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Review Article

The Role of Water, Sanitation and Hygiene (WaSH) Interventions on Health and Behavioral Outcomes during Humanitarian Crisis: A Systematic Review and Meta-Analysis

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Abstract

Background: In humanitarian crises, water, sanitation and hygiene interventions are critical for the survival of people. However, strong evidence-based information is still limited. In order to describe the quantity and quality of current evidence, we conducted an evidence gap map provides a visual overview, highlighting areas lacking evidence.

Methods: According to developed inclusion and exclusion criteria, a systematic literature search was conducted to find related systematic reviews and meta-analyses. The databases, including PubMed, Web of Science, SCOPUS and Cochrane were searched using search strings from 2000 until 2021. Characteristics of the included reviews were extracted and summarized. Two persons evaluated methodological quality independently using the AMSTAR tool. Invite a third person to solve any discrepancies.

Results: This study revealed seven systematic reviews, including one meta-analysis. One study was of high quality, four of medium, and two of low quality. A total of 272 primary studies were included with a median value of 38.8 (range, 6-106) which deeply analyzed for data extraction. Cross-sectional, case-control, and qualitative case studies were the most used study designs. Diarrheal diseases were the most reported outcomes representing 46% of the impact evaluations. Cholera outbreaks account for 43% of a crisis context. The research gaps were insufficient reporting of some interventions with related outcomes and the geographical distribution of current evidence.

Conclusion: There is a limitation in current evidence represented by a lack of high-quality and experimental studies investigate the impact of water, sanitation and hygiene (WaSH) interventions on health and behavioral outcomes in humanitarian sittings.

Keywords: Diarrhea; Evidence mapping; Health Outcomes; Humanitarian Crisis

Introduction

A humanitarian crisis may arise from natural disasters, man-made disasters, and epidemics. Sometimes, we may have multiple types of crises that cause complex emergencies, increasing the vul-

nerability of communities already struggling to meet basic requirements of life like clean water and shelter. At this point in history, humanitarian crises are showing a higher effect on public health than at any previous point in recent history. The impacts of the Covid-19 pandemic exacerbated a pre-existing crisis in many countries; people in Yemen, Syria, the Democratic Republic of the Congo, and South Sudan are suffering from a complex crisis (1). One of every 6 children lives in or near zones of conflict worldwide (2), and approximately 82 million individuals were being displaced from their homes (3).

Public health interventions are an essential part of responding to a humanitarian crisis. As are seeks to alleviate the suffering of affected people. This could improve these people's quality of life and health, mostly living in complex conditions. Despite the importance of these interventions, current evidence on public health interventions in humanitarian crises indicated a limitation, and what is available is generally of poor quality, with weakness in study designs and methodology(4). Water, sanitation and hygiene (WaSH) interventions are usually performed as part of emergency public health activities where affected People are often more vulnerable to disease-related sickness and death. That is primarily related to inadequate water sources, sanitation, and the difficulty of maintaining appropriate hygiene practices (5). For example, Water-borne pathogens (*Shigella* and *Cholera*) were the reason for 85 percent of the 50,000 deaths that happened after the unexpected arrivals of eight hundred thousand Rwandan refugees into DR Congo in 1994, As well as more recent large-scale cholera outbreaks in Yemen in 2016 considered the worst cholera epidemic in modern times(6, 7).

The need for more substantial evidence bases for the effectiveness of humanitarian interventions has increased in recent years. However, the existing evidence on the role of water, sanitation and hygiene interventions in humanitarian crises is still limited (6). To address these limitations, some unique knowledge synthesis approaches were created to assess the overall impact of evidence in the broader scope while also identifying present scientific evidence gaps(8). Evidence gap map (EGM) is a new method of evidence synthesis that visualizes current evidence-based information from the SRs and MAs in easy-to-use form with a quality appraisal by methodically and completely assessing the intervention's effects on outcomes (9).

The overall aim of this study was to provide an evaluation of current evidence-based on the role of water, sanitation and hygiene interventions in times of humanitarian crisis by conducting evidence mapping summarizing existing systematic reviews (SRs) and meta-analyses (MAs), So we can assess the quantity and quality of studies to identify key research gaps rather than evaluate the effectiveness of the intervention alone. That may inform decision-makers, scientific researchers, and humanitarian public health programming globally.

Methods

Model Development

The model developed for this study illustrates the quantitative and qualitative scientific evidence of water, sanitation and hygiene interventions during humanitarian emergencies by focusing on how many studies are in this scope and the methodological quality of each study taken by the AMSTAR tool. The nature of the interventions and outcomes was identified and divided by consulting with key stakeholders working in the field as public health supervisors and environmental engineers conducting WaSH interventions programs in Yemen.

The study protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO): CRD42022306364 (10). This study was presented following the PRISMA reporting checklist (11).

Data Sources and Search Strategy

A systematic search strategy was conducted to identify related SRs and MAs. Peer-reviewed literature was searched by the electronic databases including PubMed, Web of Science, ScienceDi-

rect, SCOPUS, EBSCO, Google Scholar, and Cochrane using complex search strings integrated with AND, OR, NOT (Boolean operators) and wild card symbol (*). To ensure that no relevant material was missed, citations and reference lists were tracked down. Simple keywords were used to search grey literature and the websites of relevant humanitarian actors, such as NGOs and other relevant bodies. A detailed search strings used for database query were (((TS=(emergency OR emergencies OR crisis OR crises OR "emergency response" OR "complex emergenc*" OR "emergenc* sitting" OR disaster* OR "disaster victims" OR catastrophe* OR "natural disaster*" OR flood* OR tsunami OR earthquake OR drought* OR starvation OR famine* OR "failed state" OR conflict* OR "armed conflict*" OR war OR warfare OR refugee* OR "refugee camp" OR "IDP" OR "internally displaced" OR "displaced people" OR displaced OR displacement* OR "forced displacement" OR evacuee* OR entrapped OR relief OR rescue OR aid OR assistance* OR altruism OR humanitarian OR "humanitarian setting" OR "humanitarian assistance")) AND TS=(health OR "health outcome*" OR diarrhea OR diarrhoea OR diarroea OR disease* OR "waterborne diseases" OR "disease burden" OR "disease risk" OR "disease reduction" OR infection* OR respiratory OR gastrointestinal OR malnutrition OR "DALY" OR mortality OR morbidity OR prevalence OR evidence OR impact OR effectiveness OR "cost effectiveness" OR cost-effectiveness OR efficacy OR "quality of life" OR "well-being" OR welfare OR "QOL" OR social OR socioeconomic OR knowledge OR attitude OR behavior* OR practices OR absenteeism OR ebola OR cholera OR "hepatitis E" OR "hep e" OR "use of service" OR use-of-service OR "effective use" OR "sustained use" OR uptake)) AND TS=(WASH intervention* OR “water access” OR “water supply” OR “drinking water” OR “water provision” OR “water quality” OR “water quantity” OR “piped water” OR “water table” OR “water truck*” OR “well rehabilitation” OR “well cleaning” OR “dug well” OR “tube well” OR “point source” OR “non-point source” OR “water storage” OR “water distribution” OR “water source” OR “water management” OR “ water treatment” OR “water pollution” OR “water pollution” OR chlorination OR chlorine OR filtration OR “rain harvesting” OR sanitary OR sanitation OR sewage OR sewerage OR "sewage disposal" OR "sewage treatment" OR "sewage effluent" OR "septic tank" OR latrine* OR toilet* OR "public facilities" OR bathroom* OR "waste water" OR faeces OR feces OR "faecal excretion" OR defecat* OR "human excreta disposal" OR "human excreta" OR "excreta management" OR "soil transmitted" OR helminth* OR "waste disposal" OR hygiene OR “hand hygiene” OR handwashing or "hand wash*" OR washing OR soap OR promotion OR “hygiene kit” OR menstruation OR “hygiene education” OR “health education” OR “personal hygiene”)) AND TS=("systematic review" or "systemic review")

Inclusion and Exclusion Criteria

We included SRs and MAs regarding the relationship between water, sanitation and hygiene interventions implemented as a response for people affected by humanitarian crises and health, behavioral and socioeconomic outcomes, published in English in the 21st century between 2000 and 2021. We excluded primary studies, conference abstracts, articles that are unable to retrieve original data, and systematic reviews that don't answer a research question or did not specify their data synthesis and search methodologies. Also, we excludes systematic reviews that took place in LMIC, where the interventions were carried out for people who do not suffer from humanitarian crises. Inclusion and exclusion criteria were established according to the populations, interventions, comparisons, outcomes, and study types (PICOS framework), as shown in

Table 1: Inclusion and exclusion criteria for .

Table 1: Inclusion and exclusion criteria for studies eligibility

Category	*Inclusion criteria*	*Exclusion criteria*
Population	Populations affected by the humanitarian crisis (natural disasters, armed conflict, cholera outbreaks) and receiving humanitarian assistance in refugee camps or considered displaced persons.	Studies focus on people who are not in an emergency setting due to the crisis. Studies that research the situation of people suffering from poverty or Covid-19 have been excluded.
Intervention	Water, sanitation, and hygiene (WaSH) related interventions have been field-based, improving emergency-affected populations' health and well-being outcomes, conducted during disaster or post-disaster in refugee camps.	Studies examining the implementation of interventions as one of the anti-poverty solutions for people in (LICM) or as community bases service.
Comparison	There were no required comparisons.	
Outcomes	Health outcomes (e.g., diarrheal diseases, morbidity, mortality), behavioral outcomes (e.g., Health awareness and degree of utilization), and socioeconomic outcomes (e.g., Cost-effectiveness).	
Study type	Systematic reviews and meta-analyses.	Primary studies
Limitations	Reviews published between 2000 and 2021. The language is English.	

Studies Selection and Scanning

The studies resulting from the databases search were scanned through three filters: title, abstract, and full-text screening depending on inclusion and exclusion criteria

Table . A reference management software Endnote X9 was used mainly for document management to scan and systematically remove duplicated studies. Studies were independently double screened by two persons to avoid bias in studies selection. Invite a third person to solve any discrepancies.

Title screening – documents were removed if they were not eligible for inclusion criteria by screen title. Any questionable document was included for review in abstract screening.

Abstract screening – The abstract or executive summary of the documents resulting from the title screening were separately appraised by two persons. If either person approved a document, the document was promoted for full-text screening.

Full-text screening – The documents resulting from abstract screening were independently examined in depth by two persons to see if they met all of the inclusion criteria.

Data Extraction and Quality Appraisal

After the selection of eligible studies, the following data were extracted into an excel sheet: (i) study authors, published country, and year; (ii) study title; (iii) number of included primary studies; (iv) design of included primary studies; (v) crisis type; (vi) population/geography; (vii) intervention or exposure; (viii) outcomes; (ix) date

range of search; (x) main findings of the study. If important data was absent, it was converted to the greatest degree possible. Data that couldn't be obtained was ignored.

Methodological quality appraisal of included literature was performed independently using the AMSTAR tool by two persons. If necessary, a third person participated in the assessment. The AMSTAR is a measurement tool developed to assess multiple systematic reviews (12). The tool provides reviews of a general level of high, medium, or low quality based on a score that has a maximum of 11 points. Studies scoring between 9 and 11 were considered high quality, studies scoring between 6 and 8 were considered medium quality, and studies scoring between 0 and 5 were regarded as low quality (13).

Summarization and Visualization

The visual representation (bubble plot) was used to represent the quantity and quality of current evidence. The AMSTAR score (y-axis) against the number of included primary studies in reviews (x-axis). Each bubble represents a single review. Three quality appraisal levels were evaluated using the AMSTAR checklist tool, as shown by the traffic light colors; red bubbles refer to low quality, yellow ones refer to medium, and green bubbles refer to high quality. Bubble size indicates the number of primary studies included in SRs or MAs.

Results

The systematic literature search process for this EGM study is displayed in Fig. 1.

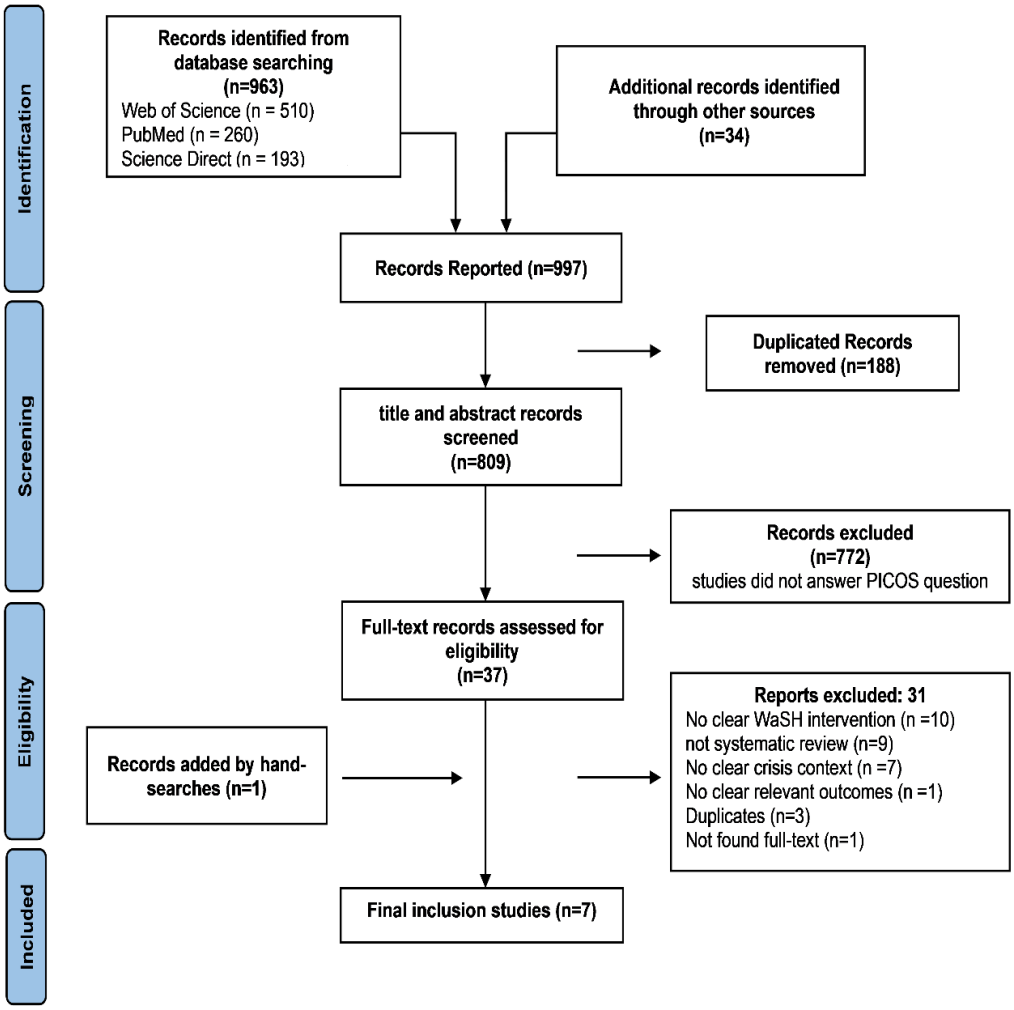

Fig. 1: PRISMA flow diagram of literature search

A total of 997 records were identified from different data bases and sources. After title and abstract screening, 37 records were eligible for the full-text screening analysis with one more study was added by hand-search after checking the reference lists in-depth. Finally, seven eligible studies were included in this EGM, including six SRs and one MAs.

Table 2 shows a descriptive analysis of the included reviews' general characteristics and quality appraisal. All reviews mainly include impact evaluations and investigations performed in refugee camps sittings. According to the AMSTAR scores used for quality appraisal, one review was regarded as high quality (5), four were medium quality (6, 14-16), and two were graded as low quality (17, 18). Only one review carried out quantitative synthesis (meta-analysis) in which WaSH interventions were classified into eight predicted risk factors and seven predicted protective factors. Results show all excepted risk factors were related with increase the odds of cholera (OR =1.9–5.6), with heterogeneity rang I^2 of 0.0–91.8%, and five of seven excepted protective factors were related with low the odds of cholera transmission (OR = 0.4–1.4) with high levels of heterogeneity rang I^2 56.8% to 90.6% (16).

Table 2: Characteristics of included reviews

First author, publication year	*Crisis type*	*Population /Geography*	*Intervention or Exposure*	*Outcomes*	*Main findings*	*Quality appraisal*
Brown 2012 (UK)	Armed conflict (15) Natural disasters (12) Cholera outbreak (4)	Sub-Saharan Africa (55 %) South Asia (19%) Latin America & Caribbean (16%) Middle East (3%)	Water intervention Water treatment (18) Water supply (11) Hygiene (6) Sanitation (9)	Diarrheal Diseases (22) Behavioural (Utilisation) (5) Water quality (4)	People in disaster still lack basic WaSH needs. More research is needed on emergency sanitation. Improved access to safe drinking water is urgently required. More effective handwashing promotion techniques may help people in crisis.	LOW
Ramesh 2015 (UK)	Natural disaster (1) Armed conflict (5)	Sub-Saharan Africa (50 %) Latin America & Caribbean (50%)	(POU) Water treatment safe water storage (SWS) (3) household water treatment (HWT) (2) Hygiene promotion (1)	Diarrheal Diseases	The present evidence base on the influence of WaSH interventions on health outcomes in humanitarian emergencies is quite limited, and various methodological limitations make it difficult to detect associative and causative correlations.	MEDIUM
De Buck 2015 (Belgium)	Post disaster phase - (refugee camps) (5) During disaster phase- (drought-affected) (1)	Sub-Saharan Africa (55 %) South Asia (27%) Latin America & Caribbean (18%)	A mount of water (water supply)	Diarrheal Diseases	The Sphere indicator, or any of the other standards in use, has no supporting evidence. On the other hand, getting more water was linked to decreased diarrhoeal episodes.	MEDIUM
Taylor 2015 (UK)	Cholera outbreak	Sub-Saharan Africa (54%) South Asia (23%) Latin America & Caribbean (23%)	Water treatment at POU 9 at source 4 Hygiene (4) Sanitation (1)	Diarrheal Disease (7) Behavioural Cholera awareness (4) Behaviour (Utilisation) (4) Water quality FRC level (7) Coliform	Found a clear lack of evidence evaluating WASH interventions implemented to control cholera. Most studies failed to report illness outcomes or compliance with the intervention.	MEDIUM

			count (3)			
Wolfe 2018 (USA)	Cholera outbreak	Sub-Saharan Africa (56%) Latin America & Caribbean (21%) South Asia (17%) Oceania (6%)	Five WASH groups (Water treatment, Water supply, Water managing, Sanitation, Hygiene) defined as 7 predicted protective factors and 8 predicted risk factors.	Association between diarrheal disease (Cholera) and WaSH exposures using an odds ratio (OR).	The findings of the meta-analysis show that expected risk variables are linked to cholera; conversely, expected preventive factors are not always protective.	MEDIUM
Yates 2018 (USA)	Cholera Outbreaks (51) Natural disasters (51) Armed conflict (12)	Sub-Saharan Africa (43%) South Asia (24%) Latin America & Caribbean (21%)	Water interventions (47) Hygiene (27) WaSH package (24) Sanitation (16)	Diarrheal Disease Behavioural (Utilisation) Cost-effectiveness	In emergency situations, WaSH interventions consistently minimized the risk of disease and transmission.; however, program design essential consideration to ensure WaSH intervention efficacy and effectiveness.	HIGH
Als 2020 (Canada)	Armed conflict	Sub-Saharan Africa (42%) South Asia (10%) Middle East (13%) East Asia and Pacific (10%)	Water interventions water supply (22) water treatment (20) Hygiene hygiene kit/soap (16) hygiene promotion (23) Sanitation (26)	Delivering of services	Gender biases favouring males' access to a school lead to limited access to school-based interventions and inefficient communications between implementers and female beneficiaries.	LOW

In all seven reviews, a total of 272 primary studies were included. The median value of primary studies is 38.8 (range, 6-106). Only one review (16) was conducted using only one study design, and the six other reviews were formed from primary studies with various study designs. Five reviews (5, 6, 15, 17, 18) included randomized controlled trials (RCTs). Cross-sectional, case-control and qualitative case studies were the top three study designs used in the primary studies included in the reviews; the corresponding numbers are 76, 56, and 53, respectively

Fig. *2*.

Focusing on the type of crises, Cholera outbreaks account for approximately 43% of the impact evaluations included in reviews, armed conflict 32%, and natural disasters 23%.

Fig. 3 shows the geographical distribution of the impact evaluations included in eligible reviews. Most of the impact evaluations focused on

WaSH interventions conducted in Sub-Saharan Africa were mainly associated with cholera outbreaks and armed conflict. But when taken into account in more detail, Haiti, which is located in the Caribbean and suffered from a terrible earthquake in 2010, appears as the most country in which impact evaluations were carried out with 37 studies then Kenya, Bangladesh, Malawi, and D R Congo; the corresponding numbers are 18, 17, 16 and 12, respectively.

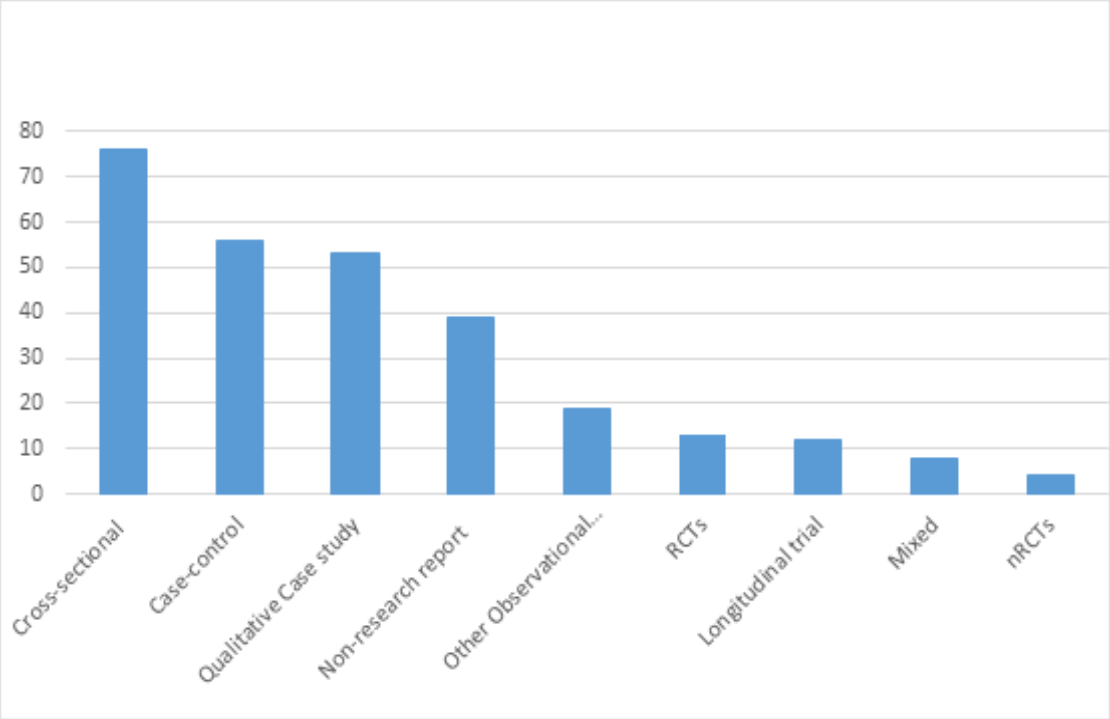

Fig. 2: Study designs of included primary studies

Water interventions constitute approximately 52% Of WaSH interventions, then hygiene interventions with 29%, and sanitation interventions with 19%. Diarrheal diseases were the most commonly reported WaSH intervention-related outcomes, accounting for approximately 46 %. Behavioral outcomes came in second with 23 %, followed by water quality 16 %, and other socioeconomic outcomes 15 %.

In terms of the relation between the WaSH interventions and related outcomes, all studies investigate the provision of hardware WaSH interventions to those affected by crises. Six reviews focused their research on health outcomes, specifically the study of the relationship between WaSH interventions and diarrheal diseases, which represent 86%. The second most connected outcome was the utilization of WaSH intervention. The utilization, which is part of behavioral outcomes, was investigated by three reviews. Also, only one review mentioned health awareness represented by cholera awareness among behavioral outcomes. Regarding socioeconomic outcomes, one reviewer studied the cost-effectiveness of WaSH intervention, two mentioned quality of interventions (water quality), and one review that formed delivery WaSH interventions as its primary study objective. Apparent gaps in evidence were determined on the wide aspect of humanitarian crisis-related WaSH interventions when focusing on outcomes. No reviews were identified for WaSH interventions based on health massage and participation of beneficiaries. Also, no review was identified for sustainable use of interventions. Regardless, most reviews identified diarrheal diseases. However, the quality varies.

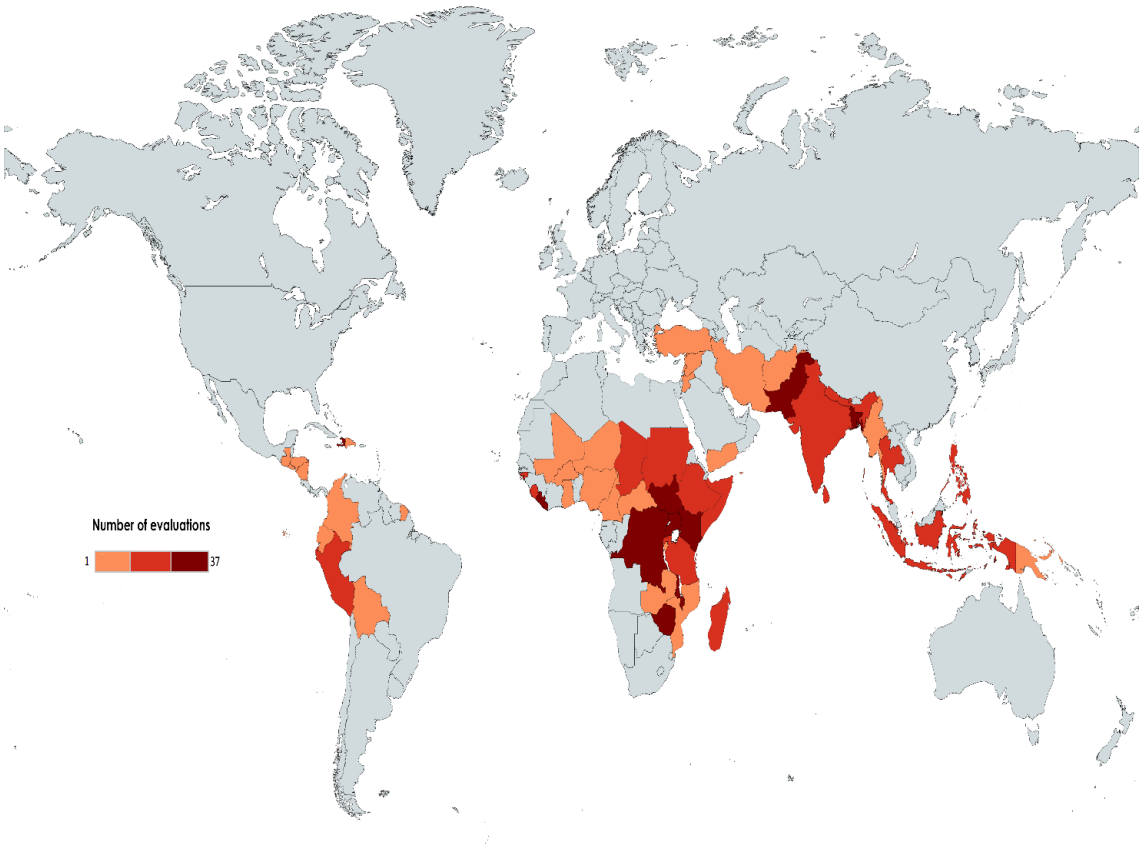

Fig. 3: Geographic distribution of the included impact evaluations

EGMs Visualization

Fig. *4* displays evidence mapping of the number of bubbles (reviews) related to the methodological quality of reviews and the number of included primary studies. The size of bubbles represents the number of included primary studies; only one review includes more than 100 studies, one review contains 58, and others include less than 50. Two of these reviews include only six primary studies. The bubble colors in the map indicate the quality appraisal of reviews, which were checked by the AMSTAR tool. Only one green bubble was identified as having high quality, four bubbles showed yellow color with medium quality, and two red bubbles were identified as having low quality.

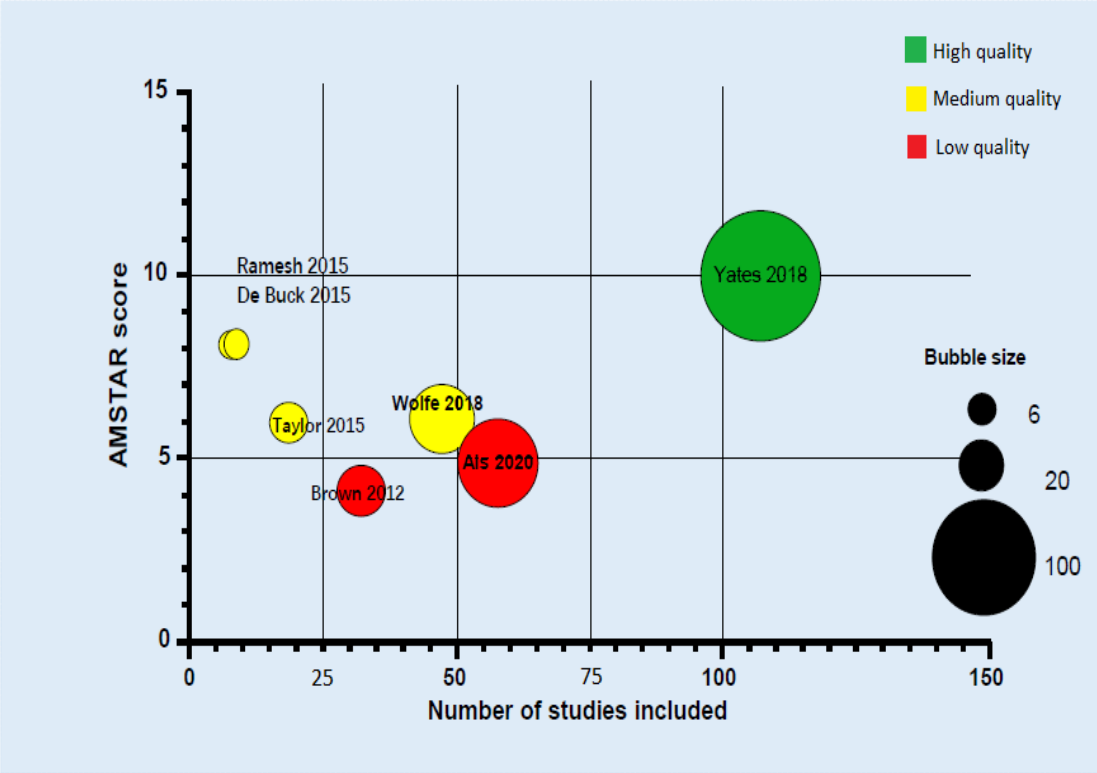

Fig. 4: Evidence mapping

Discussion

This study provides EGM for the most recent SRs and MAs to show the current scientific evidence on water, sanitation and hygiene interventions on health, behavioral and socioeconomic outcomes during complex humanitarian situations. This helps set potential research plans or highlight the evidence gaps to fund research and give evidence-based data to support actual policymaking. Although in emergency sittings, WaSH interventions are considered essential humanitarian response, especially in preventing disease transmission (19). This study identified only seven published reviews to evaluate WaSH interventions concerning the humanitarian crises in the past 21 years. This supports the hypothesis that there is a scientific gap in this context (6) and the hypothesis that conducting health scientific research and investigations during humanitarian emergencies is challenging (20).

The findings of this study detect some significant gaps in the existing evidence. First, there is a limitation in the quantity and quality of scientific information available on the impact of the delivery of WaSH interventions among people affected by humanitarian crises. This is represented by the number of identified studies containing only one meta-analysis study (16), which is generally the best form of evidence synthesis and hence positioned at the top of the hierarchy of evidence-based health care research (21). And when looking at the number of included primary studies, only 272, this also shows that the evidence is limited. Among primary studies, RCT studies represent only 6%. This is also another indication of the limited quality of the current evidence, as randomized studies are considered the highest level of evidence in experimental research (22). When looking at the quality of the current evidence, there is only one study that has high quality according to the AMSTAR score (5), but this systematic review includes more than half of the

non-research studies and only two RCT studies. This is not considered solid scientific evidence that field-based projects implement upon it. It is important to remember that the quality of the reviews included in this EGM study was assessed using the review methods stated in the publication and the AMSTAR checklist tool's standards. Nevertheless, it is necessary to note that the review's low or medium rating does not indicate that the study's findings are invalid. The rating indicates that we have less confidence in their validity under the criteria of our study.

Secondly, there is a gap regarding the geographical distribution of the impact evaluations. There is limited data on the effect of WaSH intervention on public health outcomes in countries currently suffering from humanitarian crises, according to the global humanitarian overview 2021 issued by OCHA(1). A quick comparison between the current humanitarian crises and the geographical distribution of the included studies (current evidence) in Fig. 3, There are countries and regions forgotten or didn't get enough studies and health investigations, such as Yemen, Syria, Afghanistan, Central African Republic, Burkina Faso, Somalia, Venezuela, and Myanmar.

In addition, it was noted that most of the reviews focus on LMIC, where only part of these countries has humanitarian crises. This point may cause mixing between the data of providing WaSH interventions as a community service to fighting poverty and providing them in emergency settings. Moreover, this played a significant role in excluding many reviews in the scanning stage.

Third, few impact evaluations reported the environmental hygiene interventions (e.g., sanitation), which may help in reducing open defecation, especially in refugee camps. This relatively infrequent reporting may reflect humanitarian organizations' prioritization of other WaSH interventions that are may less logistically difficult to deliver (17). Also, in the context of interventions in general, a clear gap appears in the mechanism of implementation of the interventions, where the focus is on providing hardware interventions with the complete absence of interventions based on health education, direct contact with the beneficiaries and their active participation in how the implementation of the interventions. Beneficiaries' participation in interventions planning and implementation enhances the effectiveness of interventions, suggests new solutions, and is critical for ensuring successful outcomes (23).

Finally, the outcomes mainly concentrate on diarrheal diseases, As WaSH interventions consider as predicted protective factors from diarrheal disease, mainly in cholera outbreaks (16). However, significant heterogeneity in the methodological quality of reviews calls for performing high-quality studies. Also, the gap noted is the lack of trusted definitive diagnostic criteria for diseases, depending on the self-reported diagnosis may probably lead to the exposure bias, so future research should more accurately identify and report diagnostic criteria depending on the experimental diagnosis. In the context of outcomes, some outcomes have limited investigation. Health outcomes include malnutrition, mental, respiratory, and gastrointestinal disorders; other outcomes include sustainable use and educational outcomes (school attendance); these limitations open opportunities for future investigations.

Limitations

With Given Inclusion criteria, some studies contain important information that may be neglected. First, since EGMs' primary purpose is to supply resources for policymakers, only SRs and MAs are intended to produce trustworthy conclusions (24). However, some faults in data extraction or study synthesis may go unnoticed by the SRs and MAs involved. Secondly, only English papers were included in this EGM, so maybe some papers in other languages were missing.

In this EGM study, only the AMSTAR checklist tool was used instead of other quality appraisal tools, which may show different quality results (25). On the other hand, there are limitations in communication with the authors of the included reviews.

Conclusion

Most humanitarian response activities related to WaSH interventions are not published because peer-reviewed research is understood by NGOs and humanitarian public health actors as a secondary consideration after more immediate needs for affected people are met in the field. Moreover, publication bias – recording of "positive" experiences more than "negative" results– may limit academic information. Therefore, few experimental studies of WaSH interventions with high quality are performed in complex humanitarian situations. More randomized controlled trials studies with multinationals are needed in the recent long-term humanitarian crisis. This will be useful in developing more flexible means that alleviate the suffering of affected people.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Competing interests

The authors declare that they have no competing interest.

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