



School of Public Health Independent
University, Bangladesh

**Effectiveness of Drinking Water Interventions on Health
Outcomes in Global Humanitarian Crisis: A Systematic Review**
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A thesis submitted by

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in consideration of the partial fulfillment of the requirements for the degree of

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Declaration

I, Samiha Nuzhat, declare that this systematic review is my own unaided work and all the sources to the best of my knowledge.

Samiha Nuzhat (ID 2031393)

Dedication

To my dear father, Md. Shafiqul Kabir

Acknowledgement

Aiming to fulfill a Masters in Public Health, amidst the global pandemic, still feels like a miracle to me. I wonder how it would ever be possible to without the mercy of Almighty Allah; all praises for all the kindness he bestowed upon me to come this far.

Secondly, I am extremely grateful to my thesis supervisor, Dr. Kamran Ul Baset, for all his considerations and immensely insightful suggestions anytime I needed. I have always been amazed by the amount of patience this extremely qualified person possesses to handle everything in such a positive way. A thank you is hardly enough to appreciate the amount of understanding nature he showed to me so that I never fall short of enthusiasm to progress with this work. I feel happy and proud that I met him as my supervisor and had a journey of learning, sharing and above all reshaping myself to be a better human being under the supervision of this down-to-earth educator and mentor of mine.

I am also very thankful to each of my instructors at the Department of Public Health, School of Pharmacy and Public Health, IUB. The amount of effort they have put to educate us amidst all the difficulties associated with the pandemic and online teaching is beyond description. Same goes with all the other members of the department. This has always been a matter of great relief to experience their highly co-operative approach at any issue. I would like to express my humble submission of gratitude to all the members of the department for everything they have arranged for enlightening us with knowledge.

A special thanks also goes to my fellow classmates for all their intended or unintended hands of timely support. In this regard, I would like to mention the name of Samara apu for helping us with our courses and Nusrat apu, another supervisee of my supervisor, for being a person with benevolent and appreciative nature. I fell short of word to express how indebted I am to them.

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Abstract

List of Abbreviations

Abbreviation	Elaboration
WASH	Water, Sanitation and Hygiene
IDP	Internally Displaced People
CONSORT	
STROBE	
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
ASD	Autism Spectrum Disorders
ASQ	Ages and Stages Questionnaire
ASQ- 2 SE	Ages and Stages Questionnaire Social Emotional
ASQ-II	Ages and Stages Questionnaire 2nd Edition

List of Key Definitions

Key words	Definitions
Humanitarian Crisis	
Incidence	
Prevalence	
Systematic Review	

CHAPTER 1: INTRODUCTION

1.1 Global Humanitarian Crisis: Stages and Evidence

Humanitarian crisis refers to certain situations that threaten the wellbeing of a community caused by disastrous or anthropogenic activities. The term, humanitarian crisis, can also be referred as humanitarian emergency, humanitarian disaster, humanitarian catastrophe, emergency response etc. *Humanitarian Coalition* (2022) defines it as events occurring in a wider area putting “critical threat to the health, safety, security or wellbeing of a community or other large group of people”. The book, *Health in Humanitarian Emergencies* (2018) treats humanitarian crisis as any disaster (natural or man-made) which arises the need of international humanitarian support for the affected population. Such crisis may arise due to natural catastrophe, political instability, religious conflicts, famine, disease outbreaks, wars etc. As per the estimation of the UN, around 274 million people are in need of humanitarian support globally of which 183 million are receiving the supports consisting of 41 billion USD (UNOCHA, 2022). The affected communities are regarded as ‘vulnerable’ due to their incapacity to overcome the consequences of such life threatening hazards (Humanitarian Coalition, 2022).

Despite the running wheel of globalization and modernization, every year, such crisis are arising in new forms and the already existing crisis are shifting their phases. According to CARE (2007), humanitarian crisis usually contains stages i. e. pre-crisis, crisis, stabilization and recovery. IOM (2022) classifies stages of emergencies as mitigation, preparedness, response and recovery. Depending on these phases, IOM designs its programmatic activities including emergency relief, contextualized return, reintegration, capacity building, protection of rights and so on. Another prominent organization working in this sector, ReliefWeb, identifies phases of emergency response as followed – search & rescue, emergency relief,

early recovery, medium / long-term recovery, community development and disaster risk reduction (ReliefWeb, 2013). The type of supports needed vary from phase to phase for which it is necessary to clearly identify phases to render the most appropriate supports. Realizing the importance needed to be put in this sector, UN founded its dedicated agency for the emergency crisis affected communities, named UNHCR, in 1951.

Till date, evidence of many ongoing humanitarian crisis can be found, of which, most of the evidence are noted in the developing or under-developed countries. *Concern Worldwide* (2021) identifies seven worst and recent humanitarian crisis which include – Ebola outbreak in Democratic Republic of Congo (since 2017), the Afghan conflict (since 1978), civil war in Yemen (since 2015), civilian protest by Sudan’s transitional government (since 2019), political crisis in Syria (since 2011), violence in South Sudan (since 2011) and finally political instability in Somalia (since 1980s). Another organization, *Save the Children*, adds on some more example of crisis, i. e. deadly attacks in Central Sahel Africa (since 2021), displacement in Venezuela, climate-crisis in Ethiopia, horrific attacks in Nigeria, violence in Iraq, religious conflicts in Myanmar and so on. Regardless of the region and severity of the crisis, women and children are usually the most vulnerable victims of such situation experiencing a long-lasting trauma and damage of psychosocial health (Anderson & Gerber, 2018). Yet, suitable interventions should be introduced as needed.

1.2 An Overview on Global Access to Safe Drinking Water

Access to safe drinking water is not only a very crucial basic human need to survive but also it is often regarded as a fundamental indicator to assess any individual’s living status. As per the UN committee on Economics, Socials and Cultural Rights, access to safe drinking water is a prerequisite behind the realization of human rights and human dignity (UN Committee on Economic, Social and Cultural Rights, 2003). It is, therefore, very unfortunate to notice an

unfair treatment of justice around the globe in terms of assuring uninterrupted access to safe drinking water. Though it is true that in many such cases, such injustice prevails due to geological and atmospheric conditions; but socio-economic and demographic status are also found as important determinants of water access inequalities. This influence of non-atmospheric and non-geological factors on access to safe drinking water refers to the violation of 'environmental justice' and 'social justice', as it hampers anyone's freedom to lead a healthy life (Powers, 2013; UN Water, 2010).

Despite the drastic advancements in the technological and economic sectors around the globe, it is extremely unfortunate to leave a huge share of global population, being deprived of the very basic human needs that includes inadequate access to safe drinking water. The issue is even more complicated for some specific communities, especially those which are struggling being stricken by socio-political conflicts, natural disasters or other unprecedented events. In order to improve such communities' overall good health and wellbeing, drinking water interventions are introduced in the form of humanitarian aid and thus, it is expected that their corresponding health outcomes will reach out at a satisfactory level. According to WHO (2019), over 29% of the world's population hardly have any access to a safely managed drinking water source which depicts that one in every three people are compelled to drink water from unsafe sources.

As a consequence of this, multiple health complications are caused widening the scopes of easy transmission of infectious bacteria, viruses and parasites. In this regard, the commonly happening diseases are not limited to the contagious diseases (i. e. diarrhea, dysentery, cholera, polio, typhoid, hepatitis and so on), since it also contributes indirectly to the occurrence of non-communicable diseases (i. e. cardiovascular diseases, chronic kidney diseases, urinal infections etc.) (Dharmaratne, 2015; WHO, 2019). As a consequence of this,

morbidity and mortality are caused. At least 2.2% of global deaths are caused by unsafe water sources; especially in developing countries, it accounts for 6% of total deaths (WHO, 2022). Thus, global access to safe drinking water is yet a matter of concern identifying the urgent need to put special priority in this regard.

1.3 Drinking Water Interventions in Global Humanitarian Crisis Context

In most emergency contexts, almost all the water sources are usually contaminated causing a huge scarcity of safe water. It is mostly because of the type of unsafe water sources (i. e. boreholes, unprotected dugwells, surface water etc.) available in any suddenly established camp setting. In rare cases, well-established camps are found which were established prior to the emergence of the crisis and in such cases, usually piped water is available. Yet, evidence show that these piped water are also polluted in most cases (UNHCR & WHO, 2021). In this regards, UNHCR sets the minimum standard of water (both quality and quantity-wise) to ensure comfort and wellbeing of the affected individuals. According to UNHCR, during emergency situation, a minimum of 15 liters of water is required per capita per day which should be expanded by 5 liters to maintain basic hygiene needs (UNHCR & WHO, 2021). And regarding the safety of water, WHO & UNHCR (2021) prioritize the treatment of only drinking water during emergencies, especially when the treatment facilities are limited. Here, basic treatment includes 0.5 mg/liter free Chlorine concentration for fecal coliform contaminated water (UNHCR, 1997). UN adds more details (i. e. 80-100 individuals/waterpoint; <200 m walking distance for water collection etc.) with the minimum standard to assure more feasible water dynamics during emergency (UNHCR, 1997).

The commonly adopted interventions to improve the quality and availability of drinking water in emergency contexts include – water trucking, treating piped water, protected well installation, safe water storage supply, chemical treatment of water, promoting improved

water transportation and storage practices etc. (Ramesh et al., 2015; UNICEF, 2021; Yates et al., 2018). Many aspects are considered while choosing the most appropriate water intervention for a specific emergency contexts. Organizations, working in this sector, built their own guidelines in this regard. For instance, IOM (2019) works towards gaining its WASH strategic objectives following its *Global WASH Strategic Plan 2019 – 2022* where it classified all program interventions associated with humanitarian emergencies in four categories – scalable, immediate, sustainable and appropriate. Phases and tentative longevity of the crisis is considered in this case for choosing the most convenient intervention in this regard. This is why piped networks are only popular for long-term crisis while instantaneous and point-of-use water treatment is popular during the initial phases or during any short-term crisis (Yates et al., 2018). Other factors considered are – the type of re-habitation setup which can be concentrated camp setting or dispersed individual households, atmospheric conditions (temperature, rainfall etc.).

Since there is a huge time and resource constraint associated with any emergency situation, it is necessary adopt certain time-efficient and easily implementable measures to assess the drinking water interventions' effectiveness in uplifting factors i. e. health status, wellbeing, cleanliness etc. This requires constant monitoring, evaluation of the service, water quality testing, epidemiological data collection, etc (Bromwich, 2015). Above all, multi-dimensional initiatives should be introduced to ensure the most suitable water service for the affected individuals. These information are not only necessary to assist required technological modifications but also suitable to realize the security challenges for future crisis (Akhter et al., 2020). This is why constant documentation and frequent situation analysis is needed for more effective planning associated with water interventions during emergencies.

1.4 Thesis Organization

This thesis is organized in seven chapters. The next chapter of the thesis includes the research question addressed in this study along with the study objectives. Later, the detailed methodology has been added. The next chapter contains the major findings from this study. It is followed by a summary and critical appraisal of the chosen articles. At the end, the study discusses the major topics derived from the study findings and ends with conclusive remarks.

CHAPTER 2: RESEARCH QUESTION & OBJECTIVES OF THE STUDY

2.1 Research Question of the Study

This study is designed to answer one major research question which is,

“How drinking water interventions adopted in global humanitarian emergency influenced health outcomes of the beneficiaries?”

2.2 General Objective of the Study

The general objective of this study is to explore how different drinking water interventions adopted in global humanitarian emergencies influenced the health outcomes of the beneficiaries.

2.3 Specific Objectives of the Study

In order to achieve the general objective of the study, some of the specific objectives of the study are as followed.

- (a) To identify health outcomes that have improved significantly through different drinking water interventions adopted during global humanitarian emergencies.
- (b) To determine drinking water interventions adopted during global humanitarian emergencies that couldn't assure expected improvements in health outcomes.

(c) To examine the quality and quantity of scientific evidence on drinking water interventions-mediated health outcomes specifying to the context of humanitarian emergencies.

CHAPTER 3: METHODS

The study was conducted following standard systematic review methodology as per 27-itemized PRISMA checklist (Attached in Annex A). The author, herself, was responsible to conduct various stages of this review under the guidance of the supervisor. The overall process of the study included multiple stages which have been discussed in the following sub-sections of the paper.

3.1 Search Strategy Formulation

Multiple keywords were listed for literature searching. Some of the most used keywords included humanitarian crisis, drinking water interventions, drinking water and health, humanitarian crisis and health, public health intervention, water-borne diseases, and so on. Table 1 contains a more detailed list of keywords used for literature searching in this study. In addition, suitable search engines were also chosen and it comprised journal article search engines such as EBSCO and Springer. Both of these two search engines were accessed using IUB library database. In addition, hand searching was also performed using Google Scholar and PubMed. Since, google scholar and PubMed is open access website, IUB library domain was not needed to get access in these two search engines. Also, in order to improve the literature analysis capacity of the author, relevant online courses and available literature review-related documents were thoroughly revised. Besides, during this preliminary stage of the study, respective tools needed for literature review (i. e. Microsoft Excel and Mendeley) were also detected in order to assure better information organization.

3.2 Literature Searching and Paper Selection

Peer-reviewed journal articles were searched in the above-mentioned electronic databases using different combinations of the keywords mentioned in the following Table 1.

Table 1: List of Keywords Used in this Current Study

Concept	Keywords
Population	Refugee*, refugees, forcefully migrated population, forcefully displaced migrated population, forcefully displaced, FDMN, internally displaced population, humanitarian crisis, child*, children, elderly people, old people, women, female, adolescent*, conflicts, humanitarian response, disasters, conflicts, hurricane, tsumani, flood, civil war, emergency response,
Intervention	Humanitarian aid, drinking water, water treatment, water purification, chlorination, handpump, underground water, safe water, clean water, water truck, water, sanitation and hygiene, WASH, sanitation*, hygiene*, water trucking, point of use water, storage, water intervention trial,
Outcome	Health*, healthy, unhealthy, disease*, diseases, water borne disease*, non-communicable disease*, infectious disease*, communicable disease*, mineral*, minerals, deficiency*, deficiencies, nutrition, nutritious, diarrhea, cholera, dysentery, typhoid

Additionally, on-hand searches were also performed using available IUB library resources. Then, based on an initial screening of the study titles, suitable articles were extracted. Also, the reference lists of the primarily selected articles were searched to find out more suitable journal articles that have relevant study titles. Thus, all the finally selected articles were imported to the reference manager, Mendeley, to produce a study library and some important facts (author name, facts, study title and so on) from each of the chosen articles were organized in an excel sheet. To assure a better organization of the articles, each paper was assigned a unique paper ID for future ease.

Then, titles, the abstracts of the articles were reviewed. At this stage, depending on the exclusion and inclusion criteria, suitable articles were chosen and based on the final selection

of articles, the prepared reference manager software and the excel sheet were updated.

Table 2 illustrates the respective inclusion and exclusion criteria for paper selection.

Table 2: Selection Criteria for Paper Selection

Topic	Inclusion Criteria	Exclusion Criteria
Interventions	Drinking water intervention for the improvements of health outcomes or that prevents water-borne diseases usually	Studies with no health interventions or drinking water intervention
Targeted Population	Global populations receiving humanitarian aid after being affected by any humanitarian crisis (i. e. the refugees, internally displaced persons and forcefully migrated population)	Populations receiving no humanitarian aid
Outcomes	Studies that measured different health outcomes	Studies that measured environmental, economic or social outcomes of the intervention
Phase of the Humanitarian Crisis	During the crisis phase and during the recovery phases of the humanitarian crisis	Studies from pre-humanitarian crisis phase and from events that are not related with any humanitarian crisis
Study Types	Quantitative studies such as randomized or non-randomized controlled trials, time series	- Qualitative study - Quantitative studies with description of intervention without any health outcome measurement
Time Interval	1 January 1981 to 30 November 2021	Studies published before 1 January 1981 and studies published after 30 November 2021
Study Language	English	Any language except English

3.3 Data Extraction and Analysis

At this stage of the study, each of the selected papers was carefully gone through and an excel database was prepared where the following 18 information were inserted for each of the 7 chosen articles,

- a) In-text reference (authors and year of publication)
- b) Country
- c) Type of population
- d) Type of the crisis
- e) Stage of the crisis
- f) Drinking water intervention
- g) Measurements of the intervention
- h) Health outcome assessed
- i) Process of outcome assessment
- j) Study design
- k) Sampling
- l) Type of statistical analysis
- m) Notable statistical findings
- n) Major success of the intervention
- o) Failure or limitation of the intervention
- p) Identified confounding factors
- q) Quality rating of the study

r) Summary

Also, if any interesting or uncommon aspect was covered in the selected study, it was inserted in the respective excel database. The inserted information was thus prepared for descriptive analysis and to produce the review paper. Descriptive analysis was performed using Microsoft Excel on the basis of the extracted data.

3.4 Study Quality Assessment

The study quality was assessed using STROBE and CONSORT checklist. Here, STROBE checklist was used for the chosen observational studies, while CONSORT checklist was specified for the chosen studies on clinical trials. These instruments were standardized with an itemized checklist, each having 22 items. Each item of the checklist was given an equal score and there were comparatively more sections for some segments of the research paper (i. e. Methods and Result section). After the review of the author, an overall quality score and justification were provided to the articles using the STROBE and CONSORT checklist. Both of the two checklists, along with the steps followed in grading the study quality, have been illustrated in ANNEX B

Table 9 and ANNEX C

Table 10 of the Annexure section.

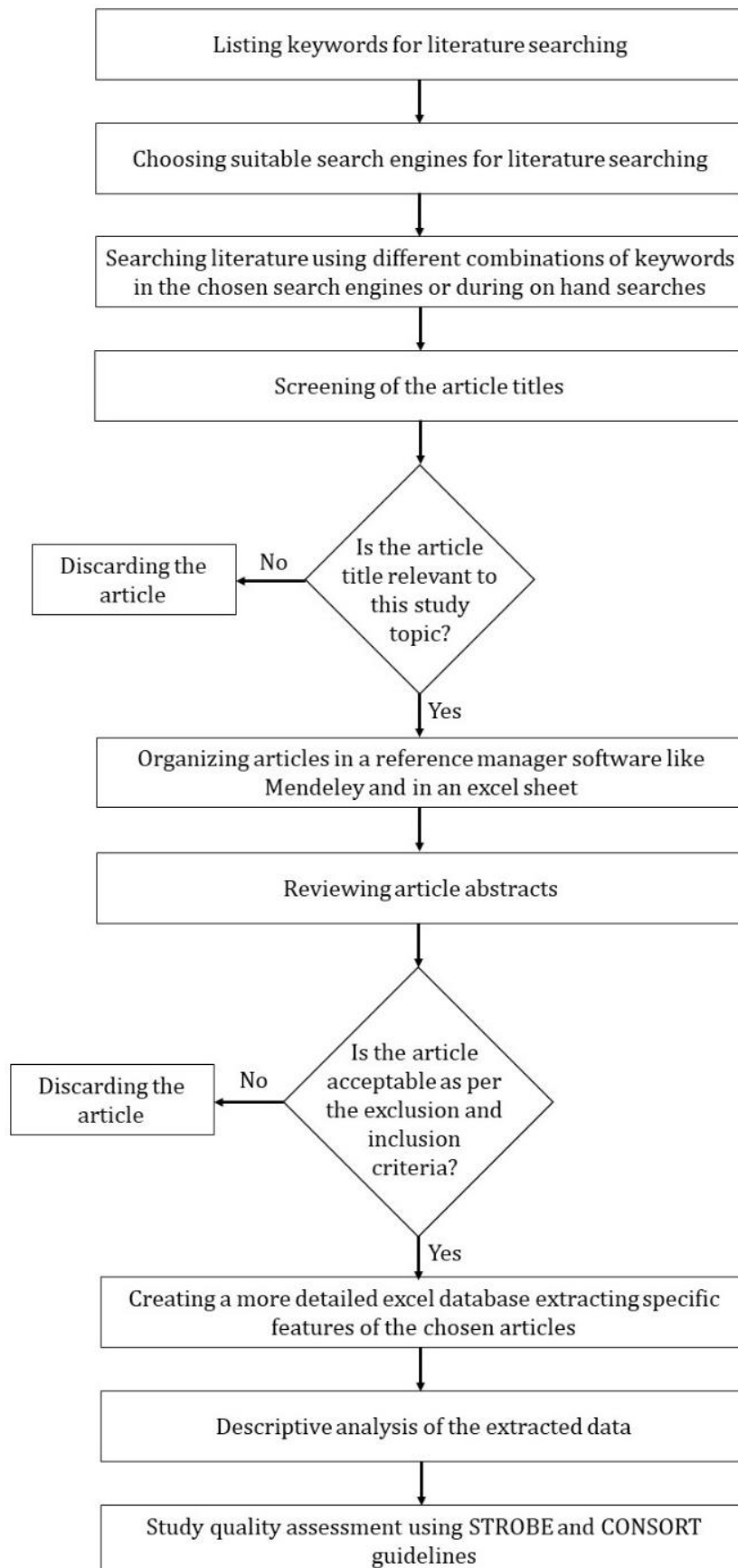


Figure 1: Flow Chart Showing Different Stages of the Methodology

CHAPTER 4: RESULTS

4.1 Findings from Literature Searching

Seven articles were finally selected from literature searching which followed a series of steps; including the initial retrieval of 1240 articles from the bibliographic database searching and the retrieval of additional 1009 articles from hand searching of databases (PubMed and Google Scholar). By removing duplicates, 1978 unique articles were found. Title and abstract screening resulted in the retrieval of 23 articles which were screened once again following the study's exclusion and inclusion criteria. These series of steps concluded to the final identification of seven articles which were relevant and suitable as per the study's exclusion and inclusion criteria. The seven selected articles (Roberts et al., 2001; Walden et al., 2005; Doocy & Burnham, 2006; Moll et al., 2007; Elsanousi et al., 2009; Mahamud et al., 2012; Harshfield et al., 2012) were later used for data extraction and data analysis. To illustrate the numeral findings from the study's literature searching and study selection process, figure 2 has been prepared as per the standardized PRISMA flow diagram.

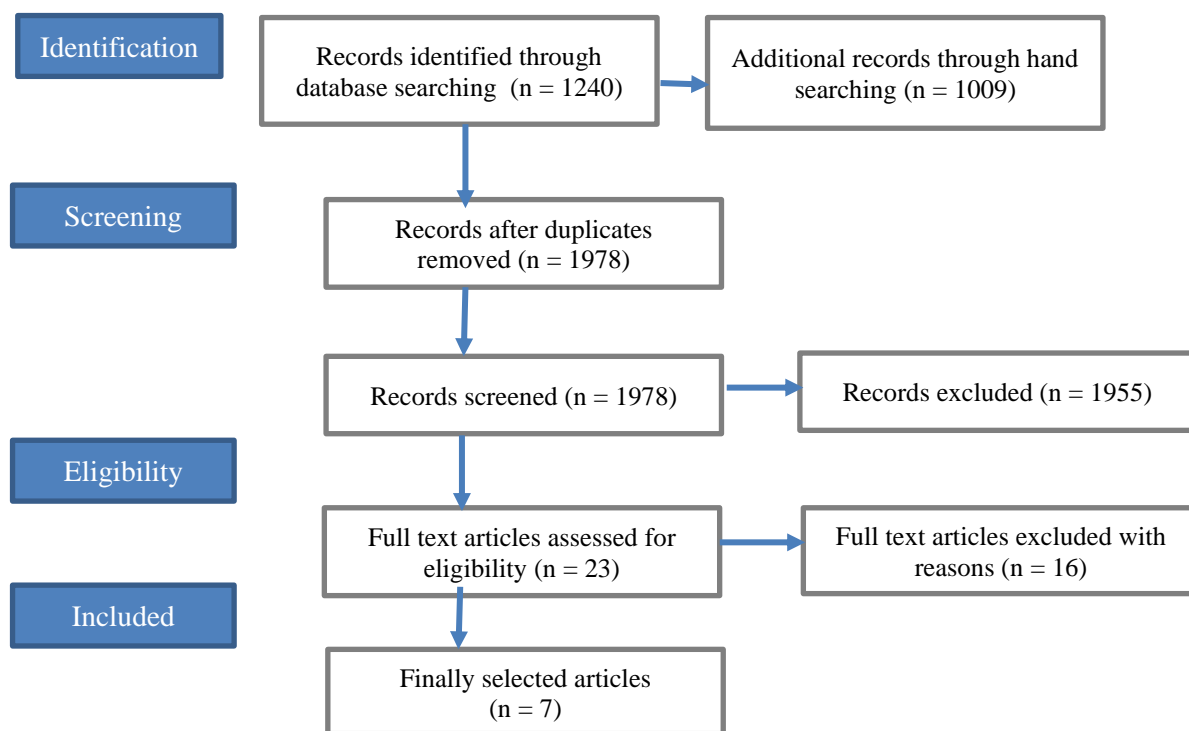


Figure 2: PRISMA Flow Diagram Summarizing the Findings from Literature Searching

Here, among the finally selected seven articles, only 3 were found from the three chosen bibliographic databases, while the remaining 4 articles were retrieved from handsearching in PubMed and Google Scholar. Such outcomes from literature searching indicate that none of the chosen bibliographic databases was a very effective source of article searching for this specific topic in humanitarian emergency context. Also, no other suitable bibliographic database was also found which had a main focus on storing articles with direct connections between interventions and its effects on health outcomes for such humanitarian crisis context. Source databases used for the identification of each of the selected articles have been mentioned in table 1. This table also includes some additional information (i. e. article title, authors, year of publication, journal name etc.) to better understand different features of the selected articles.

Table 3: Basic information of the selected published articles that measured health outcomes as the impacts of drinking water interventions

Paper ID	Study References	Study Title	Authors	Year of Publication	Search Engine	Journal Name, volume (issue)	Link of the Article
ID 1	Roberts et al., 2001	Keeping clean water clean in a Malawi refugee camp: a randomized intervention trial.	Les Roberts, Yves Chartier, Oana Chartier, Grace Malenga, Michael Toole & Henry Rodka	2001	Springer	<i>Bulletin of the World Health Organization</i> , 79	https://pubmed.ncbi.nlm.nih.gov/11357205/
ID 2	Walden et al., 2005	Container contamination as a possible source of a diarrhoea out- break in Abou Shouk camp, Darfur province, Sudan.	Vivien Margaret Walden, Elizabeth-Anne Lamond and Sally A. Field	2005	Wiley Online Library	<i>Disasters</i> , 29(3)	https://onlinelibrary.wiley.com/doi/abs/10.1111/j.0361-3666.2005.00287.x
ID 3	Doocy & Burnham, 2006	Point-of-use water treatment and diarrhoea reduction in the emergency context: An effectiveness trial in Liberia.	Shannon Doocy and Gilbert Burnham	2006	Wiley Online Library	<i>Tropical medicine & international health</i> , 11(10)	https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-3156.2006.01704.x
ID 4	Moll et al., 2007	Health impact of water and sanitation infra- structure reconstruction programmes in eight Central American communities affected by Hurricane Mitch.	Deborah M. Moll, Rebecca H. McElroy, Raquel Sabogal, Lana F. Corrales and Richard J. Gelting	2007	EBSCO	<i>Journal of water and health</i> , 5(1)	https://iwaponline.com/jwh/article/5/1/51/1996/Health-impact-of-water-and-sanitation
ID 5	Elsanousi et al., 2009	A study of the use and impacts of LifeStraw in a settlement camp in southern Gezira, Sudan.	Salwa Elsanousi, Samira Abdelrahman, Ibtisam Elshiekh, Magda Elhadi, Ahmed Mohamadani, Ali Habour, Somaia E. ElAmin, Ahmed Elnoury, Elhadi A. Ahmed and Paul R. Hunter	2009	EBSCO	<i>Journal of water and health</i> , 7(3)	https://iwaponline.com/jwh/article/7/3/478/1725/A-study-of-the-use-and-impacts-of-LifeStrawT-in-a
ID 6	Mahamud et al., 2012	Epidemic cholera in Kakuma Refugee Camp, Kenya, 2009: the importance of sanitation and soap	Abdirahman S. Mahamud, Jamal A. Ahmed, Raymond Nyoka, Erik Auko, Vincent Kahi, James Ndirangu, Margaret Nguhi, John W. Burton, Bosco Z. Muhindo, Robert F. Breiman and Rachel B. Eidex	2012	Hand searching	<i>The Journal of Infection in Developing Countries</i> , 6(3)	https://jidc.org/index.php/journal/article/view/1966
ID 7	Harshfield et al., 2012	Evaluating the Sustained Health Impact of Household Chlorination of Drinking Water in Rural Haiti (Earthquake prone)	Eric Harshfield, Daniele Lantagne, Anna Turbes, and Clair Null	2012	Springer	<i>The American journal of tropical medicine and hygiene</i> , 87(5)	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3516252/

4.1 Study Contexts of the Selected Articles

The introductory information for all the seven selected articles have been illustrated in Table 4 including the corresponding country name, type of affected population, crisis type, type of adopted drinking water intervention, measurement of intervention and health outcome assessed in the study.

Table 4: Background and introductory information of the selected published articles that measured health outcomes as the impacts of drinking water interventions

Paper ID	Country	Affected population	Type of the crisis	Stage of the crisis	Drinking water intervention	Measurements of the intervention	Health outcome assessed
ID 1	Malawi	Forcibly displaced refugees	Armed conflict	Early recovery	Providing lid-covered buckets with spout as safe water storage	Distribution and impact	Non-specific watery diarrheal disease (defined as three or more loose stools in a 24 hour period)
ID 2	Sudan	Internally displaced people	Armed conflict	Early stage	Mass Container Disinfection (MCD) via chlorination	Distribution and impact	Diarrhea and bloody diarrhea (Diarrheal symptoms with evidence of bloody and loose stools)
ID 3	Liberia	Internally displaced people	Civil war and political instability	Acute	Use of flocculant disinfectant (also supplied narrow-opening water storage containers)	Distribution and impact	Non-specific diarrheal disease (defined as three or more loose stools in a 24 hour period)
ID 4	Central America	Internally displaced people	Hurricane Mitch	Acute	Safe water storage provision and drilled well to household-level tap	Distribution and impact	Non-specific diarrheal disease (defined as three or more loose stools in a 24 hour period)
ID 5	Sudan	Internally displaced people	Armed conflict	Acute	Household iodinated water filter (IWF)	Distribution and impact	Non-specific diarrheal disease (defined as three or more loose stools in a 24 hour period)

ID 6	Kenya	Refugees	Armed conflict	Early recovery	Improved storage and container cleaning using soaps	Distribution and impact	Diarrheal diseases and cholera
ID 7	Haiti	Rural population	Earthquake	Recovery	Sodium hypochlorite solution-mediated treatment	Impact	Non-specific diarrheal disease (defined as three or more loose stools in a 24 hour period)

4.2 Methodology of the Selected Articles

The seven selected articles followed different study designs which has been discussed in Table 5 with a focus on the process of outcome assessment, type of study design, sampling strategy and type of statistical analysis.

Table 5: Methodology of the selected published articles that measured health outcomes as the impacts of drinking water interventions

Paper ID	Process of outcome assessment	Study design	Sampling	Type of statistical analysis
ID 1	Self-report after 4 month study period	Unblinded randomized intervention trial	Systematic sampling of 400 interviewed households and random sampling of 100 intervened households out of the 400 interviewed households	Relative risk, attack rate, p-value
ID 2	Identification from clinical cases after two months of identifying the first few cases	Uncontrolled longitudinal study	No sampling, since data was collected at a population level or in other words, covered all the households in the camp.(7,000 households with no control group)	Incidence
ID 3	Dichotomous measure of diarrhea for 12 weeks	Unblinded randomized controlled trial for systematically stratified sample	Stratified sampling (200 intervened sample households and 200 control households which had one or more children under age 5)	Prevalence, adjusted risk ratio, change in incidence, p-value
ID 4	Self-report	Uncontrolled longitudinal study	Random sampling of 800 households (100 households from each site)	Change in prevalence; 95% CI; p value, OR
ID 5	Self-report; laboratory testing (limited); clinic diarrhea admissions (variable)	Uncontrolled longitudinal study	Convenience sampling (647 participants or ~90% camp residents)	Change in incidence, cumulative incidence, correlation, 95% CI, p-value
ID 6	Self-report and surveys	Unblinded randomized intervention trial	Random sampling (224 participants)	AOR, p-value, risks
ID 7	Survey, self-report, laboratory testing	Unblinded randomized intervention trial	Random sampling (201 participants in intervention groups & 425 participants as control)	Change in incidence, 95% CI, p-value

4.3 Findings from the Selected Articles

Findings from the seven selected articles have been elaborated in Table 6 under categories such as – notable statistical findings, successes of the intervention, limitations of the interventions, identified confounding factors and summarized outcome.

Table 6: Major findings from the selected published articles that measured health outcomes as the impacts of drinking water interventions

Paper ID	Notable statistical findings	Major success of the intervention	Failure or limitation of the intervention	Identified confounding factors	Summary
ID 1	<p>Risk: 8.4% less diarrhea among the intervened groups of individuals (not statistically significant). Children under age 5 from the intervened group experienced 3.81% less episodes of diarrhea compared to the control group.</p> <p>Diarrheal reduction: With p-value = 0.06, the provided buckets could reduce 31.1% diarrheal episodes.</p>	Reduction in diarrheal occurrence which is more applicable for the individuals over age 5.	Could not reduce diarrheal episodes with statistical significance.	WASH education, sanitation set up	Though provided safe water storage bucket played role in diarrheal reduction, it is not considered as an intervention that can lead to statistically significant reduction in diarrhea among the refugees.
ID 2	<p>Incidence: 88% reduction in diarrheal cases in 4 weeks; in the first week, ratio of watery and bloody diarrheal cases was 200 - 210 / 90 - 100 that reduced to 80 - 90 / 0 - 10 at the end of 4th week.</p>	Reduction on the identified cases of watery and bloody diarrhea	No assessment of statistical significance	No confounding exists as other related factors were same throughout the study period	Reduction in diarrheal cases was found. No need for statistical significance test, since it is conducted at a population level.

ID 3	<p>Incidence: 90% reduction in diarrheal incidence through intervention; 10-times higher percentage of incidence for the control households than the intervened households (p-value < 0.001). Incident weeks for the control and intervened households are respectively 3.2 and 0.3.</p> <p>Prevalence: 83% reduction in diarrheal prevalence; Over 11-times higher percentage of prevalence for the control households than the intervened households (p-value < 0.001). Prevalent weeks for the control and intervened households are respectively 4.7 and 0.4 (p-value < 0.001).</p> <p>Adjusted risk ratio for control over intervened households: 3.0 for incidence and 4.4 for prevalence.</p>	Reduction on diarrheal incidence and prevalence with point-of-use intervention through flocculant disinfectant	Lack of water quality testing parameters, reporting bias, high compliance	Quality of water storage containers	Flocculant disinfectants helped drastic reduction in diarrhea in a civil war affected camp setting.
ID 4	<p>Change in diarrheal prevalence in children <3 years of age: in 2000, 25–48%; by 2002, 11–44%.</p> <p>Association between select WASH indicators and diarrhea in children<3 years (univariate): improved water access [OR = 0.61; 95% CI = 0.47, 0.78; (p<0.0001)]; stored household water covered [OR = 0.58; 95% CI = 0.43, 0.78; (p = 0.0004)]</p>	Reduction on diarrheal prevalence among children under age 3 by upgrading water storage container	Specified for under 3 years old children	Sanitation situation and hygiene behavior	Upgrading water storage container is useful for diarrheal episode reduction
ID 5	<p>Diarrheal prevalence: Pre-IWF survey prevalence: 15%; post-IWF survey prevalence: 2.3%.</p> <p>Diarrheal incidence: 4 months prior to IWF: 58 people presented in two weeks; 4 months post IWF: 6 people presented in two weeks; indicates decline in clinic attendance post IWF (compared to regional hospitals: uncorrected X2: 30.71 p<0.0001)</p>	IWF contributed to the reduction in diarrheal prevalence and incidence	Non-identification of bias	None	IWF brought statistically significant reduction in diarrheal incidence and prevalence

ID 6	Risk factor: Presence of dirty water storage containers increase the occurrence of diarrhea / cholera (AOR=4.39[1.12-17.14]; p=0.03)	Improved storage and container cleaning using soaps reduced the occurrence of diarrheal diseases and cholera	Compliance issue due to self-reporting	Hygiene behavior, availability / affordability of soaps	Soaps can be useful tool to clean water storage containers leading to long-term reduction in diarrhea and cholera
ID 7	Change in diarrheal occurrence among children: Fewer children < 5 had an episode of diarrhea (32% versus 52%; P < 0.001) with 59% reduced odds (odds ratio = 0.41)	Sodium hypochlorite solution-led treatment helped to reduce diarrheal occurrence	Lower retention and follow-up period	None	Water treatment using Sodium hypochlorite solution helped to reduce the occurrence of diarrheal episodes in longer term.

4.4 Quality Rating of the Selected Studies

Among the seven selected articles, 4 articles were rated using STROBE guidelines and 3 articles were rated using CONSORT guidelines. In both cases, the study quality is presented in percentage in order to harmonize the units of study quality assessment (table 7).

Breakdown of the quality rating has been attached in Annex B and Annex C.

Table 7: Quality rating of the selected studies

Paper ID	Quality rating of the study	Guideline used
ID 1	54.55%	CONSORT
ID 2	27.73%	STROBE
ID 3	68.18%	CONSORT
ID 4	72.73%	STROBE
ID 5	45.45%	STROBE
ID 6	36.22%	CONSORT
ID 7	42.24%	CONSORT

CHAPTER 5: ARTICLE SUMMARY & CRITICAL APPRAISAL

The seven selected studies have been summarized in the following subsections. In addition, the following tables, Table 2, Table 3 and Table 4, also illustrate the extracted data from the selected articles.

(a) Paper ID 1 (Roberts et al., 2001):

Context: Roberts et al. (2001) conducted this study in a water-borne disease prone refugee camp, named Nyamithuthu camp, situated in southern Malawi. The objective of the study was influenced by the findings of some former studies which demonstrated the proximities of household-level water contamination over the time. Thus, this study assessed how a specifically designed covered water container with spout could prevent household level water contamination in an emergency context of the aforementioned refugee camp.

Though the study was conducted during an early recovery stage of the emergency crisis, one significant challenge that this study addressed was conducting the study in such a setting that already experienced repeated waterborne disease (diarrhea and cholera) outbreaks. It had been found from some former studies that in this Nyamithuthu camp, water sources (mostly wells) were free of *Vibrio cholerae* contamination during the outbreak that means the contamination happened involving stages related to water transportation and storage at home. And, non-specific watery diarrheal disease might have emerged as a consequence of this.

Methodology: This study focused on the southernmost region of the Nyamithuthu camp and every fourth house was marked with a red paint and thus, 400 marked houses were interviewed using a structured questionnaire containing 42 questions on demographic factors, household status and hygiene behaviors. Randomly selected 100 of these 400 households were provided with an improved bucket in exchange for one traditionally used vessel. This

improved bucket was a lid-covered container with a spout and handle for efficient pouring of water without any chance of hand contamination.

In addition, information on the behavior and practices in terms of the water collection, transportation and storage behavior were collected, both at the water collection point and at the household-level. Besides, each of the interviewed households were visited twice a week to identify any occurrence of diarrhoea (defined as 3 or more loose stools in 24 hours period). Later, in addition to some descriptive water quality test, collected information were analyzed using General Estimating Equations (GEE) technique using SPIDA (Statistical Package for Interactive Data Analysis) that determined correlation between covariates and outcome variables. Also, a 2-tailed t-test analysis was performed to determine the association between the presence of improved buckets and incidences of diarrhea.

Findings: Since this thesis is focused on the impacts of drinking water interventions on health outcomes, relevant findings from the study by Roberts et al. (2001) covered the analysis on diarrheal episodes connecting with the presence of improved buckets. As per this study, 310 individuals from 100 households with improved buckets experienced 60 episodes of diarrheal diseases over the 4 month study period, with an attack rate of 44.5 episodes / 1000 / month. On the contrary, 850 individuals from the 300 control households experience 207 episodes of diarrhea, with an attack rate of 48.6 episodes / 1000 / month. This shows the intervened individuals experienced 8.4% less episodes of diarrhoea without any statistical significance of this finding (p-value = 0.26). But for under five children, this percentage refers to a 31.1% reduction in diarrheal episodes with p-value = 0.06. Besides, Poisson regression analysis found houses with more improved storages, houses with good latrines and houses that consumed more water had faced a smaller number of diarrheal episodes. In this regard, identified risk factors included presence of animals in the household, visible feces on

the latrine floor and so on. Improved water quality, being well-maintained at home, can thus contribute to such reductions in diarrheal occurrence in a heavily waterborne disease-affected refugee camp.

Critical Appraisal: The researchers chose a very appropriate study design with decent duration of intervention's follow-up. The follow-up process was strictly maintained at a regular interval of 3-4 days which is a major strength of this study. However, during the follow-up and right before providing the intervention, a good amount of information were collected, especially on water collection and transportation practice, time distribution and water quality assessment. From the result section, it seemed that all such collected data were not used for the analysis. Despite getting the scopes to analyze several water quality parameters and behavioral patterns, the study didn't try to determine the correlation of these parameters with the evidence of diarrheal incidence. Thus, collecting all these detailed information was a waste of resources, since these haven't been used at the analysis stage. In some cases, such elaborated methodology might be a bit misleading for the readers, since it makes the achievement of the core study objectives a bit blurry. Thus, I find, it would be more ideal to have a more organized and concrete analysis plan before data collection from the field.

In addition to this, another major thing addressed in this study is to reduce the effects of bias and confounding factors in many ways, i. e. collecting information on latrine inspection, handwashing behaviors, number of water containers used at the sample households, educating intervened households frequently about the cleaning process of the containers with hand contact etc. Also, it was quite interesting to see the statistical association determination between diarrheal incidences with other corresponding factors (i. e. presence of animals, latrine status etc.). Yet, acquiring data for some additional small details would be ideal. For

instance, it would be more comfortable for the readers to know the factors for which the southern part of the camp has been chosen for the study leaving the other regions of the camp. Though the study collects and displays very solid and useful information, it would be more convenient to get answers for such type of details.

(b) Paper ID 2 (Walden et al., 2005):

Context: This study was designed considering the findings of former studies that had found no contamination of water at source, yet, addressed the occurrence of diarrheal episodes in the Abou Shouk camp of northern Darfur, Sudan. Darfur is an internal conflict and drought-prone region with several histories of mass-scale internal displacements and fleeing to neighboring countries. Unlike many refugee camps, Abou Shouk, is a well-planned camp since it existed before the internal displacement in order to accommodate people during flooding. Thus, houses are very organized in blocks and compounds providing comparatively easier scopes to conduct household visits and to map out the area well. This study was carried out with chlorination as drinking water intervention in a non-epidemic situation of the camp containing approximately 7,000 people. Thus, this study aimed to introduce a mass disinfection (or chlorination) program for all water containers (referring to post-collection contamination reduction) and it also envisioned to assess its impact on the occurrence of diarrheal diseases.

Methodology: Unlike the other six selected studies for this thesis, this article by Walden et al. (2005) was not initially designed as a research study, instead it was nothing but an intervention to stop an ongoing diarrheal outbreak in the camp. Later it was written in the form of a research paper. Therefore, no control group was also kept for this study, since the primary focus of this intervention was to fully stop diarrheal outbreak. However, the series of activities for this study started with the collection of baseline data (on water consumption

practices, hygiene behavior etc.), two month prior to the intervention. Baseline information also identified boreholes connected with handpumps, submersible pumps and tank to tap stands as the major types of drinking water sources. Being driven by opinions from field workers regarding lack of water quality testing, the authors also arranged water quality tests both at the source and at the households. Then after a series of discussions from the baseline information and observations from the camp, the camp authority facilitated a mass container disinfection campaign. Chlorination was conducted for 88% of the water container used at the camp (13,224 containers) following WHO's Guidelines. Containers were chlorinated properly with vigorous shaking and scrubbing. Some more initiatives were also introduced so that no container gets excluded from this campaign.

Findings: The campaign took five days and the comparison between baseline and post-campaign data revealed reduction in diarrheal incidence. The camp clinics confirmed that the intervention reduced at least 88% combining the episodes of watery and bloody diarrhea. It also helped the diarrheal outbreak end at the earliest. However, the authors admit several methodological flaws in the article, since it was more like an intervention than research. The study also admits the incapacity to obtain statistically rigorous data in any emergency setting as one major limitation of this study. Altogether, despite having significant loopholes in the study design, it is quite suitable to understand the topic in an emergency setting, with many challenges.

Critical Appraisal: This study depicts a very realistic scenario, since it was conducted at a population level without any sort of sampling and discussions on statistically significant findings. This is both a matter of strength and weakness for this study. Since there was no data analysis plan while introducing the intervention, the amount and type of data collected and its analysis is not up to the mark. The study design also involves certain loopholes (i. e.

no specific initiative to reduce the effects of confounding factors and bias, no existence of control group, short period of intervention etc.). Yet, it is good that the authors took the initiative to document the intervention outcomes in the form of a research paper to guide and inform future researchers about the specific situation faced in the context of this specific emergency crisis context. Also, as the intervention was applied at a population-level, the findings are expected to be more reliable and adaptable for similar cases in other parts of the world.

(c) Paper ID 3 (Doocy & Burnham, 2006):

Context: The study by Doocy & Burnham (2006) addressed to the minimization of the water, sanitation and hygiene practices-borne communicable diseases (e. g. diarrhea, cholera etc.) during acute emergency crisis, especially in a camp setting. Concerning the toll of lives it costs, this issue, needs to be solved with high priority through certain interventions which should be contextualized and oriented with the demand of the ongoing crisis. For instance, in a camp context where such diarrheal infections spread from polluted water sources or from processes associated with water transportation and storage, point-of-use water treatment along with improved water storage set up seems more convenient to prevent such diseases. On the contrary, in emergency situations where the affected population is dispersed in a certain area, require household-level water purification. However, as per the authors, such disinfection is still challenging due to the high concentration of organic matters found as water pollutants in humanitarian crisis context.

In this interventional study, the internally displaced population of Liberia (affected by civil war and armed conflicts) participated and received point-of-use water treatment using flocculant-disinfectant in a camp setting. This intervention is not only suitable for this certain camp setup but also cost-effective and capable to purify organic matter-polluted water up to

certain concentration. This technology is more preferable than conventional sodium hypochlorite treatment, since this bleaching material changes the taste and smell of water drastically causing unwillingness to drink sodium hypochlorite treated water. Therefore, to overcome the existing limitations of choosing the most effective water treatment technology, this study objectified to explore the in-field effectiveness of flocculant-disinfectant-mediated point-of-use water treatment.

Methodology: This study is conducted over a 12 weeks period in 2 camps (Last Displaced Camp – 17,000 people reside and Morris Farm Camp – 5,800 people reside) of Monrovia, Liberia and the study sites were chosen through initial assessment and logistical convenience. During this study, open unprotected wells and boreholes were the major water sources in the camps. The available water was of poor water quality (very turbid) with no treatment facility. Unsafe water storage and complicated transportation were also prevalent. As a result, there was a huge cholera epidemic 1 year prior to the study conduction; but, no epidemiological data was available in this regard because of poor clinical setup in the camp.

To address this matter, in this study, a stratified sample of 400 households with 2215 participants was selected (systematically enrolled 100 control and 100 intervention group from each of the 2 study sites). Baseline information on household composition, water access, water storage practice and pre-intervention diarrheal rates were collected. The intervention groups received flocculant-disinfectant water treatment along with improved water storage while the control groups received only the improved storage containers. Such distribution helped to attribute the role of water treatment in diarrheal episodes. After proper orientations to the participants, weekly visits were conducted for diarrheal monitoring, sachet distribution and for chlorine & coliform testing. For statistical analysis of the collected data, household-level was considered instead of participants count. Chi-square and *t*-tests were performed to

compare baseline and interventional findings. Diarrhea prevalence, regression model for adjusted risk ratio, residual sum of squares and F-statistics were also calculated.

Findings: This study found effectiveness of the adopted water treatment process in the chosen emergency crisis context. Initially, during the baseline study, a huge limitation in the availability of safe water storage was noted for which both the control and intervention groups were provided to minimize bias caused by unsafe water storage. Besides, from the weekly observations, 878 new diarrheal episodes were noted for 2215 participants of which 41% were caused among children under 5 years. Prevalence and incidence of diarrhea was higher by 3.1 times in the larger camp (Last Displaced Camp) with p-value <0.001. As intervened, the intervention group had lower incidence and prevalence of diarrhea (incidence respectively 2.8% of weeks and 28.7% of weeks; prevalence respectively 3.5% and 38.7%) with p-value <0.001. Here, the adjusted risk ratio for the control group in terms of diarrheal prevalence and incidence of the intervention group was respectively 4.4 and 3.0. These findings show the statistically significant effectiveness of flocculant-disinfectant treatment in reducing diarrheal episodes among the humanitarian crisis-prone camps.

Critical Appraisal: This study is a well-designed and well-planned one with many small matters addressed at different stages of the study. One major appreciative initiative adopted in this study is the effort put to reduce the effects of confounding factors associated with the water storage containers. It is because the poor quality and unavailability of water containers in the chosen camps (as observed during baseline study) may contribute to the diarrheal episodes in the area and this is why improved water storage containers were provided to both the control and intervention groups to measure the exact contribution of the treatment mechanism in reducing diarrheal episodes. The authors also chose systematic sampling to cover a larger span of the area in the camp which is useful to understand wider scale scenario.

However, despite being a very well-structured articles, few areas could have been improved which may include – more frequent follow-up, identifying other confounding factors and bias such as variation in the number of awareness raising programs, water quality tests with more focus on physical and biological parameters and so on. However, despite these identified areas to improve, the article itself contains good explanation of the related measures and even, the study findings have also been illustrated in many ways (or, using multiple statistical terminologies) which will help the readers to understand and relate the study findings more in other emergency crisis contexts.

(d) Paper ID 4 (Moll et al., 2007):

Context: The article by Moll et al. (2007) focused on a humanitarian emergency caused by a natural calamity named Hurricane Mitch which struck the Central American countries in 1998 causing a death of ten thousand people, damage of one lac homes and hampering the lives of over three and half million people. Epidemic of water borne diarrheal diseases became worse right after the hurricane for which American Red Cross (ARC) arranged improved water access in addition to other basic needs of lives for 100 communities of four central American countries (Honduras, Nicaragua, El Salvador and Guatemala).

Based on their intervention, ARC with CDC (Centers for Disease Control and Prevention) evaluated the health implications of the adopted measures through a series of three major surveys. In light to this initiative, the authors of this selected paper determined the appropriateness of the intervention in improving the diarrheal outbreak. In this regard, the authors only considered the findings from the baseline and end-line surveys.

Methodology: For this study, the authors selected eight study sites, 2 from each of the four above-mentioned countries. The study site selectin was decided upon ARC's areas of interventions. Adopted drinking water inventions included – additional arrangement of HH-

level taps from drilled wells and clean storage distribution. Types of evaluation conducted are cross-sectional survey with visual inspection, water sampling (both at households and at sources) and infrastructural evaluation (through technical analysis and Key Informant Interviews). For household survey, a sample of 800 household was selected (100 from each site). And for water sample tests, 12 households out of 100 households were selected. One major aspect of this water quality test is to quantify the amount of fecal coliforms in addition to its existence. Infrastructural quality assessment was conducted for the same 12 households' water sources. The survey data were analyzed in SAS using chi-square tests, univariate analysis and logistic regression.

Findings:

Critical Appraisal: The time frame of this study is very small to properly rely on the numbers found as the episodes of diarrhoea.

(e) Paper ID 5 (Elsanousi et al., 2009):

(f) Paper ID 5 (Mahamud et al., 2012):

(g) Paper ID 5 (Harshfield et al., 2012):

CHAPTER 5: DISCUSSIONS

5.1 Key Findings and Analysis of the Selected Articles

All the seven selected articles were conducted in seven different humanitarian emergency setting bridging connections between different drinking water interventions and changes health outcomes. Five of the seven selected articles are originated from five different African countries while the other two are from central America. Though there are evidence on such severe emergencies happening around different parts of Asia, no such studies were included in this review. It is because of the very specific inclusion and exclusion criteria adopted in this review. Other tentative reasons for not getting any article from the largest continent might be – lack of documentation, sudden change in crisis phases, complicated socio-political situation and religious ideologies etc. (Donnelly, 1993; McAuliffe, 2016). Also, two out of the seven selected articles were conducted in emergencies held due to natural catastrophe while the rest of the events were caused by anthropogenic disasters (Moll et al., 2007; Harshfield et al., 2012). One study was held in dispersed household setup while the remaining ones were conducted in concentrated camp setting (Harshfield et al., 2012). Thus, this review also covered a wide range of contexts associated with the review topic.

In addition to the variety in study contexts associated with the selected articles, the type of water interventions adopted in these studies also varied. While some authors worked with point-of-use water treatment, the rests worked on interventions such a water storage container distribution, behavioral change and so on. Disregarding the type of intervention adopted, all the authors agreed that for any humanitarian emergency context, water pollution during transportation and storage is as common as water source pollution. This has also been the same in other emergency crisis of African and Asian countries (Ramesh et al., 2015). This is why the chosen studies also put priorities on water transportation and water storage through

their interventions. In doing so, several water quality test parameters were also included at different stages between water collection to water consumption (Roberts et al., 2001; Elsanousi et al., 2009). However, no huge shift from the existing water sources was noted in any of the studies, instead the authors tried to adapt with the existing water sources by introducing some additional stages for water treatment and storage practices.

In order to measure the impacts of the interventions, self-reporting has been chosen as the most convenient measure for all the articles. Here, the reporting frequency and mechanism varied from one to other. This study aimed to explore a wide variety of health outcomes without any specific focus on diarrheal diseases. But at the later stage of the study, it was found that none of the suitable articles addressed any health outcome other than diarrheal diseases. Also, most of the studies tried to minimize the effects of confounding variables and bias by adopting certain measures in some extent; but none of them specifically listed the type of biases reduced while conducting this study. Studies, especially those based on any critical context, i. e. humanitarian emergencies, often limits the scope to list all the biases, since many programs run in this specific contexts without proper planning and documentation (Ruby et al., 2015). It causes difficulties to track and list the effects of factors.

Besides, the methodology and findings of the chosen articles covered multiple aspects with detailed description. The study designs of the chosen articles were not identical at all and the methodologies contextualized as needed. This is why different types of sampling procedure and study types have been noted in the tables of the result section. The findings were also discussion using the concepts of prevalence, incidence, adjusted risk ratio and other terminologies. These are the commonly reported parameters for any diarrheal disease (Agustine et al., 2013). Also, other types of analysis were also conducted using statistical software as elaborated in the summary sections. In brief, all the adopted interventions were

found to be useful in uplifting the status of the health outcomes, since the episodes of diarrheal diseases reduced drastically for all the introduced interventions. This is useful to predict the effectiveness of different interventions for other humanitarian emergency crisis context.

5.2 Comments on Study Quality Assessment

Study quality of the chosen articles have been rated using standardized CONSORT and STROBE checklist and study quality for all the chosen articles lie below 80%. Since both of these guidelines are widely adopted to improve the quality of study design and findings organization, it is definitely necessary to include the aspects mentioned in the checklists for producing a good quality article (Bolignano et al., 2013). Besides, Auerbach (2016) and Vandembroucke (2009) suggest that while designing and writing papers for any randomized / non-randomized trial, CONSORT checklist should be followed and for observational studies, STROBE checklist should be followed. The authors of the selected articles could have gone through these checklists to enhance their study quality. This is also okay to go through other such well-known checklists or expanding the CONSORT-STROBE checklists as needed. This will not only improve the study quality but also cover a wider scale of discussions in a more organized manner. Here, since the graded percentages for most of the selected articles are not up to the mark (<80%), it is evident that the amount and quality of studies related with this specific topic is inadequate. This indicates the need for higher priority in this sector through future researches.

5.3 Limitations of the Study

The thesis focuses on an important area of public health studies, drinking water interventions, in an extremely critical situation, humanitarian crisis contexts happening around the globe. However, while conducting the study, several limitations have been identified which have

been briefly discussed below.

Firstly, in terms of literature searching, the study used limited number of databases concerning the accessibility using Independent University Bangladesh's library database. Though the databases searched were good enough to choose seven final articles following all the stages of choosing articles, it would be more resourceful if some more databases (especially, databases focused on public health studies) were accessible using IUB's library domain. Some of such databases could have been Medline, Scopus, Embase etc. However, to overcome this limitation in some extent, huge time was put on hand-searching the articles in google scholar and PubMed which helped to bring about ample amount of relevant articles.

Besides, the study holds very strict restrictions associated with exclusion and inclusion criteria. Especially, choosing only quantitative studies that links drinking water interventions with health outcomes limited the scope of choosing the finally selected articles. It is because the criteria narrowed down the number of suitable articles. Also, the study context, humanitarian emergencies, is also quite critical for researchers to implement this specific type of study according to the thesis's selected criteria. This caused some challenge in identifying the most suitable articles.

Other than this, the variation of health outcomes addressed in this study is also very low, since almost all the finally-selected studies focused on diarrheal diseases. Thus, this thesis is unable to provide much knowledge on how drinking water interventions can contribute to other health outcomes, especially for mortality, morbidity and non-communicable diseases. These are the major limitations of this study which should be overcome in future researches.

CHAPTER 6: CONCLUSION & RECOMMENDATIONS

This systematic review explored how different drinking water interventions helped to promote health outcomes in humanitarian emergencies. Through systematic identification of studies, the review conducted an in-depth analysis on the selected study and analyzed the effectiveness of interventions to reduce diarrheal episodes mostly. At the same time, study quality was analyzed to assess the quality of existing knowledge in this regard. Findings show positive outcomes brought by different interventions which reduced the occurrence and episodes of diarrheal diseases with statistical significance. But the overall quality of the existing studies was not found to be much satisfactory while testing with CONSORT and STROBE checklist. The checklist identifies several areas where the articles should improve. Besides, more sophisticated reduction in the effects of bias and confounding factors is also necessary for most of the selected articles. However, future research should be more focused on bridging the effectiveness of drinking water interventions with health outcomes other than diarrheal episodes and it will be a noteworthy addition to the co-currently existing literatures. In doing so, more collaborative research should also be planned including professionals with specializations on emergency contexts, public health and water technologies. In addition, the following recommendations can be suggested based on the outcomes of the study.

- a) Studies on drinking water interventions should incorporate the public health aspects.

While doing literature searching, many studies were found bridging no connection with health aspects. This situation should be changed to properly draw links between interventions and corresponding health outcomes. In this regard, non-communicable diseases and non-diarrheal diseases should be prioritized, since there is hardly any good research on these health concerns connecting with drinking water interventions adopted during emergency crisis context.

- b) During humanitarian emergencies, evidence on epidemiological data collection and storage is highly inadequate. This is the reason the stakeholders associated with humanitarian crisis management cannot plan and prepare better using the experience and knowledge from former crisis. As a result, outbreak of diarrheal diseases and child mortality is quite common incidents for many humanitarian emergencies. This situation should be changed through proper knowledge documentation, training and contextualized supports derived from past experiences.
- c) Identification on all the different ways of bias is also necessary in such studies. Situation during humanitarian emergencies change quite suddenly and it is often difficult to keep track on all the things happening in such cases. Yet, the researchers should carefully reduce the effects of bias so that more appropriate linkages can be drawn between drinking water interventions and health outcomes. Some of the selected studies in this review also lag behind in this matter.

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CHAPTER 7: ANNEXURE

ANNEX A

Table 8: PRISMA Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	

Section and Topic	Item #	Checklist item	Location where item is reported
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	
Risk of bias in	18	Present assessments of risk of bias for each included study.	

Section and Topic	Item #	Checklist item	Location where item is reported
studies			
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	
	23b	Discuss any limitations of the evidence included in the review.	
	23c	Discuss any limitations of the review processes used.	
	23d	Discuss implications of the results for practice, policy, and future research.	
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	
Availability of data,	27	Report which of the following are publicly available and where they can be found: template data collection	

Section and Topic	Item #	Checklist item	Location where item is reported
code and other materials		forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	

ANNEX B

Table 9: CONSORT Checklist & Paper Grading

CONSORT	Item No	Recommendation	ID 3	ID 1		
			(X)	(X)		
Title and abstract						
Title and abstract	1	How participants were allocated to interventions (eg, “random allocation”, “randomised”, or “randomly assigned”).	X	X		
Introduction						
Background	2	Scientific background and explanation of rationale.	X	X		
Methods						
Participants	3	Eligibility criteria for participants and the settings and locations where the data were collected.	X			
Interventions	4	Precise details of the interventions intended for each group and how and when they were actually administered.	X	X		
Objectives	5	Specific objectives and hypotheses.	X	X		
Outcomes		Clearly defined primary and secondary outcome measures and, when applicable, any methods used to enhance the quality of measurements (eg, multiple observations, training of assessors, etc).	X	X		
Sample Size	7	How sample size was determined and, when applicable, explanation of any interim analyses and stopping rules.				
Randomisation						
Sequence generation	8	Method used to generate the random allocation sequence, including details of any restriction (eg, blocking, stratification).		X		
Allocation concealment	9	Method used to implement the random allocation sequence (eg, numbered containers or central telephone), clarifying whether the sequence was concealed until interventions were assigned.				
Implementation	10	Who generated the allocation sequence, who enrolled participants, and who assigned participants to their groups.				
Blinding (masking)	11	Whether or not participants, those administering the interventions, and those assessing the outcomes were aware of group assignment. If not, how				

		the success of masking was assessed.				
Statistical methods	12	Statistical methods used to compare groups for primary outcome(s); methods for additional analyses, such as subgroup analyses and adjusted analyses.	X	X		
Results						
Participant flow	13	Flow of participants through each stage (a diagram is strongly recommended). Specifically, for each group, report the numbers of participants randomly assigned, receiving intended treatment, completing the study protocol, and analysed for the primary outcome. Describe protocol deviations from study as planned, together with reasons.	X	X		
Recruitment	14	Dates defining the periods of recruitment and follow-up.	X			
Baseline data	15	Baseline demographic and clinical characteristics of each group.	X			
Numbers analyzed	16	Number of participants (denominator) in each group included in each analysis and whether the analysis was by “intention to treat”. State the results in absolute numbers when feasible (eg, 10/20, not 50%).	X			
Outcomes and estimation	17	For each primary and secondary outcome, a summary of results for each group, and the estimated effect size and its precision (eg, 95% CI).	X	X		
Ancillary analyses	18	Address multiplicity by reporting any other analyses performed, including subgroup analyses and adjusted analyses, indicating those prespecified and those exploratory.				
Adverse events	19	All important adverse events or side-effects in each intervention group.				
Discussion						
Interpretation	20	Interpretation of the results, taking into account study hypotheses, sources of potential bias or imprecision and the dangers associated with multiplicity of analyses and outcomes.	X	X		
Generalisability	21	Generalisability (external validity) of	X	X		

		the trial findings.				
Overall evidence	22	General interpretation of the results in the context of current evidence.	X	X		
		Total Scores	15	12		
		Total Scores (in percentage)	68.18%	54.55%		

ANNEX C

Table 10: STROBE Checklist & Paper Grading

STROBE	Item No	Recommendation	ID 5	ID 4		ID 2
			(X)	(X)	(X)	(X)
Title and abstract						
	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract				
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	X	X	X	
Introduction						
Background / rationale	2	Explain the scientific background and rationale for the investigation being reported	X	X	X	X
Objectives	3	State specific objectives, including any prespecified hypotheses	X	X		
Methods						
Study design	4	Present key elements of study design early in the paper	X		X	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	X	X		X
Participants	6	a) Cohort study: Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. Case-control study: Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls. Cross sectional study: Give the eligibility criteria, and the sources and methods of selection of participants		X		

		b) Cohort study: For matched studies, give matching criteria and number of exposed and unexposed Case-control study: For matched studies, give matching criteria and the number of controls per case				
Background / rationale	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable			X	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group		X		
Bias	9	Describe any efforts to address potential sources of bias				
Study size	10	Explain how the study size was arrived at		X		X
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	X		X	
Statistical methods	12	a) Describe all statistical methods, including those used to control for confounding		X	X	
		(b) Describe any methods used to examine subgroups and interactions				
		(c) Explain how missing data were addressed		X		
		(d) Cohort study:If applicable, explain how loss to follow-up was addressed				
		Case-control study:If applicable, explain how matching of cases and controls was addressed				
		Cross sectional study:If applicable, describe analytical methods taking account of sampling strategy				

		(e) Describe any sensitivity analyses				
Results						
Participants	13	a) Report numbers of individuals at each stage of study: eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	X			
		(b) Give reasons for non-participation at each stage				
		(c) Consider use of a flow diagram				
Descriptive data	14	a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders		X	X	
		b) Indicate number of participants with missing data for each variable of interest				
		(c) Cohort study: Summarise follow-up time (eg average and total amount)				
Outcome data	15	Cohort study: Report numbers of outcome events or summary measures over time	X		X	
		Case-control study: Report numbers in each exposure category, or summary measures of exposure				
		Cross sectional study: Report numbers of outcome events or summary measures		X		
Main results	16	(a) Report the numbers of individuals at each stage of the study: eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed		X	X	
		(b) Give reasons for non-participation at each stage				
		(c) Consider use of a flow diagram				

Other analyses	17	Report other analyses done:eg analyses of subgroups and interactions, and sensitivity analyses		X		
Discussion						
Key results	18	Summarise key results with reference to study objectives	X	X	X	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias		X	X	X
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence		X	X	
Generalisability	21	Discuss the generalisability (external validity) of the study results				
Other information						
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	X			X
		Total Scores	10	16	12	5
		Total Scores (in percentage)	45.45%	72.73%	54.55%	22.73%