RESEARCH ARTICLE

Research priorities for water, sanitation and hygiene (WASH) in humanitarian crises: A global prioritisation exercise

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Abstract

Water, sanitation and hygiene (WASH) interventions should provide access to safe water and sanitation, and promote good hygiene practices with dignity, comfort and security. Multiple systematic reviews have noted evidence gaps and a paucity of good quality evidence related to the effectiveness and implementation of WASH programmes and interventions in humanitarian crises. The aim of this study was to generate consensus-based actionable research priorities for the humanitarian WASH sector. A research prioritisation exercise was conducted by adapting the Child Health and Nutrition Research Initiative (CHNRI) method. Research questions were compiled from a rapid scoping review, key informant interviews (KIs) and focus group discussions (FGDs). Questions were reviewed by a technical expert group. An online survey was circulated to score research questions according to five criteria. An overall prioritisation score was calculated and weighted to prioritise questions. A diverse range of 286 global WASH and health experts engaged in the CHNRI process. A list of 128 questions were generated and scored by experts. Prioritised research questions focussed on evaluating existing interventions or programmes, and making iterative changes to current programmes. Other important questions centred on describing WASH conditions and associated health risks in crises contexts. Priorities were also stratified by gender, organisation and region to understand differences globally. The WASH in Crises Research Agenda has identified key research questions of most importance to those implementing WASH in humanitarian crises and has established a list of research priorities. The identified priorities reinforce how more evidence is needed, and underlines the need for research to evaluate current practices in order to improve the quality of humanitarian response. Stakeholders, including donors, international and national organisations, governments and academic institutions, are invited to use this research agenda to encourage, inspire and enable relevant and high-quality research that will be used to inform humanitarian responses.
Introduction

Humanitarian crises are occurring at increasing rate and scale. In 2021, approximately 300 million people were in need of humanitarian assistance [1–5]. Drivers of crises often intersect, compounding the risks of, and exposure to, humanitarian crises such as outbreaks, and both natural and human-made conflicts or disasters. Socioeconomic fragility, high-intensity conflict, climate change and COVID-19 have all played a role in increasing the number of vulnerable populations globally [6–8]. In 2021, two-fifths of people in need (120 million people) were living in countries facing a combination of high-intensity conflict, high levels of socioeconomic fragility and high levels of vulnerability to the impacts of climate change [1]. In the same year, 160.4 million people were experiencing food insecurity (food crisis, emergency or famine) [9] and the frequency and magnitude of disease epidemics is increasing [5,10]. Long-term, multi-dimensional crisis are increasingly becoming the new normal.

Despite humanitarian needs increasing, growth in total humanitarian assistance funding has not kept pace with the growing needs [11]. Governments and agencies are faced with increasingly difficult choices related to their aid budgets, with clear risks to development and humanitarian assistance. Evidence to aid decision-making and selection of effective, appropriate and efficient interventions for populations affected by, or at risk of, humanitarian crises are increasingly important [12,13].

Water, sanitation and hygiene (WASH) interventions should provide access to safe water and sanitation, and promote good hygiene practices with dignity, comfort and security [12]. While WASH interventions are commonly implemented as part of humanitarian response activities, multiple systematic reviews have noted evidence gaps, some of which but not all have been filled in recent years, related to the effectiveness and implementation of WASH programmes and interventions in humanitarian crises [14–19]. Whilst there have been efforts to increase the quality and quantity of research on WASH in crises contexts, there is a need to invest more resources to support decision-making for effective programmes. This weak evidence base has been attributed to prioritising response activities over research, difficulty in conducting research, a lack of technical knowledge and personnel for data collection and analysis, and a dearth of clear research questions or objectives when using collected data [20,21].

The operational and academic community can play an important role in addressing the evidence gaps in humanitarian WASH [22–29]. In 2020, the Global WASH Cluster (GWC) articulated a strategy to enhance the capacity of the WASH sector to deliver a predictable, quality humanitarian response through strengthened collective commitments and strategic partnerships [30]. Partners and partner-consortia developed and designed initiatives that would build the capacity and resources needed to deliver quality WASH responses. A specific initiative was developed by the London School of Hygiene and Tropical Medicine (LSHTM) and Tufts University that focussed building and supporting evidence-generation to inform humanitarian WASH response. Building on an existing collaboration between the GWC and Enhanced Learning and Research for Humanitarian Assistance (ELRHA), a WASH research priority setting exercise was commissioned as part of ELRHA’s Research for Health in Humanitarian Crises (R2HC).

This study aimed to generate consensus-based actionable research priorities for the humanitarian WASH sector. An agenda for research investments will also ensure that we respond to recognised needs and gaps in the sector; ensure fair and direct benefits reach people affected by crises; and mobilise resources among governments, organisations, academic institutions and funders [22]. In this paper, we describe the methodology of this process and present the research priorities as a guide for researchers, humanitarian practitioners and funding agencies by providing a prioritised list of research questions that, when answered, will contribute to improved WASH policy and practice in humanitarian crises.
Methods

We used the Child Health and Nutrition Research Initiative (CHNRI) method, to identify WASH research priorities in a transparent, consultative, comprehensive and replicable manner [31–36]. CHNRI has been refined over years and been used in several other sectors to assist stakeholders in prioritising health research investments [37–40]. We adapted the standard CHNRI approach into a 10-step process for the research prioritisation of WASH in humanitarian crises contexts, and the output is known as the WASH in Crises Research Agenda. The methods and steps are summarised below and in Supplementary Material 1.

1. Selection of the process managers

Process Managers comprised individuals from LSHTM, Tufts University, Action Contre la Faim (ACF) and the Global WASH Cluster (GWC), all with experience in research and policy in the area of humanitarian WASH. The seven Process Managers were invited to four virtual meetings to discuss the scope and provide feedback on the process.

2. Selection of a set of most useful and important criteria

Process Managers defined five different criteria by which research questions were critiqued when prioritising the research from a list of 15 potential criteria specified by the CHNRI methodology (Table A in S1 Text). Individuals were asked to distribute 100 points across the criteria based on their perceived level of importance, and weights determined by dividing the mean values allocated to each criterion by 20. The agreed criteria by which to judge research questions included:

- **Impact (criteria weight = 0.96):** Do you think the proposed research will contribute to improve the health, social, economic, or development outcomes of populations affected by or at risk of humanitarian crises (conflict, displacement, complex emergencies, disasters triggered by natural hazards, climate-induced shocks, and WASH-related disease outbreaks)?

- **Answerability (criteria weight = 0.92):** Do you think the proposed research is answerable in humanitarian contexts and time scale (between now and 2030)?

- **Relevancy (criteria weight = 0.92):** Do you think the proposed research will answer relevant evidence gaps in populations or contexts affected by crises?

- **Potential for translation (criteria weight = 0.88):** Do you think the proposed research will be more likely to generate knowledge that will be translated into feasible health and WASH interventions?

- **Implementability (criteria weight = 0.83):** Do you think the proposed research will lead to solutions that are implementable (e.g., feasible in crises contexts, acceptable to populations and communities affected by crises)?

3. Specification of context in space, impacts of interest and context in time

Contextual factors determine the scope of the research agenda including the who, where, when and what of the intended research (Table B in S1 Text). The Process Managers specified on the following scope of the research:

- **Target populations:** all countries and communities affected by or at-risk of humanitarian crises (conflict, displacement, complex emergencies, disasters triggered by natural hazards, climate-induced shocks, and WASH-related disease outbreaks)
Research priorities for water, sanitation and hygiene (WASH) in humanitarian crises

- **Geographical scope**: global, regional, country and local levels
- **Time Scale**: present day to 2030
- **Outcomes of interest included**: health outcomes (e.g., morbidity and mortality); behavioural outcomes (e.g., hygiene practices); human rights-based outcomes (e.g., right to adequate wash, wellbeing, dignity, privacy); laboratory efficacy outcomes (e.g., pathogen removal); economic outcomes (e.g., cost-effectiveness, efficiency, value for money); humanitarian-development nexus outcomes (e.g., sustainability, recovery, war-to-peace transition); climate change outcomes (e.g., climate change resilience and adaptation, drought resilience, climate shock resistance); process outcomes (e.g., coordination, coverage, implementation, sustainability); inclusion outcomes (e.g., inclusion of people with disabilities, women and girls, older people).

4. **Rapid scoping review of WASH in humanitarian crises**

A rapid scoping review of WASH in humanitarian crises was conducted, and finalised in October 2021, to inform the listing of research questions based on the current evidence base (Tables C-E in S1 Text C-E).

5. **Key informant interviews with key stakeholders**

Process Managers proposed individuals to speak to among WASH researchers, technical working groups (TWIGs) and both member and observing agencies of the GWC (Table F in S1 Text). Individuals were randomly asked to participate in a key informant interview (KIIs) or focus group discussions (FGDs) between September to December 2021. Interviews followed a topic guide, were carried out until saturation of data, and participants were asked to detail any existing research questions within their agency or TWIG including any published, ongoing or planned research, and what they perceive were WASH research gaps.

6. **Systematic listing of research questions**

Research questions were collected and compiled from the rapid scoping review, KIIs, FGDs, and discussions among the project team. Questions were assigned to the ‘4Ds framework’ (description, delivery, development and discovery) (29). Under the framework, ‘description’ includes research to assess the burden of health and non-health outcomes and determinants; ‘delivery’ encompasses research to evaluate already available interventions; ‘development’ describes research to improve existing interventions; and ‘discovery’ includes research that may lead to innovations or completely new interventions (Table G in S1 Text). Additionally, questions were assigned to relevant WASH intervention category (Table H in S1 Text), based on definitions used in a series of previously published systematic reviews, and common terminologies from the WASH sector (39–45). Research questions were screened, de-duplicated and reviewed for relevance to WASH by the Process Managers.

7. **Selection of technical experts to reflect on research questions**

Eighteen technical advisors, selected from operational agencies and academic institutions (see Acknowledgments), reviewed the research questions for relevance to WASH in humanitarian crises contexts and generated a refined list of research questions (Table A in S2 Text).

8. **Scoring of research questions**

An online survey (Qualtrics, SAP, Seattle, WA, US) was developed with the list of research questions and circulated via existing networks, mailing lists, contacts, social media and posted...
on the GWC website. For each research question, respondents were asked to judge how each question may meet each criteria by indicating “Yes” (which was allocated 1 point), “Maybe” (0.5 points), “No” (0 points), or “Not my Area of Expertise” (no input), respectively. The survey was available in Arabic, English, French and Spanish, and accessible between June-September 2022. Demographic information from respondents was collected, including: gender; organisation type; cluster affiliation (WASH or other); region and country location according to World Health Organization (WHO) regions; geographic level of focus; region and country of focus for their work; years of experience in WASH; and areas of expertise. The survey was available between May and August 2022.

9. Calculating scores and ranking research questions

Over >1500 individuals were invited to take the survey and score the research questions via an online survey. For each research question two scores were calculated, the research priority score (RPS) and average expert agreement score (AEA) (Table I in S1 Text). Weights, which were derived by the initial allocation of 100 points to different criteria by process managers (Step 2), were applied to both the RPS and AEA. The weighted AEA was selected over the weighted RPS as a more reliable score that would not be affected by the number of respondents with knowledge of the subject matter. Scores were converted into an overall weighted AEA ranging between 0 to 100% which allowed a rank to be assigned. In addition to the top 20 research questions, the top five highest-scoring questions per the 17 WASH intervention categories were selected to form intervention-specific research priorities (Tables A-Q in S4 Text). Lastly, we also stratified research priorities by individuals whose work is focused on each of the WHO regions globally.

10. Feedback and revisions

Final revisions to the list of research questions were made with the technical advisors in February 2023. In addition to the research questions listed in this project, survey respondents thought that several thematic areas were missing or required more specific questions. The themes were varied, and individuals did not always refer to specific WASH interventions, but rather to aspects of WASH programming. The thematic areas survey respondents proposed for inclusion in the next WASH in Crises Research Agenda are listed in Table A in S3 Text.

Ethical approval

Ethical approval was received from both LSHTM (No. 26312) and Tufts University (No. STUDY00001841) before the research began. Prior to KII and FGD, participants received a participant information sheet and signed informed consent forms. Survey respondents were anonymous as no personal identifiers or information were required from respondents. However, survey respondents were asked at the end of the survey if they would like to join the WASH in Crises Research and Innovation Working Group and receive further updates on the project by sharing a professional email address.

Results

Number of questions listed in the WASH in Crises Research Agenda

A total of 932 research questions were collected and compiled from the rapid scoping review; KIIs, FGDs, and discussions among the project team. These were drawn from a total of 498 journal articles and reports which were reviewed and used for generating WASH research questions, and 44 individuals who were randomly asked to participate in a KII or FGD of
which we performed 27 KIs and four FGDs. Participants worked for international and national organisations, donor organisations, governments, academic institutions and/or were part of technical working groups (TWIGs). All organisations were either members or observing agencies of the GWC. A list of participants, including their gender and geographical origins, is included in Table F in S1 Text.

From the list of 932 research questions, questions were reviewed by Process Managers and technical advisors in two stages. During primary screening, duplicative questions and questions that were not relevant to WASH were removed by the Process Managers. There remained 250 research questions. In secondary screening, the technical advisors were asked to review questions and their relevance to WASH in humanitarian crises contexts. There remained 130 questions after this step. The list of 130 questions was sent out via the online survey to >1500 individuals for the WASH in Crises Research Agenda.

Lastly, as the final step in the CHNRI process and after the scoring of the research questions, the top twenty questions were reviewed once again by the technical advisors, which resulted in two questions being merged with two other questions within the top twenty research priorities. The WASH in Crises Research Agenda thus resulted in 128 research questions overall (Table A in S2 Text).

Characteristics of the WASH in Crises Research Agenda survey respondents

Of the >1,500 individuals who received the online survey, 286 people in 65 countries completed the prioritisation exercise. Respondents were predominantly from the African Region (AFR) (33%), European Region (EUR) (24%) and Eastern Mediterranean Region (EMR) (15%); the majority were male (67%) and mostly took the survey in English (81%) (Table 1). On average, they had 13 years’ experience working in WASH and/or WASH humanitarian programmes (range: 1–45 years). Respondents represented international non-governmental organisations (NGOs) (37%), United Nations agencies (18%) and academic institutions (11%).

<table>
<thead>
<tr>
<th>Region of origin</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>African Region (AFR)</td>
<td>94</td>
<td>33</td>
</tr>
<tr>
<td>European Region (EUR)</td>
<td>68</td>
<td>24</td>
</tr>
<tr>
<td>Eastern Mediterranean Region (EMR)</td>
<td>43</td>
<td>15</td>
</tr>
<tr>
<td>Region of the Americas (AMR)</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td>South-East Asian Region (SEAR)</td>
<td>28</td>
<td>10</td>
</tr>
<tr>
<td>Western Pacific Region (WPR)</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Not reported</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>192</td>
</tr>
<tr>
<td>Female</td>
<td>90</td>
</tr>
<tr>
<td>Non-binary</td>
<td>1</td>
</tr>
<tr>
<td>Not reported</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language survey taken in</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>231</td>
</tr>
<tr>
<td>French</td>
<td>25</td>
</tr>
<tr>
<td>Arabic</td>
<td>19</td>
</tr>
<tr>
<td>Spanish</td>
<td>11</td>
</tr>
</tbody>
</table>

Average experience (years) 12.7 (1–45)

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Their work focused on the AFR, EMR or globally. Most worked for organisations that were part of the GWC (83%) and many were also members of other clusters (Fig 1).

**Top 20 research priorities for the WASH in Crises Research Agenda**

The top 20 highest-scoring research questions according to overall score are presented in Table 2. The number of respondents per criterion and question ranged from 200 to 216. The
Table 2. Key 20 research priorities for WASH in Crises Research Agenda.

<table>
<thead>
<tr>
<th>Rank</th>
<th>WASH category</th>
<th>4Ds framework</th>
<th>Research question</th>
<th>n</th>
<th>Weighted AEA score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distribution of hygiene materials or non-food items (NFIs)</td>
<td>Delivery</td>
<td>What are the best strategies for maintenance of and operational sustainability of handwashing infrastructures (e.g., handwashing stations, facilities or stands) in crises contexts?</td>
<td>208</td>
<td>100.0</td>
</tr>
<tr>
<td>2</td>
<td>Improvements to the design and implementation of WASH in crises programmes</td>
<td>Development</td>
<td>What adaptations to WASH programmes or WASH services (including hardware and software) are appropriate, inclusive and effective for people affected by disabilities (PWDs) in crises contexts?</td>
<td>209</td>
<td>98.0</td>
</tr>
<tr>
<td>3</td>
<td>Distribution of hygiene materials or non-food items (NFIs)</td>
<td>Development</td>
<td>What WASH non-food items (NFIs) are appropriate, effective and cost-effective for distribution to households during outbreaks (e.g., cholera, Ebola, hepatitis E, typhoid, COVID-19)?</td>
<td>202</td>
<td>96.0</td>
</tr>
<tr>
<td>4</td>
<td>Improvements to the design and implementation of WASH in crises programmes</td>
<td>Development</td>
<td>How can we improve consultation with women and girls to design and provide safe, accessible WASH facilities and infrastructure (e.g., sufficient water access, locks in sanitation facilities, bathing areas, appropriate menstrual hygiene management (MHM) products and disposal, appropriate to needs and cultural beliefs) in crises?</td>
<td>213</td>
<td>95.2</td>
</tr>
<tr>
<td>5</td>
<td>Improving access to and use of sanitation facilities and reducing exposure to faeces</td>
<td>Development</td>
<td>What additional features can improve the experience and utilisation of sanitation in humanitarian contexts (e.g., lighting, locks, privacy screens, space for menstrual hygiene management (MHM), roof, torches), and particularly by women and girls?</td>
<td>207</td>
<td>93.6</td>
</tr>
<tr>
<td>6</td>
<td>Improving access to and use of sanitation facilities and reducing exposure to faeces</td>
<td>Delivery</td>
<td>How effective are existing technologies and approaches in improving sanitation uptake among populations affected by crises, particularly among people with disabilities (PWDs) and young children in humanitarian crises?</td>
<td>207</td>
<td>93.1</td>
</tr>
<tr>
<td>7</td>
<td>Behaviour change interventions to improve hand, domestic and food hygiene practices</td>
<td>Description</td>
<td>How can we identify, define and categorise the determinants and motives of hand hygiene behaviour in crises contexts and among different population groups (e.g., children, adults, people with disabilities (PWDs), etc) and at different stages of an emergency (acute, post-acute or protracted phases)?</td>
<td>214</td>
<td>92.5</td>
</tr>
<tr>
<td>8</td>
<td>Behaviour change interventions to improve hand, domestic and food hygiene practices</td>
<td>Delivery</td>
<td>How can we improve and sustain hygiene practices within different humanitarian contexts (e.g., natural disasters, protracted crises, outbreaks (e.g., of cholera, Ebola, hepatitis E, typhoid, COVID-19, etc))?</td>
<td>209</td>
<td>92.4</td>
</tr>
<tr>
<td>9</td>
<td>Improving access to and use of sanitation facilities and reducing exposure to faeces</td>
<td>Development</td>
<td>How can we improve the satisfaction and use of sanitation facilities among crisis-affected populations, particularly among women and girls regarding menstrual hygiene management (MHM) infrastructure and services?</td>
<td>200</td>
<td>91.3</td>
</tr>
<tr>
<td>10</td>
<td>Distribution of hygiene materials or non-food items (NFIs)</td>
<td>Delivery</td>
<td>What are the effectiveness and cost-effectiveness of in-kind distribution of WASH items (e.g., soap, hygiene kits, menstrual hygiene management (MHM) materials, chlorine water treatment, water containers, etc) on health and non-health outcomes among people affected by crises?</td>
<td>202</td>
<td>90.6</td>
</tr>
<tr>
<td>11</td>
<td>Improvements to the design and implementation of WASH in crises programmes</td>
<td>Description</td>
<td>What are the most effective methods to identify/monitor WASH needs in host communities and urban centres impacted by population influxes?</td>
<td>214</td>
<td>89.9</td>
</tr>
<tr>
<td>12</td>
<td>Improving access to water sources and/or quantity of water</td>
<td>Development</td>
<td>How effective is improved access to safe water (e.g., coverage of water points and distribution networks) in controlling and preventing outbreaks (e.g., of cholera, Ebola, hepatitis E, typhoid and COVID-19)?</td>
<td>204</td>
<td>89.6</td>
</tr>
<tr>
<td>13</td>
<td>Improvements to the design and implementation of WASH in crises programmes</td>
<td>Description</td>
<td>How does poor access to WASH contribute to increased risk of gender-based violence in humanitarian settings?</td>
<td>209</td>
<td>89.6</td>
</tr>
<tr>
<td>14</td>
<td>Behaviour change interventions to improve hand, domestic and food hygiene practices</td>
<td>Delivery</td>
<td>How can hygiene promoters reduce disinformation or myths associated with outbreak-prone diseases (e.g., cholera, Ebola, hepatitis E, typhoid and COVID-19)?</td>
<td>210</td>
<td>88.4</td>
</tr>
<tr>
<td>15</td>
<td>Burden of and risk factors for WASH-related health and non-health outcomes</td>
<td>Description</td>
<td>What are the health outcomes (e.g., increased incidence of disease, increased morbidity, increased mortality and/or increased incidence of poor mental health outcomes, etc) related to WASH experienced by people affected by crises?</td>
<td>210</td>
<td>88.1</td>
</tr>
</tbody>
</table>

(Continued)
Weighted AEA in the top 20 research questions was high (85.6–100%), indicating a high level of agreement among respondents. Two intervention categories common to the highest priority questions was evaluating the effectiveness of hygiene materials or non-food items (NFIs) and in the improvements to design and implementation of WASH in crises programmes (especially inclusion of women, girls, people with disabilities (PWDs) and older adults). Other common WASH interventions that featured in the top twenty included: evaluating and improving access to and use of sanitation facilities and reducing exposure to faeces; implementing and understanding behaviour change for hand, personal and domestic hygiene; evaluating and improving access to water sources and/or quantity of water; understanding the burden of and risk factors for WASH-related health and non-health outcomes; developing climate change interventions; and examining WASH policy, coordination and/or governance.

According to the 4Ds framework, the top 20 questions selected represent and highlight the need to optimise delivery of existing interventions to maximise their impact on populations affected by or at risk of crises (delivery: n = 8, 40%) and the need to develop or improve on existing interventions and strategies (development: n = 6, 30%). Some of the questions related to describing the current associated health and wellbeing burden, or practices and services of WASH interventions (description: n = 5, 25%) and there was a single research question on new interventions (discovery: n = 1, 5%) (Table 3).

In addition to the top 20 research questions, the top five highest-scoring questions per the 17 WASH intervention categories were selected to form intervention-specific research priorities. Questions by WASH intervention category, weighted AEA and RPS and overall ranking can be seen in Table A in S2 Text. Lastly, we have also stratified research priorities by individuals whose work is focused on each of the WHO regions globally. This may help national and

### Table 2. (Continued)

<table>
<thead>
<tr>
<th>Rank #</th>
<th>WASH category</th>
<th>4Ds framework</th>
<th>Research question</th>
<th>n</th>
<th>Weighted AEA score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Climate change interventions</td>
<td>Discovery</td>
<td>What designs or adaptations are required for climate change-resilient water supply and sanitation infrastructure that are appropriate and effective in humanitarian contexts?</td>
<td>211</td>
<td>86.3</td>
</tr>
<tr>
<td>17</td>
<td>Distribution of hygiene materials or non-food items (NFIs)</td>
<td>Delivery</td>
<td>How can organisations work with people to determine what are the most appropriate products to be included in hygiene kits in different response phases (e.g., acute, post-acute and protracted phases) or for different population groups (e.g., families with young children, child-headed households, people with disabilities (PWDs), adults with incontinence, etc)?</td>
<td>200</td>
<td>85.9</td>
</tr>
<tr>
<td>18</td>
<td>WASH policy, coordination and/or governance</td>
<td>Description</td>
<td>What are effective mechanisms to build the capacity of WASH professionals who work in emergencies?</td>
<td>216</td>
<td>85.8</td>
</tr>
<tr>
<td>19</td>
<td>Improving access to and use of sanitation facilities and reducing exposure to faeces</td>
<td>Delivery</td>
<td>What are the effectiveness and cost-effectiveness of sanitation promotion campaigns on health and non-health outcomes among populations affected by crises?</td>
<td>207</td>
<td>85.7</td>
</tr>
<tr>
<td>20</td>
<td>Improving access to water sources and/or quantity of water</td>
<td>Delivery</td>
<td>How can organisations support people affected by crises in accessing safe, sufficient and reliable drinking water supplies at reasonable cost?</td>
<td>205</td>
<td>85.6</td>
</tr>
</tbody>
</table>

https://doi.org/10.1371/journal.pwat.0000217.t002

### Table 3. Research questions organised by the 4Ds framework: description, delivery, development and discovery.

<table>
<thead>
<tr>
<th></th>
<th>Questions (n = 128)</th>
<th>Questions in the top 20 (n = 20)</th>
<th>Proportion in the top 20 research questions (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>36</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Delivery</td>
<td>60</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Development</td>
<td>30</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Discovery</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

https://doi.org/10.1371/journal.pwat.0000217.t003
regional researchers and implementers to identify which research questions were considered the highest priority from a national or regional perspective. Similarly, we have stratified research priorities by organisation type and gender. The list of stratified research priorities can be explored via an online data visualisation tool: https://www.elrha.org/wash-research-agenda/#research-questions.

Discussion

A diverse range of global WASH and global health experts with knowledge and experience across many contexts and facets of WASH engaged in a CHNRI process to identify research priorities for improving WASH in humanitarian crises. This filled a critical gap by generating consensus around research questions that would enable the international and national communities to move forward with effective and better-quality WASH intervention strategies. The results of this process highlight that experts’ priorities for future research focus on optimising delivery of existing interventions to maximise their impact on populations affected by or at risk of crises. In total, 286 global experts undertook the scoring for this priority setting exercise. The more experts who agree to participate in the scoring, the more reliable the outcomes of this exercise are [35,41], and the geographical spread and level of agreement in the ranking of the research questions gives confidence in the identified priorities.

The WASH in Crises Research Agenda has identified the key research gaps that are most important to the WASH sector and produced a consensus-based list of key research questions for the 2023–2030 period. Results point to the need for research on: 1) the distribution of hygiene materials or NFIs, 2) improvements to design and implementation of WASH in crises programmes (especially inclusion of women, girls, PWDs and older people); 3) improving access to and use of sanitation facilities and reducing exposure to faeces; 4) behaviour change for hand, personal and domestic hygiene; 5) improving access to water sources and/or quantity of water; 6) burden of and risk factors for WASH-related health and non-health outcomes; 7) climate change interventions; and, 8) WASH policy, coordination and/or governance. These findings are in accordance with several other research prioritisation exercises conducted in both WASH and across global health in the past few years including the 2022 USAID Bureau for Humanitarian Assistance’s Emergency WASH Research and Capacity Building Priorities [42]; 2020 Global Task Force for Cholera Control’s Cholera Road Map Research Agenda [40]; the newly established WHO WASH and Public Health Emergencies Group, which intends to reflect on key research priorities in the post-COVID-19 era; and others that have or may develop research agendas relevant to WASH [37–39,43–45].

The majority of the prioritised research questions fell into the “Delivery” and “Development” categories, which may reflect a want to take a look at existing programmes and interventions being carried out and how to make iterative changes to those programmes to improve effectiveness and quality of response. This gap in knowledge on what works echoes the recent multiple reviews on WASH in crises contexts, which conclude that interventions have had or may have an effect, but that these effects are not currently being consistently measured within programmes and there is a low quantity of evidence for WASH in crises contexts [14–19]. Only a small number of research priorities focussed on new or “Discovery” research. While “Discovery” research plays an important part in humanitarian programmes, new innovations were not seen as a priority to respondents at this time. Overall, there was a focus on practical questions that could provide answers to operational decisions, rather than questions that may take longer to test and provide answers to inform programming.

Due to the diversity of WASH intervention types included within the research questions, it may be difficult for individuals with a particular discipline or interest in an intervention to...
solely look or feel represented in the top twenty research questions. As such, we have selected the five top scoring research questions for each of the 17 WASH intervention categories to form intervention-specific research priorities. These lists aim to support individuals looking at particular areas of WASH programmes and understand the priorities related to these interventions.

Lastly, in order to compare responses by sub-groups, research priorities stratified by geographic location, organisation and gender. This may help direct national researchers and agencies to identify research priorities that are relevant to their setting and/or organisation. For example, there was moderate variation in priorities between regions, with the biggest differences being between the AMR and the AFR and EMR regions. This may be due to the high- or middle-income nature of countries in the AMR experiencing different types of crises compared to the AFR and EMR, and thus affecting the research priorities identified in different regions. Gender-based and organisational ranking of research priorities may also differ.

**Strengths and limitations**

The CHNRI methodology has a number of advantages over other priority setting approaches. The systematic listing and scoring of research questions is a validated approach associated with comprehensibility, good replicability and transparency. The method also prevents one or a small group of individuals from dominating the process, whilst also providing a quantitative measure from the exercise. The process also allows non-technical stakeholders, those with varying disciplines, and individuals with a wide range of expertise to simultaneously take part and evaluate the proposed research questions according to the same set of criteria [32,34,36].

Strengths of our study include using a validated methodology, a high number of respondents (as compared to other CHNRI exercises [37–40,43,44]), with an acceptable geographical spread and occupational balance.

Several potential limitations may arise from the methodology and limit the full potential of the CHNRI exercise to represent all research gaps in the WASH sector. There are several methodological limitations on how the CHNRI exercise was carried out may bias how representative the priorities selected for the WASH in Crises Research Agenda are. The first of these limitations is the availability and accessibility of the current evidence base. Within the methods used, we may have been unable to map all the currently available evidence due to bias in the reporting of ongoing or planned research, lack of sharing of research, publication bias (i.e., not publishing negative effects) and pre-specified protocols were limited for studies on WASH in crises contexts. More could be done in the WASH sector to improve pre-specification, registration or posting of research updates, and also promote the protocols of new research. The second limitation is in simplifying complex question, as for practical reasons, questions were condensed, consolidated or phrased differently; this may have been reductive and led some respondents to think that some areas of WASH were missing in the prioritisation survey. The third limitation was the limited involvement of all stakeholders, especially national NGOs and national governments. Whilst there was high engagement from Process Managers and the technical advisors, there was suboptimal engagement with governments and individuals based outside of Europe for KIIs and FGDs. Additionally, there may have been selection bias in survey respondents due to internet connectivity, language of the survey or inclusion in WASH networks; this may also have led to differences in global, national and sub-national response rates. Selection bias may also have been introduced as the survey took 2–3 hours, on average, to complete and had a high non-response rate, whereby 612 individuals opened the link in our invitation email, but only 286 ranked the research questions. This may bias the results, as we were not able to capture the priorities of non-responders compared to those who responded,
and it may introduce bias as those that did not respond may be different in their prioritisation from those who did respond [35]. Whilst CHNRI methods are based on the wisdom of crowds that suggests ~24 scorers are needed in order to cancel out personal biases and speak for a group ([35,41]), there may be differences between the responders and non-responders in their priorities. Lastly, there may be bias in the ranking of research questions. This project did not quantify existing available evidence on each research question included in the survey; as such respondents may have been unaware of current research, and falsely prioritised certain questions, based on where respondents thought there were gaps based on their current knowledge and awareness.

**Conclusions and lifespan of the WASH in Crises Research Agenda**

The WASH in Crises Research Agenda has identified key evidence gaps of most importance to the WASH humanitarian community of practice and has established a prioritised list of critical research questions. This list of research priorities reinforces how little is known about impactful interventions for WASH programmes in crises contexts, and underlines the need for research to evaluate current practices ensuring that attention is given to improving the quality of humanitarian responses. All stakeholders, such as donors, international and national organisations, governments and academic institutions, are invited to use this research agenda to encourage, inspire and enable relevant and high-quality research that will be used to inform humanitarian response. A collaborative and coordinated environment is required to advance research on WASH in crisis contexts, and to strengthen capacity to identify, finance and implement relevant research to answer key humanitarian WASH questions. A full report and executive summary of the process can be found via the ELRHA website at [https://www.elrha.org/wash-research-agenda/#overview](https://www.elrha.org/wash-research-agenda/#overview).

The identified research priorities were ranked based on current opinions agendas and environment. The lifespan of the WASH in Crises Research Agenda is only projected to be up to 2030. Aligning with the Sustainable Development Goals (SDGs), the 2030 timescale prioritises research that can be done now to put all available resources into these priorities over the next six years. Continuous monitoring will still be required during this period, and can signal when the process needs to be refreshed or repeated in future. The research priorities will inevitably change over time. New or unpredictable humanitarian crises may elicit new challenges and new questions. Research questions will be answered and influence change in both policy and practice, and new thematic areas could emerge and evolve. The environment itself may change and new important areas for efforts may receive attention that was previously withheld.

**Supporting information**

S1 Text. Detailed CHNRI methodology adapted for the WASH in Crises Research Agenda. (DOCX)

S2 Text. List of 128 research questions for the WASH in Crises Research Agenda. (DOCX)

S3 Text. Other thematic areas for WASH in crises research suggested by survey respondents. (DOCX)

S4 Text. Priority research questions by WASH intervention category. (DOCX)
S5 Text. Organisations and individuals that contributed to the WASH in Crises Research Agenda.

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