study design, study quality, effect estimation, outcomes and impacts and barriers and facilitators to implementation (further described in detail in Appendix 2 within supplemental information). Data collection was completed and double screened by four research assistants.

4.3.5 Quality of Evidence

Each included evaluation was assessed for the potential risk of bias. For quantitative studies, the bias assessment tool was based on the *Cochrane Handbook* 'Risk of bias' tool and adjusted 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; spillover effects and contamination; incomplete outcome; selective reporting and other risks of bias. For qualitative studies, four appraisal categories were adapted from Spencer et al., (2003) (Spencer et al., 2003): design; bias; data collection; and clarity of findings. Each category was scored as 'low risk,' 'high risk' or 'unclear.' The summary risk of bias for a study was based on the number of 'low risk' assessments across the four or five categories depending on research design.

To establish the summary quality of evidence from multiple studies of varying qualities and study designs for each WASH intervention, a protocol was developed based on the Grading of Recommendations Assessment, Development and Evaluation (GRADE) of evidence outlined in Cochrane Review Standards (Higgins and Green, 2011). The baseline was determined by the study design of the evaluation; then downgraded or upgraded considering biases, effect size, consistency, and generalizability. The summary of evidence was then described through four categories (Oxman and GRADE Working Group, 2004): *high evidence* is defined as further research is very unlikely to change confidence in the estimate of effect or accuracy; *moderate evidence* as further research is likely to have an important impact on confidence in the estimate of effect or accuracy and may change the estimate; *low evidence* as further research is very likely to change the estimate; and *very low evidence* as any estimate of effect or accuracy is very uncertain.

4.3.6 Analysis Plan

Considerations for missing data and meta-analysis techniques were 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 were not utilized. Procedures to address unit of analysis issues, independent findings, economic synthesis, use of weighted average, pooled effect, forest plots and funnel plots were described in the protocol but not further described herein because they were not used. Formal heterogeneity analysis with I^2 could not be completed, as reported outcomes were too different for direct comparison.

A narrative synthesis approach was used to summarize the information gathered. A summary of all included evaluations is first presented with descriptions of outbreaks by country, disease type, intervention type, published or grey literature, risk of bias assessment and evaluation methodology. Then, for each WASH intervention, a description of the intervention is presented, followed by information on the number of studies identified, risk of bias, outcomes and impacts and summary of evidence. Results were then summarized in general tables and a summary map of evidence. Lastly, results were stratified by objective. Please note that based on included evaluations, the original eight WASH intervention categories were modified to ten categories, including: well disinfection, source-based treatment, household water treatment with chlorine-based options, household water treatment with other options, community-driven sanitation, hygiene promotion, social mobilization, hygiene kit distribution, jerrican disinfection and WASH Package (a term for when multiple interventions were delivered in the same response).

4.4 Results

Overall, 15,026 documents were identified in the systematic review process. After applying the three selection filters, 47 studies describing 51 evaluations were included (Figure 12). Each included study is detailed in Appendix 2.

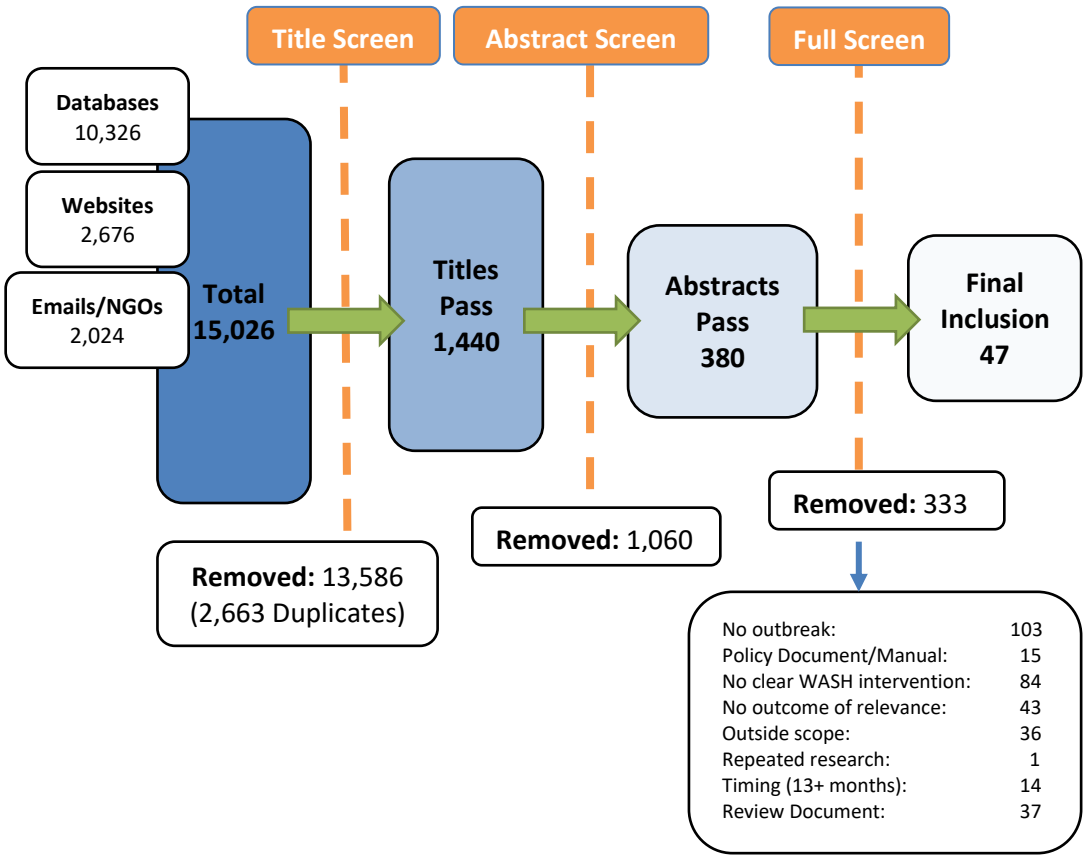

Figure 12: Screening Process

The included evaluations described WASH interventions in 19 countries, with the highest frequency of evaluations from Zimbabwe (8/51) and Haiti (7/51). Cholera was the most researched and discussed disease, representing 86% (44/51) of the diseases responded to in the included evaluations; Ebola (2, 4%), acute watery diarrhea (3, 6%),

shigellosis (1, 2%) and typhoid fever (1, 2%) accounted for the remainder of the diseases.

Water interventions represented the largest grouping of included evaluations (n=22, 43%), followed by hygiene (n=15, 29%) and WASH Package (n=12, 24%). Sanitation specific interventions were represented by two evaluations (4%).

A near equal number of evaluations were identified from the peer-reviewed (26, 51%) and grey literature (n=25, 49%). Most evaluations (70%, 38/51) had a high risk of bias (Figure 13). The quantitative studies were mostly completed on water interventions, were more likely to be in the peer-reviewed literature and had less risk of bias. For example, published water evaluations were 47% low risk of bias (9/19), while 4% (2/32) of the other interventions had a low risk of bias result. The WASH Package evaluations were primarily field commentaries in the unpublished grey literature, with a high risk of bias.

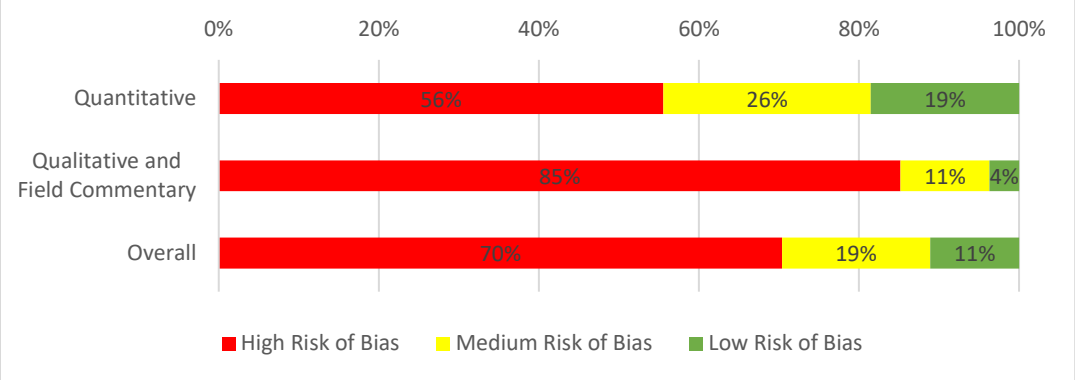

Figure 13: Risk of Bias Summary

Overall, 14% of the included studies (7/51) had a control group and less than 4% (2/51) were RCTs. Health impacts were measured in 12% (6/51) of the evaluations; use was evaluated most frequently for HWT interventions 31% (16/51).

Results by Intervention

4.4.1 Well Disinfection

A common outbreak response intervention is to disinfect a contaminated well with chlorine; the objectives of which are to reduce microbiological contamination and/or maintain FCR in the well. Five evaluations of high (3) and low (2) risk of bias were identified that described four slightly different approaches to well disinfection with chlorine (note two studies evaluated multiple methods): 1) a shock dose of liquid chlorine (bleach) added directly to the well; 2) pot chlorination where powdered chlorine, sand and gravel in a pierced jerrican were inserted into wells, intending to slowly disperse chlorine and treat water over time; 3) pot chlorination with locally pressed chlorine tablets in a perforated container; and 4) floating pot chlorinator (commercial plastic devices used in swimming pools).

One-time shock chlorination did not provide FCR protection for more than a few hours and did not reduce microbiological contamination. Traditional pot chlorination inconsistently maintained measurable FCR for 1-4 days. Floating pot chlorinators could be effective, but materials needed to be imported and required specialized tablets. Finally, in comparative evaluations, albeit with inconsistent methods, pressed HTH tablets with a pot chlorination approach maintained FCR for 3-4 days and were the preferred mode of well disinfection by responders. Microbiological impact of treatments was not assessed. An important programmatic consideration identified was

communication with community members, as: 1) well disinfection interventions were often perceived to maintain water safety for longer than it was actually maintained; and 2) communities unnecessarily doubled the chlorine dose by also treating water at the home with chlorine-based options.

4.4.2 Source-based Treatment

Source-based treatment is water treatment that occurs at the point of collection. Evaluations were identified in the review only for the intervention of chlorine dispensers; bucket chlorination, where a person is stationed near a water source and adds a dose of chlorine directly into the recipient's water collection container was described as an activity but not evaluated. A chlorine dispenser program 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 into their water collection container.

Dispensers were used in three different cholera contexts: Haiti, Sierra Leone and Democratic Republic of Congo (DRC) with three different responders presented in one low risk of bias manuscript (Yates et al., 2015c). Results varied over two acute evaluations (2–8 weeks after installation) and three sustained evaluations (4–7 months after installation) for reported use (26-75% acute, 31-75% sustained), confirmed use (11-34% acute, 5-18% sustained) and effective use (10-28% acute, 0-10% sustained) metrics. 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% of households in Haiti reported using chlorine tablets as an

alternative treatment. With regression analysis of household survey data, factors consistently associated with higher use across contexts were: speaking to the promoter within the last month; and collecting water from a source with a dispenser. 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). The three implementing organizations gathered at project end and reflected on factors leading to success. These included: appropriate source selection; chlorine solution quality and supply chain; dispenser hardware installation and maintenance; integration into a larger WASH program; promoter recruitment and remuneration; experienced program staff; partnering with local organizations; conducting ongoing monitoring; and having a sustainability plan.

HWT

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 stand-alone intervention or included as one of several items in a hygiene kit. Distributions also sometimes include hygiene promotion.

HWT was the most studied intervention with 16 evaluations and a mixture of high, medium and low risk of bias. For analysis, HWT interventions were separated by chlorine-based products (chlorine tablets, liquid chlorine, flocculant/disinfectants) and other products (filters, solar disinfection (SODIS), safe storage and boiling), while several contexts included more than one HWT product.

4.4.3 HWT – Chlorine-based Products

The most common HWT products distributed in emergencies were chlorine products; this was particularly true in cholera response, because they effectively inactivate most bacterial and viral pathogens, lead to residual protection, are low cost and easy to use and transport (Lantagne and Clasen, 2012a). Chlorine-based HWT products were separated into three sub-categories: chlorine tablets, liquid chlorine, and flocculant/disinfectants.

Chlorine Tablets. Sodium dichloroisocyanurate chlorine tables (e.g. Aquatabs®), used to treat 1-20L of water, were evaluated in six contexts with mixed risk of bias. The distributed tablets (67–167mg) were freely distributed through hygiene kits and intended to treat 10–20L of water. The reported use ranged between 8-31% (n=5), while confirmed use ranged between 7-87% (n=6) with one noticeable outlier; without the outlier the range was 7-31% (n=5). Effective use was identified in one study, 5.3% (n=1). 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, 2012b, Imanishi et al., 2014, Ruiz-Roman, 2009). Overdosing may have led to strong smells/taste, as some beneficiaries did not have the appropriate water storage container for the tablet size distribution (Imanishi et al., 2014, ACF, 2009). Knowing a HWT method before the outbreak and ease-of-use were indicators for use in Zimbabwe (Imanishi et al., 2014) and Nepal (Lantagne and Clasen, 2012b).

Liquid Chlorine. Small bottles of 1-1.25% sodium hypochlorite (e.g. WaterGuard, sized so one cap treats 20L of water), and commercial bleach (where the dosage is generally in drops), were evaluated in four contexts in three countries with mostly high risk of bias. Reported use ranged between 20-88% (n=4), confirmed use ranged between 12-69% (n=3) and effective use was not assessed. 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 to the beneficiary may explain the low use in Madagascar (Dunston et al., 2001) as the free distribution of the same product had higher use rates in the same outbreak (Mong et al., 2001). Excessive dosing was observed in Madagascar (FCR >3.5mg/L) (Mong et al., 2001) and taste was noted as a hindrance to use in Nepal (Lantagne and Clasen, 2012b). Liquid chlorine was linked to long-term development approaches, including promotion (ACF, 2014c), cost-recovery and social marketing (Dunston et al., 2001), local production (Date et al., 2013) and vouchers (ACF, 2014c). These development program strategies were used with liquid chlorine programming, and not described in other HWT interventions. Liquid chlorine was also more regularly used in endemic situations, where responses can be scaling up existing ongoing development interventions.

Combination Flocculent/Disinfectants. Flocculent/disinfectant sachets (e.g., P&G Purifier of Water® 'PuR') are most often used to treat turbid water. Users add the contents of one sachet 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 was evaluated in three evaluations, two were low risk of bias and one high risk of bias. Reported use ranged between 6-78% (n=2), while confirmed use ranged between 4-95% (n=2). Effective use was measured in one evaluation, 2.3% (n=1). Household knowledge may explain some variability. High use was attributed to high knowledge of correct use in South Sudan and when households were also provided all materials necessary to use PuR at no cost, received extensive training and were visited weekly in Liberia (ACF, 2014b, Doocy and Burnham, 2006). On the other hand, in Kenya, PuR was distributed through an NFI distribution with minimal promotion, resulting in only 2.3% of households able to describe correct use; ultimately translating to similarly low reported use of 5.9% and confirmed use of 3.7% (Lantagne and Clasen, 2012b). Health impact was reported in one evaluation (with high use, in Liberia) where PuR reduced diarrhea incidence by 67% (adjusted RR 0.33; 95% CI 0.30–0.37) and diarrhea prevalence by 77% (adjusted RR 0.23; 95% CI 0.21–0.25) (Doocy and Burnham, 2006).

4.4.4 HWT – Other Products

Fewer non-chlorine HWT interventions were identified in the review and were all implemented in non-acute endemic outbreak contexts. The quality of evaluation design was higher than that of chlorine or PuR studies, but were not generalizable to other contexts without multiple studies of the same intervention. Other HWT products were separated into four sub-categories: filters, solar disinfection (SODIS), safe storage and boiling.

Filters. 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 in intervention groups and compared with a control group in a large low bias evaluation (Colwell et al., 2003). More than 90% of households reported following the filtering instructions, and cholera morbidity was reduced by approximately 40% in both the nylon and sari cloth filter groups (nylon filter RR: 0.59; sari cloth RR: 0.52). In a follow-up medium bias study, reported use of the sari cloth filters was 35% five years after intervention and the protective reduction in morbidity was also seen in neighbors of users (Huq et al., 2010).

SODIS. SODIS was evaluated in one high risk of bias study in a development context in Kenya that led into an outbreak evaluation when cholera began in the project area (Conroy et al., 2001). SODIS was effective at reducing self-reported diarrhea rates by 88 percent in children less than six (OR=0.12; 95% CI 0.02–0.65; p=0.014) but impact was inconclusive with older children and adults.

Safe storage. Two evaluations isolating safe water storage were identified in the review; both were low bias. The control group in the PuR evaluation in Liberia received jerry cans, and this alone significantly reduced diarrhea rates by 16% from the preceding week (OR=0.84, 95% CI 0.82–0.86) (Doocy and Burnham, 2006). The second evaluation was from an 'improved bucket' intervention with a spout and a permanent partial lid preventing hands inside the bucket (Roberts et al., 2001). Diarrhea rates were reduced by 31% in children under 5 years and 8% overall for the intervention group; however; neither reduction was statistically significant (p=0.06 and p=0.26). The community preferred the improved buckets to chlorination, as chlorine was associated with a bad taste and smell.

Boiling. 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 (Einarsdbttir et al., 2001). After the campaign, 40% of households reported boiling water; however, 66% reported using lemon to treat water, no households reported consistent use of either method, and no confirmed use evidence was collected.

Overall, these less common HWT interventions were consistently reported to be simple, sustainable and accepted by the communities. However, the overall evidence for each individual intervention is weak.

Sanitation

While latrine building was a commonly listed as an activity, no evaluations of latrine building were identified in the review. Sanitation was indirectly addressed in evaluations of two community-driven interventions: one community led total sanitation (CLTS), and one participatory hygiene and sanitation transformation (PHAST). Both intervention strategies aimed to educate and motivate communities to addressing their own needs with minimal external support.

4.4.5 Community-driven Sanitation

A CLTS program in Liberia was implemented for five years before Ebola erupted in Liberia and the intervention continued throughout the outbreak. In a medium risk of bias study, households in villages that achieved 'open defecation free' status through CLTS were found to be 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 achieved open defecation free status had eight times fewer Ebola cases than communities not in the project.

A PHAST approach with community health clubs was trialed in the midst of a cholera outbreak in an Ugandan internally displaced camp (Waterkeyn et al., 2005). The evaluation was a high risk of bias field commentary, but reportedly reached more than 15,000 people while constructing more than 8,000 latrines and 6,000 bath shelters in less than four months. Group cohesion and peer pressure were noted as effective behavior change mechanisms.

Hygiene

Hygiene messages educate affected populations on disease risks and transmission routes. Often in emergencies, *hygiene promotion* is condensed to key messages, such as handwashing at critical times. Promotion can be at schools, in large community groups or at the household level. *Social mobilization* includes strategies for engaging and facilitating communities to address identified risks with local solutions (e.g., CLTS as described above). There was no direct evaluation of hygiene practices identified for the review, however, there were eight evaluations of hygiene promotion and six social mobilization evaluations identified, although all were medium and high risk of bias.

4.4.6 Hygiene Promotion

In five hygiene promotion evaluations, interpersonal communication was highlighted as positively received by beneficiaries (Williams et al., 2015, Matemo, 2014, Contzen and Mosler, 2013, Date et al., 2013, Einarsdbttir et al., 2001, Wall and Chéry). Additionally, material demonstrations (i.e. instruction on HWT), visits by community health workers and conversations with friends and family were consistently reported as positively received by beneficiaries. Radio communication was 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). It was unclear if hearing a message on the radio translated to action or a realistic understanding of the local situation (Wall and Chéry). There were also noted difficulties with dialect differences (Einarsdbttir et al., 2001) and errors in printed information (Neseni and Guzha, 2009).

Other impacts from hygiene education included a reported decline in morbidity and diarrhea rates (WHO, Williams et al., 2015), confirmed increase in HWT use (Date et al., 2013) and self-reported changes in behavior by reducing physical contact (i.e. hugs, shaking hands) during a cholera outbreak (WHO).

4.4.7 Social Mobilization

In a mix of research methods, including quantitative, qualitative and field commentary, there were six medium and high risk of bias evaluations describing some version of social mobilization. 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 reported to have positive impact on programs by 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). Moreover, stronger community relationships were also described in three of the social mobilization evaluations described with 'community ownership,' 'trust,' and 'group cohesion' (Wall and Chéry, 2011, Waterkeyn et al., 2005, ACF, 2015a). Social mobilization was also qualitatively reported in high risk

of bias studies to reduce disease transmission better than disease case management (2015a, Rees-Gildea, 2013, Neseni and Guzha, 2009); while the CLTS program in Liberia Ebola response (described above) had a strong and significant reduction in disease risk (Meyer Capps and Njiru, 2015).

4.4.8 Hygiene Kit Distributions

The goal of most hygiene kit distributions was to deliver HWT products and/or support hygiene activities addressed in other intervention categories. Hygiene kit distributions were mentioned in 17 mixed risk of bias evaluations. HWT products, soap and safe water storage containers most commonly included in the kits. Barriers and facilitators of hygiene kits were described throughout studies described within other interventions (e.g., HWT and WASH Package below). 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, 2012b) 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 distribution of standardized kits was a barrier to families with different sizes and needs (Gauthier, 2014, Simpson et al., 2009).

4.4.9 Environmental Hygiene

Environmental hygiene interventions were identified as jerrican disinfection, and spraying household surfaces with a chlorine solution or disinfection kit distribution.

Jerrican disinfection. Jerrican disinfection was investigated in three high risk of bias evaluations, all in camp settings, and all assessed with no beneficiary input. All three jerrican cleaning methods were assessed to reduce disease risk with very weak

evaluation methods. Chlorine concentration reduction was noted in all three documents (Steele et al., 2008, Walden et al., 2005, Roberts et al., 2001). One-time disinfection did not have a long-term impact on recontamination.

Household spraying. Household spraying was mentioned as an activity in five documents but not evaluated (Neseni and Guzha, 2009, Gauthier, 2014, Grayel, 2014, Grayel, 2011, 2012). A known outbreak activity, household or community spraying was noted to have several potential drawbacks: 1) stigmatizing households; 2) logistical, financial and staffing resources required; 3) false sense of protection to households; and 4) limited impact as 80-85% of people infected with cholera are asymptomatic (Grayel, 2011). In an example from the Ebola response in West Africa, household spraying was described as 'incomplete' and likely ineffective (Nielsen et al., 2015). The UNICEF Cholera Toolkit also recommends that household spraying *by responders* not to be carried out (Unicef, 2013); however, it is recommended that families should thoroughly clean the house with soap and chlorine solution. In alignment with these recommendations, an NGO provided cholera patients with a family self-disinfection kit for the household in the cholera outbreak in Haiti. After a group hygiene session, kits were given to the patient or caretaker, including: 0.5–1 kg of soap, a 14L bucket, a 10L jerrican, 3.8L of bleach, a cloth, a scrubbing brush and an instruction book (Gartley et al., 2013). Self-reported use of hygiene kit contents was high (>90%) in a high risk of bias evaluation.

4.4.10 WASH Package

WASH interventions are regularly implemented in combination 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 were high risk of bias grey literature documents, with 11 being 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. However, the water interventions included in WASH Package were not source or water treatment, as seen in the individual intervention evaluations, but well rehabilitation and water trucking. While well rehabilitation and water trucking were described as activities in WASH Package interventions, we did not identify any evaluations of these interventions in the review, either as individual activities or within WASH Package interventions.

Health impacts were reported through reduced diarrhea and cholera rates (Pennacchia et al., 2011, Gauthier, 2014, ACF, 2007). Improved hygiene behavior was self-reported in Zimbabwe (DeGabriele and Musa, 2009), DRC (Pennacchia et al., 2011) and Somalia (Dinku, 2011), although respondents in Zimbabwe acknowledged the behaviors were not consistently practiced. Additional impacts included reported reduced time needed to collect water, with undocumented methods (Dinku, 2011, Pennacchia et al., 2011), 'psychosocial support' to cholera-affected communities after a hygiene kit distribution (Neseni and Guzha, 2009) and a change in people's attitude, especially toward open defecation in Sierra Leone (Ngegba, 2002).

The importance of expert staffing was documented in Zimbabwe (Simpson et al., 2009, El-Mahmid and Roussy, 2009), whereas integrating epidemiological experts into response and surge capacity was described as important in the DRC (Grayel, 2014), (Gauthier, 2014). Pre-positioned hygiene kits were useful for quick initial distributions

(Lantagne and Clasen, 2012b, Ruiz-Roman, 2009, Neseni and Guzha, 2009, DeGabriele and Musa, 2009, Simpson et al., 2009), and programs without pre-positioned stock at times described difficulty in procuring items leading to delays (Neseni and Guzha, 2009). Similarly, accessible 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 were identified as challenges (Simpson et al., 2009). In outbreak response, well rehabilitation, NFI kit distributions and hygiene promotion were the most frequently included individual interventions in these WASH Package interventions; meanwhile water trucking was slightly less common and sanitation was rarely present. These qualitative field commentaries had a high risk of bias but consistent descriptions of anecdotal health impacts and non-health behavior change impacts. Expert staffing and rapid response timing were consistently identified as critical factors for program success.

Cost-Effectiveness

Cost-effectiveness and economic outcomes were not able to be assessed. Cost-related outcomes – not cost-effectiveness - were commented on in nearly half of evaluations (45%, 23/51), but were too heterogeneous for analysis. For example: acute chlorine HWT interventions cost about US$1/day for a household with confirmed FCR in Nepal and Kenya (Lantagne and Clasen, 2012b) while a bottle of chlorine solution able to treat 1,000L cost about US$0.46 in Madagascar, but did not include promotion or indirect costs (Dunston et al., 2001). Additional examples of the complicated cost-effectiveness analysis include a project where costs were calculated without donated (gift-in-kind) hygiene kit values (Gauthier, 2014) and a different project where cash vouchers were

used in a special market day where beneficiaries could negotiate prices and select their own items (US$70 for 2,184 households) (Pennacchia et al., 2011). Overall, no cost-effectiveness studies were identified in the review and general economic outcomes were unclear if staffing, indirect costs, or headquarters costs were included.

Summary of evidence

Through this review, we identified breakages along the causal chain in each of the WASH interventions. All interventions evaluated could be 'efficacious,' with documented potential to have positive impact on WASH conditions; although some common WASH interventions in emergencies were not evaluated, including: well rehabilitation, water trucking, bucket chlorination, household spraying, handwashing, latrine building and environmental clean-up. Cost-effectiveness is lacking for all interventions. Household spraying was assumed to not be efficacious. Well and jerrican disinfection were evaluated without beneficiary involvement, thus the 'effectiveness' – how well the intervention worked in the context – depended on how the intervention was carried out by the responding agency in the particular context. The effectiveness of the remaining interventions was influenced by beneficiary factors such as: taste/smell, their knowledge of use, and how the intervention was implemented.

Summaries of findings and assessment of evidence are presented in Table 10 and Table 11. Overall, the quality of evidence is low; this was attributed to weak study designs that lacked control groups and had high likelihood of spillover effects. As can be seen in Figure 14, well disinfection, 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. While most of these evaluations were poor quality with high bias, the strength of evidence comes from the consistency of reported outcomes and impacts.

Table 10: Water Intervention Summary of Evidence

Intervention	Number of Studies	Quality of Outcomes			Summary of Findings	Overall Evidence
		Health	Use	Non-health		
Well Disinfection	5	Not Assessed	Not Assessed	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	3	Not Assessed	Moderate	Moderate	Variation in reported, confirmed and effective use – context specific. Speaking with promoter and easy access to dispenser associated with use.	Moderate
HWT – Chlorine-based Products – Chlorine Tablets	6	Not Assessed	Moderate	Moderate	Low and wide range of reported and confirmed use with an outlier. Taste and smell consistently described as a barrier to use.	Moderate
HWT – Chlorine-based Products – Liquid Chlorine	4	Not Assessed	Low	Low	Low and wide range of reported and confirmed use. Links with development and sustainability, including prior exposure and free distribution identified as factors for success.	Low
HWT – Chlorine-based Products – Flocculant/ Disinfectants	3	Low	Low	Low	Use varied greatly – knowledge of use a factor. High potential health impact with high use.	Low
HWT – Other Products – Filtration, SODIS, Safe Storage and Boiling	6	Low	Very Low	Low	Limited number of interventions, but higher quality evaluation methods. Consistently used in endemic contexts with links to development. Consistently reduced disease risks.	Low

Table 11: Sanitation, Hygiene and WASH Package Intervention Summary of Evidence

Intervention	Number of Studies	Quality of Outcomes			Summary of Findings	Overall Evidence
		Health	Use	Non-health		
Community-driven Sanitation – CLTS/PHAST	2	Low	Not Assessed	Low	Limited number of interventions, but strong positive health and social aspects from community-led interventions.	Low
Hygiene Promotion	8	Low	Very low	Low	Consistently, personal communication and radio are preferred and trusted by the community Use and health reportedly improved	Low
Social Mobilization	6	Low	-	Low	Limited assessments but anecdotal health impact Community trust and ownership important factors	Low
Hygiene Kit Distribution	8	Not Assessed	Not Assessed	Low	Consistent factor of influence through materials, quantity, timeliness. Low quality evaluations, HWT primary investigation of hygiene kits.	Low
Environmental hygiene	4	Very low	Very low	Low	With weak evaluations, jerrican disinfection consistently reported to reduced disease transmission risk and chlorine concentration monitoring was necessary. Household consistently spraying not recommended for responders.	Very low
WASH Package	12	Very low	Not Assessed	Low	Weak evaluations had consistent anecdotal descriptions of disease reductions, behavior adjustments and psychosocial support; staffing and timing also important factors.	Low

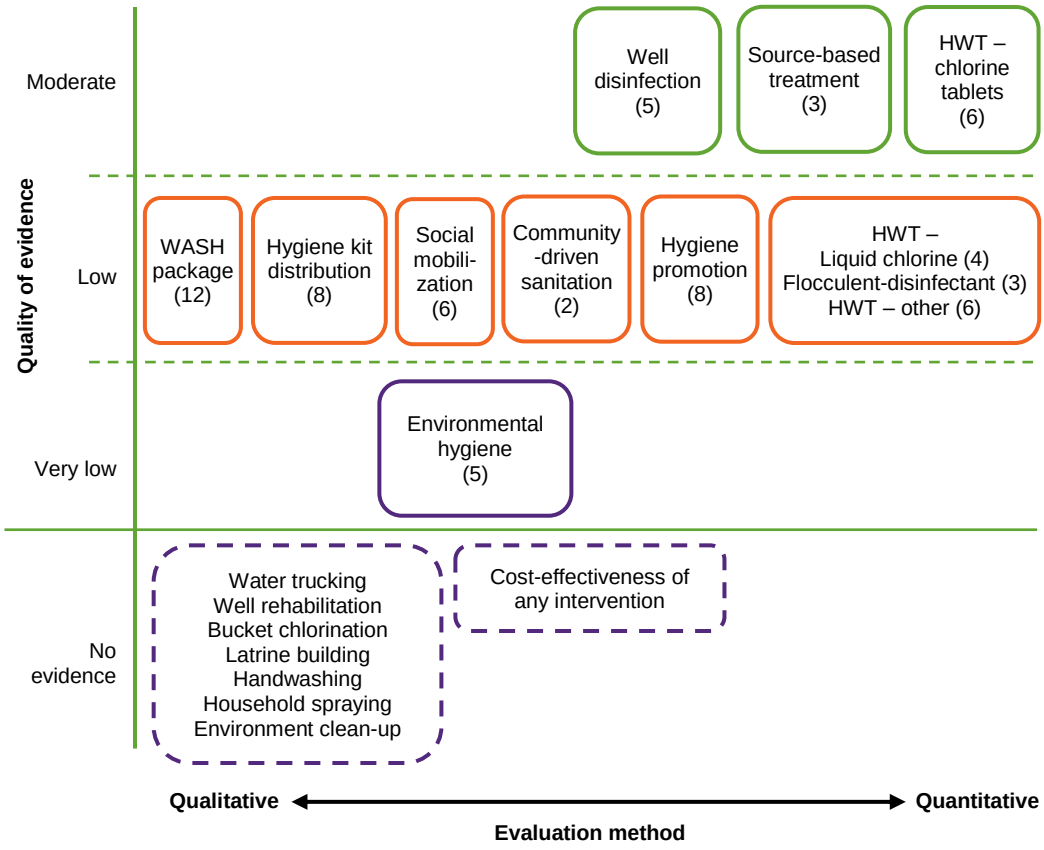

Figure 14: Evidence Map

Results by Objective

Objective #1: *Health impacts of WASH interventions in disease outbreaks*

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 were 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 community-led total sanitation (CLTS) intervention implemented before and during the Ebola outbreak had a large and significant reduction in disease risk (Meyer Capps and Njiru, 2015).

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

WASH interventions consistently reduced both the risk of disease and the risk of transmission in outbreak contexts; however, program design and beneficiary preferences were important considerations to ensure WASH interventions reach their potential.

Objective #2 *Important WASH program design and implementation characteristics*

Four program design and implementation characteristics were consistently reported as positive program characteristics identified through a mixture of research designs and across risk of bias assessments, including: simple interventions that were appropriately timed, community-driven and had linkages between relief and development. Some of the most basic interventions, such as: simple cloth filters, nylon screen, safe storage

with a jerrycan or bucket, or hygiene kit provision, had a clear positive impact (Roberts et al., 2001, Colwell et al., 2003, Huq et al., 2010, Gartley et al., 2013). These interventions required little to no promotion and led to incremental improvements that reduced the risk of disease. 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, 2012b). Engagement in the community empowers and builds trust and community-driven interventions can increase awareness, trigger behavior change and identify local solutions (Waterkeyn et al., 2005, Neseni and Guzha, 2009, Rees-Gildea, 2013, Meyer Capps and Njiru, 2015, ACF, 2015a, Wall and Chéry, 2011). Linking with pre-existing programming builds upon recipient population familiarity and having a sustainability plan encourages better cultural understanding and improves emergency response programs (Meyer Capps and Njiru, 2015, Dunston et al., 2001, Tokplo, 2015, Imanishi et al., 2014, Lantagne and Clasen, 2012b, WHO, No Date).

Objective #3: *Cost-effectiveness of WASH interventions in emergency outbreak situations*

Cost-effectiveness of WASH interventions in outbreaks were not able to be assessed as there were only minimal, and disparate economic outcomes in the evaluations identified in the review.

Objective #4: *Population-related barriers and facilitators that affect WASH interventions in disease outbreaks*

In the review, four community perceptions and preferences that consistently affected the success of WASH outbreak interventions were identified across the mixture of evaluation methods and risk of bias assessments: taste and smell, communication methods, inaccurate perception of efficacy and trust/fear. Taste and smell of HWT products may hinder use (e.g. chlorine treatments can have an off-putting smell or taste) (ACF, 2009, Lantagne and Clasen, 2012b, Imanishi et al., 2014, Ruiz-Roman, 2009) or facilitate use (e.g. filters and flocculent disinfectants improved taste) (Doocy and Burnham, 2006, Colwell et al., 2003, Huq et al., 2010). Radio and face-to-face communication were consistently reported as 'most trusted' or 'most valued' for hygiene communication (Einarsdbttir et al., 2001, Date et al., 2013, WHO, No Date, Contzen and Mosler, 2013, Matemo, 2014, Williams et al., 2015, Wall and Chéry, 2011). Community understanding of some interventions overestimated the effectiveness and risk reduction (i.e. household spraying and well disinfection) (Grayel, 2011, Rowe et al., 1998). Social mobilization and open communication between the community and NGOs built trust and greater community cohesion (Wall and Chéry, 2011, Waterkeyn et al., 2005, ACF, 2015a).

4.5 Discussion

To determine the efficacy and effectiveness of WASH interventions in disease outbreaks, we investigated: reductions in the risk of disease; critical program design and implementation characteristics; cost-effectiveness; and barriers and facilitators to WASH outbreak response. We found that WASH interventions consistently reduced both the risk of disease and the risk of transmission in outbreak contexts; however, program design and beneficiary preferences were important considerations to ensure

WASH intervention effectiveness in the specific emergency response context reached their potential efficacy. Critical program design and implementation characteristics included simple interventions that were appropriately timed, community driven and had linkages between relief and development. Economic outcomes of WASH interventions in outbreaks were not able to be assessed. Barriers and facilitators to WASH interventions in outbreak response were taste and smell, communication methods, inaccurate perception of efficacy and trust/fear.

Previous systematic review efforts reported only on health impacts (Ramesh et al., 2015), have been limited by the narrower scope (Taylor et al., 2015, Ramesh et al., 2015) and therefore few lessons learned were reported. Our inclusion criteria permitted a greater quantity of lower quality less technical studies than is traditional to systematic reviews. This led to disparate outcomes and impacts that were not possible to directly compare thus precluding meta-analysis, but increased the foundational knowledge and synthesized current information.

In conducting the review, it was more difficult than expected to: assess whether the WASH intervention was in the same geographic location as the outbreak; compare interventions conducted at different times in the outbreak; clearly suggest impact without suitable control groups to compare; and search and extract information from grey literature. 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.

4.5.1 Recommendations

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, water trucking, bucket chlorination, household spraying, handwashing, latrine building, environmental clean-up and formal economic analysis. Additionally, there was disparity between what was researched and published in the literature and what was implemented by responders and written up as grey literature; as water treatment interventions were most commonly researched and published by academics and WASH Package interventions were commonly implemented and reported for a narrow audience by responders. While we need more research on specific WASH interventions that are under-researched, it is anticipated that the implementation and non-health factors identified in the review would remain critical, especially for more complex WASH interventions.

To improve the evidence on WASH interventions in emergencies, clear reporting with consistent evaluation methods and common and robust methods is needed. Well-designed non-experimental and qualitative studies can be used to increase the evidence base. Additionally, evaluations should be conducted at the beneficiary level, to better understand rather than presume the impact. Publishing results, while not necessary, does offer transparency and an additional sharing platform for the humanitarian community.

4.5.2 Limitations

There were several limitations to this research. Most organizations that submitted documents to the review provided only a select handful of reports, and it is likely that

the provided reports were limited to those with favorable outcomes or innovative approaches. Self-reported data (such as diarrheal disease incidence or use of HWT products) was subject to both recall and courtesy bias, which would likely over-estimate positive outcomes. FCR, diarrhea incidence and prevalence and *E. coli* microbiological results are proxies for the outcomes and impacts of disease outbreaks. Outcomes were reported inconsistently. For example, confirmed use of a HWT intervention was the clearest outcome measured (using FCR); however, reporting thresholds varied by: 'detectable,' >0.0mg/L, >0.1mg/L, ≥0.2mg/L and ≥0.5mg/L which precluded comparative analysis. Furthermore, database searching was completed primarily in English, keywords searched may not have captured all relevant studies with variations of intervention names or names in local languages. There was difficulty in securing non-published studies from known responding agencies, likely influencing the results. And lastly, only WASH interventions implemented in outbreak settings were included, likely excluding interventions derived from other sectors or development approaches.

4.6 Conclusion

A systematic review process was used to identify more than 15,000 documents; ultimately, 51 evaluations of WASH interventions in outbreaks were included in the review. We found that WASH interventions consistently reduced both the risk of disease and the risk of transmission in outbreak contexts; however, program design and beneficiary preferences were important considerations to ensure WASH intervention effectiveness in the specific emergency response context reached their potential efficacy. Some of the most commonly implemented WASH interventions in outbreaks were found to be severely under-researched, and further research investigating

outcomes and impacts of specific interventions is recommended. It is recommended that responders implement efficacious, simple interventions that are appropriately timed, community driven and have linkages between relief and development in collaboration with the recipient communities to address barriers and facilitators to use.

4.7 Acknowledgements

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4.8 Citation

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Chapter 5: Efficacy and Effectiveness of Water, Sanitation, and Hygiene Interventions in Emergencies in Low and Middle-income Countries: A Systematic Review

5.1 Abstract

There are increasing numbers of people affected by natural disasters, disease outbreaks and conflict. Water, sanitation, and hygiene (WASH) interventions are used in nearly all emergency responses to help reduce disease risk by providing safe water, reducing open defecation and promoting good hygiene practices. However, there is a lack of summarized evidence on the efficacy and effectiveness of these interventions. We conducted a systematic review of the published and grey literature on the efficacy and effectiveness of short-term WASH interventions in emergency response in low- and middle income countries, including: developing theory of change models; setting inclusion criteria; conducting the search; selecting evaluations for inclusion; assessing the quality of the evidence and analyzing the included evaluations. Overall, 15,026 documents were identified and 106 studies describing 114 evaluations met inclusion criteria. Interventions from 39 countries were included. Most included evaluations (77%) were high risk of bias and half were from grey literature (50%). We found that WASH interventions consistently reduced both the risk of disease and risk of transmission in emergency contexts; however, program design and beneficiary preferences were important considerations to ensure WASH intervention efficacy and effectiveness. Critical program design characteristics included simple interventions that were appropriate timed, community driven, and had linkages between relief and development. Barriers and facilitators to WASH interventions in outbreak response were taste and smell, communication methods, inaccurate perception of efficacy and trust/fear. Research on commonly implemented but severely under-researched WASH interventions is needed. It is recommended responders implement efficacious, simple interventions that are appropriately timed, community driven, have linkages between

relief, and development in collaboration with the recipient communities to address barriers and facilitators to use.

5.2 Introduction

Emergencies – including natural disasters, conflict, and disease outbreaks – are occurring at increasing rates and affecting an increasing number of people. Natural disasters (i.e. earthquakes, hurricanes, flooding events, disease outbreaks or droughts) affect more than 200 million people annually (EM-DAT, 2014). Climate change is expected to increase the scale and frequency of natural disasters, while the rapidly increasing urban and slum populations in disaster prone regions are expected to increase the number of people impacted by natural disasters (Walker et al., 2012). Currently, more than 1.5 billion people are potentially threatened by conflict and violence (Institute for Economics and Peace, 2014, IISS, 2015). In 2015, there were more than 60 million displaced persons worldwide, the highest number ever recorded (UNHCR, 2015). Lastly, disease outbreaks have increased in number and diversity (Smith et al., 2014). Between 1980 and 2013, there were 12,102 outbreaks in 219 nations impacting more than 44 million people. These increases are attributed to microbial adaption of pathogens, changing human susceptibility, climate change, changing human demographics, economic development, breakdowns in public health, poverty, social inequality, war, and famine.

With a growing number of people at risk, evidence-based strategies to provide interventions to affected populations are needed to prevent and control waterborne diseases, diseases transmitted through the fecal-oral route and diseases transmitted by direct contact (Sphere Project, 2011, 2014, Watson et al., 2007, Darcy et al., 2013a,

Parkinson, 2009, Connolly et al., 2004, Toole, 1995, Toole, 1996). According to the *Humanitarian Charter and Minimum Standards in Humanitarian Response:*

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

Emergency WASH interventions should provide access to safe water and sanitation and promote good hygiene practices with dignity, comfort and security (Sphere Project, 2011). WASH interventions in emergency situations are not necessarily intended to provide long-term sustainable access, but instead provide rapid relief. The overall aim of all emergency WASH interventions is to promote safe practices that reduce preventable waterborne and communicable diseases (Sphere Project, 2011). WASH interventions can prevent and control waterborne diseases, diseases transmitted through the fecal-oral route and diseases transmitted by direct contact (Sphere Project, 2011, 2014, Watson et al., 2007) (Figure 15). *Water* interventions aim to increase water quantity and/or improve water quality; *sanitation* interventions aim to isolate feces from the environment; *hygiene* interventions aim to prevent transmission through hands, and more broadly, promote awareness among affected populations on the disease and equip these populations to act; and *environmental hygiene* interventions reduce risks by disinfecting household objects and managing rubbish.

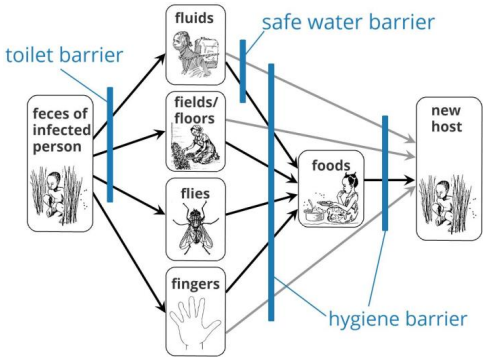


Figure 15: F-Diagram (Water 1st International, 2015)

WASH interventions are commonly implemented as part of outbreak response activities by United Nations (UN) agencies, local governments, and emergency responders. WASH interventions currently used in emergency response may be known to be efficacious and effective, but were only evaluated in development contexts (Darcy et al., 2013; Parkinson, 2009). There is currently little evidence on the efficacy and effectiveness in emergency situations in low and middle-income countries (LMIC) (Blanchet et al., 2013, Ramesh et al., 2015, Brown et al., 2012, Taylor et al., 2015). The weak evidence base in emergencies is attributed to two factors: 1) prioritizing rapid response activities over research; and 2) acknowledging the difficulty of conducting research in the rapidly changing and unstable settings of emergencies (Spiegel et al., 2007). Responders also note that there is a lack of technical knowledge related to data collection, lack of personnel to collect data and lack of clear goals for how to use the information (Vujcic et al., 2015).

In the absence of evidence, responders often default to familiar interventions using "intuition" and "if it worked before it will work again" (Darcy et al., 2013b, Loo et al., 2012, Steele and Clarke, 2008). As the efficacy and effectiveness of WASH interventions depends on contextual factors unique to each emergency (Bastable & Russell, 2013; Loo

et al., 2012; Parkinson, 2009), contextually appropriate information on WASH intervention effectiveness may provide more relevant and effective guidance for responders and lead to better WASH interventions in emergencies.

In 2015, a systematic review on the efficacy of WASH interventions for cholera response (Taylor et al. 2015) and another on the health impact of WASH interventions in emergencies (Ramesh et al. 2015) concluded there is a lack of data to establish firm evidence for implementing WASH interventions in outbreaks and emergencies. As Taylor et al. (2015) only included published studies of a certain quality and Ramesh et al. (2015) only included manuscripts documenting health impacts, neither review included all available information sources or full scope of evaluation methods and outcomes available in emergency contexts. Ideally, a synthesis of evidence would include both published and grey literature, as well as quantitative and qualitative information on outcomes, impacts and influencing contextual factors that contribute to program effectiveness and efficacy in order to fully encompass the evidence base (Brown et al., 2012).

5.2.1 Objectives

The objective of this review was to assess the outcomes and impacts of short-term emergency WASH interventions in LMIC, including both published and grey literature, with the aim of including a broader set of contextual factors that may shape intervention effectiveness. We specifically intended to address five research questions in WASH interventions during emergency response, including:

1. What are the effects of use in emergency WASH situations?
2. What are the health-related outcomes in emergency WASH situations?

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

5.3 Methods

To address these research questions, we conducted a systematic review of published and grey literature, including development of: 1) theory of change models; 2) search strategy; 3) inclusion criteria; 4) selection and processing strategy; 5) quality of evidence appraisal; and 6) analysis plan. Please note the full systematic review protocol was peer-reviewed and made publicly available before conducting the review (Yates et al., 2015b). Each step of the systematic review process is summarized below.

Theory of Change Model Development. A theory of change model was developed for each WASH intervention to describe the theoretical route from intervention activities to outputs, outcomes, and impacts, while also identifying influencing factors and assumptions (Figure 16). We developed a model for each of the eight WASH activities we anticipated seeing in the review: increasing access to water, source-based water treatment, household water treatment (HWT), temporary or permanent latrines, latrine alternatives, hygiene promotion (including handwashing), distribution of soap and/or hygiene materials/kits and environmental hygiene.

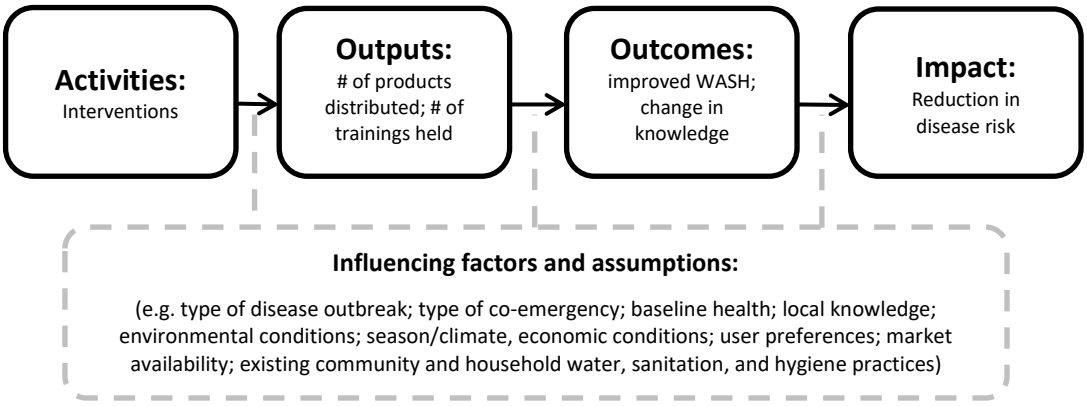


Figure 16: Theory of Change Template Adapted from (WHO, 2014)

5.3.1 Search Strategy

A search strategy was developed to identify published and unpublished grey literature. Individualized search terms and strings were developed for each of the eight WASH interventions from their associated theory of change, and included keywords and outcome and impact measures specific to that intervention. The search strings were used in a total of nine peer-reviewed databases and 10 searches, 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. Searching took place in November and December 2015, and was re-run in September 2016. Six journals identified as most likely to have relevant research and reference lists of included evaluations and reviews identified in the searchers were screened by hand. Responder websites were also searched with keywords, including: non-governmental organizations (NGO), UN and other relevant websites.

Additionally, solicitation for relevant documents was carried out through email and personal contacts. Requests for information were sent to the international community

via the Global WASH Cluster in September 2015 and February 2016, and to the International Network on Household Water Treatment and Safe Storage in September 2015. Overall, more than 75 organizations were contacted through email. Lastly, personal solicitations, online posts and international conferences were also used to collect relevant information.

5.3.2 Inclusion Criteria

Inclusion criteria were established according to the populations, interventions, comparisons, outcomes and study types (PICOS) framework (Yates et al., 2015a).

Populations. All age, gender, and socioeconomic populations in World Bank defined LMIC were eligible for inclusion. Populations must also have been affected by an emergency. For this analysis, an 'emergency' was defined as an event affecting a specific population that requires national or international assistance because local capacity is overwhelmed (UNISDR, 2007). For natural disasters, conflict or outbreaks, factors used to help define an emergency included: a United Nations Disaster and Coordination response, international funding appeal, population displacement or acute events in chronic emergencies. An outbreak was defined in accordance with WHO definitions (WHO, 2016b) and were limited to communicable diseases for which WASH interventions can break known transmission routes, specifically: cholera, Ebola, Hepatitis E, Hepatitis A, typhoid fever, acute watery diarrhea, and bacillary dysentery (shigellosis).

Interventions. A WASH intervention was eligible for review if it targeted an emergency-affected population and was carried out within 12 months of the start of the

emergency. Interventions must have been field-based. Laboratory research and health focused interventions (i.e. clinic or hospital interventions) were excluded.

Comparisons. No specific comparisons were required for inclusion.

Outcomes. Evaluations were included if at least one intermediate outcome (use of service or non-health outcome) or final impact (disease reduction or cost-effectiveness) were reported. Use of service includes three specific indicators: self-reported use, confirmed use and effective use. Self-reported use is beneficiary reported use without additional verification. Confirmed use is when an evaluator tests or observes the use or service in some way (i.e. testing free chlorine residual (FCR) in chlorine-based water treatment programs). Effective use is a measure of improving quality of contaminated water requiring confirmed use and microbiological testing. Cost-effectiveness included economic analyses investigating cost-benefit, cost-utility, cost per beneficiary and cost per disability adjusted life-year averted. Disease reduction data were included if beneficiary morbidity and mortality impact were self-reported or clinically measured. Non-health outcomes 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 were included.

Study Types. Experimental, quasi-experimental, non-experimental, mixed-methods, and qualitative methodological study type designs were eligible for review.

Dates for inclusion were 1995-2016. Both peer-reviewed and unpublished grey literature documents were eligible. Personal blogs, diaries, newspapers articles, magazine articles, website postings, poster abstracts, and legal proceedings/court

documents were not included. Review documents were not included, but individual references in review documents were screened for inclusion.

5.3.3 Selection and Processing

Identified studies were screened first by titles, then by abstracts, and full texts. From abstract to final inclusion, studies were independently double screened by two of the authors. Any discrepancies were discussed with a third author for 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 was completed with a detailed coding sheet using Microsoft Excel 2010, and included author and publication details, type of intervention, context of the intervention, study design, study quality, effect estimation, outcomes and impacts and barriers and facilitators to implementation. Data collection was completed and double screened by four research assistants.

5.3.4 Quality of Evidence

Each included evaluation was assessed for the potential risk of bias. For quantitative studies, the bias assessment tool was 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; spillover effects and contamination; incomplete outcome; selective reporting; and other risks of bias. For qualitative studies, four appraisal categories were adapted from Spencer et al., (2003) (Spencer et al., 2003): design; bias; data collection; and clarity of findings. Each category was scored as 'low risk,' 'high risk' or 'unclear.' The summary risk

of bias for a study was based on the number of 'low risk' assessments across the four or five categories depending on research design.

To establish the summary quality of evidence from multiple studies of varying qualities and study designs for each WASH intervention, a protocol was developed based on the Grading of Recommendations Assessment, Development and Evaluation (GRADE) of evidence outlined in Cochrane Review Standards (Higgins and Green, 2011) but modified to have less emphasis on RCTs (as it was not expected the search would return many RCTs). The baseline was determined by the study designs in the intervention; then downgraded or upgraded considering biases, effect size, consistency, and generalizability. The summary of evidence was then described through four categories, which mimic GRADE (Oxman and GRADE Working Group, 2004): *high evidence* is defined as further research is very unlikely to change confidence in the estimate of effect or accuracy; *moderate evidence* as further research is likely to have an important impact on confidence in the estimate of effect or accuracy and may change the estimate; *low evidence* as further research is very likely to change the estimate; and *very low evidence* as any estimate of effect or accuracy is very uncertain.

5.3.5 Analysis Plan

Considerations for missing data and meta-analysis techniques were 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 were not utilized. Procedures to address unit of analysis issues, independent findings, economic synthesis, use of weighted average, pooled effect, forest plots and funnel plots were described in the protocol but not further described herein because

they were not used. Formal heterogeneity analysis with I^2 could not be completed, as reported outcomes were too different for direct comparison.

A narrative synthesis approach is used to summarize the information gathered. A summary of all included evaluations is first presented with descriptions of emergencies by country, intervention type, published or grey literature, risk of bias assessment and evaluation methodology. Then, for each WASH intervention, a description of the intervention is presented, followed by information on the number of studies identified, risk of bias, outcomes and impacts and summary of evidence. Results were then summarized in general tables and a summary map of evidence. Lastly, results were stratified by objective. Please note that the original eight WASH intervention categories remained within the original scope, but were adjusted to 13 more detailed categories based on evaluations identified in the review, including: saltwater pumping, well disinfection, large and small scale source-based treatment, HWT with chlorine-based products, HWT with filters, HWT with other options, latrines, latrine alternatives, hygiene promotion including social mobilization, hygiene kit distribution, environmental hygiene and WASH Package (a term for when multiple interventions were delivered in the same response). Please also note, for space considerations, interventions with less than three evaluations are not described individually herein. We refer the reader to the full report for interventions with very few evaluations (Yates et al., 2017).

5.4 Results

Overall, 15,026 documents were identified in the systematic review process. After applying the three selection filters, 106 studies were included, describing evaluations of 114 relevant contexts (Figure 17). Each included study is detailed in Appendix 3.

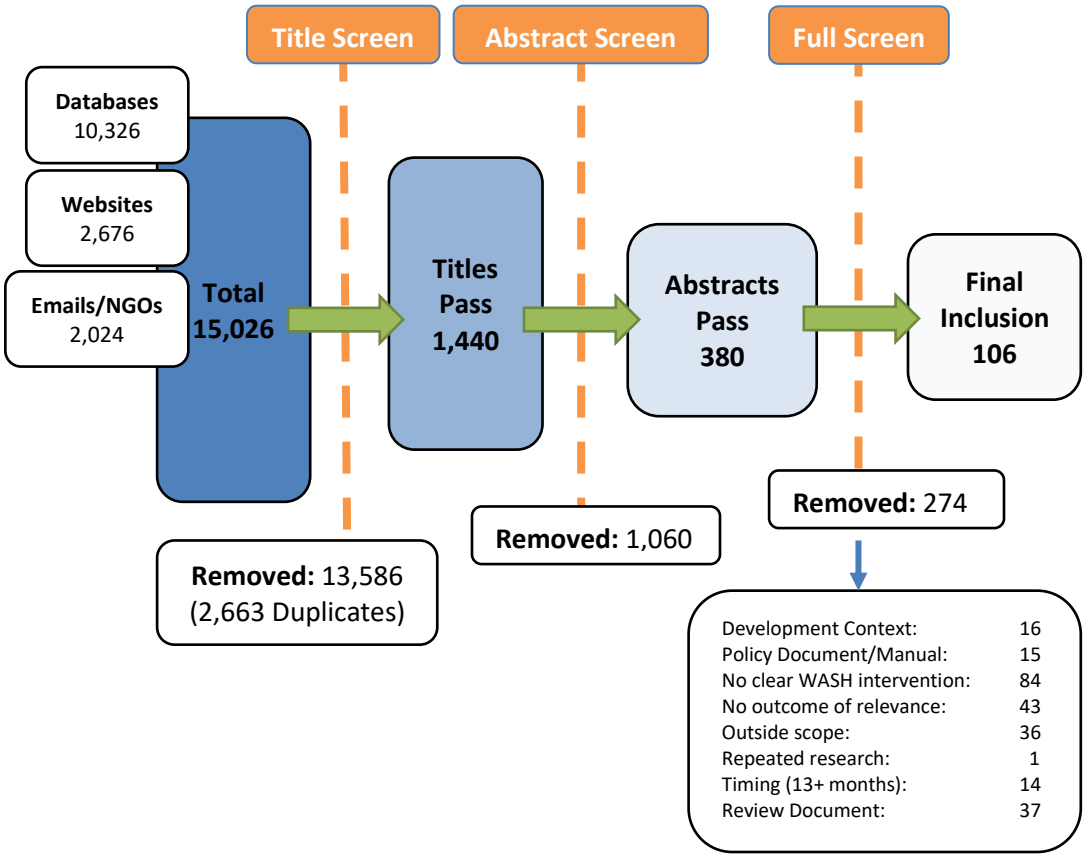


Figure 17: Screening Process

The included evaluations describe WASH interventions in 39 countries, with the highest frequency of evaluations from Zimbabwe and Haiti. Africa was the most common World Bank Region (43%), while South Asia (24%), and Latin America and the Caribbean (21%) were also strongly represented. Water interventions represented the most included evaluations (n=47, 41%), followed by hygiene (n=27, 24%) and WASH Package (n=24, 21%); sanitation interventions were least represented (n=16, 14%).

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

more grey literature evaluations. Half of the evaluations (57/114) were published or documented between 2010 and 2015, and 85% (97/114) were within the last 10 years. The high proportion of documents in the last decade coincides with several major emergencies, including the Southeast Asian Tsunami in 2004; cholera outbreaks in Zimbabwe and Haiti in 2008 and 2010; the earthquake in Haiti in 2010; flooding in Pakistan in 2010; and typhoons in the Philippines and Bangladesh in 2013 and 2008.

The majority of the evaluations (77%, 82/106) had a high risk of bias (Figure 18). The quantitative evaluations were mostly completed on water interventions, which were also more likely to be published and had less risk of bias. For example, published water evaluations were 23% low risk of bias (7/30), while only 3% of the other WASH intervention evaluations had a low risk (2/76). Conversely, nearly all (96%, 23/24) of the WASH Package evaluations were field commentary or qualitative evaluations, all were unpublished and most were high risk of bias evaluations (83%, 20/24). The study designs of included evaluations were weak, as only 9% (10/106) of studies had any type of control group and less than 4% (4/106) were RCTs. Diversity of outcomes were also weak, with measured health impacts in only 8% (9/106) of the interventions.

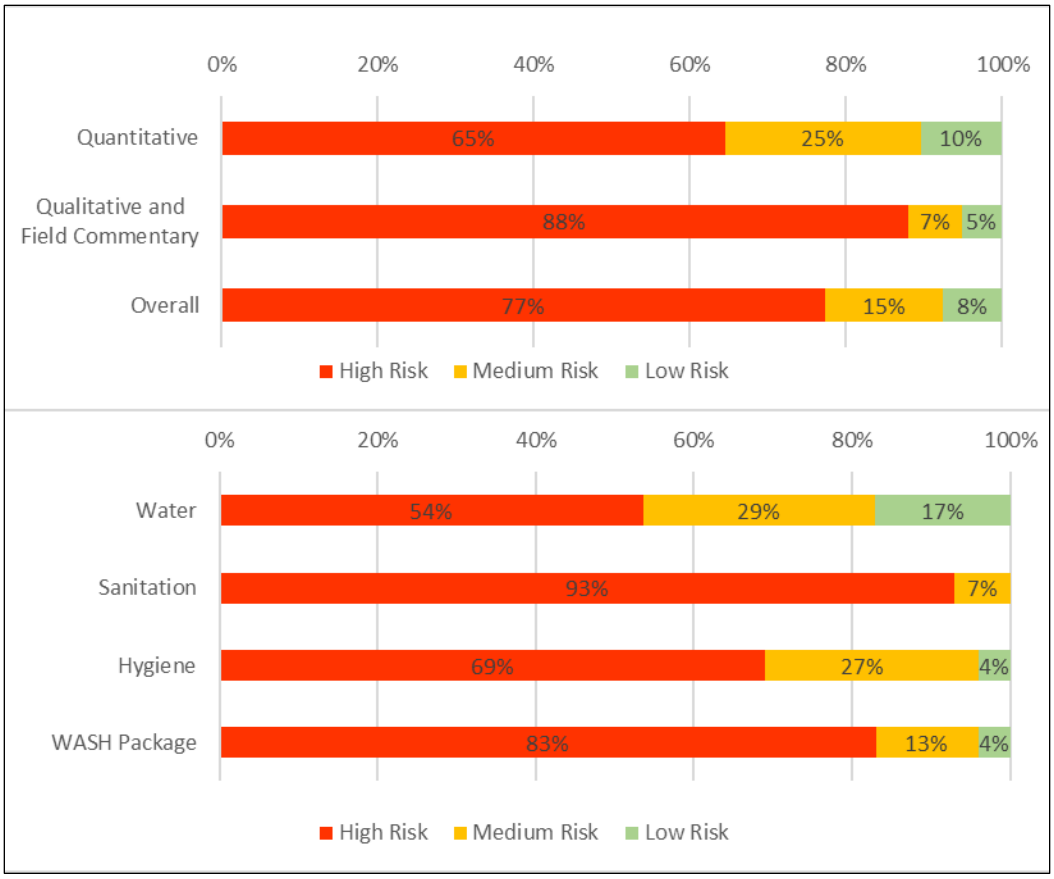


Figure 18: Risk of Bias by Evaluation Method and Sector

Results by Intervention

Below evaluations are presented in the main categories of water, sanitation, hygiene, and WASH Package. All identified interventions are summarized in Table 12 and

Table *13* with descriptions of all included evaluations in the supplemental information; also, the full report is available from the International Initiative for Impact Evaluation (3ie) website, www.3ieimpact.org.

Water. Water interventions were separated into three general intervention types with seven specific interventions, including: water point rehabilitation (saltwater pumping and well disinfection), source-based treatment (large and small-scale) and HWT (chlorine-based treatments, filters, and other less-common methods). Of these seven

specific interventions, five had more than three evaluations, including: saltwater pumping, well disinfection, small-scale source treatment, chlorine-based HWT, and HWT with filters.

5.4.1 Saltwater Pumping

Pumping and cleaning a well to physically remove silt, sand and debris is a common activity after a flood or tsunami. Pumping wells flooded with seawater is expected to reduce the impact of saltwater intrusion (as measured by salinity or conductivity) and speed the recovery of the well to return to normal operation. Six evaluations of well pumping were identified with low (4) and high (2) risk of bias. All evaluations were after the 2004 Southeast Asian tsunami, in similar porous and sandy soil types. All evaluations concluded that pumping wells had, at best, no effect and recommended using alternative water sources until salinity levels naturally decrease - instead of pumping. A facilitating factor was the communities perceived that saltwater pumping was necessary to safely rehabilitate the well, although over-estimated the impact (Saltori and Giusti, Villholth, 2007, Lipscombe, 2007). A barrier that communities did not like the taste of the rehabilitated well water and preferred deliveries of trucked water despite irregular supply and low quantity of trucked water, complicating the transition to recovery phase (Villholth, 2007, Lipscombe, 2007).

5.4.2 Well Disinfection

A common emergency response intervention is to directly disinfect a contaminated well with chlorine. The objectives of well disinfection are to reduce microbiological contamination and/or maintain FCR in the well. Six evaluations of low (3) and high (3) risk of bias were identified that described four slightly different approaches to well

disinfection with chlorine from six different countries (note two evaluations used multiple methods): 1) a shock dose of liquid chlorine (bleach) added directly to the well; 2) pot chlorination where powdered chlorine, sand and gravel in a pierced container/jerrican was inserted into the well; 3) pot chlorination with locally pressed chlorine tablets in a perforated container; and 4) floating pot chlorinator (commercial plastic devices used in swimming pools). Shock chlorination is a one-time activity to simply disinfect, whereas, the three pot chlorinator methods were intended to slowly disperse chlorine over time and maintain consistent FCR. Ideally, the FCR 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 (CDC SWS Project).

One-time shock chlorination did not provide FCR protection for more than a few hours and did not reduce microbiological contamination (Rowe et al., 1998, Luby et al., 2006). Traditional pot chlorination inconsistently maintained measurable FCR for 1-4 days (Libessart and Hammache, 2000, Garandeau et al., 2006, Guevart et al., 2008, Cavallaro et al., 2011). Floating pot chlorinators could be effective, but could only be imported and required specialized tablets (Garandeau et al., 2006). In comparative evaluations, although with inconsistent methods, pressed HTH tablets with a pot chlorination approach maintained FCR for 3-4 days and were the preferred mode of well disinfection by responders (Libessart and Hammache, 2000, Garandeau et al., 2006). Microbiological impact of treatments was assessed in only one evaluation and did not have impact (Luby et al., 2006). Communication with community members was an important programmatic consideration identified, as well disinfection interventions were: often

perceived to maintain FCR for longer than it was maintained; or communities unnecessarily doubled the chlorine dose by also treating water at home.

Source-based Treatment

Source-based treatment interventions occur at the source or point of collection. Large-scale water treatment was considered the treatment of more than 200L (0.2 m^3) of water with systems operated and managed by responders (as opposed to beneficiaries). Small-scale source treatment is water treatment that occurs at the source, by the beneficiary.

5.4.3 Large-scale Source Water Treatment

Large-scale source water treatment included three types of interventions, including: bulk water treatment (BWT), decentralized BWT and water trucking. BWT mimics traditional municipal or city water treatment processes and requires well-trained staff. BWT typically involves chemical treatments to reduce turbidity and chlorine disinfection using large semi-permanent storage vessels (e.g. 45 m^3) or mobile bladders (e.g. 5-20 m^3) and could also include a piped distribution network. With water trucking (or water tankering), water is transported from a distant source to the affected population using a large truck or lorry and is often treated with chlorine. Water trucking usually has high costs with limited capacity, thus it is often a temporary solution used in acute situations until other water sources are available. Large-scale source treatment interventions had less than three interventions, thus specific results are not included herein. Overall, BWT and water trucking are well-known interventions, with established methods in emergencies; however, the interventions are not often evaluated, particularly at the beneficiary level.

5.4.4 Small-scale Source Water Treatment

Small-scale source water treatment included two types of interventions, including: chlorine Dispensers and bucket chlorination.

Dispensers. A chlorine 'Dispenser' program 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. Dispensers were used in three different cholera contexts presented in one low bias manuscript in: Haiti, Sierra Leone, and Democratic Republic of Congo (DRC) with three different responding organizations; one additional context was carried out in a non-acute emergency in Senegal (Yates et al., 2015c). Results varied over two acute evaluations (2–8 weeks after installation) and three sustained evaluations (4–7 months after installation) for reported use (26-75% acute, 31-75% sustained), confirmed use (11-34% acute, 5-18% sustained) and effective use (10-28% acute, 0-10% sustained) metrics. 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% of households in Haiti reported using chlorine tablets as an alternative treatment. With regression analysis of household survey data, factors consistently associated with higher use across contexts in were: speaking to the promoter within the last month; and collecting water from a source with a Dispenser. The three implementing organizations gathered at project end and reflected on factors leading to success. These included: appropriate source selection; chlorine solution quality and supply chain; Dispenser hardware installation and maintenance; integration into a larger WASH program; promoter recruitment and remuneration; experienced

program staff; partnering with local organizations; conducting ongoing monitoring; and having a sustainability plan.

Bucket chlorination. Bucket chlorination is a common emergency response intervention where a person is stationed near a water source and adds a dose of chlorine directly into the recipients' water collection container. No evaluations of bucket chlorination were identified in the review; however, bucket chlorination was mentioned twice as an activity in the included evaluations (Grayel, 2011, Neseni and Guzha, 2009).

Household Water Treatment

HWT products (also called point-of-use water treatment products) are interventions used in the home to improve 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, which may also include hygiene promotion. HWT was the most studied intervention with 39 evaluations with a mixture of high, medium, and low risk of bias. For analysis, HWT interventions were separated by: chlorine-based products (chlorine tablets, liquid chlorine, combined flocculant/disinfectants), filters (ceramic, hollow-fiber, sand) and other products (solar disinfection (SODIS), coagulants, safe storage and boiling).

5.4.5 HWT – Chlorine-based Products

The most common HWT products distributed in emergencies were chlorine products, because they effectively inactivate most bacterial and viral pathogens, lead to residual protection, are low cost and easy to use and transport (Lantagne and Clasen, 2012a). Chlorine-based HWT products were separated into three sub-categories: chlorine tablets, liquid chlorine, and flocculant/disinfectants.

Chlorine Tablets. Sodium dichloroisocyanurate chlorine tables (e.g. Aquatabs®), were evaluated in 12 contexts; half (6) were low risk of bias, one (1) medium risk and five were high risk of bias. The distributed tablets (33–167mg) were freely distributed through hygiene kits and intended to treat 5–20L of water. The reported use ranged between 1-84% (n=9), while confirmed use ranged between 1-87% (n=11). Effective use ranged between 5-63% (n=4). The highest rates were reported in South Sudan and Haiti where 92% of households reported recent household promotion and 75-82% households knowing the correct use due to a long-running treated water campaign (ACF, 2014b, Lantagne and Clasen, 2013). The taste and smell of chlorine tablets was reported as a barrier to use in nearly half of the contexts (5/11) from three countries (ACF, 2009, Lantagne and Clasen, 2012b, Imanishi et al., 2014, Ruiz-Roman, 2009, Johnston, 2008). Overdosing may have led to strong smells/taste, as some beneficiaries did not have the appropriate water storage container for the tablet size distribution (Imanishi et al., 2014, ACF, 2009, Johnston, 2008, Varampath, 2008). Knowing a HWT method before the emergency and ease-of-use were indicators for use in Zimbabwe (Imanishi et al., 2014) and Nepal (Lantagne and Clasen, 2012b). Health impact was measured in one document after the typhoon/flooding in Bangladesh; a 55% diarrhea reduction was measured in children under five but was not statistically significant (RR 0.45, 95% CI 0.19-1.03) (Johnston, 2008).

Liquid Chlorine. Small bottles of 1-1.25% sodium hypochlorite (e.g. WaterGuard, sized so one cap treats 20L of water), and commercial bleach (where the dosage is generally in drops), were evaluated in nine contexts in six countries in four (4) high, two (2) medium and three (3) low risk of bias evaluations. Reported use ranged between 6-88%, and confirmed use ranged between 1-69%. Effective use was not measured. While not

definitive, some of the heterogeneity may be explained by the active promotion of liquid chlorine before the emergency in the two evaluations with higher usage 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 free distribution of the same product had much higher rates in the same region (Mong et al. 2001). Excessive dosing was observed in Madagascar (FCR >3.5 mg/L) (Mong et al., 2001) and taste was noted as a hindrance to use in Nepal and Philippines (Lantagne and Clasen, 2012b, Plan, 2013). Liquid chlorine was linked to long-term development approaches, including promotion (ACF, 2014c), cost-recovery and social marketing (Dunston et al., 2001), local production (Date et al., 2013), and vouchers (ACF, 2014c), as liquid chlorine is regularly used in development situations, and responses can scale-up existing ongoing development interventions.. These development program linkages were not described in other HWT interventions.

Combination Flocculent/Disinfectants. Flocculent/disinfectant sachets (e.g., P&G Purifier of Water® 'PuR') are most often used to treat turbid water. Users add the contents of a sachet 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 was evaluated in seven contexts, two (2) low and five (5) high risk of bias. Reported use ranged between 6-83% (n=3) and confirmed use ranged between 4-95% (n=6). High use was reported with strong promotion and knowledge of how to use PuR (Doocy and Burnham, 2006, ACF, 2014b, Colindres et al., 2007). Low knowledge was reported in an NFI distribution with minimal promotion in Kenya, where only 2.3% of households could describe the five steps necessary for PuR translating to similarly low reported use of 6% and confirmed use of 4% (Lantagne and Clasen, 2012b). Community preference to taste and smell of PuR ranged widely, with two populations (Haiti and

Liberia) reporting liking the taste (Doocy and Burnham, 2006, Colindres et al., 2007) and two populations reporting not liking the taste or smell (Bangladesh and Vietnam) (Hoque and Khanam, 2007, Handzel and Bamrah, 2006). Similarly, PuR was diversely described as easy to use in one evaluation (Colindres et al., 2007), but also 'too time consuming' in another (Hoque and Khanam, 2007). When PuR was distributed together with Aquatabs, PuR was preferred by beneficiaries (Johnston, 2008, Hoque and Khanam, 2007). Health impact was reported in two evaluations, a randomized control trial for cholera in Liberia and typhoon response in Bangladesh. In Liberia, PuR use reduced diarrhea incidence by 67% (adjusted RR 0.33; 95% CI 0.30-0.37) (Doocy and Burnham, 2006), with similar results of 77% reduction in Bangladesh (RR 0.23; 95% CI 0.07-0.72) (Johnston, 2008).

5.4.6 HWT - Filters

HWT filter types include: ceramic, sand and hollow-fiber filters. These filters are generally effective at removing protozoa and bacteria, and some hollow-fiber filters can also remove viruses. Filters provide immediate water treatment that can also last into the recovery phase (3-9 months after the disaster) without additional distributions from responders. Six evaluations in five countries were identified in the review with two (2) low and four (4) high risk of bias evaluations. Reported filter use ranged from 53-100% (n=3) in the acute evaluations and 0-96% (n=7) in sustained evaluations 6-16 months after distribution. Effective use ranged from 8-20% (n=2) in the acute phase, and 0-28% in sustained evaluations. Factors impacting filter interventions, included: turbidity, filter capacity, and taste. Muddy, turbid source waters can quickly clog filters, reducing the flow rate and limiting the microbiological effectiveness (Clasen and Boisson, 2006). Also, the time needed to treat enough water for a household may not match beneficiary

needs or expectations (Cressey, 2015), but beneficiaries often reported improved taste with filter use (Clasen and Boisson, 2006, Ensink et al., 2015, Palmer, 2005).

5.4.7 HWT – Other Products

Other HWT interventions (non-chlorine or non-filter) were separated into four sub-categories: SODIS, coagulants, safe storage and boiling. Less than three interventions per category was identified for the other HWT interventions, thus specific results are not included herein. Other HWT were evaluated with higher quality evaluation methods with several RCTs measuring health impact, however, the evidence for each individual intervention is weak. In RCTs, self-reported cholera cases were 88% less likely in children under five with a SODIS intervention in Kenya ($p=0.014$) (Conroy et al., 2001) and safe storage interventions reduced diarrhea by 16% ($p<0.05$) in Liberia (Doocy and Burnham, 2006) and 8% ($p=0.06$) in Malawi (Roberts et al., 2001). Overall, these less common HWT interventions were consistently reported to be simple, sustainable and accepted by the communities.

Sanitation. The goal of sanitation programs in emergency response is to break disease transmission by isolating feces from the environment, either using output driven approaches (e.g. latrine construction or latrine alternatives) or community driven approaches (e.g. community led total sanitation (CLTS)). *Note: community driven approaches are described within Social Mobilization below.*

5.4.8 Latrines

Latrine construction was often carried out with water and/or hygiene interventions described in other sections of this manuscript; 12 evaluations were focused on provision

of latrines, 11 were high risk of bias and mostly field commentaries. Latrine use or impact was rarely evaluated, so analysis was limited to reporting common themes: acute disaster latrines, eco-sanitation (ecosan), rehabilitation of damaged latrines, vulnerability targeting and reduced disease burden. Acute disaster latrines were considered as interventions less than one week from disaster. In dense urban areas or places where digging is not feasible, portable toilets (e.g. porta-johns, porta-loos) were successful at providing safe dignified sanitation immediately after the Haiti earthquake, but requires thoughtful consideration for desludging and final sludge disposal (Eyrard, 2011b). Raised latrines were also temporary solutions used in Haiti and Bolivia, which included a cubicle structure placed over a barrel or tank operating similar to port-a-johns, but required less frequent desludging (Bastable and Lamb, 2012, Kinstedt, 2012). Simple 'shallow trench latrines' were trialed with success in the Pakistan flood response in 2010, constructed as a temporary solution with tarpaulin and timber/bamboo poles (Singh, 2012, Bastable and Lamb, 2012). Ecosan includes many latrine designs (e.g. urine diversion or composting toilets) but all focus on decomposition of waste, rather than desludging. Ecosan latrines were informally evaluated in nine countries after earthquakes, floods and camp settings (Bastable and Lamb, 2012, Mwase, 2006, Kinstedt, 2012), but was considered best suited for recovery or development phases. Rehabilitating latrines was a viable option after an earthquake in Iran and flood in China. Rehabilitating latrines was better suited than temporary latrines because materials were locally and immediately available, longer lasting and more culturally appropriate with similar costs to other options (Pinera et al., 2005, Lin et al., 2008). Specific consideration for women and vulnerable populations (i.e. handicapped, elderly, pregnant and children) were documented in South Sudan, India and Liberia (de Lange et al., 2014,

Moyenga and Rudge, 2011, Visser, 2012, Singh, 2009). Targeting was not found to be burdensome but led to more appropriate latrine designs (e.g. locking doors, handrails) with marginal additional costs. In South Sudan, female use of latrines was significantly higher ($p<0.001$) where women were specifically engaged in the latrine design process compared to another camp in the area without dedicated targeting (de Lange et al., 2014). Increasing latrine coverage was noted to impact disease rates in China and Nepal but sanitation interventions were carried out with other interventions simultaneously with unknown spillover effects (Lin et al., 2008, Puddifoot, 1995). Overall, while each context is unique, it was consistently found that beneficiaries will use latrines provided they are safe, clean and offer privacy.

5.4.9 Latrine Alternatives

Latrine alternative interventions (e.g. Peepoo® bags) include a supply of bags (often biodegradable), a safe private location (in the home or a community cubical) and a system of waste collection. Latrine alternatives were a short-term solution aimed to fill a temporary gap in sanitation services, often due to timing or location constraints. Three evaluations, all high risk of bias, were included in the review, two from the Haiti earthquake and one from Typhoon Haiyan response in the Philippines. All three contexts were in IDP settings and were intended to be used for 4-8 weeks. In Haiti, self-reported use was 91%, whereas, use based on distribution records was much lower at 13% (range: 8-18%). It was noted that distribution records and estimated camp population may underestimate the use, although a full scale operational project 10 times larger than the trial may also explain the differences. In the Philippines, use of latrine alternatives was 74% from NGO monitoring. Intended location of use could be a factor, as Peepoo® interventions at households had high (>70% use), compared to

community cubicles (<20% use). Cultural acceptance of using bags to defecate was a concern from responding agencies. In Haiti, responders identified that this was an existing practice, termed 'flying toilets,' while in the Philippines, the practice did not previously exist, but key informant interviews and focus group discussions suggested that Peepoo® bags would be acceptable. Management and disposal of the bags was different in each context, but all were successful, although 100% of beneficiaries from the pilot in Haiti reported disposing of bags in 'indiscriminate locations' (Coloni et al., 2012). Hauling the waste away was considered easier than desludging a latrine that often requires specialized equipment with excessive costs. There was also consideration for community involvement in all evaluations and ranged from community volunteers to cash-for-work.

Hygiene. Hygiene messages educate affected populations on disease risks and transmission routes. Often in emergencies, *hygiene promotion* is condensed to key messages, such as handwashing at critical times. Promotion can be at schools, in large community groups or at the household level. For this review, *social mobilization* is considered a sub-set of interventions within hygiene promotion and includes strategies for engaging and facilitating communities to address identified risks with local solutions. There was no isolated evaluation of hygiene behavior change (e.g. changing in handwashing behavior from promotional activities) identified in the review, however, there were evaluations of hygiene promotion and social mobilization

5.4.10 Hygiene Promotion

Hygiene promotion was evaluated through nine evaluations of medium and high risk of bias describing preferred message delivery and health impacts. Common hygiene factors

that were evaluated were: person sharing the message (i.e. community health worker, NGO, friend, neighbor, family member, local leader), how it was shared (i.e. radio, TV, posters/pamphlets, theatrical skits, face-to-face) and location (e.g. home, school, place of worship, community). Face-to-face communication was preferred by beneficiaries in seven evaluations (Williams et al., 2015, Matemo, 2014, Contzen and Mosler, 2013, Date et al., 2013, Einarsdbttir et al., 2001, Wall and Chéry, Khan and Syed, 2008). Additionally, material demonstrations (i.e. instruction on HWT), visits by community health workers and conversations with friends and family were consistently reported positively. Short radio 'spots' or radio communication was the other consistently preferred and trusted source for hygiene messages. However, delivering simple, clear messages was noted as a challenge in four evaluations. Different and conflicting messages undermined the response in the Haiti cholera and Liberia Ebola response (Wall and Chéry, 2011, Meyer Capps and Njiru, 2015) and it was unclear if hearing a message on the radio translated to action or a realistic understanding of the local situation (Wall and Chéry). There were also noted difficulties with dialect differences (Einarsdbttir et al., 2001), and errors in printed information (Neseni and Guzha, 2009). Other impacts from hygiene education included a reported decline in morbidity and diarrhea rates (WHO, Williams et al., 2015), increase in HWT use (Date et al., 2013) and changes in behavior by reducing physical contact (i.e. hugs, shaking hands) during a cholera outbreak (WHO).

Handwashing was a primary component of 'key hygiene messages' used in emergency response. Handwashing promotion was mentioned in 17 evaluations included in the review, with six reporting building handwashing stations (ACF, 2015a, Plan, 2013, Visser, 2012, Varampath, 2008, Singh, 2009, Fortune and Rasal, 2010). While handwashing was

widely promoted, it was rarely evaluated and often implemented in combination with other activities. Only two documents with low and high risk of bias report specific outcomes or impacts of handwashing interventions in emergencies. In an acute refugee camp setting, distribution of a handwashing bag was observed to have a high use of >65% after three months, although reported use was lower at 36-46% and soap access was limited, despite >99% reportedly liking the bag (Husain et al., 2015). The only other handwashing evaluation was a high risk of bias alcohol based hand sanitizer intervention used in IDP camp kitchen staff after an earthquake in Peru (Cabezas et al., 2008). The hand sanitizer significantly reduced bacterial loading (1.7 log reduction, 95% CI 0.6-2.4 log reduction, $p<0.001$) and was deemed effective for areas without access to potable water.

Social Mobilization. Social mobilization describes strategies for engaging communities and responders facilitating communities to address identified risks with local solutions. Social mobilization approaches define a process, often at a community level, and outputs are often determined by the community. A notable example is community led total sanitation (CLTS), where communities are engaged through a facilitator with a specific process and encouraged to build their own latrines from locally available materials, ultimately intending to end open defecation at a community level. Community mobilization, in particular CLTS, has consistent success stories in many development contexts (Pickering et al., 2015); however, in emergency contexts, there are concerns of social projects because of a weak sense of community, lack of timing and scarce resources.

Social mobilization strategies were identified in nine evaluations in seven countries; most (7) were high risk of bias and five interventions were aimed specifically at

sanitation but described here because of the mobilization approach. Social mobilization was effective at reducing disease risk, output of structures and building stronger community relationships. A long-running CLTS intervention was found to have a high and significant impact on rates of Ebola as open defecation free (ODF) communities were 17 times less likely to have cases of Ebola than non-CLTS communities (OR=0.06, 95% CI 0.01-0.32, $p<0.001$) (Meyer Capps and Njiru, 2015). Social mobilization was also assessed descriptively to reduce disease transmission in outbreaks (ACF, 2015a, Rees-Gildea, 2013, Neseni and Guzha, 2009). Community driven sanitation resulted in thousands of latrines and community structures in Uganda, Pakistan, and Zambia – all in less than four-month interventions with low material input from responders (Waterkeyn et al., 2005, Miziniak, Khan, 2012). Furthermore, ACF piloted a community Ebola management project based on the CLTS approach which resulted in 80% of villages planning to build community isolation rooms for Ebola patients and handwashing stations (ACF CLEME). Stronger community relationships were also described in four of the social mobilization evaluations (trust, group cohesion, and ownership) (Wall and Chéry, 2011, Waterkeyn et al., 2005, ACF, 2015a, Miziniak). After the Haiti earthquake, a pilot CLTS project had limited success carried out in five IDP camps as the disaster affected population was conditioned for free distributions and scarce resources available (Pollo, 2010). 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.

5.4.11 Hygiene Kit Distribution

Hygiene kit distributions (e.g., non-food items (NFIs)) were mentioned in 21 evaluations with HWT products, soap and safe water storage containers (e.g. jerrican or buckets with lids) most commonly included. The primary goal of most hygiene kit distributions was to deliver HWT products and/or support hygiene activities addressed in other intervention categories with mixed risk of bias. Valuing items differed by gender, but also with time since the emergency (Mountfield, 2013, Hayden, 2012, ACF, 2015b). Differences in kits (e.g. several different Aquatabs doses), caused confusion (Varampath, 2008, Imanishi et al., 2014). Standard sized kits may not address the needs of larger families or those with different preferences or needs (Gauthier, 2014, Simpson et al., 2009, Ruiz-Roman, 2009). Vouchers were used in a specially organized market to offer flexibility and choice to beneficiaries in the DRC (Pennacchia et al., 2011), and cash based assistance in Philippines was also preferred. Pre-positioning hygiene kits was noted as a key aspect of the response (Simpson et al., 2009, DeGabriele and Musa, 2009, Neseni and Guzha, 2009, Ruiz-Roman, 2009, Lantagne and Clasen, 2012b, Varampath, 2008), while non-functioning markets and procurement delays reduced the overall impact of interventions, especially considering the rapidly changing needs of beneficiaries in acute emergencies (ACF, 2007, Khan and Syed, 2008, Varampath, 2008, Mountfield, 2013, Wango, 2011, Neseni and Guzha, 2009).

Menstrual Hygiene Management (MHM) interventions and specific hygiene kits for women (a.k.a. dignity kits) often include women's underwear and sanitary pad, and are regularly distributed with an increase in gender mainstreaming (Khan and Syed, 2008, ACF, 2014a, Singh, 2009, Baker and Mbogha, 2009). Identifying culturally appropriate items was noted as an issue (Khan and Syed, 2008, ACF, 2014a) and focus groups from

three separate needs assessments identified needs for access to water a private safe space for washing, increased education, appreciation of the influence of local beliefs and local MHM materials (Parker et al., 2014, Hayden, 2012, Wickramasinghe, 2012).

5.4.12 Environmental Hygiene

Environmental hygiene interventions identified in the review were jerrican disinfection, spraying household surfaces with a chlorine solution, and disinfection kit distribution. No evaluation on improving local environment conditions was identified in the review, although several organizations reported activities or results such as "improved garbage practices" (Dinku, 2011), construction of solid waste areas and drainage improvements (Pennacchia et al., 2011, Plan, 2013) and decongestion and rehabilitation of sewer pipes (Neseni and Guzha, 2009).

Jerrican disinfection. Jerrican disinfection uses a chlorine solution to wash water collection containers and reduce disease transmission risks. Jerrican disinfection was investigated in three high risk of bias evaluations, all in camp settings, and all assessed with no beneficiary input. All three jerrican cleaning methods (3 slightly different methods) were assessed to reduce disease risk, but with very weak evaluation methods. Chlorine concentration reduction was noted in all three documents (Steele et al., 2008, Walden et al., 2005, Roberts et al., 2001). One-time disinfection did not have a long-term impact on re-contamination.

Household spraying. Household spraying was mentioned as an activity in five documents but not evaluated (Neseni and Guzha, 2009, Gauthier, 2014, Grayel, 2014, Grayel, 2011, 2012). A known outbreak activity, household or community spraying was noted to have several potential drawbacks: 1) stigmatizing households; 2) logistical, financial and

staffing resources required; 3) false sense of protection to households; and 4) limited impact as 80-85% of people infected with cholera are asymptomatic (Grayel, 2011). The UNICEF Cholera Toolkit also recommends that household spraying by responders *not* to be carried out (Unicef, 2013); however, it is recommended that families should thoroughly clean the house with soap and chlorine solution. Self-reported use of a household disinfection kit contents was high (>90%) in a high risk of bias evaluation during the Haiti cholera outbreak (Gartley et al., 2013).

5.4.13 WASH Package

WASH interventions were regularly implemented in combination by responders to address multiple transmission routes and attempt to provide comprehensive protection to beneficiaries. Overall, 24 WASH Package evaluations from 12 countries were identified; all 24 were grey literature documents, most (22/24) field commentary documents with limited analysis and high bias. The specific intervention activities included in the WASH Package mirrors the results above, with more water and hygiene interventions completed than sanitation interventions. However, the water interventions included in WASH Package were more likely to be well rehabilitation and water trucking which are described as activities but not evaluated for outcomes or impacts.

Health impacts were reported through reduced diarrhea and cholera rates (Pennacchia et al., 2011, Gauthier, 2014, ACF, 2007, Baker and Mbogha, 2009, van der Wijk, 2010). Improved hygiene behavior was self-reported in Zimbabwe (DeGabriele and Musa, 2009), DRC (Pennacchia et al., 2011) , and Somalia (Dinku, 2011), although respondents in Zimbabwe acknowledged the behaviors were not consistently practiced. Additional

impacts included reported reduced time needed to collect water, with undocumented methods (Dinku, 2011, Pennacchia et al., 2011, Plan, 2013, Visser, 2012, Alem, 2004), 'psychosocial support' to cholera-affected communities after a hygiene kit distribution (Neseni and Guzha, 2009) and a change in people's attitude, especially toward open defecation in Sierra Leone (Ngegba, 2002).

The importance of expert staffing was documented in Zimbabwe (Simpson et al., 2009, El-Mahmid and Roussy, 2009), whereas integrating epidemiological experts into response and surge capacity was described as important in the DRC (Grayel, 2014) (Gauthier, 2014). Pre-positioned hygiene kits were useful for quick initial distributions (Lantagne and Clasen, 2012b, Ruiz-Roman, 2009, Neseni and Guzha, 2009, DeGabriele and Musa, 2009, Simpson et al., 2009), and programs without pre-positioned stock at times described difficulty in procuring items leading to delays thereafter (Neseni and Guzha, 2009, Wango, 2011). Similarly, accessible 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). In outbreak response, sanitation and water trucking were rarely carried out, while in general emergency response both sanitation and water trucking was more prominent. These field commentaries had a high risk of bias but consistent descriptions of anecdotal health impacts and non-health behavior change impacts. Expert staffing and rapid response timing were consistently identified as critical factors for program success.

Cost-Effectiveness

Cost-effectiveness and economic outcomes was not able to be assessed because outcomes were too heterogeneous for analysis, despite cost-related outcomes mentioned in nearly half of evaluations (43%, 46/106). For example: BWT was deemed 'cost-effective' for about $7,500 but without alternative cost descriptions (Dorea and Jalaber, 2014); acute chlorine HWT interventions cost about US $1/day for a household with confirmed FCR in Nepal and Kenya (Lantagne and Clasen, 2012b) while a bottle of chlorine solution able to treat 1,000L cost about US$0.46 in Madagascar, but did not include promotion or indirect costs (Dunston et al., 2001). Temporary portable latrine costs were comparable to semi-permanent latrines ($5.4/user/month compared to $5.2/user/month), although prices were negotiated and averaged over six months and several contracts (Eyrard, 2011a). Additional examples of the complicated cost-effectiveness analysis include a project where costs were calculated without donated (gift-in-kind, GIK) hygiene kit values (Gauthier, 2014) and a different project where cash vouchers were used in a special market day where beneficiaries could negotiate prices and select their own items (US$70 for 2,184 households) (Pennacchia et al., 2011). In general, economic outcomes were unclear if staffing, indirect costs, or headquarters costs were included, and no cost-effectiveness evaluations were identified in the review.

State of Evidence

Summaries of findings and assessment of evidence are presented in Table 12 and

Table *13*. Overall, the quality of evidence is low; this was attributed to weak study designs that lacked control groups and had high likelihood of spillover effects. As can be seen in Figure 19, 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, more qualitative evaluations. The majority of quantitative evaluations designs were weak cross-sectional designs relative to true experimental designs. The weak evaluations designs were expected from the onset of the protocol development, but still greatly undermine the ability to establish a strong evidence base; for example, only 9% of evaluations (10/106) had any type of control group, less than 4% (4/106) were randomized control trials, and none were in the same intervention category. While most of the evaluations were poor quality with high bias, the strength of evidence comes from the consistency and collaboration of reported outcomes. Saltwater pumping was the only intervention assessed to have high quality of evidence, and this was evidence showing the intervention was not efficacious.

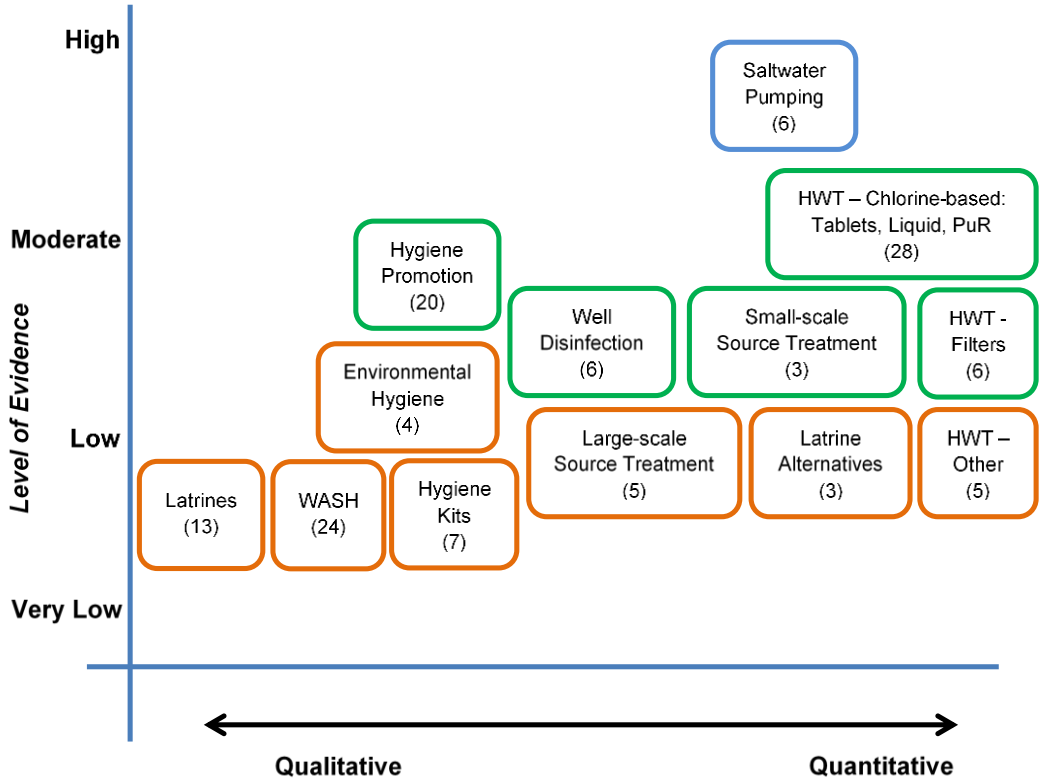
Table 12: Water Intervention Summary of Evidence

Intervention	Number of Studies	Quality of Outcomes			Summary of Findings	Overall Evidence
		Health	Use	Non-health		
Saltwater Pumping	6	Not Assessed	Not Assessed	High	Evidence suggests that well pumping after a saltwater intrusion is NOT efficacious. Waiting for seasonal rains, naturally reduced salinity faster compared to pumping.	High
Well Disinfection	6	Not Assessed	Not Assessed	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
Large-scale Source-based Treatment	4	Not Assessed	Moderate	Moderate	BWT – Well established treatment methods (not evaluated) requires well-trained staff and regular monitoring. Smaller, decentralized BWT offers mobility and flexibility to respond in difficult locations. Water Trucking is a common activity in emergencies, but FCR was inconsistent and often had microbiological contamination with limited evaluations.	Low
Small-scale Source-based Treatment	3	Not Assessed	Moderate	Moderate	Variation in reported, confirmed and effective use – criteria for favorable contexts outlined through case studies. Speaking with promoter and easy access to Dispenser associated with increased use.	Moderate
HWT – Chlorine-based Products - Chlorine Tablets	11	Very Low	Moderate	Moderate	Low and wide range of reported and confirmed use with an outlier. Taste and smell consistently described as a barrier to use.	Moderate
HWT – Chlorine-based Products - Liquid Chlorine	9	Not Assessed	Moderate	Moderate	Low and wide range of reported and confirmed use. Links with development and sustainability, including prior exposure and free distribution as factors.	Moderate
HWT – Chlorine-based Products - Flocculant/ Disinfectants	7	Low	Moderate	Moderate	Use varied greatly – knowledge of use a factor. Preferred by beneficiaries compared to other chlorine tablets when distributed together. High potential health impact with high use.	Moderate
HWT - Filtration	6	Not Assessed	Moderate	Moderate	Use varied greatly – acute use was higher than long-term use. Improved taste consistent among populations.	Moderate

HWT – Other	5	Low	Very Low	Moderate	Limited evaluations for each intervention. Not common in emergency response, ease of use and community acceptance reported. Consistent reduced disease risks.	Low

Table 13: Sanitation, Hygiene and WASH Package Intervention Summary of Evidence

Intervention	Number of Studies	Quality of Outcomes			Summary of Findings	Overall Evidence
		Health	Use	Non-health		
Latrines	13	Low	Low	Moderate	Reduced diarrheal rates with increased coverage and use. Ease of access, cleanliness and privacy are important non-health considerations. Vulnerable targeting increased use.	Low
Latrine Alternatives	3	No evidence	Low	Low	Reported use ranged: 8-91%; interventions promoting use in the home had higher rates of use.	Low
Hygiene promotion	18	Low	Low	Moderate	Descriptions and documentation of disease or disease risk reductions. Personal communication and radio are preferred and trusted by the community. Community trust and ownership important factors.	Moderate
Hygiene Kit Distribution	13	Not Assessed	Low	Moderate	Reported use of contents was high. Quantity of materials and timeliness of distribution are key factors Low quality evaluations, HWT primary investigation of hygiene kits.	Low
Environmental Hygiene	4	Very low	Low	Low	With weak evaluations, jerry can disinfection consistently reported to reduced disease transmission risk and chlorine concentration monitoring is necessary. Household consistently spraying not recommended for responders.	Low
WASH Package	24	Low	Not Assessed	Low	Weak evaluations had consistent anecdotal descriptions of disease reductions, behavior adjustments and support; staffing and timing also important factors.	Low



(#) is the number of interventions per category, n=130 (16 documents included in more than one intervention)

Figure 19: Short-term WASH in Emergencies Evidence Map

Results by Objective

Objective 1: *Use of Interventions in Emergency WASH*

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

The evidence from this review validates the causal chain for emergency WASH interventions. Interventions with access to WASH services and measured high use also had large and significant reductions in diarrhea (Johnston, 2008, Doocy and Burnham, 2006, Meyer Capps and Njiru, 2015, Puddifoot, 1995, Roberts et al., 2001). Breakages along the causal chain are also apparent due to context and social barriers (Figure 20). Five interventions had minimal beneficiary involvement but known efficacy, thus intervention design and implementation were primary barriers to impact. Bulk water treatment, well disinfection and jerrycan disinfection could be efficacious but were not evaluated at the beneficiary household level, thus the effectiveness depended on how the intervention was carried out by the responding agency in the particular context.

Disease reduction was not regularly evaluated and remains a gap in the literature. The barrier between effective outcomes and impact (disease reduction) was primarily attributed to behavioral preferences that impact use. Wide variation in use was dependent on familiarity of products, ease-of-use, personal preferences to taste/smell and culture. Education and promotion were also key factors that could facilitate or hinder impact of emergency WASH.

Some common WASH interventions in emergencies were not evaluated: repairing damaged water points, bucket chlorination, household spraying and environmental clean-up. Also, water trucking, latrine construction and handwashing were not well documented.

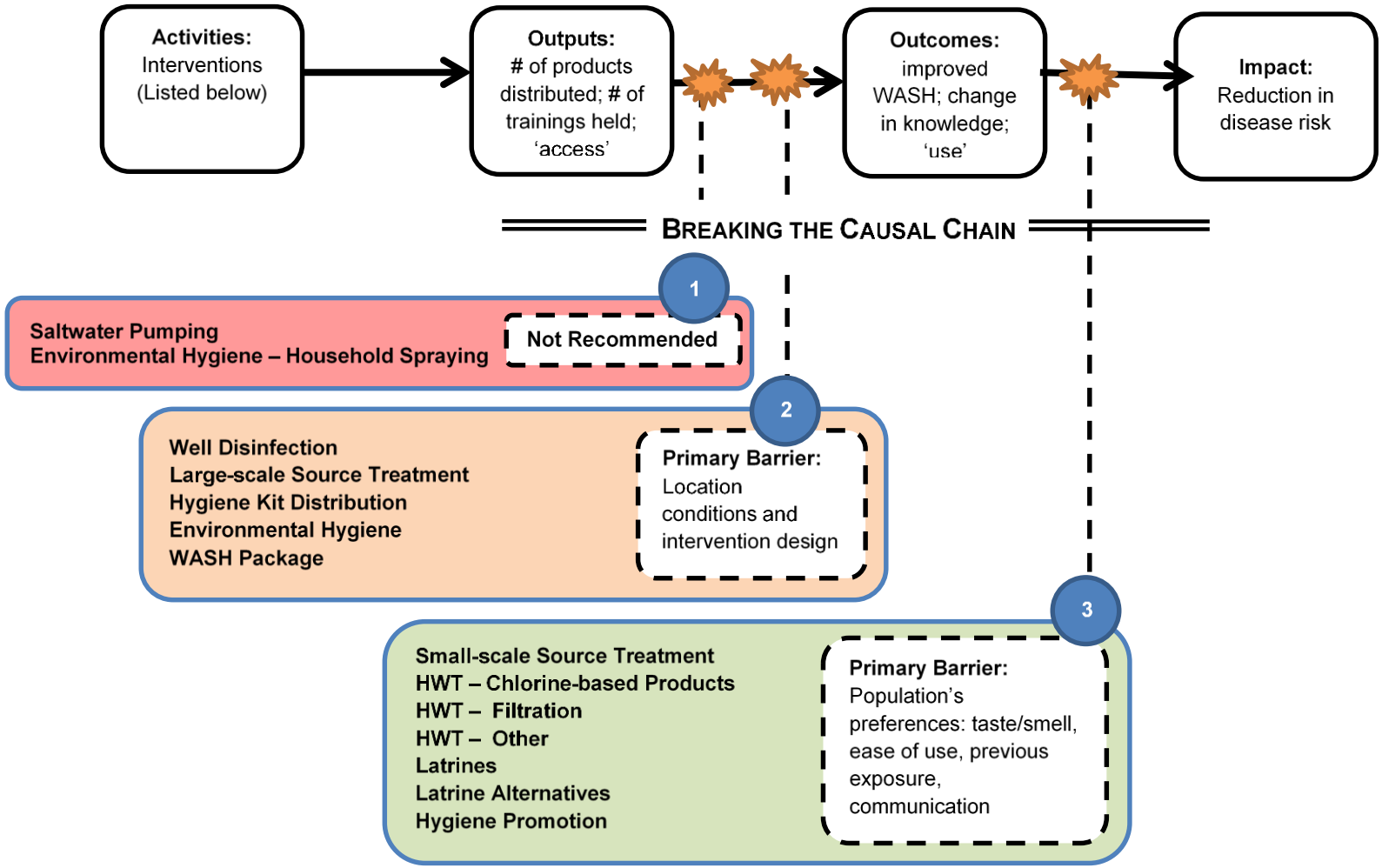


Figure 20: Causal Chain Intervention Evidence

Objective 2: *WASH Interventions that Reduce Disease Risk*

WASH interventions have the potential to reduce disease in emergencies. Weak designs and limited number of evaluations explain the low quality of evidence, but interventions consistently reduced disease risk and risk of disease transmission. Interventions directly measuring a health impact were few and mostly in HWT: chlorine tablet, PuR, SODIS and safe storage and assessed as low or very low quality of evidence as there was only one to two evaluations for each intervention type. Additionally, latrine use and a CLTS intervention documented reduced disease risk, but were also low quality evidence. More common than disease reduction evaluations were interventions that evaluated the risk of transmission through non-health indicators. Interventions documenting FCR in drinking water are known to reduce disease transmission and had moderate quality of evidence including: well disinfection, Dispensers and HWT (liquid chlorine, chlorine tablets and PuR). Environmental hygiene interventions using chlorine to clean jerricans reduced short-term transmission risk with measurable FCR, yet had low quality of evidence. Overall, WASH interventions consistently reduced both the risk of disease and the risk of transmission in emergency contexts; however, program design and beneficiary preferences are important considerations to ensure WASH interventions reach their potential.

Objective 3: *Impact of Non-Health Related Outcomes*

In the review, four community perceptions and preferences that consistently affect the success of emergency WASH interventions are identified through a mixture of evaluation methods and risk of bias assessments, including: taste and smell; communication methods; inaccurate perception of efficacy; and trust/fear. Taste and

smell of HWT hindered use (e.g. chlorine treatments can have an off-putting smell or taste) or facilitated use (e.g. filters and flocculent disinfectants improved taste). Radio and face-to-face communication were consistently reported as 'most trusted' or 'most valued' for hygiene communication. Community understanding of some interventions overestimate the effectiveness and risk reduction (i.e. saltwater pumping, household spraying and well disinfection). Correct knowledge of intervention use was also a factor. Social mobilization and open communication between the community and NGOs build trust and greater community cohesion.

Objective 4: *Program Design and Implementation Characteristics Associated with More Effective Programs*

Four program design and implementation characteristics, identified through a mixture of research designs and across risk of bias assessments, were consistently reported as positive program characteristics, including: simple interventions that were appropriate timed, community driven and had linkages between relief and development. Some of the most basic interventions (e.g. safe storage with a jerrican or bucket, simple hygiene messages or hygiene kit provision) had a clear positive impact. These interventions required little to no promotion and led to incremental improvements that reduced the risk of disease. 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 empowers and builds trust and community-driven interventions can increase awareness, trigger behavior change and identify local solutions. Linking with pre-existing programming builds upon recipient

population familiarity and having a sustainability plan encourages better cultural understanding and improves emergency response programs.

Objective 5: *Economic Analysis of Emergency WASH Interventions*

Cost-effectiveness of emergency WASH interventions could not be assessed, as there were only minimal and heterogeneous economic outcomes in the evaluations included in the review.

5.5 Discussion

To determine the efficacy and effectiveness of WASH interventions in emergencies, we investigated: use of interventions, reductions in the risk of disease; critical program design and implementation characteristics; non-health related (beneficiary) factors and cost-effectiveness to emergency WASH response. We found that (with access and use) WASH interventions consistently reduced both the risk of disease and the risk of transmission in emergency contexts; however, program design and beneficiary preferences were important considerations to ensure WASH intervention effectiveness in the specific emergency response context reached their potential efficacy. Critical program design and implementation characteristics included simple interventions that were appropriate timed, community driven and had linkages between relief and development. Barriers and facilitators to emergency WASH interventions were taste and smell, communication methods, inaccurate perception of efficacy and trust/fear. Economic outcomes of WASH interventions in emergencies were not assessed.

The findings presented here align with other recent review documents (Taylor et al., 2015, Ramesh et al., 2015, Vujcic et al., 2015). Previous systematic review efforts

included only health impact evaluations (Ramesh et al., 2015) or did not include grey literature (Taylor et al., 2015). Thus, few lessons learned were generated in these reviews. Our inclusion criteria permitted a greater quantity of lower quality less technical evaluations than is traditional to systematic reviews. This led to disparate outcomes and impacts that were not possible to directly compare, but increased the knowledge gained and synthesized current information. In conducting the review, it was more difficult than expected to: assess whether the WASH intervention was in the same geographic location as the emergency; compare interventions conducted at different times in the response phases (acute, recovery, development); clearly suggest impact without suitable control groups to compare; and search and extract information from grey literature. There was also a notable lack of evaluations from the more recent emergencies of the West African Ebola outbreak and the Syrian regional response. 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.

It is clear from the results of the review that some of the most commonly implemented WASH interventions in emergencies are severely under-researched. We need additional research for: repairing damaged waterpoints, water trucking, bucket chlorination, household spraying, handwashing, latrine construction, environmental clean-up and formal economic analysis. Additionally, there was disparity between what was researched and published in the literature and what was implemented by responders and written up as grey literature; water treatment interventions were most commonly researched and published by academics and WASH Package interventions were commonly implemented and reported by responders. While we need more research on

specific WASH interventions that are under-researched, it is anticipated that the implementation and non-health factors identified in this review would remain critical, especially for more complex WASH interventions.

To improve the evidence on WASH interventions in emergencies, clear reporting with consistent evaluation methods and common and robust methods is needed. Well-designed non-experimental and qualitative evaluations can be used to increase the evidence base. Evaluations should be conducted at the beneficiary level, to better understand, rather than presume, the outcomes and impacts. Publishing results, while not necessary, does offer transparency and an additional sharing platform for the humanitarian community.

5.5.1 Limitations

There were several limitations to this research. There is no comprehensive or consolidated website or location with responder evaluations; thus, there was difficulty in securing non-published evaluations, likely influencing the results. Most organizations that submitted documents to the review provided only a select handful of reports, and it is likely that the provided reports were limited to those with favorable outcomes or innovative approaches. The two organizations that provided the most documents, Action Contre la Faim and Oxfam, were also the most included, which likely influenced results. Self-reported data (such as diarrheal disease incidence or use of HWT products) was subject to both recall and courtesy bias, which would likely over-estimate positive outcomes. FCR, diarrhea incidence and prevalence and *E. coli* microbiological results are proxies for the outcomes and impacts of disease. Outcomes were reported inconsistently. For example, confirmed use of a HWT intervention was the clearest

outcome measured (using FCR); however, reporting thresholds varied by: 'detectable,' >0.0mg/L, >0.1mg/L, ≥0.2mg/L and ≥0.5mg/L. Furthermore, database searching was completed primarily in English, keywords searched may not have captured all relevant evaluations with variations of intervention names or names in local languages. And lastly, only WASH interventions implemented in short-term emergency settings were included, likely excluding interventions derived from other sectors, chronic emergencies, or long-term development approaches.

5.6 Conclusion

A systematic review process was used to identity more than 15,000 documents; ultimately, 114 evaluations of WASH interventions in emergencies were included in the review. We found that most WASH interventions were efficacious and that WASH interventions consistently reduced both the risk of disease and the risk of transmission in emergency contexts; however, program design and beneficiary preferences were important considerations to ensure WASH intervention effectiveness in the specific emergency response context reached their potential efficacy. Some of the most commonly implemented WASH interventions in emergencies were found to be severely under-researched, and further research investigating outcomes and impacts of specific interventions is recommended. It is recommended that responders implement efficacious, simple interventions that are appropriate timed, community driven and have linkages between relief and development in collaboration with the recipient communities to address barriers and facilitators to use.

5.7 Acknowledgements

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5.8 Citation

This work has been peer-reviewed and published in through the International Initiative for Impact Evaluation (3ie) and funded by the United States Agency for International Development Office of Foreign Disasters (USAID/OFDA) in 2017. Additionally, a journal paper has also been developed and intended for PLOS One. The full citation is:

Yates, T, Allen, J, Leandre Joseph, M and Lantagne, D. 2017. *Short-term WASH interventions in emergency responses: a systematic review.* 3ie Systematic Review Summary 8. London: International Initiative for Impact Evaluation (3ie).

Chapter 6: Contribution to the Evidence Base

6.1 Contribution to the Evidence Base

As a contribution to the academic evidence base, each of the four projects have been peer-reviewed, published, and described in detail in Table 14. These manuscripts were specifically intended to inform responders and provide policy makers additional information concerning the efficacy and effectiveness of emergency WASH interventions. Specific dissemination strategies were developed for two of the projects to help guarantee a wide audience. Actors directly involved in these processes included:

International Donors. United States Agency for International Development (USAID)/Office of Foreign Disaster Assistance (OFDA), United Kingdom Department for International Development (DFID), and the Bill and Melinda Gates Foundation (BMGF)

Government Agencies. USAID/OFDA, DFID, Centers for Disease Control and Prevention (CDC), Office for Global Aids Coordinator (OGAC)

UN Agencies. UNICEF, UNHCR, and the WHO

NGOs. Oxfam, ACF, IRC, Evidence Aid, and a multitude of additional NGOs were contacted through emails and personal discussion.

The results of each project have been presented at international conferences, including in Nepal, Ghana, and the United States; additionally, the protocols for the outbreak and emergency systematic reviews were also presented at the 2015 Emergency Environmental Health Forum in Kenya. The impact and dissemination of projects are described in Table 14.

Table 14: Contribution to the Evidence Base

Title ***Publication (Year)***	**Presented**	**Significance**
The Impact of Water, Sanitation, and Hygiene Interventions on the Health and Well-being of People Living with HIV: a Systematic Review *Journal of Acquired Immune Deficiency Syndrome (JAIDS) 2015*	2015 UNC Water and Health Conference (USA)	Presented at the PEPFAR Care and Support Evidence Review Meeting, Washington DC, November 2013. Selected by UNAIDS to be part of the 5th issue of *HIV this month*.
Effectiveness of Chlorine Dispensers in Emergencies: Case Study Results from Haiti, Sierra Leone, DRC, and Senegal *Environmental Science and Technology (ES&T) 2015*	2014 UNC Water and Health Conference (USA)	Dispensers were developed more than 10 years ago, and are currently used by more than 2 million people; however, this publication remains the only peer-reviewed manuscript on Dispensers.
WASH Interventions in Outbreak Response: Evidence Synthesis *Humanitarian Evidence Program (HEP); PLoS ONE (submitted) 2017*	2016 WEDC International Conference (Ghana), 2016 Emergency Environmental Health Forum (Nepal)	This review was in answer to responders seeking evidence for outbreak interventions. It has already reached a wide international audience through the Humanitarian Evidence Program, the United Kingdom Department for International Development (DFID), and the World Humanitarian Summit.
Short-term WASH Interventions in Emergency Response: A Systematic Review *International Initiative for Impact Evaluation (3ie); PLoS ONE (submitted) 2017*	2016 UNC Water and Health Conference (USA), 2016 Emergency Environmental Health Forum (Nepal), 2016 WASH Summit of the Accord Network (USA)	This review was requested from the Office of Foreign Disaster Assistance (OFDA) a part of the United States Agency for International Development (USAID) and is expected to directly influence United States policy for emergency relief in low and middle-income countries. Access to this review will also be provided to responders through the Global WASH Cluster network led by Unicef.

Chapter 7: Conclusions

7.1 Overall Conclusions

The impact of emergency WASH interventions was identified through primary data collection as well as through secondary data analysis. Primary data analysis was completed with regards to the efficacy and effectiveness of Dispensers, in four distinct emergency contexts. Three different systematic reviews were completed, two of which included grey literature. Across the breadth of these projects, seven common themes were identified.

Evidence Remains Lacking. Overall, research methodologies are generally weak. They are characterized by inconsistent methods, and a high likelihood of bias. The efficacy of most - but not all – emergency WASH interventions is well established, yet large knowledge gap remain, as several well-known WASH interventions were not evaluated or had very little information including: repairing damaged waterpoints, water trucking, bucket chlorination, household spraying, handwashing, latrine construction, environmental clean-up, and formal economic analysis.

Suspected Impact. The aim of all WASH interventions is to support the health of emergency affected populations; however, health impact (disease reduction) is not regularly measured. Proxy indicators like population coverage, usage rates, or measured FCR are used in place of health impact – thus *suspected* and not directly measured. Where disease reduction is measured, it is mainly measured with a HWT intervention, ignoring the potential impact of sanitation or hygiene interventions. With all three systematic reviews, cost-effectiveness of WASH interventions was rarely found, yet cost-effectiveness remains suspected even if not clearly documented. Only one study evaluated the cost-effectiveness of a HWT intervention distributed with long-lasting bed

nets for PLHIV in Kenya, and was published in three manuscripts (Kern et al., 2013, Kahn et al., 2011, Walson et al., 2013).

Water is the Focus. Sanitation and hygiene interventions were not evaluated at the same as frequently as water interventions. All three systematic reviews highlighted the prominence of water interventions compared to other interventions. Additionally, while Dispenser interventions are not commonly implemented in emergency response, a donor specifically wanted to fund such an investigation. There is also a notable difference in that the published literature focuses on water interventions, particularly HWT, while responders most often implement integrated WASH Package interventions, which include water as one of several components. All four projects identified that WASH interventions carried out in combination with other interventions were positive and yielded improved health of the emergency affected populations. The evidence supporting this conclusion is limited and current published research does fully capture the potential synergies found in emergency WASH Package interventions.

Importance of Grey Literature. Grey literature comprised nearly half of the "accepted" documents in both systematic reviews where it was eligible for inclusion. The grey literature clearly impacted conclusions for WASH Package interventions, as noted above, but also supported HWT, sanitation, and hygiene interventions that would otherwise likely have gone unrecognized. The body of grey literature effectively bridged several gaps in the published literature and allowed for the arrival at a set of clearer findings. Responding organizations regularly evaluate interventions both to improve programming and also to facilitate donor reporting. This is achieved most often with simple cross-sectional surveys that are not shared beyond the organization. While these evaluation methods may have higher bias than RCTs and are not peer-reviewed, there

remain ample and valuable opportunities to improve the overall evidence base by appreciating and accessing the grey literature.

Sustainability in Emergencies. Even though sustainability (i.e. an intervention continuing several years after project inputs are complete) is not often a priority in emergency response, linking projects to development interventions and having a sustainability plan were identified as facilitating factors in several emergency interventions. For instance, among the lessons learned following the Dispenser project were that sustainability plans and identifying handover partners were critical to success (Yates et al., 2015c). Long-running chlorine HWT interventions in Haiti had higher use compared to other similar interventions (Lantagne and Clasen, 2013), and a CLTS intervention in Liberia had a large and positive impact on Ebola transmission while utilizing locally available materials at little to no cost (Meyer Capps and Njiru, 2015).

Implementation Matters. Key aspects for how interventions are designed and implemented are critical for success. Themes identified across the projects included: keeping interventions simple, timing of response, having experienced field staff, and linking relief and development. Examples of each of these aspects are detailed below in Table 15.

Table 15: Implementation Considerations and Intervention Examples

Implementation Criteria	**Examples**
Simple Interventions	Interventions that were easy to adopt by the beneficiary with only a few steps or components were often beneficial. Safe storage, simply keeping water in a jerrican or covered container, was effective at reducing diarrhea rates (Doocy and Burnham, 2006, Roberts et al., 2001). Basic mesh screens and folded cloth were effective at reducing cholera rates and easily accepted by the community (Colwell et al., 2003, Huq et al., 2010). Chlorine-based HWT and Dispensers were also described by beneficiaries to be easy to use (Imanishi et al., 2014, Lantagne and Clasen, 2012b, Yates et al., 2015c).
Timing of Response	Ability to respond quickly was described by responders as critical, which required adequate supply of materials - often prepositioned stock, and adequate funds to respond at scale (Lantagne and Clasen, 2012b, Ruiz-Roman, 2009, Neseni and Guzha, 2009, DeGabriele and Musa, 2009, Simpson et al., 2009, Wango, 2011, Gauthier, 2014, Condor and Rana, 2011).
Experienced Staff	Experienced staff was noted as a critical part of success with Dispensers and several outbreak responses, which provided technical expertise and surge capacity (Simpson et al., 2009, El-Mahmid and Roussy, 2009, Baker and Mbogha, 2009, Grayel, 2014, Gauthier, 2014, Yates et al., 2015c).
Linked Relief Rehabilitation and Development	With links to previous or existing interventions, responders could already have an established understanding of the local context and have a platform for new or expanded interventions. Sustainability plans and community-based approaches were also described as positive (Meyer Capps and Njiru, 2015, Dunston et al., 2001, Lantagne and Clasen, 2012b, Yates et al., 2015c, Date et al., 2013, ACF, 2014c).

Social Aspects. The attitudes and preferences of the target population are important considerations when designing an intervention. These aspects are easily overlooked, but are key considerations for bridging the gap between efficacy and effectiveness, including: such tangible elements as the taste and smell of provided water; ease of use and ease of access, communication preferences, and open communication with the community. Examples of each of these aspects are detailed below in Table 16.

Table 16: Social Considerations and Intervention Examples

Social Aspects	Examples
Taste / Smell	Particularly true for HWT, beneficiaries were often put-off by the smell or taste of chlorine in a range of countries – from Kenya to Haiti, to Zimbabwe, and Nepal (ACF, 2009, Lantagne and Clasen, 2012b, Imanishi et al., 2014, Ruiz-Roman, 2009, Johnston, 2008, Plan, 2013, Hoque and Khanam, 2007, Handzel and Bamrah, 2006). Filters often reportedly improved taste (Clasen and Boisson, 2006, Ensink et al., 2015, Palmer, 2005), while taste was also a barrier to use with saltwater pumping (Villholth, 2007, Lipscombe, 2007) and well disinfection (Libessart and Hammache, 2000).
Ease of use / Ease of access	Similar to the 'simple interventions' described above, interventions that did not require much change to beneficiary behavior were easier to use and adopt. For instance, one significant factor for Dispenser use was simply walking by it (Yates et al., 2015c); and use of PuR dependent on knowing how to use (Doocy and Burnham, 2006, ACF, 2014b, Colindres et al., 2007, Lantagne and Clasen, 2012b).
Communication Preference	Beneficiaries repeatedly reported that personally delivered messages and radio communication was the most liked and trusted (Williams et al., 2015, Matemo, 2014, Contzen and Mosler, 2013, Date et al., 2013, Einarsdbttir et al., 2001, Wall and Chéry, Khan and Syed, 2008).
Open Communication Between Beneficiaries and Responders	Open communication between communities and responders was beneficial to address fears and establish trust – leading to a better understanding of the local community and improved programming (Contzen and Mosler, 2013, Wall and Chéry, 2011, Waterkeyn et al., 2005, ACF, 2015a, Miziniak). Open and clear communication was also necessary to mitigate the community perception of impact is necessary to reduce disease transmission risk. In an emergency, rumours spread and expectations are often beyond the capability of responders. Saltwater pumping, well disinfection, and household spraying each had examples of beneficiaries being at increased risk without clear explanation of the intervention and its capabilities (Rowe et al., 1998, Saltori and Giusti, Villholth, 2007, Lipscombe, 2007, Grayel, 2011, Nielsen et al., 2015, Unicef, 2013).

7.2 Recommendations and Future Work

Based on the general conclusions across these projects, several recommendations for future work were developed:

Further Improvement of the Evidence Base. Improvements to the evidence base of emergency WASH interventions are attainable from non-experimental methodologies if consistent indicators of program success and standard methods are applied across diverse geographic contexts and interventions. Experimental methods, such as RCTs, are robust, but not likely to be carried out in emergencies due to the natural difficulty of controlling external factors, as well as, the required financial and resource costs. At this time, the evidence gaps are fundamental and can be addressed with non-experimental methods (i.e. step-wedged design, mixed-method evaluations, qualitative collection methods, or simply consistent cross-sectional surveys). The integration of the grey literature can also provide valuable insight that is currently lacking in the published literature. Academic researchers and practice-based emergency responders should approach addressing these gaps together in order to reap mutual benefits. The research community will gain increased access and familiarity with the pressures and constraints of emergency contexts; responders will gain additional expertise in the conducting of rigorous evaluation culminating in valuable additions to the published literature.

Closing the Gaps. There are several well-known emergency WASH interventions that will benefit from additional scrutiny; these include: repairing water points, water trucking, bulk water treatment, sanitation interventions, handwashing, household spraying, and environmental cleanup. These interventions are known interventions and sometimes described; however, evaluations considering the full theory of change, down to the end

user - the beneficiary, have not been assessed. In emergencies, responders initially focus on achieving access to WASH services which are described as providing a certain volume of water or distributing a number of hygiene kits. The organizational effort to further assess the use of these services by the beneficiary is higher; however, relatively simple and inexpensive non-experimental evaluation methods could address these gaps (i.e. repeated cross-sectional evaluations in different contexts). Desire for increased evidence of impact for the beneficiary is gaining momentum among responders but prioritizing this level of evaluation could be expedited if donors simply required such reporting.

Cost-effectiveness. The research arc of this thesis found cost-effective analysis to be severely under-studied. While cost-effectiveness is a priority for development interventions, in emergency contexts - location, timing, and the market status often drive costs higher, which would undermine broad cost comparisons across countries or regions. For example, a WASH project in southern coastal India is likely very different from mountainous north Pakistan and would not be suitable for comparison. However, a comparative cost-benefit analysis of different interventions *within the same context* could prove to be very insightful for both responders and researchers to highlight differences and impact for money. On the other hand, focusing purely on cost-effectiveness could also lead to increased competition between responders, which could undermine the benefit provided to beneficiaries. For instance, remote areas may be avoided due to increased cost of reaching far-flung areas; or cheaper less durable products could be distributed to contain costs. Considering the scale of unfunded interventions and the need to reach more beneficiaries with less funding, cost-effectiveness is an especially pertinent policy inflection point to consider further.

Building Back Better. Deciding how long to support an emergency-affected community can be a contentious point. Currently, *building back* better is a term that describes objectives of responders and donors to assist communities beyond their pre-disaster status. Many communities affected by disasters are already below the poverty or development line and are the focus of the Millennium and Sustainable Development Goals, thus helping to restore a community to what would be below the accepted global standard of living is not an efficient use of funds. This is a logical point, but with already strained funding for basic services it is more difficult to justify. Also, there is no clear level of 'suitable development' and it is highly debatable for how to achieve universal access to safe water and sanitation. Donor funding mechanisms are also not currently set up to bridge the transition from simply rebuilding to long-term planning. For example, the mandates and interventions that are possible between USAID (development) and OFDA (emergency relief) are very different and difficult to link together considering project durations and funding availability. Building back better is an opportunity to improve disaster-affected communities but remains a conceptual idea until there is an increase in funding and responders and donors align long-term objectives.

Evaluate WASH Package Interventions. The sector needs to identify or develop methods to evaluate a comprehensive WASH intervention package with water, sanitation, and hygiene components. No peer-reviewed studies were identified that evaluated interventions with multiple WASH components. This is likely due to the difficulty in researching multiple intervention variables simultaneously. Nonetheless, responders carry out WASH interventions as a package, so research objectives should reflect actual

interventions. Improving the understanding of intervention synergies is necessary to further advance the success of the emergency response sector.

This work was directly focused on WASH interventions, but most often these interventions are regularly a part of a much larger response that includes other sectors like: health, nutrition and food security. Health or disease impact is often the priority; however there are additional impacts and crossovers between nutritional status, especially in children under five years, and securing water for crops and animals. Easily overlooked in short-term emergencies, these additional sectors can greatly influence the relevance and success of interventions. Increasing the scope of interventions and highlighting the complex connections with other sectors confounds and caveats results, yet demand for increased understanding between sectors continues to rise.

Increase the Scope of Emergencies. The distinction between emergency, recovery, and development are not clearly defined, with emergency and recovery stages often lasting years or even decades. The importance of pre-emergency programming and sustainability plans was identified in each of the four projects examined in this thesis. Evaluations were still limited over short timeframes, thus not fully investigating the impact of interventions over medium (1-2 years) or long (3-5 years or more) time intervals. Focusing on the transitions between emergency and development phases could make for improved emergency responses, but also more efficient programming benefiting the beneficiaries as well as the responders. Organizational experience in the region before the emergency can also lead to a better understanding of the local coping mechanisms and social influences, which can lead to increased confidence in appropriate emergency programming.

Understanding People. The efficacy of WASH interventions is, for the most part, well established and understood. The primary hurdle in emergency WASH interventions is how to improve effectiveness, which translates to how to engage and inform beneficiaries. Responders encouraging behavior change, often through hygiene promotion, must overcome cultural barriers with generations of influence and also adapt to the rapidly changing conditions of an emergency. Even in stable long-term interventions, the ability for beneficiaries to achieve safe and consistent use have been a challenge, but in an emergency the importance of quick adoption of such behaviors is even greater. Some responders identify behavior change as a development strategy and can not truly be approached in an emergency context because it takes months or years to achieve. Furthermore, the tools used to encourage behavior change, like the use of disgust and fear, are also debated, questioning the ethics of such triggers in an emergency. Regardless, more effort is needed to identify how to engage the emergency affected population and encourage rapid adoption. A priority to understanding mechanisms of behavior change with a stronger appreciation for the social sciences, like psychology and anthropology, would only benefit the emergency sector.

Increase Coordination. Coordination is often discussed as an objective that is easily attainable, but the reality is that it is slow and difficult. Within emergency response, relationships between responders, donors, and academics can be difficult with varying objectives. Coordination between responders in an emergency is seemingly the most logical, but literal competition for projects and funds does not support free-flowing coordinated efforts. Relationships between responders and donors are unbalanced with donors holding the checks, leaving responders with limited ability to steer direction of response. Academic effort is not well suited for the dynamic changes in contexts and the

'quick and dirty' assessment methods often used in emergencies. The high bar of academic rigor is often unpractical for responders or donors to easily adapt. For example, in the short-term WASH in emergency review, the protocol was developed under the direction of an organization that was more accustom to sectors with higher qualities of evidence and did not grasp the practical challenges and gaps in emergency response. As a result, the protocol had more than 20 pages of contingency planning for various statistical and formal systematic review processes that were never relevant for the included studies. Ultimately, this led to results full of caveats that were more difficult to clearly communicate. There is real progress to bridge the gaps between responders, donors, and academics – but more progress is needed. To achieve this, donor agencies must lead. Money talks and responders and academics will abide. Gathering consensus from various stakeholders in the emergency sector can help direct the scope and priority, but ultimately a consolidated donor body (e.g. institutional donors, bilateral donors, large private foundations) should set unified objectives, evaluations, and reporting requirements. Even a single proposal format would reduce administrative effort for the NGO and academic. Some of these efforts are in progress, for example: the Sphere Handbook is a large consolidated effort from many different parties and is widely accepted and during the 2016 World Humanitarian Summit donors also reported to agree on common reporting indicators. Coordination remains a work-in-progress, but possibly the closest to tangible and lasting impact for the sector.

7.3 Closing

From the academic research community and emergency responders, WASH interventions have greatly improved and been refined by decades of adopting best practices. Evidence arising from emergencies must include non-experimental and qualitative research methods to best capture the scope and complexity of rapidly changing contexts. Even with the broader appreciation of evidence, there remain significant knowledge gaps for many of the widely practiced WASH interventions, but also for how to achieve greater beneficiary behavior change. Overwhelmingly, WASH interventions benefit emergency-affected populations, how responders implement WASH interventions and engage those populations ultimately determines the magnitude of impact.

Chapter 8: Supporting Information

Appendix 1: WASH and PLHIV Review Assessment of Individual Studies by Outcome

Appendix 2: WASH in Disease Outbreaks – Detailed Study Description

Appendix 3: Short-term WASH Interventions in Emergencies – Detailed Study Description

8.1 - Appendix 1: WASH and PLHIV Review Assessment of Individual Studies by Outcome

*[i]*The expected impact of the intervention was rated as: **High** = Intervention expected to have a high impact on the outcome, **Moderate/Medium** = Likely to have a moderate impact on the outcome, **Low** = Intervention expected to have a low impact on the outcome, and **Uncertain** = Available information is not adequate to assess estimated impact on the outcome.*

*Note: Assessment of the **expected impact** of the intervention was based on published evidence. Additional considerations that would inform implementation decisions would have to take into account the cost-effectiveness information and country-specific contextual considerations.*

Table 17: Summary of Evidence from All Studies Addressing an Outcome

	Overall Quality of Evidence		Impact of the intervention	Evidence from Economic Evaluation		Comments
	Studies	**Overall Quality of Evidence**	**Expected Impact of the intervention***	**Studies**	**Quality of evidence from economic evaluation**	
Mortality	Walson et al. 2013[18] Kern et al. 2013[29]	Poor	Uncertain	1	Cost-effectiveness was not presented independently from a joint bednet/malaria intervention and was estimated to be $3,095 per death averted with water filters and bednets. (Kern et al 2013)	Conflicting results in different populations (children vs. all ages) from a limited number of studies. No studies were ideal in design or execution to measure mortality.
Morbidity	16 studies	Good	High	3	Compared to the recommended threshold of 3-times per capita GDP, WASH is cost effective and/or cost savings for the care and health of PLHIV. Intervention cost per DALY = <$20 - $1252. (Kahn et al. 2012; Kern et al 2013; Shrestha et al 2006.)	Expected high and cost-effective impact from water treatment, water supply, sanitation, hand-washing programs.

Overall Quality of Evidence;* ***Strong* *(Systematic Review/meta-analysis of RCTs with consistent findings; High-quality individual RCT),* ***Medium*** *(Systematic Review/meta-analysis of lower-quality clinical trials or of studies with inconsistent findings; Lower-quality clinical trial; Cohort study; Case control study) or* ***Weak*** *(Consensus guidelines; Usual practice; Opinion; Case series). The rating could be modified by other factors, including the number of participants in the study and the internal and external validity of the study data.*

The* ***cost-effectiveness *of the interventions was assessed based on the quality of evidence from economic evaluations and was rated at three levels:* ***Level 1:*** *Full economic evaluation (i.e. cost-effectiveness analysis (CEA), cost-utility analysis (CUA), cost-benefit analysis (CBA));* ***Level 2:*** *Partial economic evaluations (i.e. cost analyses, cost-description studies, cost-outcome descriptions);* ***Level 3:*** *Randomized trials and studies reporting more limited information, such as estimates of resource use or costs associated with intervention(s) and comparator(s)*

Study Characteristics				Key Findings	Quality of Evidence for Individual Studies			Evidence from Economic Evaluation	Comments
					External and Internal Validity (1=Good; 2=Fair; 3=Poor)		Overall Quality of Evidence Rating* (1=Strong; 2=Medium; 3=Weak)	(Yes or No; if Yes, Level 1, 2, or 3)**	
Citation	**Study Design**	**Study Period, Country**	**No. Participants**		**Internal Validity**	**External Validity**			
Mortality									
Walson et al. 2013[18]	Prospec-tive cohort	2009-2012. Kenya	589 HIV+ ART-naive adults. 361 in intervention cohort and 248 in control cohort	No difference in overall mortality between intervention and control cohorts.	1 - Good	2 - Fair	2 - Medium	Yes, Level 1 – *See Kahn et al 2012 and Kern et al 2013*	Water filters and bednets provided to intervention arm; no way to identify independent effects of filters vs nets. Use of intervention and outcome of diarrhea were self-reported. Initiation of ART not controlled for and more frequent in intervention arm. Funded by filter manufacturer.

Kern et al. 2013[29]	Cost effectiveness *(See Walson et al 2013 and Kahn et al 2012)*			Cost of combined intervention per death averted = $3,095				Yes, Level 1 – research coordinated with Walson et al 2013 and Kahn et al 2012	Cannot distinguish in original research paper the impact of water filters from the impact of bednets. Decrease in CD4 decline could delay onset of ART but increase the risk of HIV transmission by an additional 0.56 HIV infections over the study period leading to a decrease in overall CE.
Morbidity									
Walson et al. 2013[18]	Prospec-tive cohort	2009-2012. Kenya	589 HIV+ ART-naive adults. 361 in interven-tion cohort and 248 in control cohort	Delayed CD4 (cells/mm$^{3)}$) regression, intervention vs. control (p=0.03). Participants in intervention arm less likely to self-report diarrhea in preceding 3 months than participants in control arm (RR 0.65; 95% CI 0.45-0.93).	1 – Good	2 - Fair	2 - Medium	Yes. Level 1 – *See Kahn et al 2012 and Kern et al 2013*	Water filters and bednets provided to intervention arm; no way to identify independent effects of filters compared to bednets. Use of intervention and outcome of diarrhea were self-reported. Initiation of ART not controlled for and more frequent in intervention arm.

									Funded by filter manufacturer.
Barzilay et al. 2011[20]	Prospective cohort	2005. Nigeria	187 HIV+ women. 66 on ART and 28 on prophylaxis	36% decrease in diarrhea post intervention (p=0.04). Confirmed frequent chlorinators had less diarrhea than less-frequent chlorinators (46% decrease vs. 15% decrease).	2 - Fair	1 - Good	2 - Medium	No	HWTS - Sodium hypochlorite and safe storage container distribution. Intervention compliance measured by free chlorine residuals in water; diarrhea was self-reported.
Missaye et al. 2011[23]	Cross-sectional study	2012. Ethiopia	272 HIV+ adults. 136 pre-ART and 136 on-ART	Increased risk factors associated with a prevalence of intestinal parasites (IP) included: not having a toilet (AOR (adjusted odds ratio) 7.57; 95% CI 1.3-44.2) and not having tap water source (AOR=6.03, 95%CI=1.1-31.9).	2 - Fair	2 - Fair	3 - Weak	No	Stool sampling with a study questionnaire. Multivariate analysis and regressions used while controlling for ART. Significant decrease in IP for beneficiaries on ART (18% vs. 39%; p<0.001).

Lule et al. 2005[14]	RCT	2001-2002 Uganda	392 House-holds (196 interven-tion, 196 control): 509 HIV+ and 1,521 HIV- members	In HIV+, household water treatment and storage (HTWS) reduced diarrhea episodes by 25% (IRR adjusted incidence rate ratio = 0.75; 95% CI = 0.50-0.94); HWTS + Cotrimoxazole prophylaxis = 67% reduction in diarrhea (IRR = 0.33; 95% CI 0.24-0.46). Less viral loading with HWTS users (0.4 vs. 0.71 log_{10} per person-year HWTS compared to control).	1 - Good	1 - Good	1 - Strong	Yes, Level 1 – *See Shrestha et al. 2006*	HWTS - Sodium hypochlorite and safe storage container distribution. More diarrhea episodes in HIV+ than HIV-, and more episodes in CD4 <200 than CD4 >200.

Yallew et al. 2012[25]	Cross-sectional study	2009 Ethiopia	294 HIV+ adults. Qualitat-ive inter-views with 28	Unimproved water source was a risk factor for diarrhea among PLHIV (AOR = 6.1, 95% CI=1.2-30.6). Access to both improved sanitation and hygiene facilities was protective against diarrhea, but not statistically significant.	2 - Fair	2 - Fair	3 - Weak	No	Study `questionnaire and qualitative interviews with logistic regression and thematic framework. Diarrhea and WASH conditions/practices were self-reported. PLHIV experienced discrimination with access to public water sources, shared latrines, and hand-washing facilities because of fears of virus transmission.
Nkenfou et al. 2013[13]	Cross-sectional study	2012 Cam-eroon	396 adults. 354 HIV- and 42 HIV+ (30 ART naive).	PLHIV have increased risk of IP compared to HIV- (AOR=14, 95% CI 7.0-29.2). Consuming water from a controlled source was protective (AOR=2.4, 95%CI 1.2 - 5.2).	2 - Fair	2 - Fair	3 - Weak	No	Clinical collection of blood and stool samples with patient questionnaire. Multivariate regression analysis used to identify risk factors. *Controlled source* is protected and consistently used.

Peletz et al. 2013[19]	Systematic review and meta-analysis	1973-2012 Global	WASH intervention among PLHIV. 4,128 studies identi-fied; 10 included for analysis.	All (9) water treatment studies were protective against diarrhea (pooled reduction in diarrhea morbidity = 43%; 8 of 9 statistically significant).	1 - Good	1 - Good	1 - Strong	No	9 studies on drinking water quality (1 treatment plant; 8 household treatment, incl. chlorination, ceramic filtration, carbon filtration and UV) with outcome of diarrhea-related morbidity.
Gumbo et al. 1999[24]	Cross Sectional	1995. Zimbab-we.	88 HIV+ adults	Prevalence of IP among PLHIV was 51% by PCR and associated with nonpiped water source (RR 2.0; 95%CI 1.1-3.5); with traditional lab testing IP prevalence was but was 18% without significant association.	2 - Fair	3 - Poor	3 – Weak	No	Stool samples with a risk factor questionnaire. Wide variability in results from different lab techniques. Unusually high IP prevalence from PCR for Enetrocytozoon bieneusi (microsporidian parasite).
Kipyegen et al. 2012[22]	Cross-sectional and questionnaire	Dates not reported. Kenya.	285 HIV+ adults	Piped water, treated water, and a reliable water source were all associated with not having IP among PLHIV (p=0.0001; p=0.0001; and p=0.04, respectively).	2 - Fair	2 - Fair	3 - Weak	No	Univariate analysis with stool sampling and risk questionnaire. IP was also associated with having diarrhea (p=0.0001) and urban residence (p=0.002).

Abebe et al. 2014[3]	RCT	2009-2010 South Africa	74 HIV+ adults on ART. Interven-tion group (39) and control group (35)	Reduced diarrhea rate in intervention group (RR = 0.21, 95% CI 0.18-0.26, p<0.0001, adjusted by Poisson regression). *Cryptosporidium* prevalence decreased by 25% in intervention and by 4% in control group but was not statistically significant.	1 - Good	1 - Good	1 - Strong	No	Household nano-silver impregnated ceramic water filter and safe storage intervention. Stool and water samples collected. Self-reported diarrhea weekly over 12 months.
Pavlinac et al. 2014[2]	Prospecti ve cohort *Nested within Walson et al 2013*	2009-2012 Kenya	*See Walson et al 2013*	Reduced diarrhea rate with filter provision (OR = 0.39; 95% CI = 0.23–0.66; p<0.001); water filter with cotrimoxazole prophylaxis also reduced diarrhea rates (OR = 0.47; 95% CI = 0.25–0.88; p=0.019). Educational reinforcement associated with reduced diarrhea rates (OR = 0.50; 95% CI = 0.20–0.99; p=0.047).	2 - Fair	1 - Good	2 - Medium	No	*See Walson et al 2013*

Wanyiri et al. 2013[21]	Cross sectional study	2009-2010 Kenya	167 HIV+ adults ART-naive	Use of treated water was protective against diarrhea (OR = 0.231; 95% CI 0.126–0.830). Close contact with cows or pigs were diarrhea risk factors (OR = 3.2, 95% CI 1.26–8.13) and (OR = 11.2, 95% CI 3.8–43.6), respectively.	2 - Fair	2 - Fair	3 - Weak	No	Stool samples with risk factor questionnaire. Multivariate regression analysis. Higher CD4+ was associated with less diarrhea (OR = 0.995, 95% CI 0.992 – 0.998).
Mohan et al. 2013[26]	Case control study	2009-2009. India.	Case: 100 HIV+ patients with diarrhea Control: 50 HIV+ positive patients without diarrhea	IP prevalence was significantly higher in public toilet users (47%) compared to house toilets (7%) and those practicing open defecation (12%) ($p<0.01$). Contact with pets and animals were also significant factors in acquiring parasitic infections ($p<0.05$).	2 - Fair	2 - Fair	3 - Weak	No	Stool samples with a risk factor questionnaire. Chronic diarrhea was also significant factors in acquiring parasitic infections ($p<0.05$).
Shrestha et al. 2006[48]	Cost effectiveness *(See Lule et al 2005)*			Net program cost per diarrhea episode averted = $5.21, or $0.62 per diarrhea day averted, and $1,252 per DALY gained.				Yes, Level 1 – research coordinated with Lule et al 2005	HWTS (sodium hypochlorite distribution). Study not designed or powered to look at mortality contributing to relatively high cost per DALY.

Kahn et al. 2012[49]	Cost effectiveness *(See Walson et al 2013)*			In multivariate sensitivity analyses, 83% of simulations result in net savings and 93% in cost per DALY<$ 20. Projected reductions in cases of diarrhea, malaria, and HIV infection avert an estimated 359 DALYS and $85,113 in medical costs per 1000 participants (including deaths averted).				Yes, Level 1 – research coordinated with Walson et al. 2013	Cannot distinguish the cost-effectiveness impact of water filters from the impact of bednets. Impact represents combined affect of diarrhea and malaria prevention, and slowing of rate of CD4 count decrease.
Kern et al. 2013[29]	Cost effectiveness *(See Walson et al 2013 and Kahn et al 2012)*			Cost of combined water filter and bednet intervention per DALY averted = $99.				Yes, Level 1 – research coordinated with Walson et al. 2013 and Kahn et al. 2012	See Kahn et al 2012

8.2 - Appendix 2: WASH in Disease Outbreaks – Detailed Study Description

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	High risk of bias Unspecified methodology and sampling

Author (year) title ***Type***	**Context**	**Description of activities**	**Evaluation**	**Key impacts**	**Bias** **Comments**
				Locally pressed calcium hypochlorite tablets in bag of sand was most effective with sustained FCR for several days	
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
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

Author (year) title ***Type***	**Context**	**Description of activities**	**Evaluation**	**Key impacts**	**Bias** **Comments**
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
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

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

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 info 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

Author (year) title ***Type***	**Context**	**Description of activities**	**Evaluation**	**Key impacts**	**Bias** **Comments**
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
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

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
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

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
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
Waterkeyn (2005) Rapid sanitation uptake in the internally displaced	Cholera Uganda	Community mobilization through community health club and PHAST approaches: community trainers, drama	Field commentary	Group cohesion and peer pressure adjusted hygiene behaviour and improve hygiene practices	High risk of bias

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
people camps of northern Uganda through community health clubs *Published*	Outbreak	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)	Case study	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	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
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);	High risk of bias Limited methods

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
				other NGOs did not appreciate paying for a 'volunteer' job	
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
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
CRS – Pennacchia (2011) Bridging the Gap: Providing Water and Sanitation and Non-Food Item Assistance to Returnees, IDPs and Host Communities in North Kivu	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,	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	High risk of bias Commentary – limited methods

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
Grey literature		radio, drama, IEC book; topics: handwashing, boiling of water, proper latrine usage NFI vouchers – US$70 for 2,184 beneficiaries (HH)		Time savings to collect water: average 322m before to 92m after (also less time in insecure environment)	
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
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

Author (year) title *Type*	Context	Description of activities	Evaluation	Key impacts	Bias Comments
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

8.3 - Appendix 3: Short-term WASH Interventions in Emergencies – Detailed Study Description

Intervention	Quantitative	Qualitative	Field Commentary	Published or Grey Literature (P:G)
Water	**52**	**4**	**3**	**43:16**
Well Disinfection	4	2	0	6:0
Well Rehabilitation	5	1	0	6:0
Water Tankering	2	0	1	2:1
Source-based Treatment	3	0	2	4:1
HWT – Chlorine Tablets	12	0	0	7:5
HWT – Liquid Chlorine	9	0	0	6:3
HWT - PUR®	6	1	0	3:4
HWT - Filtrations	6	0	0	4:2
HWT - Other	5	0	0	5:0
Sanitation	**3**	**1**	**12**	**12:4**
Latrines	2	1	10	9:4
Latrine Alternatives	1	0	2	3:0
Hygiene	**9**	**6**	**16**	**11:20**
Hygiene Promotion	3	2	4	4:5
Social Mobilization	1	1	7	1:8
Handwashing	1	1	0	2:0
Hygiene Kit Distribution	2	0	5	0:7
Environmental Hygiene	2	2	0	4:0
WASH Package	**0**	**9**	**15**	**0:24**
WASH - Outbreaks	0	3	10	0:13
WASH – General Emergency	0	6	5	0:11
Totals	**63**	**20**	**47**	**66:64**

Water

Well Disinfection

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Cavallaro (2011) Evaluation of pot-chlorination of wells during a cholera outbreak, Bissau, Guinea-Bissau, 2008 Published	Cholera – Outbreak Guinea-Bissau	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 a sustained FCR above 1.0 mg/L (WHO outbreak guidelines) After 24 hrs: 15% had FCR >1.0 mg/L After 48 hrs: 4% had FCR >1.0 mg/L After 72 hrs: 0% had FCR >1.0 mg/L Deemed costly and ineffective	Low Risk Consistent collection procedures
Garandeau (2006) Chlorination of hand-dug wells in Monrovia Published	Cholera – Endemic Liberia	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 0.2 mg/L all day 4) Pressed tablet pot chlorination with local pressed tablet - effective and appropriate FCR 0.2-1.0 mg/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

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Guevart (2008) Handmade devices for continuous delivery of hypochlorite for well disinfection during the cholera outbreak in Douala, Cameroon (2004) Published	Cholera - Outbreak Cameroon	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 0.2 mg/L for 3 days, after 4 days half of the wells were below 0.2 mg/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
Libessart (2000) Integrated chlorination campaign in Mogadishu Published	Cholera – Endemic Somalia	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 >0.1 mg/L (28% >0.6 mg/L) Jerry can pot chlorination: 87% measured FCR >0.1 mg/L (27% >0.6 mg/L) Pressed tablet pot chlorination: 96% measured FCR >0.1 mg/L (45% >0.6 mg/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
Luby (2006) Chlorine spot treatment of flooded tube wells, an efficacy trial Published	Flood Bangladesh	Chlorination of 13 tube wells hypochlorite (35g per 100ft of well mixed with 10L water) compared with 13 control tube wells	Quantitative 15 intervention wells, 15 control wells – TTC was measured after 30min, 60min, and 7-14 days	Bleach spot treatment had no effect on microbiological quality. 0% success rate of disinfection with chlorine (77% of the intervention wells were contaminated before; 77% were contaminated after)	Low Risk of Bias Consistent collection procedure, clear reporting of results

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Rowe (1998) Chlorinating well water with liquid bleach was not an effective water disinfection strategy in Guinea-Bissau Published	Cholera – Endemic Guinea-Bissau	Liquid chlorine ('bleach' sodium hypochlorite) 'shock' dose added to shallow wells to achieve about 30 mg/L	Qualitative 10 wells monitored every 24 hours until FCR ceased	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

Well Rehabilitation

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Fesselet (2006) Saline Wells in Aceh Published	Tsunami Indonesia	289 wells monitored after cleaning	Quantitative Cross-sectional; 289 wells	14% had salinity levels <2,500 µS/cm; 1.7% below the taste threshold of 900 µS/cm (repeated cleanings had not effect) Cleaning improved the turbidity, but did not reduce salinity levels suitable for drinking, heavy rains reduced salinity	Low Risk of Bias Clear selection criteria and reporting of results
Lipscombe (2007) Groundwater salinity and hand dug wells in Ampara, Published	Tsunami Sri Lanka	9 wells – salinity measured before and after pumping; 20 wells measured salinity over time	Quantitative Cross-sectional	Pumping had no effect and possibly increased salinity. Over and repeated pumping not useful – only to remove silt and debris. Community expectations were not met.	High Risk of Bias Unclear methods and reporting of results
Lytton (2008) Deep impact: why post-tsunami wells need a measured approach Published	Tsunami Sri Lanka	Clearing and pumping of 64 wells to reduce salinity	Quantitative Cross-sectional: 5 wells – salinity (TDS) monitored during pumping	Monitoring showed no reduction in salinity Pumping was stopped after 5 (of 64) wells, because there was no apparent effect on salinity and possible damage to well structures	Low Risk of Bias Inconsistent data collection
Saltori (2006) Challenges of tsunami and conflict affected rural water supply in Sri Lanka Published	Tsunami Sri Lanka	Cleaning and pumping of well after tsunami, 122 wells by ACF for microbiological contamination. Sets of 50 and 30 wells monitored by ICRC for salinity	Quantitative Case Study	Perception from community that the more the well is pumped the faster and better the recovery would be Taste of water (psychological) was main hurdle - despite safe levels of salinity Waiting for the rainy season is best option - well pumping had no effect; well pumping can be hazardous to the integrity of the well	Low Risk of Bias Clear reporting of findings

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Villholth (2007) Tsunami impacts on groundwater and water supply in eastern Sri Lanka Published	Tsunami Sri Lanka	~150 well in three villages monitored. Well pumping and chlorination carried out.	Quantitative Mixed methods; 120 wells	Pumping wells to remove salinity was not recommended because it was deemed to be ineffective and, in some cases, worsened the salinity. The majority of flooded wells were unfit for drinking 7 months after the tsunami. 65-83% of HH reported problems with diarrhea when all HH had returned to well 2 years after tsunami	High Risk of Bias Limited methods, mostly commentary
Vithanage (2009) Effect of well cleaning and pumping on groundwater quality of a tsunami-affected coastal aquifer in eastern Sri Lanka Published	Tsunami Sri Lanka	2 transects observed: Disturbed transect (15 hand dug wells with piezometers, 4 wells were abandoned) Undisturbed transect (20 piezometer wells)	Qualitative Case Study	Salinity decreased 5 fold from Jan to Sep (rainy season) with no disturbance. This decrease was smaller with pumping. With saltwater flooding, it is better to let the wells be.	Low Risk of Bias Clear methods and reporting of results

Water Trucking

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Gupta (2006) Inadequate drinking water quality from tanker trucks following a tsunami disaster, Aceh, Indonesia, June 2005 Published	Tsunami Indonesia	Water tankering – 40 tanker trucks collecting water from safe source; wait times were long, and trucks occasionally collected from unsafe sources to avoid the line	Quantitative Case Study	17% of 54 samples were contaminated (E.coli); 1 in 6 trucks had E.coli present 56% of 75 sample for FCR had 0.1 mg/L or above Median wait time at safe water source for truck: 2.75 hours	High Risk of Bias Inconsistent reporting, spillover effects likely
Lantagne (2013) Effective Use of Household Water Treatment and Safe Storage in Response to the 2010 Haiti Earthquake Published	Earthquake Haiti	25 E.coli and 22 FCR samples taken from tanker trucks	Quantitative Cross-sectional	56% (n=25) had microbiological contamination 77% (n=22) had no measurable FCR	Low Risk of Bias Clear methods and reporting of outcomes
Martin (2011) Rapport final - Water trucking DINEPA-ACF, Zone métropolitaine de Port-au-Prince, mai 2010 - 15 mai 2011 Grey Literature	Earthquake Cholera – Outbreak Haiti	Water trucking in the area of Port-au-Prince. About 1500-2000 m3 distributed daily during one year; 156 distribution points in August 2010	Field Commentary Organizational reflection	End-of-intervention strategy defined late Good knowledge of intervention area; extended coverage Collaboration with at least 10 partners in the WASH cluster (sharing information)	High Risk of Bias Unclear data collection methods

Source-based Treatment

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2014) Feasibility study and piloting of a Decentralized safe water access solution dedicated to emergency and natural catastrophes through a pre-trained community based Emergency Response Team (ERT) "Aquasure" Published	Flood Bangladesh	Water treatment units (WTU): 583 field batches of water treatment	Field Commentary Case study	FCR: more than 98% of samples/batches >0.2 mg/L Majority of batches had more than 0.5 mg/L FCR - people complained of smell Most people were not used to chlorine treatment, but accepted it eventually 1000 L/ batch - but only 900 L usable -flocculent/settling and chlorine treatment	High Risk of Bias Case study description
Dorea (2009) Up-flow Clarifier for emergency water treatment Published	Tsunami Typhoon Indonesia, Haiti	Treatment of high yield water sources with the Clarifier, a coagulant-based system, to reduce turbidity	Field Commentary Case Studies	Capable to treat variety of turbid waters and reduce natural organic material (thus less chlorine demand) Approximate 2 log reduction in thermotolerent coliform (TC) Simple, robust, capable of being managed with minimal to no training Clarifier unit cost about 5,000 Pounds (low cost compared to other options explored in 1995)	High Risk of Bias Commentary – personal observation
Yates (2015) Effectiveness of chlorine dispensers in emergencies: Case Study DRC Published	Cholera – Endemic D.R Congo	Chlorine Dispenser installed on paths near river/lake with promotion	Mixed-methods 300 HH (initial and sustained); FGD; 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 Clear methods and reporting; Large difference in municipal water supply access between evaluations

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Yates (2015) Effectiveness of chlorine dispensers in emergencies: Case Study Sierra Leone Published	Cholera – Endemic Sierra Leone	Chlorine Dispenser installed at community wells with promotion	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 Clear methods and reporting.
Yates (2015) Effectiveness of chlorine dispensers in emergencies: Case Study Haiti Published	Cholera – Outbreak Haiti	Chlorine Dispenser installed at high risk sources. Pilot program	Mixed-methods 298 HH (sustained); FGD; KII	12% reported use (sustained) 9% confirmed use (sustained) 5% effective use (sustained)	Low Risk Clear methods and reporting.

HWT – Chlorine-based Product - Chlorine Tablet

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2009) Household NFI monitoring Report (PDM) May 2009 Grey Literature	Cholera – Outbreak Zimbabwe	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 (> 0.5 mg/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.
ACF (2014) Hygiene Kits Post Distribution Monitoring Report Grey Literature	Cholera – Outbreak South Sudan	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 (>0.1 mg/L) in HH with Aquatabs (6% of HH FCR >0.5 mg/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.
ACF - Topklo (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), R.D. Congo Grey Literature	Cholera – Endemic D.R. Congo	Chloramine tablets with hygiene promotion	Quantitative Before/After: 384 HH	14% reported use of tablets. 14% confirmed use (54/ 54 HH had FCR 0.3-0.6 mg/L) Reduction from 11 to 0 and from 30 to 7 cholera cases (monthly basis) in the intervention areas	Low Risk of Bias Well-defined sampling strategy; limitations clearly stated

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Hoque (2007) Efficiency and Effectiveness of Point-of Use Technologies in Emergency Drinking Water: An Evaluation of PUR and Aquatab in Rural Bangladesh Grey Literature	Flood Bangladesh	Distribution of Aquatabs and PuR in relief packages to 4,800 HH with demonstrations of use	Quantitative Cross-sectional; 200 HH (random); TTC and FCR measured	100% of water samples tested negative for TTC (n=200) The mean and median values of FCR in samples treated with Aquatabs were 1.45 mg/L and 1.08 mg/L respectively – higher than PuR samples Beneficiaries reported a significant preference to PuR over Aquatab	High Risk of Bias Spillover effects likely
Imanishi (2014) Household Water Treatment Uptake during a Public Health Response to a Large Typhoid Fever Outbreak in Harare, Zimbabwe Published	Typhoid – Outbreak Zimbabwe	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 ≥0.2 mg/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
Johnston (2008) Point-Of-Use water treatment in Emergency Response: Experiences in cyclone Sidr Grey Literature	Typhoon Bangladesh	Distribution of 5 million of WPT (Water purification tablets)	Quantitative Cross-sectional; 126 HH; control group 291 HH	65% had WPT in house, 10% had treated water All samples tested negative for TTC Over 40% of beneficiaries reported unacceptably high chlorine smell and taste; over 60% said they were not at all satisfied with the product WPT is unpopular among respondents – PuR is preferred HH reporting diarrheal disease cases in children under 5 was 5.7% (RR 0.45 (0.19 – 1.03)) for those using PuR compared to 12.7% in the control group	High Risk of Bias Unclear methods and reporting of results

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Indonesia Published	Earthquake Indonesia	International NGOs providing HWTS to 1,578 HH – received chlorine tablets (Rotary) but also Air Rahmat liquid chlorine	Quantitative Cross-sectional: 270 HH	1.4% of HH reported use (Liquid chlorine 'Air Rahmat' 6.2%, Boiling 88.1%) 1.4% of HH confirmed use (Liquid chlorine 'Air Rahmat' 0.9%)	Low Risk of Bias Selection bias not likely. Clear and consistent reporting of outcomes.
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Nepal Published	Cholera – Outbreak Nepal	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 ≥0.2 mg/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 – Outbreak Kenya	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 ≥0.2 mg/L) 5.3% effective use <1 CFU/100mL (PuR: 2.3%)	Low Risk of Bias Selection bias not likely, consistent reporting of outcomes
Lantagne (2013) Effective Use of Household Water Treatment and Safe Storage in Response to the 2010 Haiti Earthquake – DSI program Published	Earthquake Haiti	Aquatabs distributed to 2880 HH	Quantitative Cross-sectional; 182 HH surveyed within 8 weeks of emergency onset (acute) and 143 HH 10 months after onset (recovery)	Acute: 84% of HH report Aquatab use 72% of HH confirmed use (FCR >0.2 mg/L) Recovery: 52% of HH report Aquatab use 48% of HH confirmed use (FCR >0.2 mg/L)	Low Risk of Bias Clear methods and reporting of outcomes

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Lantagne (2013) Effective Use of Household Water Treatment and Safe Storage in Response to the 2010 Haiti Earthquake – HRC program Published	Earthquake Haiti	Aquatabs distributed in an NFI kit to 87 HH in an IDP camp	Quantitative Cross-sectional; 87 HH surveyed within 8 weeks of emergency onset	Acute: 22% of HH report Aquatabs use 15% of HH had FCR >0.2 mg/L No promotion	Low Risk of Bias Clear methods and reporting of outcomes
Sirajul Islam (2007) Faecal contamination of drinking water sources of Dhaka city during the 2004 flood in Bangladesh and use of disinfectants for water treatment Published	Flood Bangladesh	Field trial of Halotab (15 mg chlorine tablet) and bleaching powder (calcium hypochlorite); 300 water samples from 20 drinking water sources	Quantitative 300 samples – total coliforms (TC), faecal coliforms (FC), faecal streptococci (FS) tested	81.5% and 64.7% effectiveness against TC (Halotab, bleaching powder) 77.1% and 72.4% effectiveness against FS (Halotab, bleaching powder)	Low Risk of Bias Clear and consistent methods

HWT – Chlorine-based Product - Liquid Chlorine

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2014) Projet pilote de l'approche de marché pour la promotion du chlore liquide Grey Literature	Cholera – Endemic D.R. Congo	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 ≥0.2 mg/L; Average FCR 0.5 mg/L) 97% of HH (31/32) reported being satisfied with liquid chlorine as a HWT	Medium Risk of Bias Potential spillover and selective reporting
Dunston (2001) Collaboration, cholera, and cyclones: A project to improve point-of-use water quality in Madagascar Published	Cholera – Outbreak Madagascar	Liquid Chlorine marketed to community (Safe Water System-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 0.23 mg/L (median), compared to 0.1 mg/L in HH not using (p=0.005)	High Risk of Bias Selective reporting, incomplete outcomes.
Gupta (2007) Factors associated with E. coli contamination of household drinking water among tsunami and earthquake survivors, Indonesia Published	Tsumani, Earthquake Indonesia	Safe Water System (SwS) consisting of 1) locally-made sodium hypochlorite solution, 2) safe water storage, and 3) behaviour change communication 16,002 HH across 3 districts (Aceh Besar, Nias, Simeulue)	Quantitative Cross-sectional; 1,127 HH	23% reported use (across Aceh, Nias, and Sim) 11.3% confirmed use (FCR >0.1 mg/L) (across Aceh, Nias, and Sim) Boiling water was highly promoted, but was found to make no change in E.coli contamination	Medium Risk of Bias Controlled for factors, limited conclusion

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Indonesia Published	Earthquake Indonesia	International NGOs providing HWTS to 1578 HH – received liquid chlorine (Air Rahmat) but also Rotary chlorine tablets	Quantitative Cross-sectional: 270 HH	6.2% reported use 'Air Rahmat' (Tablet 'rotary' 1.4%, Boiling 88.1%) 0.9% of HH confirmed use 'Air Rahmat' (Tablet 'rotary' 1.4%)	Low Risk of Bias Selection bias not likely. Clear and consistent reporting of outcomes.
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Nepal Published	Cholera – Outbreak Nepal	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 ≥0.2 mg/L)	Low Risk of Bias Selection bias not likely, clear and consistent reporting of outcomes
Macgregor-Skinner (2005) Preventing diarrhea following water emergencies: An evaluation of home-based chlorination in West Timor, Indonesia, 2004 Grey Literature	Flood Indonesia	SwS project including liquid chlorine and training – emergency-affected population (# of HH not mentioned)	Quantitative 2 stage random; 320 people in Betun and Panite – HH visited 2x/week for 7 weeks	70-94% ('Peak rates' for Betun and Panite areas) of HH confirmed use (FCR >0.0 mg/L) Bleach users had a lower risk of diarrhoea compared to non-users Betun: (RR=0.13, 95%CI 0.1-0.3) Panite: (RR=0.3, 95%CI 0.2-0.5)	High Risk of Bias Unclear methods and reporting of results
Mong (2001) Impact of Safe Water System on Water Quality in Cyclone-Affected Communities in Madagascar Published	Cholera – Outbreak Madagascar	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 ≥0.2 mg/L) 76% report receiving jerry can; 76% reported using	High Risk of Bias Selective reporting and outcomes.

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Plan International (2013) Emergency Assistance to Typhoon Usagi-Affected Populations in Central Luzon Grey Literature	Typhoon Philippines	4000 HH NFI distribution with hygiene promotion: Hyposol (sodium hypochlorite) and hygiene kit	Quantitative 105 HH 2 FGD	54% confirmed use (had measurable FCR). Respondents reported an aversion to taste and lack of education on use	High Risk of Bias Unclear methods and reporting
Sirajul Islam (2007) Faecal contamination of drinking water sources of Dhaka city during the 2004 flood in Bangladesh and use of disinfectants for water treatment Published	Flood Bangladesh	Field trial of Zeoline□-200 (commercial liquid chlorine); 300 water samples from 20 drinking water sources	Quantitative 300 samples – total coliforms (TC), faecal coliforms (FC), faecal streptococci (FS) tested	83.8% effectiveness against TC 72.6% effectiveness against FS	Low Risk of Bias Clear and consistent methods

HWT – Chlorine-based Product - PUR®

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2014) Hygiene Kits Post Distribution Monitoring Report Grey Literature	Cholera – Outbreak South Sudan	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	>90% of HH had FCR in Juba (range 83-100%) (PuR or Aquatabs) 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.
Colindres (2007) After the flood: an evaluation of in-home drinking water treatment with combined flocculent-disinfectant following Tropical Storm Jeanne — Gonaives, Haiti, 2004 Published	Typhoon Haiti	PuR (410,000 sachets) and PuR-related education provided to 9,000 HH	Quantitative Mixed Methods; KAP study of three communities 100 HH chosen randomly from clusters	58% of HH reported using PuR post-flood compared to 37% of HH using any type of treatment before the flood 41% (9/22) samples had FCR between 0.2 and 2 mg/L	High Risk of Bias High risk of spillover, small sample size
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 Diarrhoea incidence reduced by 67% (ARR 0.33; 95%CI 0.30-0.37); diarrhoea prevalence reduced by 77% (ARR 0.23; 95%CI 0.21-0.25). Covered stored water alone was also protective for diarrhoea incidence (ARR 0.84; 95%CI 0.82-0.86). Improved visual appearance and taste from PuR group	Medium Risk of Bias Weekly visits for 12 weeks prone to courtesy bias; rainy season over – less diarrhoea.

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Handzel (2006) Evaluation of Pilot Intervention to Improve Household Drinking Water Grey Literature	Flood Vietnam	Distribution of 90 PuR sachets (intended to last 3 months) to 2,500 HH	Qualitative Cross-sectional; 30 HH visits	IEC monitors confirmed daily use of PuR by all HH in evaluation Avg FCR level was 0.25 mg/L (n=32) 10.5% (2/19) of samples had FCR =0 mg/L 53% (10/19) of samples had FCR <0.2 mg/L 0.90 USD per month to purchase PuR compared to 0.1 USD per month to purchase alum (plus cost of boiling) Very high satisfaction with PuR – easy to use, acceptable taste	High Risk of Bias Unclear methods
Hoque (No Date) Efficiency and Effectiveness of Point-of Use Technologies in Emergency Drinking Water: An Evaluation of PUR and Aquatab in Rural Bangladesh Grey Literature	Flood Bangladesh	Distribution of PuR and Aquatabs in relief packages to 4,800 HH with demonstrations of use	Quantitative Cross-sectional; 200 HH (random); TTC and FCR measured	100% of water samples tested negative for TTC (n=200) The mean and median values of FCR in samples treated with PUR were 0.28 mg/L and 0.19 mg/L respectively Beneficiaries reported a significant preference to PuR over Aquatabs	High Risk of Bias Spillover effects likely
Johnston (2008) Point-Of-Use water treatment in Emergency Response: Experiences in cyclone Sidr Grey Literature	Typhoon Bangladesh	Distribution of 120,000 sachets of PuR	Quantitative Cross-sectional; 131 HH, control group 291 HH	100% had PuR in house, 72% had treated water All samples tested negative for TTC About 45% of beneficiaries reported being 'highly satisfied' with the product, about 40% reported being 'satisfied' PuR is much preferred to WPT HH reporting diarrheal disease cases in children under 5 was 2.9% (RR 0.23 (0.07 – 0.72)) for those using PuR compared to 12.7% in the control group	High Risk of Bias Unclear methods and reporting of results
Lantagne (2012) Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Kenya Published	Cholera - Outbreak Kenya	Pre-positioned stock. Distribution of Aquatabs® and PuR® Purifier of Water in an NFI kit to 5,592 HH.	Quantitative Cross-sectional: 409 HH	5.9% reported use 3.7% confirmed use (FCR ≥0.2 mg/L) 2.3% effective use <1 CFU/100mL	Low Risk of Bias Selection bias not likely. Clear and consistent reporting of outcomes.

HWT – Filtrations

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Clasen (2006) Household-Based Ceramic Water Filters for the Treatment of Drinking Water in Disaster Response: An Assessment of a Pilot Programme in the Dominican Republic Published	Flood Dominican Republic	Ceramic candle filter (ceramic element and granulated activated carbon in a 20L bucket) distributed to 40 HH	Quantitative Randomized control trial followed by a cross-sectional study 16 months later; 80 HH (40 control, 40 intervention)	38% self-reported using filter after 16 months. 51% of those were still drinking from other sources. Breakage and lack of access to replacement filters were reported as reasons for disuse 70.6% of water samples met WHO guidelines for 0 TTC/100 mL compared to 31.8% of samples from control HH's	High Risk of Bias Selection bias likely
Ensink (2015) Assessment of a membrane drinking water filter in an emergency setting Published	Conflict Pakistan	Intervention group using the Nerox microfiltration system compared to a control group using a Stefani porous ceramic filter	Quantitative Before/After; 3,075 HH. 2,097 HH intervention, 78 HH control	10% self-reported use of filter after 6 months 5.7% confirmed use -- HH had a functional filter on visual inspection Filters were not compatible with turbid water (clogged easily) No filter eliminated TC	High Risk of Bias Inconsistent methods, possibility of selection bias
Lantagne (2013) Effective Use of Household Water Treatment and Safe Storage in Response to the 2010 Haiti Earthquake Published	Earthquake Haiti	Distribution of FilterPure Ceramic filter to 350 HH	Quantitative Cross-sectional; 43 HH surveyed within 8 weeks of emergency onset (acute) and 28 HH 10 months after onset (recovery)	Acute: 72% (31) HH report any treatment, 72% (31) HH report filter use No confirmed or effective use in the acute context Recovery: 61% (17) HH report any treatment, 32% (9) HH report filter use, 7% (2) report use of chlorine	Low Risk of Bias Clear methods and reporting of outcomes; small sample size

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Lantagne (2013) Effective Use of Household Water Treatment and Safe Storage in Response to the 2010 Haiti Earthquake Published	Earthquake Haiti	Distribution of Biosand filter to 238 HH	Quantitative Cross-sectional; 51 HH surveyed within 8 weeks of emergency onset (acute) and 47 HH 10 months after onset (recovery)	Acute: 53% (27) HH report any treatment, 53% (27) HH report filter treatment, 8% (19) had E.coli <1 mg/L Recovery: 72% (34) HH report any treatment, 45% (21) HH report filter use (22% (10) with chlorine), 74% (17) had FCR >0.2 mg/L, 28% (6) had E.coli had <1 mg/L	Low Risk of Bias Clear methods and reporting of outcomes; small sample size
MEDAIR (2015) Post-Distribution Assessment Report for Point of Use Water Filter Distribution in Palei Grey Literature	Population Displacement – Conflict South Sudan	Distribution of Sawyer PointONE filter and one pre-drilled bucket (12L or 14L) to 206 HH	Quantitative Mixed methods – 85 HH randomly selected	100% self-reported daily filter use 84% confirmed use by demonstrating how to use filter correctly 86% complained that the filters were too slow. 72% complained that the buckets were too small. Highly turbid surface water caused filters to clog after every use.	High Risk of Bias Limited methods
Palmer (2005) Community Acceptability of Household Water Filters in Sri Lanka After the Tsunami Grey Literature	Tsunami Sri Lanka	Largescale distribution of candle-style and pot-style filters	Quantitative FGD and 79 KII with community members, HH visits	75% (59/75) reported use of daily use of filter 75% (55/73) confirmed use, had a sufficient amount of treated water to fill a cup 75% (6/8) of those given both types of filters preferred the pot chlorinator – better taste, holds more water	High Risk of Bias Inconsistent methods and reporting of results

HWT – Other Products

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Conroy (2001) Solar disinfection of drinking water protects against cholera in children under 6 years of age Published	Cholera - Outbreak Kenya	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
Doocy (2006) Point-of-use water treatment and diarrhoea reduction in the emergency context: an effectiveness trial in Liberia Published	Cholera – Endemic Liberia	200 HH distribution of 2 10L buckets compared to 200 HH given buckets AND PuR sachets (weekly distributions)	Quantitative RCT: 200 HH intervention and 200 HH control	Covered stored water alone reduced incidence of diarrhea by 16% compared to the preceding week (OR 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 diarrhea.
Roberts (2001) Keeping clean water clean in a Malawi refugee camp: a randomized intervention trial Published	Cholera – Endemic Malawi	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. 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) 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

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Einarsdbttir (2001) Health Education and Cholera in Rural Guinea-Bissau Published	Cholera – Endemic Guinea-Bissau	Promotion of boiling and lemon as HWT: radio, TV, health staff, poster, word-of-mouth, song, theatre group	Quantitative 53 HH (Random)	66% reported use of 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
Sirajul Islam (2007) Faecal contamination of drinking water sources of Dhaka city during the 2004 flood in Bangladesh and use of disinfectants for water treatment Published	Flood Bangladesh	Field trial of alum potash; 300 water samples from 20 drinking water sources	Quantitative 300 samples – total coliforms (TC), faecal coliforms (FC), faecal streptococci (FS) tested	73.0% effectiveness against TC 29.7% effectiveness against FS	Low Risk of Bias Clear and consistent methods

Sanitation

Latrines

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Bastable (2012) Innovative designs and approaches in sanitation when responding to challenging and complex humanitarian contexts in urban areas Published	General Emergency Haiti, Philippines, Pakistan	Various latrine types used in three emergency contexts	Field Commentary 3 Case Studies	Temporary latrines often become long-term solutions Privacy barrier could be constructed to increase women's ability to use latrines without shame Additional consideration needed for desludging	High Risk of Bias Case study description
de Lange (2014) Keeping it simple: a gender-specific sanitation tool for emergencies Published	Population spike in existing camp setting South Sudan	147 women's latrines built using a gender-specific 'tool' providing technical guidance and instructions compared with 69 latrines built using normal methods	Quantitative Mixed methods; control (1800 people) and intervention (3300 people) group 4 FGD; 7 KII	High involvement from women in the community – added and cancelled parts of the project based on their input Observed latrine usage: 13.2% and 13.5% (control and intervention) Tool added 7.5% cost from a normal latrine Incidence Diarrhea Rate (confirmed – clinic test) Control: 3.8 and 4.8 cases/1000/week Intervention: 11.4 and 7.9 cases/1000/week	High Risk of Bias Data collection methods questionable
Eyrard (2011) Portable toilets in emergencies: lessons learned from Port-au-Prince, Haiti Published	Earthquake Haiti	Construction of 400 public portable toilets (Port-a-potties)	Field Commentary Lessons Learned	Viable option in an emergency Initial cost: $25/unit/day with desludging; Negotiated later: $9-13/unit/day (with 6 month contract) Needs daily service/desludging No handwashing unit	High Risk of Bias Commentary – unclear reporting

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
				Final destination of the sludge is a critical thought before the intervention	
Fortune (2010) British Red Cross – Mass Sanitation Module 2010 Haiti Earthquake Response Post Deployment Learning Evaluation Grey Literature	Earthquake Haiti	300 latrines in IDP camps (525 planned) 13 handwashing stations (66 planned); 11 bathing units (65 planned); 103 rubbish bins (525 target) Hygiene promotion - transmission, handwashing, how to use a latrine, safe water practices	Field Commentary Lessons Learned	Scale of work needed - MSM response intended for up to 20,000 people - needs were more than 2.5 times that Hygiene volunteers not from within the camp and were seen as outsiders Limitations of space within the camp and a high population density complicated latrine construction	High Risk of Bias Commentary – limited methods
Howard (1996) Rethinking the unthinkable—effective excreta disposal in emergency situations Published	Multiple Emergencies India, Bangladesh, Malaysia	Various methods of human waste containment: sewage ponds, collection in plastic bladders, gravity systems	Field Commentary 3 Case Studies	Several options are usually available for each situation People will use safe, clean, private latrines Point of contact for beneficiary is important, more so than involving beneficiary in design of intervention Use machines to make deeper/bigger trenches	High Risk of Bias Case study description
Kinstedt (2012) The Application of Ecological Sanitation for Excreta Disposal in Disaster Relief Grey Literature	Multiple Emergencies Bolivia, Haiti, Chad, Phillipines, Bangladesh	EcoSan (Ecological Sanitation) toilets in disaster relief: Urine-diverting dry toilets (UDDT); Composting toilets; Arborloo toilets Also, PeePoo bags (see Latrine Alternatives)	Field Commentary Several Case Studies	Composting toilets showed good results, but the complicated process was a barrier to extended use. UDDT had widest implementation amongst the EcoSan options – flexible and possible for high groundwater. Arborloo: simple system that uses few resources, but not possible in areas where excavation is impossible or groundwater is high	High Risk of Bias Unclear methods, limited analysis
Lin (2008) Rapid evaluation on the risk of vector and emergency vector control after the earthquake Published	Earthquake China	Rehabilitation of latrines and construction of pit latrines where rehabilitation of old latrines was impossible;	Quantitative Case Study	Diarrheal disease decreased from 11.22 cases per 1,000 to 3.61 cases per 1,000 nine days after the intervention period Prevalence of improper garbage disposal and open defecation decreased	Medium Risk of Bias Selection bias possible, clear

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
		sanitation of fecal matter storage areas using chlorine			reporting of outcomes
Moyenga (2011) Sanitation solutions for a refugee camp: Field trial of sanitation for the vulnerable Grey Literature	Population displacement – Conflict Liberia	Construction of 10 latrines designed for vulnerable people (handicapped, elderly, pregnant, children) and rehabilitation of 17 public latrines	Qualitative 18 FGD; 14 KII	Increased access to vulnerable groups (4% of the camp) High community involvement; handrails and seats most requested upgrade Small changes can have a big impact	High Risk of Bias Limited methods
Mwase (2006) The Potential of Ecosan to Provide Sustainable Sanitation in Emergency Situations and to achieve "quick wins" in MDGs Grey Literature	Multiple Emergencies Pakistan, Afghanistan, El Salvador	UDDTs trialed in several emergency contexts	Field Commentary 3 Case Studies	Challenging to provide access to mobile populations Ease of transportation and quick installation of assembled units Works better in long term phase of disaster rather than the acute phase	High Risk of Bias Commentary – bias in reporting likely
Puddifoot (1995) Improved drainage - stakeholders said it reduced dengue and accidents related to flooding Published	Population Displacement – Conflict Nepal	8000 vented improved double pit latrines constructed from prefab kits with beneficiary contribution Personal hygiene messaging	Field Commentary Personal Observation	Diarrhea rates: 6.6 cases/100 people dropped to 3.5 cases/100 when latrines were done (measured at same time in the year) Latrine cost less than $50 USD - concrete rings, superstructure - 1 latrine for 2 families 98% said they stopped traditional practice of open defecation 80% report washing hands after defecation Desludging needed after 500 days not 1 year like they assumed - natural decomposition	High Risk of Bias Commentary – personal experience
Pinera (2005) Restoring sanitation services after an earthquake: Field experience in Bam, Iran Published	Earthquake Iran	Targeting of HH without toilet for new or upgraded latrine and shower – 153 toilets constructed/repaired, 68 and 47 showers constructed (private and communal)	Field Commentary Case Study	Cost of construction: Private: $130 (45 to mason), Private bathroom (w/shower): $220 (60 to mason), Communal bathroom: $850 (150 to mason) Using resources within community gave authority to leaders, money to masons, and recovery for families as they rebuild. Finding enough skilled labor (masons) was difficult	High Risk of Bias Case study description

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
		Detailed needs assessment done with village leader; community volunteers used for unskilled labor; utilization of local materials			
Pinera (2006) Water and sanitation in camps on the Andaman Islands Published	Tsunami Andaman Islands	Construction of 1962 toilets and bathing facilities (1 per family) Built in blocks of 6 cubicles in all communities except one where the cubicles were built in front of people's homes	Field Commentary Personal Observation	Sanitary blocks granted little privacy, were poorly lit, and far from people's homes – few people used them Beneficiaries were used to open defecation – hard to change behavior When water is available (24 hours, like in the one exception camp) and latrines and bathing facilities are convenient - people will use and maintain them	High Risk of Bias Commentary – personal experience
Singh (2012) Note from the field: The Pakistan floods: Success of the household trench latrine Published	Flood Pakistan	Construction of temporary trench latrines – more than 6000 latrines in 2 months	Field Commentary Case Study	Cheap – ~4.5 GBP per latrine paid by organization Speedy construction – 2 hours per latrine Suitable for high water table – no lining	High Risk of Bias Case study description

Latrine Alternatives

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Coloni (2012) Biodegradable bags as emergency sanitation in urban settings: the field experience Published	Earthquake Haiti	Distribution of biodegradable bags for sanitation in emergency context – 22,000 individuals using for 16 weeks	Field Commentary Case Study	Use of plastic bags for defecation already widely adopted (locally referred to as “flying toilets”) Temporary cubicle facilities were modular and easy to install quickly (no digging) No biogas issues reported Smell not an issue A good solution to waste collection is needed Bags have short self-life	High Risk of Bias Case study description
Parsa (2014) Human waste management in first phase response, protecting groundwater and human health: case study from Haiyan 2013 Published	Typhoon Philippines	Distribution of PeePoo Personal Packs (28 biodegradable bags, 1 disposal bag, 1 seat) to 2,580 HH and 700 school children from 3 different NGOs	Field Commentary Case Study	74% of beneficiaries ‘observed’ use by organization 280 HH Prepositioned PeePoo stocks preferred to ensure quick response Paying local workers for collection is a good resource, but proper disposal mechanisms should be defined An exit/continuous sanitation plan must be in place before the end of the intervention	High Risk of Bias Commentary – limited reporting of results
Patel (2011) Excreta disposal in emergencies: Bag and Peepoo trials with internally displaced people in Port-au-Prince Published	Earthquake Haiti	2 week trial of Peepoo bags followed by 2 weeks of normal plastic bags in one IDP camp 4 week trial of Peepoo bags in another camp Hygiene promotion messaging with IEC materials	Quantitative Before/after: 151 HH pre-emergency, 146 HH post-emergency 19 FGD; KII (not described)	Both Peepoo and standard bags were generally accepted and had high reported use Peepoo bags contained odor, but had inadequate circumference to spread over a container. Children, disabled, and elderly found it difficult to use. Hygiene and bag removal are critical PreTrial: 42% of HH experienced diarrhea, PostTrial: 36% of HH; ($X2=1.32$, $p<0.03$)	High Risk of Bias Inconsistent methods and reporting

Hygiene

Hygiene Education

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF – Matemo (2014) Use Of H2S To Support Hygiene Promotion Grey Literature	Cholera/Hep – Spike in Cases Kenya	H2S used as part of hygiene promotion	Field Commentary 2820 HH tests – methods unclear	Use of H2S 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
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

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Williams (2015) Perceptions of health Communication, Water Treatment and Sanitation in Artibonite Department, Haiti, March-April 2012 Published	Cholera - Outbreak Haiti	Evaluation of WASH preferences in regional cholera response.	Qualitative 18 FGD	Most valuable source of information - Community Health Worker (CHW); Megaphone and CHW 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	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
Einarsdbttir (2001) Health Education and Cholera in Rural Guinea-Bissau Published	Cholera Guinea-Bissau Endemic	Hygiene promotion: radio, TV, health staff, poster, word-of-mouth, song, theatre group	Quantitative 53 HH (Random)	94% (50/53) respondents reported hearing hygiene messages 68% (34/50) of respondents could identify at least 1 cholera prevention method promoted. 38% (19/50) could identify 3 or more. 66% reported use of lemon to treat water; 40% reported boiling water; no one reported only drinking treated (boiled/lemon) water.	High Risk of Bias Small sample size, open-ended questions, self-reported results
Khan (2008) Assessment of hygiene communication plan in the aftermath of the 2005 earthquake in Pakistan Grey Literature	Earthquake Pakistan	Promotion messaging (radio, TV, house to house) Key messages: ODF spreads disease, construct a latrine, hand washing, risk of feces	Field Commentary FGD, KII, HH surveys (quantity not described)	IE materials mostly text based - not good for illiterate populations TV programming was not as relevant because most TVs were destroyed in earthquake Radio, face to face communication, and 'entertainment events' best mode of communication because that was accessible	Medium Risk of Bias Clear reporting of outcomes, observational

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Wall (no date) Ann Kite Yo Pale (let them speak) Best Practice and Lessons Learned in Communication with Disaster Affected Communities: Haiti 2010 Grey Literature	Earthquake Cholera - Outbreak Haiti	Various communication strategies from many organizations	Qualitative 15 FGD, KII (not described)	Immediately after earthquake, local radio stations disseminated key information and reunited families 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." (pg. 28)	Medium Risk of Bias Unclear methodology and selective reporting.
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 – Outbreak South Africa	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 program. Hygiene messages were known beforehand	High Risk of Bias Case study commentary

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
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 – Outbreak Zimbabwe	Cholera prevention, control, food prep, hand washing, use of HWT (tablets/sachets) Mode: T-shirts and dramas used, 310000 flyers, 14000 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.

Social Mobilization

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2015) Trigger Behavioural Change to strengthen community's resilience to Ebola Outbreaks Grey Literature	Ebola – Outbreak Sierra Leone	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.
WV – Khan (2012) CLTS in 2010 post-flood emergency response effort Grey Literature	Flood Pakistan	CLTS in 10 pilot communities (~10,000 people) Clean up campaigns following flood – repairing piping, drainage Creation of Community Resource Persons (CRP) to each 500 HH	Field Commentary Case study	525 latrines built within 4 months Low-cost building materials made available to poor members of the community CRP mobilized community for hygiene promotion	High Risk of Bias Case study description

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
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 – Outbreak Liberia	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.
Miziniak (No Date) Sustainable Relief Programming for dispersed communities Case Study: Zambia Floods 2007 Grey Literature	Flood Zambia	Community-driven approach: Voluntary Water Sanitation Hygiene and Education (VWASHE)	Field Commentary Organizational reflection	761 latrines built in 3 months Use of local materials and flexibility of design Latrines could be built at no cost to household	High Risk of Bias Commentary – personal experience
IWSD - Neseni (2009) Evaluation of the WASH Response to the 2008- 2009 Zimbabwe Cholera Epidemic and Preparedness Planning for Future Outbreaks Grey Literature	Cholera - Outbreak Zimbabwe	Social mobilization: production materials and dissemination of IEC, awareness raising, mobilization of communities, distribution of NFIs	Field Commentary Case study	Social mobilization considered most impactful to reduce disease transmission	High Risk of Bias Case study – commentary, limited methods
Polo (2010) CATS: Community Approaches to Total Sanitation Pilot in Haiti Grey Literature	Earthquake Haiti	Pilot CATS project in 5 IDP camps – emphasis on reducing open defecation Transect walk ('taboo walk') and education about food/water contamination from flies; introducing community-ownership of latrines	Field Commentary Case Study	1 camp had a strong positive reaction, 2 camps had promising results Quality of facilitation more important than the site; previous concern if camps would not have the same cohesion as an established village. Land availability in camps/urban setting and availability of materials were strained Culture of waiting for latrines to be built by NGO's; individuals not shocked by talking about 'shit'	High Risk of Bias Case study description

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
IFRC - Rees-Gildea (2013) Sierra Leone Cholera ERU Operation Review Grey Literature	Cholera – Outbreak Sierra Leone	Cholera surveillance and hygiene promotion through social mobilization	Field Commentary Case study (limited evaluation)	Decrease in CFR deemed to be more influenced by social mobilization than case management	High Risk of Bias Organization review; case study commentary .
Wall (No Date) Ann Kite Yo Pale (let them speak) Best Practice and Lessons Learned in Communication with Disaster Affected Communities: Haiti 2010 Grey Literature	Earthquake Cholera - Outbreak Haiti	Social mobilization; 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)	Medium Risk of Bias Unclear methodology and selective reporting.
Waterkeyn (2005) Rapid sanitation uptake in the internally displaced people camps of northern Uganda through community health clubs Published	Cholera – Outbreak Uganda	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 8500 latrines, 6000 bath shelters, 3400 drying racks, and 1550 handwashing stations in a 4 month timeframe Rapid, scalable, and cost-effective	High Risk of Bias Case study description.

Handwashing

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Cabezas (2008) Efectividad del uso de alcohol glicerinado para la descontaminación de manos en una población sin aceso al agua potable posterremoto en Pisco, Perú Published	Earthquake Peru	Promotion of handwashing with alcohol-based sanitizer	Quantitative Before and after 20 kitchen staff in IDP camp	A significant reduction in bacterial load on the hands ($p<0.001$), but did not eliminate all bacteria 'Successful' for area without access to potable water	High Risk of Bias Limited sample size and evaluation strategy
Husain (2015) A pilot study of a portable hand washing station for recently displaced refugees during an acute emergency in Benishangul-Gumuz Regional State, Ethiopia Published	Population Displacement – Conflict Ethiopia	Distribution of handwashing bag (HWB) with soap	Quantitative Mixed methods; 211 HH baseline survey; 4, 8, 12 week monitoring visits; 222 HH 6 month follow-up 6 FGD	Self-reported use: 91% of HH stated that HWB purpose was for handwashing, but 46% report HWB was their primary handwashing device, and 31% report that no one in their family uses it. Confirmed use: 93% of newly sampled HH had original HWB, 72% were observed hanging, 38% had water in them. Respondents said the amount of soap provided was insufficient	Low Risk of Bias Clear reporting of results

Hygiene Kit Distribution

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2014) DRM and WASH Post Distribution Monitoring Report KPK, Pakistan- November 2014 Grey Literature	Flood Pakistan	1500 HH NFI distribution: Bath and laundry soap, bucket, water cooler, nail cutter, toothbrush, toothpaste, sanitary cloth	Quantitative Cross-sectional; 10% of distribution (random)	83% of HH reported that items were NOT culturally appropriate (Males 93%, Females 67%) 100% of HH reported that the items were of good quality Reported use: 99% of HH reported they have soap, 100% of HH reported covering containers Confirmed use: 80% observed soap available, 76% of HH observed bucket for latrine, 67% of HH had toothbrushes	High Risk of Bias Unclear methods and reporting
ACF (2015) Non Food Items and Emergency Shelter Post Distribution Monitoring Report, Yobe State, Nigeria Grey Literature	Conflict Nigeria	1,350 HH NFI distribution: bathing soap, laundry soap, jerry can, sanitary cloth, Aquatabs®	Quantitative Cross-sectional: random sampling of 295 HH	100% of HH received hygiene education before receiving the kits 99.75 of HH report being satisfied with kits (Aquatabs distribution 58.3% satisfaction) 98% of respondents report washing hands with soap 65% of respondents always treat water, 32% sometimes, 3% do not treat	High risk of bias Unclear methods and reporting
Bonnaud (2014) Typhoon Haiyan – Post Distribution Monitoring Report Grey Literature	Typhoon Philippines	20,220 HH NFI distribution: 1 hygiene kit (including soap and other undescribed items), 2 10L jerry cans, 2 sets of bed sheets and mosquito nets, 2 sleeping mats	Quantitative Cross-sectional: 1011 HH	87% of distributed items were used by the beneficiaries Most useful: Hygiene Kit (29%), Sleeping mat (29%), Bedding (22%), Mosquito net (12%), Jerry Can (8%) People 'preferred' non-collapsible (rigid) jerry cans Time changes need of beneficiary: hygiene kits preferred at first, later tarpaulins.	Medium risk of Bias Selection bias not likely, possibility of spillover effects

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Khan (2008) Assessment of hygiene communication plan in the aftermath of the 2005 earthquake in Pakistan Grey Literature	Earthquake Pakistan	NFI kits (washing and laundry soap, toothbrushes, nail cutter, sanitary pads, towels, combs, water container, mug, and radios)	Field Commentary FGD, KII, HH surveys (quantity not described)	Pre-existing stock took 1 month to distribute (mid-Nov), Hub distribution in mid Dec. (2 months after) Lead times of 3 months to get NFI materials Distribution from men was not appropriate for women to collect 'Western' design sanitary pad and underwear not culturally appropriate	Medium Risk of Bias Clear reporting of outcomes, observational
Mountfield (2011) SMS Survey Grey Literature	Earthquake Haiti	Hygiene kit distribution: bath soap, laundry soap, sanitary pads, toothpaste Amount of HH's not described	Quantitative Cross-sectional: 2200 phone numbers sent survey	Only 75 responses (3.4% response rate) Men and women value different items. Men prefer bath soap, toothpaste, laundry soap Women prefer sanitary pads, bath soap, laundry soap	High risk of bias Collection procedure questionable.
0CRS - Pennacchia (2009) Bridging the Gap: Providing Water and Sanitation and Non-Food Item Assistance to Returnees, IDPs and Host Communities in North Kivu Grey Literature	Cholera – Endemic D.R. Congo	NFI Vouchers - $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, interviewed with vulnerability score - was 3.2 but 1.6 after. 3.0 is the threshold for emergency intervention Voucher - beneficiaries 'empowered' to choose their own needs More than $150,000 USD 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

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Unicef - Ruiz-Roman (2009) Evaluation of the blanket distribution of non-food items as part of the cholera response in Zimbabwe Grey Literature	Cholera – Outbreak Zimbabwe	~200,000 HH NFI distribution (1 - 20L bucket, 1 - 20L bucket w tap, 30 - water purification tablets, 3 ORS sachets and 1 pack of IEC materials)	Quantitative 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.

Environmental Hygiene

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Gartley (2013) Uptake of household disinfection kits as an additional measure in response to a cholera outbreak in urban areas of Haiti Published	Cholera – Outbreak Haiti	1,220 NFI/household disinfection kits given to cholera patients or caregivers (0.5-1 kg 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 program - 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. 94% of HH said instructions were clear and simple	High Risk of Bias Sequential sampling, likely courtesy bias.
Roberts (2001) Keeping clean water clean in a Malawi refugee camp: a randomized intervention trial Published	Cholera – Endemic Malawi	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
Steele (2008) Impact of jerry can disinfection in a camp environment - experiences in an IDP camp in Northern Uganda Published	Population Displacement – Conflict and Cholera Uganda	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 – Outbreak Sudan	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.

WASH Package

WASH - Outbreaks

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2011) Emergency Water, Sanitation, and Hygiene Interventions for AWD and Drought Affected Pastorial Communities in Borana Zone, Ethiopia Grey Literature	Acute Watery Diarrhoea (AWD) – Endemic Ethiopia	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
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 – Outbreak Haiti	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 and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
DeGabriele (2009) An emergency response to humanitarian WASH-related emergencies in Zimbabwe Grey Literature	Cholera – Outbreak Zimbabwe	Hygiene kit distribution (8000 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
ACF – Dunoyer (2012) Le choléra au Tchad en 2011 et les stratégies d'intervention associées Grey Literature	Cholera – Spike in Cases Chad	Water: 320 water sources disinfected Hygiene: 29,593 HH receive a hygiene kit (contents not specified) with education/sensitization – public spaces; HH spraying in 7749 HH	Field Commentary	HH spraying deployment delay in intervention area is 6.05 day. Spraying agents had to travel to pirogues in flooded areas and were able to disinfect an average of 8 households per day. 57.29% of drinking water samples (583) had FCR >0.5mg/L	High Risk of Bias Case study description
ACF – El-Mahmid (2009) Zimbabwe Emergency Response 01/05/2008 – 30/06/2009 Capitalization Report Grey Literature	Cholera Zimbabwe Outbreak	Water: 13 bladders and 3 rigid tanks at 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 an added value Bladder used to establish safe drinking water for 34,912 people (4L/p/d) Distribution point: FCR 0.1-1.3 mg/L; turbidity <5 NTU HH (54 samples) Avg: 0.25 mg/L; NTU <5; 84 samples 0.1-0.6 mg/L	High Risk of Bias Commentary – limited methods

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF – Gauthier (2014) A Real-time Evaluation of ACF's Response to Cholera in Juba, South Sudan Grey Literature	Cholera – Outbreak South Sudan	Borehole rehabilitation; 'Support' community building latrines; Hygiene promotion – megaphone, house to house, groups; NFI kit; HH/environmental disinfection	Field Commentary 28 Staff KII	NFIs not aligned with Sphere or South Sudan and sized 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
ACF Grayel (2011) Evaluation externe - Réponse d'urgence à l'épidémie de choléra en Haïti Grey Literature	Cholera – Outbreak Haiti	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	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
Grayel (2014) Programme d'intervention pour limiter et prévenir la propagation de l'épidémie de choléra en République Démocratique du Congo Grey Literature	Cholera – Endemic D.R. Congo	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 yrs).	Medium Risk of Bias High likelihood of spillover bias and reliance on expert opinion

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
IWSD -Neseni (2009) Evaluation of the WASH Response to the 2008-2009 Zimbabwe Cholera Epidemic and Preparedness Planning for Future Outbreaks Grey Literature	Cholera – Outbreak Zimbabwe	Water trucking, drilling boreholes, rehabilitation of wells, HWTS, 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 gov't	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
Tearfund – Ngegba (2002) Water and Sanitation Programme February-December 2002 Jaluahun Chiefdom, Kailahun District Eastern Province, Sierra Leone Grey Literature	Bloody diarrhoea – Outbreak Sierra Leone	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; CHVs engage in communal activities and help one another in times of need. 50% of interviewed demonstrated knowledge of diarrhoea transmission routes There has been considerable changes in the 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
Simpson (2009) Real Time Evaluation of the Cholera Response in Zimbabwe 09 February – 19 February 2009 Grey Literature	Cholera – Outbreak Zimbabwe	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 program; decision to scale up to response difficult to assess – trigger needed NFI materials lacking, quantity (quality ok), beneficiaries appreciated Emergency staff available	High Risk of Bias Commentary – limited methods

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
CRS - Pennacchia (2009) Bridging the Gap: Providing Water and Sanitation and Non-Food Item Assistance to Returnees, IDPs and Host Communities in North Kivu Grey Literature	Cholera – Endemic D.R. Congo	Water: 25 spring rehabilitations; 3 new spring construction Sanitation: 20 shower blocks; 20 laundry stations; 2509 m of drainage; 20 - 15 m3 solid waste areas Hygiene: 20 hygiene promoters; 28 Water committee 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 - $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 Sept : 9 cases in January); clinic records Time savings to collect water: average 322m before to 92m after (also less time in insecure environment) More than $150,000 USD 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
ACF (2007) - UNOCHA Emergency Funding Water and Sanitation Program in Kebri Dehar District, Somali Region Grey Literature	Diarrhoea – Outbreak Somalia	Water: 6 community wells rehabilitated (7095 people); 120 m3/day for 3 weeks for 3500 people with water trucking; Widespread well chlorination, 150 birkhats; 1554 bottles of WaterGuard® given to families with birkhats (259 HH); 45 bottles given to schools; 1 bottle treats 1000L NFI Kits: 500 kits: (4 pcs 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.

WASH – General Emergency

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF (2014) Projet d'urgence d'amélioration des conditions d'accès à l'eau, hygiène et assainissement dans les camps de déplacés de Bangui - Document de capitalisation Grey Literature	Population Displacement – Conflict Central Africa Republic	Water: Installation of 4 bladders connected to the water distribution network in IDP camps; distribution of water through 2 mini-systems (7m3 tanks); rehabilitation/protection of 124 water sources (mostly boreholes); distribution of water treatment kits to households (number not given) Sanitation: Construction of latrines (188) with handwashing stations (0.05% chlorine) and showers (132) in two IDP camps Hygiene: Training of 40 hygiene promoters, targeting 1000 households	Field Commentary Organizational reflection	Safety/instability issues made it difficult to stay on schedule Involving the beneficiaries helped cover WASH needs more widely in the community Having local partners is important and improves efficiency The daily presence of the team on site strengthened transmission of hygiene promotion messages	Medium Risk of Bias Limited methods and inconsistent reporting of results
Alem (2004) Evaluation of Emergency Water Supply and Sanitation Grey Literature	Drought Ethiopia	Water: rehabilitation of 8 hand-dug wells (HDW) and 2 boreholes; construction of 1 new HDW Sanitation: Construction of 275 latrines Hygiene: 2 CHW stationed at each water point (1 male, 1 female)	Qualitative 16 FGD, KII (not described), 15 site visits	Communities reported reduced prevalence of diseases such as diarrhoea, vomiting in children, and intestinal parasites Fee collected for water, but still inadequate (.25-1 Birr/month or 5 Birr/month) hard where cash is not very prevalent Safe water coverage increased 9.5-17.3% Women workload in fetching water reduced, now 15 min instead of 30 min to 2 hours Queuing time decreased and water availability increased	High Risk of Bias Unclear data collection procedure

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Baker (2009) Final Evaluation Oxfam's North Kivu Emergency Response Grey Literature	Population Displacement – Conflict D.R. Congo	Water: Gravity-fed water system rehabilitated and extended in Lubero; 9 simple spring protections; 240 m3 of water provided daily through water trucking; 2353 water filters distributed (out of 3000 planned); 70m3 tank constructed in Remera/Kiringa Sanitation: 600 emergency family latrines constructed in households; 1,000 latrines constructed out of a planned 1,500 with community participation Hygiene: 13,179 HH hygiene kits (jerricans, buckets, basins, mosquito nets, jugs, cups, soap) and 5,180 female sanitary kits (bucket, underwear, string, cloth, soap) distributed in Lubero; 4,871 basic NFI and 4650 female hygiene kits distributed in Rutshuru	Field Commentary FGD, KII (quantity not described)	3 times more people arrived than originally planned. The additional 500 latrines could not be constructed due to budgetary constraints and rising cost of construction. Public health information and training increased handwashing after using latrines from 46% to 79%, and before eating or preparing food from 56% to 92%. Water quantities did not always meet Sphere.	High Risk of Bias Commentary – Unclear methods
Mattson (2013) Technical Review of Water, Sanitation and Hygiene Promotion Activities for T-Shelter Beneficiaries Grey Literature	Earthquake Haiti	Addition of WASH components to T-shelters – latrines, handwashing stations, water points, rain/spring catchment	Qualitative 8 FGD, desk review, online survey	Eco-san toilets were trialled but were thought to be low-quality by beneficiaries Respondents to survey indicated that they felt the project would be sustainable over the next 3 years Project failed to address desludging Latrine: $177 - $820 (not including labor/materials donated by community, RC indirect costs)	Low Risk of Bias Clear reporting of results

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
ACF – Patinet (2010) Evaluation externe de la réponse d'Action Contre la Faim en eau, assainissement et hygiène à l'urgence post-séisme du 12/01/2010 en Haïti Grey Literature	Earthquake Haiti	Water: Distribution of drinking water (emergency mobile stations, truck tanks, bladders); 5 boreholes; 2 protected wells; rehabilitations were initially planned but mostly not realized Sanitation: Emergency sanitation systems (latrine, construction toilets, organization of emptying); support to 18 schools for sanitation; collection of solid waste Provision of water containers; distribution of NFI and hygiene kits; sensitization on hygiene, drinking water storage, sanitation and handwashing	Qualitative FGD, KII (quantity not described)	59% of people use drinking water from bladders / ACF trucks after the earthquake. Widespread lack of preparation regarding sanitation systems: specificity of urban context - complex population displacement dynamics, lack of space (e.g. for toilets), no urban planning Implemented solutions tend to become long-term instead of emergency response	Medium Risk of Bias Data collection from semi-structured interviews, clear reporting
Plan (2014) Building Back Batter in Tacloban: Post-Haiyan Community Rehabilitation Grey Literature	Typhoon Philippines	669 water points rehabilitated, developed, repaired 635 latrines and 668 septic tanks repaired/built 630 handwashing stations with hygiene promotion on the school or community level	Field Commentary FGD, KII (not described)	Children said time to collect water reduced by more than 50% Community involved in Community Emergency Response Team (CERT) Stakeholders said improved drainage reduced dengue and accidents related to flooding	High Risk of Bias Commentary – unclear methods and reporting
Singh (2009) Evaluation Report "Sustaining the lives and dignity of IDPs in Purnea district – Bihar" Grey Literature	Population Displacement – Natural Disaster India	Water: 29 water points established (tube wells and open water bodies) Sanitation: 187 latrines, 187 washing facilities (with solar lanterns, bucket, mugs), 1100 child potties Hygiene: promotion with plays and puppet shows, 3000 Hygiene kits, 1000 Dignity kits to women/girls (MHM)	Qualitative 650 ppl FGD; 50 KII with village leaders; discussions with partner NGO's	25-30% expressed they would not able to purchase items in the kits without assistance Women and girls expressed appreciation for dignity (MHM) kit Hygiene education was widespread and received well	High Risk of Bias Unclear methods and reporting

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
van der Wijk (2010) Evaluation of the DEC-funded CAFOD Health and WASH Project in the DRC Grey Literature	Population Displacement – Conflict D.R. Congo	Water: construction of 2 gravity systems, rehabilitation of 1 gravity system; protection of 20 springs Sanitation: construction of 83 family latrines, 11 public latrines Hygiene: Water committee training, sensitisation of 22,000 HH	Qualitative 15 FGD, 25 KII	Health data showed a decline in waterborne diseases until August where there is a slight spike (but less than baseline). Provided WASH coverage to 4,400 HH Women estimate rape risk decreased by 80% because of WASH interventions	High Risk of Bias Collection procedures questionable
Varampath (2008) South Asia floods; WASH interventions/capacity review Focusing on key WASH interventions and capacity of agencies to deliver these Grey Literature	Population Displacement – Natural Disaster India	Water: various source-based treatment methods (microfiltration, UV, membrane filtration, chlorination) and HWT (Halozone and Zeoline tablets) Sanitation: various latrine types (pour flush, simple pit, shallow trench, overhung) Hygiene kits with promotion – especially focused on handwashing after defecation	Qualitative 1 KII, field observations	Latrine Use: 0-50% (poor maintenance, damage, unclean) HWT: only 7% of HH had FCR (2 of ~30) Soap: used for bathing rather than hands - was used up quickly with no replenishment	High Risk of Bias Unclear reporting
Visser (2012) WaSH Provision in Bahn Refugee Camp in Nimba, Liberia Grey Literature	Population Displacement – Conflict Liberia	Water: Water trucking; Elevated tank eventually constructed for borehole and distribution system (replacing water trucking needs) Sanitation: Vented, gender-separated latrines (1:20 persons), 26 latrines for disabled Hygiene: NFI Kit (1 jerry can, 2 buckets with lid); Handwashing station with each latrine block - maintained by a volunteer; 100 community hygiene volunteers; Household visits	Field Commentary FGD (number not described), 12 KII, transect walk, desk review	Project designed with the expectation of 18,000 refugees – only 6,000 came Water provision met Sphere: 46,000L for 3000 (15.3 L/p/day) in February; 110,000L for 6000 (18.3 L/p/day) in August Water access within 500 m for all. Not more than 250 people per tap.	High Risk of Bias Commentary – unclear collection procedure

Author and Title	Context	Description of Activities	Evaluation	Key Impacts	Bias
Wango (2011) SRCS/IFRC RESPONSE TO THE 2010/11 SOMALIA DROUGHT Grey Literature	Population Displacement – Natural Disaster Drought Somalia	Refurbishment of boreholes (with fuel subsidy); Rehabilitation of 'Berkeds' (water pans); Shallow wells in IDP camp with hand pumps; chlorination of water points Also, distribution of NFI kit (contents not described)	Field Commentary KII (not described)	Development of long-term boreholes generally considered too expensive for emergency relief Refurbishment of boreholes ensured water availability when Berkeds and shallow wells were dry No operation and maintenance training provided NFI kits - too expensive relevant to impact (procurement and shipping)	High Risk of Bias Commentary – incomplete reporting, no comprehensive findings

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