

**World Health Organization
Department of Communications**

Evidence Syntheses to Support the Guideline on Emergency Risk Communication

Q11: What are the best ways to communicate uncertainties to public audiences, at-risk communities, and stakeholders?

Final Report

Submitted by

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1.0 INTRODUCTION

1.1 Background

The World Health Organization (WHO), as an agency of the United Nations (UN), commissioned systematic reviews and syntheses of existing evidence to support the development of new emergency risk communication guidelines. The systematic reviews were required to focus on emergency risk communication to inform the development of recommendations for the WHO Risk Communication Guideline on Emergency Risk Communication, which refers to any risk communication done before, during, and after health emergencies.

As defined by the WHO, risk communication refers to the real-time exchange of information, advice, and opinions between experts and/or officials and/or the publics who face a threat (hazard) to their survival, health, or economic or social wellbeing.

The purpose of the proposed guidelines is to assist the WHO as it communicates with multiple stakeholders, exchanging information that will enable everyone at risk to make informed decisions about protective and preventive actions that will mitigate the effects of a threat (hazard).

As noted by the WHO, emergency health risk communication is distinguished from non-emergency health risk communication exchanges by a combination of the following characteristics: The existence of a perceived public health threat; a dramatically increased demand for information to protect health that often outstrips the ability of health authorities to provide it; a need to communicate with potentially at-risk populations before recommendations are certain; a rapidly evolving situation in which information about the health threat and how to prevent its continuation or spread is incomplete and changing as public health investigation proceeds.

A public health emergency event, such as an earthquake, wildfire, flood, and emergent infectious disease, is usually characterized as having four major phases: Preparation; onset; containment, which includes the peak of the emergency event; and recovery. Another characterization, also with four phases, but conceptualized slightly differently, includes: Prevention; readiness/preparedness; response; and recovery. A fifth phase, evaluation, generally follows the recovery phase although it commonly occurs along with the earlier four phases as well.

The WHO sought systematic reviews and syntheses of existing evidence regarding twelve questions of interest related to emergency risk communication. Of these, the Wayne State University team was responsible for six questions, and this report presents the findings for one of them.

1.2 Rationale

Communication with the public during public health emergency events is a complex process involving multiple stakeholders. The messages from authorities to the general public specific communities, and other stakeholders, must be carefully designed to successfully influence health protection behaviors. In particular, messages from authorities during the course of an emergency event must thoughtfully convey the uncertainties related to the scientific evidence and what is known about the impact and progression of the event. This becomes even more important as a key characteristic of an event is the uncertainty the public experiences during the course of an event. Additionally, health emergency events tend to be both local and regional or global problems; thus, to fully know how to successfully communicate uncertainties in these situations, the political and cultural context in which the messages will be received and understood must also be taken into account.

1.3 Objective

1.3.1 Question

The objective was to conduct a systematic review of the extant literature on best practices for conveying uncertainties during emergency health risk communication. Specifically, the purpose of the systematic review is to address the following question:

What are the best ways to communicate uncertainties to public audiences, at-risk communities, and stakeholders?

1.3.2 SPICE Framework Question Explication

As provided by the WHO, the question is explicated using the SPICE (Setting, Perspective, Phenomena of Interest, Comparison, Time Scope) framework as follows:

Setting: In the context of preparing for and responding to events/emergencies with public health implications in high, low, middle income and fragile states.

Perspective: National governments and relevant subnational authorities (e.g., local/district health departments), responding and implementing partners; at-risk communities and stakeholders.

Phenomena of Interest: Tactics to communicate uncertainties inherent in events and emergencies with public health implications.

Comparison: Different sources of information (level of authority, local communities, national government authorities); timing of recommendations, announcements, alerts; consistency of messages; labeling recommendations as “interim”, acknowledgements of unknowns, acknowledgements of what is known. Variations in tactics to communicate uncertainty related to equity considerations such as local contextual and population characteristics.

Evaluation: Impact on public acceptance and compliance with recommendation; changes and shifts of information during the course of event/emergency.

Time Scope: 2003 to present.

1.3.3 Review Question and Rapid Knowledge Map

To ascertain the availability of existing reviews and primary studies relevant to the question, we conducted a preliminary literature search and created a Rapid Knowledge Map. The map showed existing reviews were available as were sufficient number of primary studies with a wide coverage of type, phase, and country of emergency public health events. The Rapid Map also allowed us to refine the objective of and the approach to the present review as noted below.

1.3.4 Phenomena of Interest and Outcomes/ Effects Associated with Review Question

The phenomena of interest are tactics to communicate uncertainties inherent in events and emergencies with public health implications.

To foreground the phenomena of interest that could potentially be measured, observed, or described in affected populations (communities/ publics, stakeholders, etc.), we parsed the phenomena of interest and review question to focus on strategies and tactics that were effective or in the absence of evidence of effect appeared to work best as follows:

Strategies and tactics

→ Manage, contain, or bring about ncrease/ decrease in uncertainty.

1.3.5 Phenomena of Interest and Comparison Category for Outcomes/ Effects/ Impacts and Best Practices

Given the corpus of research studies relevant to the objective for this systematic review, the SPICE framework descriptions (as noted above) of the setting, perspective, phenomena of interest, and time scope categories do not require any clarification.

However, the description of the comparison category requires additional interpretation for studies that do not include a comparison group. We have interpreted the comparison descriptors not as comparison conditions/ groups in a research study, but as concepts/ variables that may have an association with the concepts/ variables contained in the questions. The SPICE description for the comparison category includes concepts/ variables such as different sources of information; consistency of messages; labeling recommendations as interim; and acknowledgements of unknowns and knowns. Instead of seeing these terms as comparison groups, as may be the case in a randomized trial, we are taking these concepts/ variables to be as potentially associated with uncertainty to identify what works and for whom and in what contexts..

As such, when we extracted data from individual studies that were not group comparisons (randomized or nonrandomized), we did not compare (or contrast) the key concepts/ variables in a question with the concepts/ variables in the comparison category; instead, we checked for associations between the question concepts/ variables and comparison category concepts/ variables and focused on identifying best practices as directed by the review objective.

1.3.6 Data and Population of Interest

The primary data of interest were from field studies of populations that were *directly* affected by a relevant public health emergency event. Of interest were also data from studies of populations who may be likely to be affected by a relevant public health emergency event, particularly studies that focused on questions promoting individual preparedness for such events. Also of some interest were data from studies that addressed how organizations, predominantly government organizations or individuals employed by governments, respond to or work to develop risk communication messages.

2.0 EXISTING SYSTEMATIC REVIEWS

2.1 Approach to Existing Systematic Reviews

We did not conduct a structured review of the existing reviews and did not extract detailed findings from this literature. We appraised the quality of these reviews, and then identified key relevant findings from the reviews that were judged as high and moderate quality.

2.2 Quality Rating and Relevant Findings

The literature search for the present review revealed five existing systematic reviews that were relevant to the review objective. Of these, one was appraised as high quality, three as moderate quality, and one as low quality. All were narrative reviews and none were quantitative meta-analyses.

The relevancy was assessed using the criteria in Noyes et al. (in press) that provides four categories, direct, indirect, partial, and uncertain. Two coders assessed the relevancy independently and there was very little agreement between them for the indirect, partial, and uncertain categories. As such, we combined indirect, partial, and uncertain assessments and labeled them as indirect; thus, we ended with two categories for relevance, direct and indirect.

The quality of the reviews was rated using a modified Assessment of Multiple Systematic Reviews (AMSTAR) quality appraisal checklist (Shea et al., 2007). AMSTAR consists of 11 elements that address the reviews' design (i.e., a priori), data extraction, details of the literature search, inclusion of grey literature, characteristics, methods, and scientific quality of included studies, publication bias, and acknowledgement of conflict of interest(s). Each area in AMSTAR is assessed using "yes," "no," "can't answer," or "not applicable." Studies received a final rating of "high" (no significant flaws), "moderate" (minor flaws impacting credibility/validity), or "low" (some flaws likely to impact credibility/validity). Two coders did the coding independently with high agreement. The final quality assessment was judged after the coders resolved any differences.

Reviews that were rated as low quality were "unpacked" for their data-based primary studies, which were added to the literature for the present review. The four existing reviews that were appraised as high or moderate quality were read for key relevant findings. The quality ratings and key findings are noted in Section 2.2.1.

2.2.1 Existing Reviews: Ratings and Findings Summary

Notes for Table

- . All reviews were narrative synthesis.
- . Relevancy judged as only direct and indirect (see above).

<i>Review Citation and Review Purpose</i>	<i>Modified AMSTAR Quality Rating</i>	<i>Relevancy</i>	<i>Key Relevant Findings</i>
Bradley (2014). <i>The effectiveness of disaster risk communication: A systematic review of</i>	High	Indirect	Studies included a variety of human-caused, natural, and infectious disease disasters. The review attended to all four phases of disasters. Most studies used non-randomized designs. Outcomes of focus were knowledge, behavior, and incidence of health outcomes.

<i>intervention studies.</i> The aim of this systematic review was to identify, appraise, and synthesize the findings of studies of the effects of risk communication interventions during four stages of the disaster cycle.			Countries of focus were Australia (1), Canada (1), United Kingdom (2), and the U.S. (10). Others were China (1), Egypt (1), Hong Kong (1), Iran (1), Japan (1), Mauritius (1), Republic of the Congo, Singapore (1), Thailand (1), and Taiwan (1). Additionally, the Caribbean Islands of St. Vincent and the Grenadines and Turks and Caicos Islands (1). There is some representation of low and middle-income countries. Some studies included in the review studied interventions with at-risk groups of equity concern: children, prenatal women, and under-represented racial groups. In summary, there was little robust evidence of the effectiveness of risk communication for disaster knowledge, behavior, and health outcomes in the response and recovery phases of disasters. Outcomes specific to the phenomenon of interest and comparison aspects were negligible in this review.
Gesser-Edelsburg (2015). <i>Emerging infectious disease communication during H1N1: What were risk communication channels, content and strategies used?</i> The objective was to conduct a systematic literature review of the methodology used by studies that examined emerging infectious disease communication during the 2009 H1N1 pandemic outbreak through different communication channels or by analyzing contents and strategies.	Moderate	Indirect	Studies in risk communication have made a turn from predominantly using quantitative methods before 2013 to using more often qualitative methods. Research shows that studies should use triangulation based on input from different stakeholders via interviews and discussions to understand questions and needs of all in the population. Studies conclude that health agencies need to collaborate with media to ensure evidence-based coverage and make key information available. Of the 61 studies included (from English-language journals), only one focused on risk communication and uncertainty. This study claimed that uncertainty is difficult to conceptualize and can easily lead to public distrust. There is no discussion of disaster phase. Similarly, there was no discussion of countries of focus or at-risk populations.
Meredith (2008). <i>Analysis of risk communication strategies and approaches with at-risk populations to enhance emergency preparedness, response, and recovery.</i> The aim of this review was to assess the literature on emergency preparedness risk communication and	Moderate	Indirect	The one-year study focused on the U.S. and at-risk populations. The review considered event/crises in general with attention to the phases of preparedness, response, and recovery. Community-based participation in the development and dissemination of risk messages can help inform the type of strategies to be utilized. Those tasked with communicating with the public need to engage the community, use trusted sources to deliver the messages, and offer frequent messages in multiple modes that are locally and personally relevant.

public health messaging, particularly for at-risk populations.			Reaching at-risk populations requires the use of multiple channels, format, and tools. Underscored is the importance of culturally competent risk communication materials for maximal comprehension. Insufficient resources make tailored and targeted messaging, which is best practice, difficult to do. Evaluating the impact of risk communication efforts and sharing lessons learned can inform future messaging. The literature review, however, uncovered little formal evaluation of past efforts to inform communities about future risk.
Vaughan (2008). <i>Effective health risk communication about pandemic influenza for vulnerable populations.</i>	Low	---	---
Visschers (2008). <i>Probability information in risk communication: A review of the research literature.</i> The aim of this review was to integrate empirical findings to describe the evidence base for communication about probability information and resultant, general recommendations for the presentation of probability information in risk communication.	Moderate	Indirect	Nearly all studies were quantitative. Neither event/disaster type nor phase were relevant. Included studies focused only on risk messages and, specifically, the probability information. Criteria for inclusion required a medical or health risk, or a technological or accident risk that could damage people's health. Nearly half of the studies had college students as participants; the other typically included individuals for whom the risk applied. The effects of presentation format depend not only on the type of format, but also on the context in which the format is used. <i>Frequencies, Percentages, Base Rates, and Proportions</i> 1. Use the same denominator in probability information throughout the risk message, so that people who neglect the denominator can still compare the probability information. ** 2. A step-by-step description of a probability calculation is recommended to present risky situations that include false positives, such as screening test results, because step-by-step probability descriptions are relatively easy to understand and are likely to result in adequate risk estimates ** <i>Relative Risk Reduction, Absolute Risk Reduction, and Related Formats</i> 3. Be careful about presenting RRR, as this may be mistaken for ARR. *** 4. Information about the number needed to treat (NNT) should be used with care because people do not like this format and have difficulty in understanding it. ** <i>Verbal Probability Information</i> 5. Take the context of the risk communication into account when selecting appropriate verbal probability expressions for a risk message. *

			<i>Numerical Versus Verbal Probability Information</i> 6. Present both numerical and verbal probability information in a risk message. People prefer numerical information for its accuracy but use a verbal statement to express a probability to others. Presenting both makes sure that people have the right information no matter the purpose for which it is used. ** <i>Graphs</i> 7. Graphs are useful means to present probability of harm as they are more likely to draw people's attention to a probability of harm than numerical information. *** Stars indicate strength of evidence: More stars, more strength. The authors argue that the presentation format has the strongest effect when the receiver processes probability information heuristically instead of systematically. At the same time, the situation in which a message is presented may predict how people process the information and how this may influence their interpretation of it.
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2.3 Summary of Relevant Findings From Existing Systematic Reviews

The four existing reviews that were of high or moderate (and not low) quality focused on several types of public health emergency events, including emergent infectious disease, human-caused risks/ disasters, and risks/ disasters in general. Only one review drew from studies of events dispersed throughout the world; still, the 10 of the total 27 events took place in the United States (Bradley, 2014). Of the remaining reviews, one focused on the H1N1 event of 2009 rather than countries of focus, one appears to have focused only on the United States as it was a grey literature report, and one reviewed quantitative, mostly laboratory experimental design, studies wherein country of focus was not relevant.

Although the reviews were judged to indirectly relate to the phenomenon of interest, they minimally address the objective of this review. With this context in mind, the following findings may be tentatively noted:

- Uncertainty is difficult to conceptualize and can easily lead to public distrust.
- Presentation format of probability information makes a difference on understanding and interpreting messages.
- There is a lack of robust evidence for the different aspects of uncertainty.

2.4 Summary of Research Gaps Identified by Existing Systematic Reviews

The reviews do not meaningfully address the phenomenon of interest and the review question. Given this context, some gaps in the literature are:

- What are the different conceptualizations of uncertainty? How might understandings of uncertainty differ between event/ crisis type and phase? How might understandings of uncertainty differ between location, culture, social, and overall context of event/ crisis?

- Evidence on the best ways to communicate uncertainties to public audiences, at-risk communities, and stakeholders.
- The influence of different tactics, such as source, type of announcement, alert, and warning, consistency of message, and changing status of what is known and unknown, in relation to communicating uncertainties.

2.5 Use of Existing Systematic Reviews

The findings from the existing reviews were used to contextualize the present systematic review. Where appropriate, the findings from the high or moderate quality existing reviews were mapped against the findings from the present review in the discussion section and were used to underpin the Evidence to Decision (DECIDE) frameworks (Alonso-Coello et al., 2016).

3.0 METHOD

3.1 Protocol and Process Design for Evidence Synthesis

A detailed protocol for the review was developed. It is available on request from the contact persons for the report.

The process design for the evidence synthesis for the review is presented in Section 3.3. Findings were extracted only from data-based primary studies. The design shows that the findings were grouped and processed within the type of study methodology stream and then brought together in an overarching synthesis of the findings across the methodology streams. Details of the process are presented below in Sections 3.9 to 3.15.

3.2 Determining Study Methodology of Data-based Primary Studies

The WHO Minimum Methodological Expectations document in Section 2.2 required production of a knowledge map and noted the following categories for data-based primary studies: Quantitative randomized control trials; qualitative (ethnographic research, case studies, process evaluations, and mix-methods designs); mixed-method studies (combining different types of designs to explore a phenomenon of interest); observational and cross-sectional surveys; and grey literature reports.

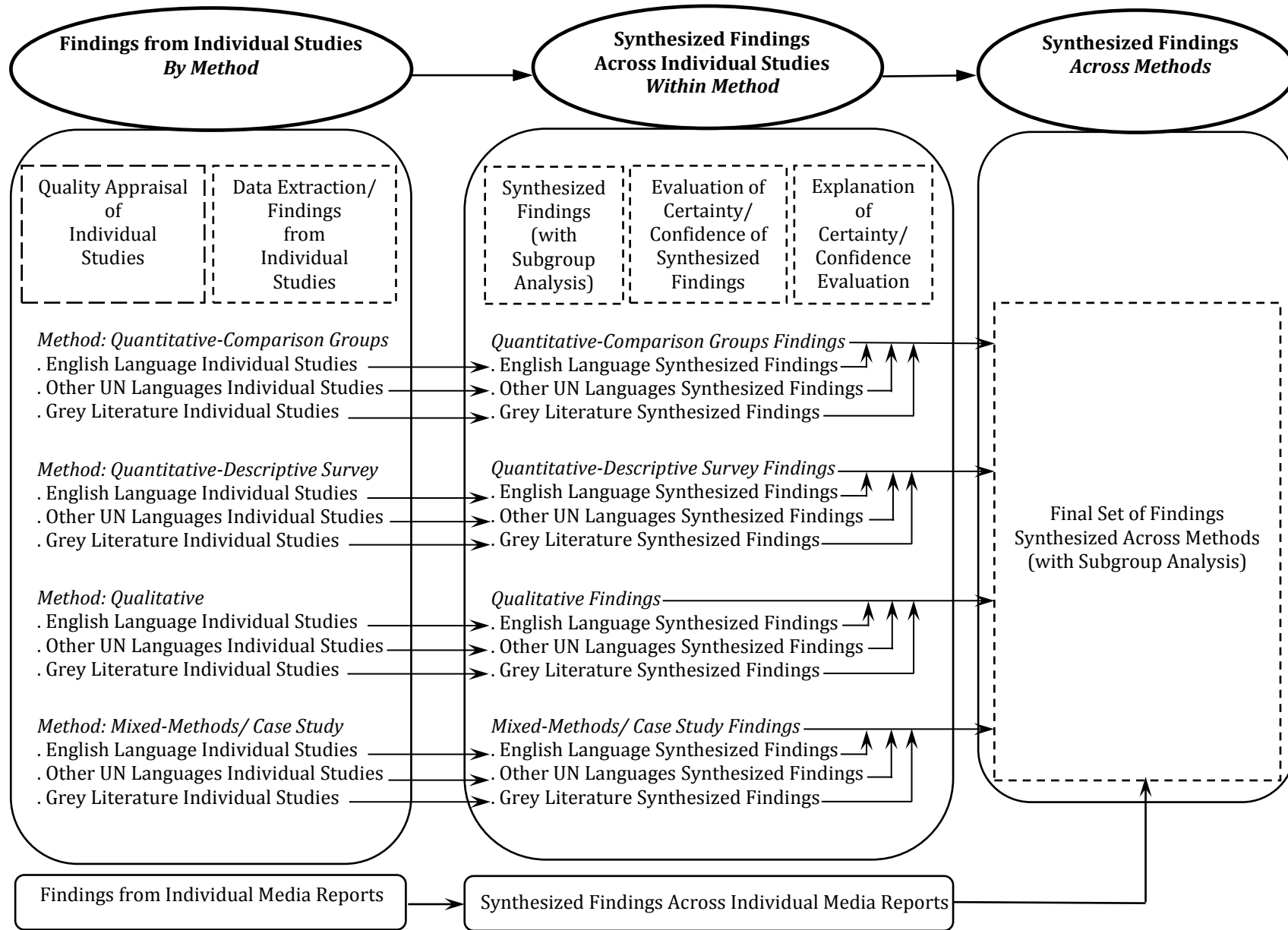
Using the above methodological groupings as a starting point, we initially identified five methodological streams that best covered the method types found in the primary studies selected for the review:

- Quantitative – randomized group comparison and non-randomized group comparison.
- Quantitative – descriptive survey and similar designs.
- Qualitative – open-ended questionnaire survey, interview, focus group, ethnography/ participant observation, and textual analysis.
- Mixed-method – use of both quantitative and qualitative methods, where the different methods usually address different hypotheses and/ or research questions.
- Case study – use of several methods, where usually all methods address the same research question and focus on one particular event/person/location.

After a more in-depth perusal of the mixed-method and case study article/ reports, we did not find any appreciable methodological differences as both types utilized quantitative and qualitative methods with similar procedures. In consultation with the WHO methodologist consultant, we combined these two methodological streams. Thus, we ended up with four methodological streams:

- Quantitative-Comparison Groups (QN-CG)
- Quantitative-Descriptive Survey (QN-DS)
- Qualitative (QL)
- Mixed-Method and Case Study (MM, CS).

3.3 Process Design of Synthesis of Evidence from Data-based Primary Studies



3.4 Existing Reviews, Guidelines, Media Reports, and Grey Literature

As noted in Section 2.1, we did not conduct a systematic review of the existing reviews. We identified key findings and used them to contextualize the findings of the present review.

We did not include guidelines, recommendations, and other such literature in the present review. Only data-based primary studies were selected for data extraction and synthesis of evidence.

English language media reports that included some type of risk communication relevant “data,” such as direct quotations or detailed descriptions of events, from populations affected by an emergency event were included. As shown in Section 3.3, the findings from media reports served as a separate input for the final synthesized set of findings.

Grey literature non-academic reports were included only if they were data-based primary studies. Academic unpublished data-based primary study masters theses and doctoral dissertations were treated as grey literature. As shown in Section 3.3, these grey literature studies were treated similar to the academic primary studies.

3.5 English and Other UN Languages

3.5.1 Languages Included in Review

The primary search was for literature in the English language. Additionally, we conducted searches for studies published in the other UN languages as well, which included Arabic, Chinese, French, Russian, and Spanish.

3.5.2 Review Process for Other UN Languages

As seen from Section 3.3, we followed the same process for both English and other UN languages articles/reports for data extraction from individual studies and synthesis of findings within methodological streams. That is, the individual studies from Arabic, Chinese, French, Russian, and Spanish were grouped into the four methodological streams, irrespective of the language, after which synthesized findings were generated within each methodological stream.

We did not completely translate Arabic, Chinese, French, Russian, and Spanish language studies into English. Portions of the studies were translated into English as needed to meet the requirements of the review. As the other UN language findings from individual studies came from studies that were only partially translated into English, we treated these findings as a separate “sub-stream” at the time of synthesis of findings within methodological streams.

3.6 Information Sources for Literature Search

3.6.1 Information Sources for English Language Literature

We conducted a general search using the Wayne State University Library Summon function, which indexes all holdings in the library, Google Scholar, and general Google search.

We also searched within individual databases including: Web of Science; PubMed/Medline-National Library of Medicine (NLM); Cumulative Index of Nursing and Allied Health Literature (CINAHL); CINAHL Complete; Communication and Mass Media Complete (CMMC); PsychInfo; and WHO databases.

3.6.2 Information Sources for Other UN Languages Literature

Native readers of Arabic, Chinese, French, Russian, and Spanish who were fluent in English conducted the search. The following information sources were searched.

For Arabic, the information sources were: Al-Manhal, Dar-Al-Manduma, Google Scholar, general Google search, Wayne State library, and WHO databases.

For Chinese, the information sources were: CNKI (China National Knowledge Infrastructure), Wanfang Patent Database, Google Scholar, general Google search, Wayne State library, and WHO databases. In addition, contact persons suggested by the WHO were solicited for suggestions for relevant studies.

For French, the information sources were: Archive ouverte UNIGE, Cairn.info, Google Scholar, general Google search, Government of Canada publications, HAL archives ouvertes, JSTOR, La Houille Blanc, Persee.fr, Revues.org, Wayne State library, and WHO databases.

For Russian, the information sources were: Cyberleninka.ru, Google Scholar, general Google search, Mgimo.ru/library/ehd, Msu.ru/info/struct/dep/library, Nbmgu.ru, Wayne State library, and WHO databases.

For Spanish, the information sources were: CONACYT, Cuiden, Elsevier, Google Scholar, general Google search, Public Health institute Mexico, Wayne State library, and WHO databases.

3.6.3 Information Sources for Grey Literature

The search for grey literature in all languages used Google Scholar and general Google search as the primary information sources. In addition, an experienced librarian at the National Hazards Center library at the University of Colorado-Boulder, United States conducted a search specifically for grey literature. The search was conducted in close consultation with a team member who was physically present on location.

3.7 Literature Search Strategy, Search Terms, and Search Inclusion and Exclusion Criteria

3.7.1 Search Strategy

We adopted a two-phase strategy for literature searching. In the first phase we did a general search that was intentionally broad in scope. In the second phase, a search focused narrowly on the objective of the present review was conducted.

3.7.2 Search Terms

We used the search terms noted below. Not all terms worked in all databases; therefore, thesauri were consulted for each database to find synonyms, if they existed, for each term, or any functionality that allowed the word to be “exploded” or “expanded.”

Disaster*	At risk population community
Disaster plan*	At risk
Communication	Uncertain*
Risk communication	Warning
Emergenc*	Community participation
Hazard*	Stakeholder
Risk*	Social network communit*
Threat*	Pubic (audience)
Emergency preparedness	Duty to protect
Emergency management	Safety
Crisis (or other truncation used in a specific database:?,#) Crisis communication	Risk population; Risk community
Disaster preparedness	Community
Hazard communication	Social media
Emergency communication	Facebook
Catastrophe communication	Twitter
Health communication	New media

3.7.3 Search Inclusion Criteria

The following broad inclusion criteria were used in the search for literature:

- Research related to the practice of risk communication and the process of disaster management with no preference for any specific emergency or health hazards.
- Research within the viewpoint or scope set by the risk communication field including, but not limited to: trust, uncertainty, communities, health, misinformation, health protection, media (including social media), messages, and stakeholders.

3.7.4 Search Exclusion Criteria

The following exclusion criteria were used in the search for literature:

- Research in organizational risk communication and disaster management such as technology failures.
- Research outside of the specified scope of the study, such as laboratory studies and those related to chronic disease, lifestyle, or personal living/ attributes (such as personal health, mental health, etc.).
- Pre-2003.

3.8 Article/ Report Selection

3.8.1 General Process

The hits generated by the literature search process were narrowed to select data-based primary articles and reports. The general process for selection of the articles/ reports for all languages was in two stages.

In the first stage:

- The hits obtained using a search were scanned by reading their title and abstract or summary;
- After scanning, the hits that were judged as related to risk communication during disaster/ emergency events were quickly read as full-texts and downloaded if found still broadly related;
- The downloaded full-texts were read carefully and selected if found related to the objective and phenomena of interest of the present review. These included, both academic and grey literature, data-based studies, reviews, guidelines, and media reports.

In the second stage:

- The full-texts of the selected articles and reports were again read and this time categorized as a data-based primary study or not. This included the grey literature.
- If an article/ report was a data-based primary study, it was further judged for relevancy to the review objective and phenomena of interest. A study that was judged as directly, indirectly, partially, or uncertainly relevant (as opposed to not relevant at all), was selected for extraction of its key findings. *Only these relevant primary study articles/ reports were directly used to generate the systematic review for this report.* These included studies used quantitative, qualitative, mixed-method, and case study methods.

To summarize, the article/ report selection process occurred in two broad stages. In the first stage, all literature that was related to disaster/ emergency risk communication, and review objective and phenomena of interest was selected. In the second stage, this literature was narrowed to select only relevant data-based primary study articles/ reports using quantitative, qualitative, mixed-method, and case study methodologies.

3.8.2 Quality Assurance of Selection Process

The first stage of the search and selection for English language articles/ reports was conducted by an experienced librarian with subject-matter expertise in the discipline of communication. Two training and norming sessions were conducted with the librarian. The second stage selection was done by all primary members of the research team, who had gone through a training and norming session.

Both the first and second search and selection stages for other UN languages were done by fluent readers and writers of Arabic, Chinese, French, Russian, and Spanish who were also fluent in English. Four norming and training sessions were conducted with this group in a group setting. In addition, individual training sessions were provided as needed.

3.9 Quality Appraisal of Selected Individual Studies

The individual data-based primary studies selected for the review were appraised for their quality. The quality appraisal for primary studies for all languages was done using the following tools:

- Quantitative-Comparison Groups (QN-CG) done by EPOC Risk of Bias
- Quantitative-Descriptive Survey (QN-DS) done by adaptation of Davids & Roman (2014)
- Qualitative (QL) done by CASP
- Mixed-method and case study (MM, CS) done by McGill University MMAT.

Quantitative control/ comparison groups were individually appraised using the Effective Practice and Organisation of Care (EPOC) (2015) Risk of Bias tool. This tool provides nine criteria for assessing randomized control trials, non-randomized control trials, and control before-after studies. Detailed information on the definitions of levels of risk used in this tool is available in section 12.2.2 of the Cochrane Handbook.

Quantitative descriptive survey studies were individually appraised using an adapted version of Davids and Roman's (2014) quality appraisal criteria. This tool assessed on a 0 to 1 scale (0-not reported, 1-reported) the following areas: sampling, response rate, validity and reliability, sources of data, content and focus of study, and relevancy to the corresponding question. Final ratings were determined by percentage; weak (0-33.9%), moderate (34-66.9%), and strong (67-100%).

Qualitative studies were individually appraised using Critical Appraisal Skills Programme (CASP) (2013) checklist. Areas of the study appraised by CASP include appropriateness of qualitative methodology, data collection, relationship between research and participants, ethics, rigor of data analysis, clarity of findings, and value of research. Each area in CASP is assessed using "yes," "no", or "can't tell." Studies received a final rating of "high" (no significant flaws), "moderate" (minor flaws impacting credibility/validity), "low" (some flaws likely to impact credibility/validity), or "very low" (significant flaws impacting credibility/validity).

Mixed method and case study studies were appraised using Pluye et al.'s (2011) Methods Appraisal Tool (MMAT). Studies were assessed for the employed methods and methodological quality (i.e., qualitative, quantitative randomized control trials or non-randomized control trials, quantitative descriptive, and overall implementation of mixed methods). Each area in MMAT is assessed using "yes," "no," or "can't tell." Studies received a final rating of "high" (no significant flaws), "moderate" (minor flaws impacting credibility/validity), "low" (some flaws likely to impact credibility/validity), or "very low" (significant flaws impacting credibility/validity).

Individual media reports were appraised for their quality using the Authority, Accuracy, Coverage, Objectivity, Date, and Significance (AACODS) tool (Tyndall, 2008). Each area in AACODS is assessed using "yes," "no," or "can't tell." Studies received a final rating of "high" (no significant flaws), "moderate" (minor flaws impacting credibility/validity), "low" (some flaws likely to impact credibility/validity), or "very low" (significant flaws impacting credibility/validity). An important factor in weight with AACODS is given to aspects of authority.

3.10 Extraction of Data from Selected Individual Studies

3.10.1 Extraction of Data: Study Characteristics

The following study characteristics were extracted from individual data-based primary studies of all method types: Method; country focus; disaster/ emergency type; disaster/ emergency phase; and whether at-risk/ vulnerable population.

3.10.2 Extraction of Data: Study Findings

The purpose of extraction of findings from the individual data-based primary studies was to identify and note evidence of interest that mapped onto the phenomena of interest and the outcomes/ effects related to the review question. To extract the findings, we used the general process of reading and re-reading the abstract, results/ findings/ analysis, and discussion and conclusion sections to isolate the findings of interest. We did this process for all four methodological streams.

A quantitative meta-analysis was not suitable for the review due to the very small number of studies that used comparison groups (randomized or non-randomized). As such, as recommended in Section 11.7.2 of the Cochrane Handbook dealing with results without meta-analyses, we followed a narrative summary approach to extraction of findings from studies in all four methodological streams.

Narrative findings were, thus, extracted from primary studies of all method types. The findings focused on the phenomena of interest and the outcomes/ impacts of the review objective. Each finding was written as a statement. The findings were extracted separately for each outcome.

Quantitative and qualitative evidentiary support for each finding was also extracted. From quantitative studies we extracted numerical data, such as means, standard deviations, and probability values. While extracting these data we kept in mind whether the study was a group comparison (randomized, non-randomized) or descriptive. From qualitative studies we extracted key phrases, sentences, and direct quotations. From mixed-method and case study studies we extracted numerical data and key phrases, sentences, and direct quotations as appropriate related to each method. The extraction included page and paragraph numbers for the supporting evidence for every finding for all methodological streams.

3.10.3 Quality Assurance of Extraction of Data

An initial codebook for extracting study characteristics and findings was developed based on examples provided by the WHO. After receiving feedback on a draft from team members and the WHO, the document was suitably revised. Training sessions for the use of the codebook were conducted with the research team.

A pilot test of the codebook portion for extracting study characteristics was conducted with approximately 1% of the English language articles/ reports. For the pilot test, three team members coded each article. An analysis of the coding showed high agreement (approx. 80%) between the three coders.

For the codebook portion for extracting findings, a pilot test was conducted with approximately 1% of the English language articles/ reports with two readers. Results showed high agreement (approx. 80%) between the two readers.

The two pilot tests generated suggestions for refinement from the team members. The final codebook was created after incorporating this feedback.

3.11 Synthesis of Findings

3.11.1 General Process of Synthesis of Findings

The synthesis of findings was done in two stages as presented in the process design in Section 3.3. In the first stage, findings from individual studies were synthesized within methodological streams and then these within-method synthesized findings were evaluated for certainty/ confidence using appropriate tools. In the second stage, the within-method synthesized findings were synthesized across methodological streams, taking into account the certainty/ confidence evaluations.

3.11.2 Subgroup and Equity Analyses

In both the within-method and across-method stages, the synthesis of findings included subgroup analyses. These included examination of type of emergency event, phase of emergency event, country of emergency event, and presence of vulnerable population. The last two subgroups allowed considerations of equity in the synthesized findings.

3.11.3 Quality Assurance of Synthesis of Findings

The synthesis of findings was done by the lead author of the report. The synthesis process and the synthesized findings were discussed with all team members in weekly meetings. One team member closely read the synthesized findings and offered critique. The synthesized findings were developed based on the discussion and critique.

3.12 Synthesis of Findings Within Each Methodological Stream

For each methodological stream, the synthesized findings were created by building explanatory and higher level analytical statements supported by quantitative and qualitative evidence from individual studies.

For the two quantitative methodological streams, we again took directions from Section 11.7.2 of the Cochrane Handbook dealing with results without meta-analyses and followed a narrative summary approach to synthesis of findings.

For the qualitative methodological stream, we broadly followed the framework synthesis model (Barnett-Page, & Thomas, 2009; Pope, Ziebland, & Mays, 2000). We found this model suited to organize and analyze large amounts of data, which for us was represented by the corpus of findings and supporting evidence. The model is a mix of deductive-inductive processes. We started with a list of a priori framework categories generated from review objectives and phenomena of interest concepts, and modified the list as appropriate based on prior subject matter knowledge and reading of individual studies. Our goal was to synthesize the findings by identifying themes that emerged across the findings from individual studies and fit the framework categories.

For the mixed-method and case study methodological stream, the individual studies typically did not differentiate their overall findings based on type of methodology. For this stream, thus, we looked at the findings holistically and followed a broadly narrative summary approach.

3.13 Evaluation of Certainty/ Confidence in Synthesized Findings Within Methodological Stream

The assessment of certainty/ confidence of synthesized findings was done separately for each methodological stream using the following tools:

- Quantitative-Comparison Groups (QN-CG) (randomized, non-randomized) done by GRADE
- Quantitative-Descriptive Survey (QN-DS) done by applying the principles of GRADE
- Qualitative (QL) done by GRADE-CERQual
- Mixed-Method and Case Study (MM, CS) done by applying the principles of GRADE and GRADE-CERQual.

Quantitative-comparison groups within methodological stream synthesized findings were assessed for certainty using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach (GRADE Working Group, 2004; Guyatt et al., 2010; Higgins & Green, 2011). Findings were assessed on allocation sequence and concealment, baseline outcomes and characteristics, protections against contamination(s), presence of selective outcome reporting, and other possible forms of bias. Each category was given a rating of “low risk,” “high risk,” or “unclear risk.” Detailed information on the definitions of levels of risk used in this tool available in section 12.2.2 of the Cochrane Handbook. Findings received a final rating of “high quality” (it is highly likely that new research will not modify the finding substantially), “moderate quality” (it is somewhat likely that new research will not modify the finding substantially), “low quality” (it is somewhat likely that new research will modify the finding substantially), or “very low quality” (it is highly likely that new research will modify the finding substantially).

Quantitative-descriptive survey within methodological stream synthesized findings were assessed for certainty using a tool developed for the present review that was based on the principles of Grading of Recommendations Assessment, Development, and Evaluation (GRADE) as noted above. Adjustments were made to the GRADE process to create the tool for evaluation of certainty of findings from quantitative cross-sectional surveys that did not have comparison groups for outcomes of interest. There were four evaluation categories: High quality (highly likely that new evidence will *not* substantially modify the study findings); moderate quality (somewhat likely that new evidence will *not* substantially modify the study findings); Low quality (somewhat likely that new evidence will substantially modify the study findings); and very low quality (highly likely that new evidence will substantially modify the study findings). The evaluation categories were based on factors that can reduce the quality of study findings: Limitations in study design or execution; inconsistency of results; indirectness of evidence; imprecision of results; and publication bias for findings collated across multiple quantitative studies. See Appendix 8.1 for the tool.

Qualitative within methodological stream synthesized findings were assessed for confidence using GRADE-CERQual (Lewin et al., 2015). Findings were assessed on methodological limitations, relevance, coherence, and adequacy of data supporting the finding. Each finding was then given a rating of “high confidence” (it is highly likely that the finding is a representation of the phenomena), “moderate confidence” (it is likely that the finding is a representation of the phenomena), “low confidence” (it is possible that the finding is a representation of the phenomena), or “very low confidence” (it was not clear if the finding is a representation of the phenomena).

Mixed method and case study within methodological stream synthesized findings were assessed for certainty/ confidence using GRADE and GRADE-CERQual approaches as appropriate.

3.14 Synthesis of Findings Across Methodological Streams

We synthesized the findings across the four methodological streams to develop an overarching synthesis of findings. The synthesized findings within a methodological stream were compared and contrasted with findings from the other methodological streams. Whenever the findings supported and amplified each other, they were combined into higher order findings that represented synthesis across the method streams. The evaluation of certainty in the within-method synthesized findings was kept in mind during this process.

All methodological streams did not yield the same kind or similar number of synthesized findings. We did not consider this a problematic issue as we were seeking to find the points of alignment of the findings across the method streams rather than simply merging them together, which would have given some methodological streams more importance than others.

Within-method findings that did not contribute to an across-method higher order finding were analyzed thematically. These thematic analyses were used to uncover a nuance or modification to the across-method findings, which were then either used to create a new higher order across-method finding or incorporated into an existing across-method finding.

A very few synthesized findings within a methodological stream provided evidence that countered the synthesized findings from other methodological streams. Whenever this happened, we strived to retain this finding as a separate finding in the final set of across-method findings or used it to modify an existing across-method finding.

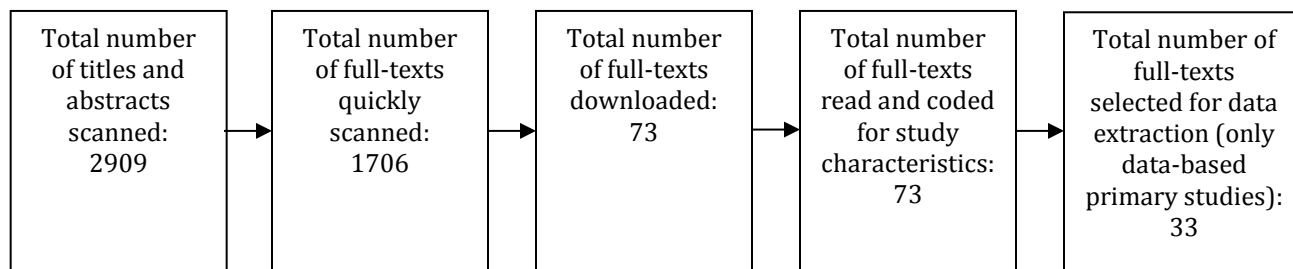
3.15 Media Reports

We extracted findings from individual media reports and then synthesized these findings across the individual reports. We used these across-media reports synthesized findings as another input for the final set of synthesized findings. A modified version of the AACODS tool was used for quality appraisal of the media reports as noted above.

4.0 RESULTS

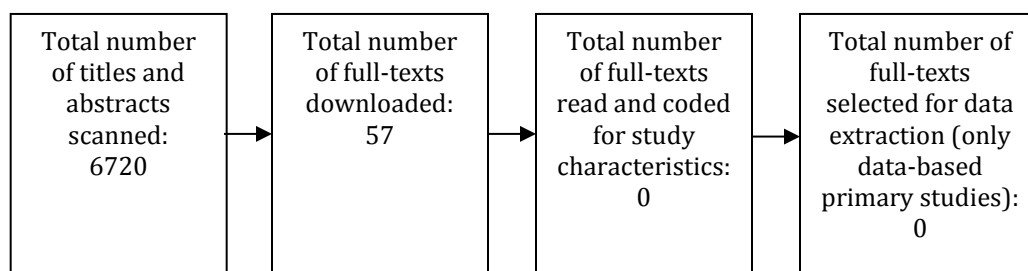
4.1 Study Selection

4.1.1 English Language

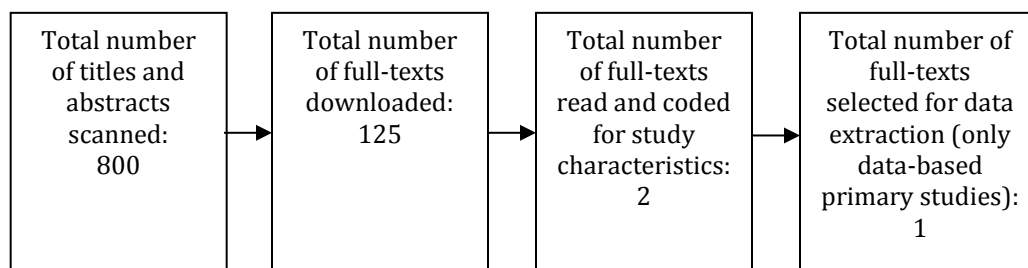


4.1.2 Other UN Languages

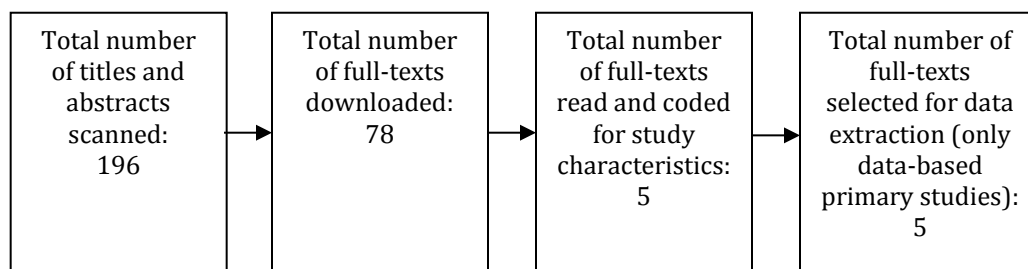
Arabic:



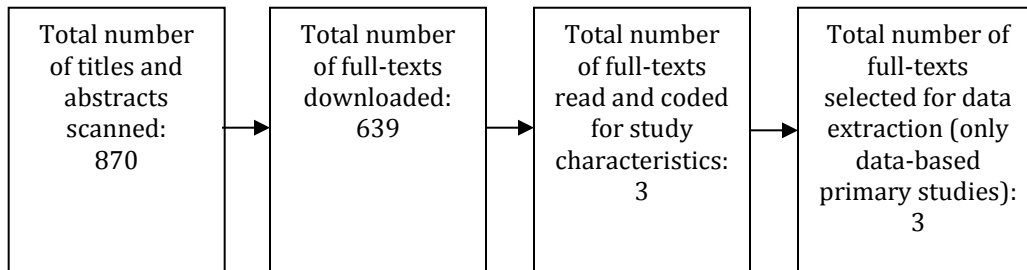
Chinese:



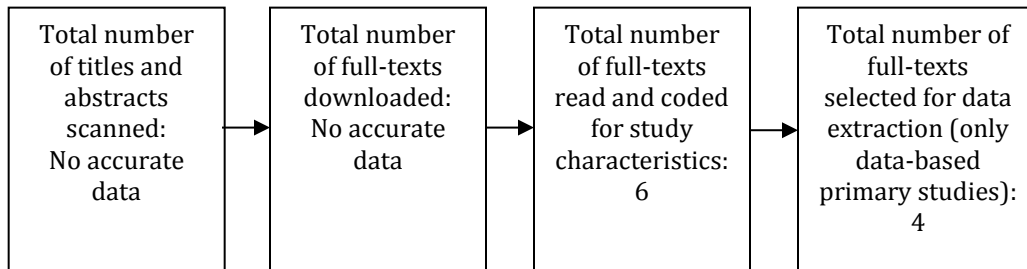
French:



Russian:



Spanish:



4.2 Study Characteristics

A knowledge map of the study characteristics is provided in Section 4.2.1 for English language studies and in Section 4.2.2 for other UN languages studies.

4.2.1 Knowledge Map of Characteristics of Studies-English Language

Key to Table

- . Total English language data-based primary studies (includes grey literature): 33
- . Grey literature studies: 0
- . Some categories are not mutually exclusive and so the frequencies will not sum to the total of 33.
- . *Method*: Quantitative-Comparison Groups (QN-CG); Quantitative-Descriptive Survey (QN-DS); Qualitative (QL); Mixed-Method/Case Study (MM, CS)

<i>Relevancy</i>	<i>Method General</i>	<i>Country Focus</i>	<i>Disaster/ Emergency Type</i>	<i>Disaster/ Emergency Phase</i>	<i>At-risk Groups</i>
Direct: 6 Indirect: 17 Partial: 10 Unclear: 0	QN-CG: 1 QN-DS: 10 QL: 11 MM, CS: 11	Australia: 1 Canada: 2 Chile: 1 China: 1 Europe general: 2 France: 1 India: 1 Indonesia: 1 Iran: 1 Israel: 1 Japan: 1 New Zealand: 1 Singapore: 1 South Africa: 1	General: 1 Bioterrorism: 2 Cyclones/ Hurricanes: 3 Earthquake: 5 Flood: 7 Food Contamination: 2 Industrial Accident: 2 Infectious Disease: 6 Landslides: 1 Tornado: 1 Volcanic: 2 Wildfire: 1	All Phases: 5 Preparation: 16 Onset: 7 Containment: 5 Recovery: 4 Evaluation: 1	Yes: 4 [Low socio-economic status (SES): 2, Minorities: 2, School Children: 1]

		Thailand: 1 United Kingdom: 2 United States: 12			
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Of the 33 English language studies examined for the present review (see Section 7.1 for the references), six were directly relevant, 17 were indirectly relevant, 10 were partially relevant, and none were unclearly relevant. One study used quantitative-comparison groups method, 10 studies used quantitative descriptive survey methods, 11 studies used qualitative methods, and 11 used mixed methods/ case study methods.

Regarding countries, the most number of studies were situated in the United States (12). Studies were also located in Australia (1), New Zealand (1), Canada (2), and different countries of Europe, including the United Kingdom (2), France (1), and the European Union in general (2). The rest of the studies were spread over Chile (1), China (1), India (1), Indonesia (1), Iran (1), Israel (1), Japan (1), Singapore (1), South Africa (1), and Thailand (1).

Regarding the types of disasters/ emergencies, the events studied most often were flood (7), infectious disease (6) and earthquake (5). Other events were cyclones/ hurricanes (3), food contamination (2), bioterrorism (2), industrial (2), volcanic (2), landslides (1), tornado (1), wildfire (1), and disaster events in general (2).

The disaster/ emergency event phase most examined was preparation (16), distantly followed by onset (7), containment (5), and recovery (4) phases. Evaluation phases was examined on one study and all phases were examined in five studies.

Regarding populations studied, the majority of the studies focused on the general population or officials and professionals at health and associated organizations. Only four studies explicitly focused on at-risk/ vulnerable populations. These included low socio-economic status (2), minorities (2), and school children (1).

4.2.2 Knowledge Map of Characteristics of Studies-Other UN Languages

Key to Table

. Total other UN languages data-based primary studies: 13

. Some categories are not mutually exclusive and so the frequencies will not sum to the total of 10.

. *Method*: Quantitative-Comparison Groups (QN-CG); Quantitative-Descriptive Survey (QN-DS); Qualitative (QL); Mixed-Method/Case Study (MM,CS)

<i>Relevancy</i>	<i>Method General</i>	<i>Country Focus</i>	<i>Disaster/ Emergency Type</i>	<i>Disaster/ Emergency Phase</i>	<i>At-risk Groups</i>
Direct: 7 Indirect: 6	QN-CS: 0 QN-DS: 2 QL: 4 MM, CS: 7	Austria: 1 Belgium: 1 Canada: 3 Chile: 1 China: 1 Finland: 1 France: 1 Mexico: 1 Norway: 1 Russia: 3 Spain: 1 United Kingdom: 1 General: 1	General: 4 Chemical/Air Pollution: 1 Flooding: 1 Food Safety: 1 Infectious Diseases: 6	Preparation: 2 Onset: 1 Containment: 1 Evaluation: 2 Preparation, & Containment: 1 Preparation, & Evaluation: 1 Preparation, Onset, & Containment: 1 Preparation, Onset, & Recovery: 1 Preparation, Onset, & Evaluation: 1 Onset, Containment, & Evaluation: 1	Yes: 3 [Children: 2 Chronic Disease: 1 Low-SES: 1 Minorities: 1 Older People: 1 Pregnant Women: 1]

Of the 13 other UN languages (i.e., not English) data-based primary studies (see Section 7.2 for the references), there were no Arabic, one Chinese, five French, three Russian, and four Spanish studies. Seven articles were directly relevant and six were indirectly relevant. The relevancy was judged as only direct and indirect due to lack of sufficient clarity for the partial and unclear categories for the coders.

Two of the articles used quantitative methods, four employed qualitative methods, two employed mixed methods, and five employed a case study approach.

Regarding countries, three of the studies focused on Canada and three on Russia, and with one study each focusing on the following countries: Austria, Belgium, Chile, China, Finland, France, Mexico, Norway, Spain, and the United Kingdom. In addition, one study was general and did not look at any specific region..

The types of emergency events was somewhat varied, with six studies focusing on infectious diseases (including Avian flu, H1N1, and SARS) and one study each focusing on chemical/air pollution, flooding, and food safety. In addition, four studies focused on emergency events in general.

No study focused on all phases of an emergency event. Two studies focused only on the preparation phase, one each only on the onset and containment phases, and two only on the evaluation phases. Several studies (6) focused on a mixture of phases, with the majority (5) including the preparation phase.

Regarding at-risk/vulnerable groups, most of the studies focused on general populations, with only three examining specific demographic information that identified at-risk/vulnerable groups. The identified at-risk/vulnerable groups included children, chronic disease, low socio-economic status (SES), minorities, older people, and pregnant women.

4.3 A Note About the Grey Literature

There was no English language grey literature used in the present review. All the grey literature identified relevant to the review question did not include any data-based primary studies; instead, the literature either was best practices that related the practices to the existing research or it was theoretical essays, that referenced data-based studies and other essays.

4.4 Quality Appraisal of Individual Studies

Of the 33 English language studies used in the present review, one was placed in the quantitative-comparison group stream, 10 in the quantitative-descriptive survey stream, 11 in the qualitative stream, and 11 in the mixed methods/ case studies stream. Within the quantitative-comparison groups stream, the study was a randomized allocation study and was rated to be of moderate quality. In the quantitative-descriptive survey stream, no studies were rated to be strong quality, four were rated to be moderate quality, and six were rated to be of weak quality. In the qualitative methods stream, three studies were rated to be of high quality, eight of moderate quality, and none of low quality. In the mixed methods/case studies methods stream, six studies were rated to be of high quality, four of moderate quality and one of low quality.

See Appendix 8.2 and Appendix 8.3 for tables for English language studies that presents the quality rating, as well as relevancy and extracted findings, for each study.

For the other UN languages individual studies, a quality appraisal could not be determined for all the studies. This is noted as needed when evaluating the certainty/ confidence of the synthesized findings (see Section 4.5).

4.5 Synthesis of Findings Within Methodological Stream and Evaluation of Certainty/ Confidence

Key to Table

Method: Quantitative-Comparison Groups (QN-CG); Quantitative-Descriptive Survey (QN-DS);

Qualitative (QL); Mixed-Method/ Case Study (MM, CS)

Citations-Language: English has no suffix; Arabic (AR); Chinese (CH); French (FR); Russian (RU); Spanish (SP)

Certainty/ Confidence Evaluation: QN-CG (GRADE) – High; Moderate; Low; Very low

QN-DS (GRADE Adapted) – High; Moderate; Low; Very low

QL (CERQual) – High; Moderate; Low; Very low

MM, CS (as appropriate) – High; Moderate; Low; Very low

Outcome/ Phenomenon of Interest	Method	Synthesized Finding Statement (with subgroup analysis of type, phase, and country of disaster, and vulnerable population)	Citations (first author) Supporting Synthesized Finding Within Method Stream	Evaluation of Certainty/ Confidence of Synthesized Finding Within Method Streams	Explanation of Evaluation
Uncertainty	QN-CG	In the United States for an infectious disease event for onset and containment phases, trust in authorities may show a slight decrease as a result of openly acknowledging uncertainties in messages. However, this decrease is only for a small proportion of the total number of message recipients; for the vast majority of message recipients, there is no change in their level of trust.	Johnson (2015)	Low to Moderate	Two studies reported in article, one not a randomized group comparison. Some evaluation categories not applicable or 'cannot tell'.
Uncertainty	QN-DS	In Thailand, New Zealand, the United Kingdom, and the United States, for food contamination, industrial accident, volcanic, and wildfire events, and for preparation and recovery phases, it should be noted that there are different types/components to the public's experience of uncertainty. As examples, one classification notes three types: uncertainty regarding personal safety; safety of home; and safety of close others. Another classification also notes three types: uncertainty about event knowledge; data; and outcome. Along the same lines, there is risk assessment uncertainty and event outcome uncertainty. Another classification	Afifi (2012); Janmaimool (2014); Doyle (2011); Miles (2003)	Low	Not fully overlapping findings by 4 studies, individually appraised as moderate (1) and weak (3).

		shows seven types of uncertainty: uncertainty about who is affected; temporal uncertainty (uncertainty about past and future states); measurement uncertainty; uncertainty due to scientific disagreement; uncertainty about the risk to humans; uncertainty about the extent (or size) of the risk; and uncertainty about how to deal with and reduce the risk.			
Uncertainty	QN-DS	In China, Mexico, and the United States, for earthquake, hurricane, infectious disease, and wildfire events, and for all phases, the public's experience of uncertainty was due to lack of information and uncertainty was reduced by greater information, and the public actively sought out information to reduce its uncertainty. Uncertainty in a time of crisis can motivate individuals to engage in information seeking, which can alleviate the uncertainty. People seek both general and specific information, and there here are demographic and mass medium differences in information seeking. People seek information (and coping support) from personal networks as well to reduce uncertainty and its impact on mental health.	Afifi (2012); Burke (2009); Spence (2007); Muniz (2011) SP	High	Overlapping findings by 4 studies, individually appraised as strong (1), moderate (2), and weak (1).
Uncertainty	QN-DS	In Thailand, New Zealand, and globally, for foodborne illness, industrial accident, and volcanic events, for preparation and containment phases, and including for low SES population, there is general agreement among experts, both scientists and non-scientists, and researchers that communication by authorities to the public should include explicit information about uncertainties associated with events.	Doyle (2011); Janmaimool (2014); FAO/WHO (2011) FR	Moderate	Overlapping findings by 3 studies, individually appraised as moderate (1) and weak (2).
Uncertainty	QN-DS	In India, Thailand, New Zealand, the United Kingdom, and the United States, for bioterrorism, cyclone, earthquake, food contamination, and industrial accident events, for preparation, onset, and containment phases, and including for urban minority African American and Hispanic populations, knowledge and understanding of uncertainty information provided in messages as predictor is associated with outcomes of: trust and confidence in authorities;	Janmaimool (2014); Sharma (2012); McClure (2015); Miles (2003); Vaughan (2012)	Moderate	Overlapping findings by 5 studies, individually appraised as moderate (2) and weak (3).

		perception of transparency of authorities; experience of fear; response to warnings; likelihood of preparation; and risk perceptions.			
Uncertainty	QN-DS	In New Zealand, for earthquake event, and for preparation phase, the public's understanding of uncertainty information provided in messages was error prone. People rated the likelihood of event occurrence higher in later intervals than in earlier intervals of a time window. This pattern was observed despite the fact that the verbal descriptions of the likelihood of event occurrence in a specific time window did not imply that the event likelihood changed across different intervals of the time window.	McClure (2015)	Low	Finding based on one study, appraised as weak.
Uncertainty	QN-DS	In New Zealand, for volcanic events, and for preparation phase, experts' (both scientists, non-scientists) understanding of uncertainty information provided in messages was error prone. Experts rated the likelihood of event occurrence higher in later intervals than in earlier intervals of a time window. Experts did not view the likelihood of a volcanic eruption as being uniform throughout a time window; they instead viewed the likelihood of an event in an earlier time interval as being lower and in a later time interval as being higher as opposed to uniform across all periods in the time window. Similarly, attempts to accurately translate verbal descriptions of event likelihoods/ uncertainty to numerical terms were with problems.	Doyle (2011); Doyle (2014)	Low	Finding based on two studies, both appraised as weak.
Uncertainty	QL	In France, Iran, and the United States, for earthquake, flood, and tornado events, for preparation and recovery phases as well as for evaluation, there are different types/ components to the public's experience of uncertainty. Experience of uncertainty is related to: disruption of roles and responsibilities; employment; influx of non-local population; reconstruction without considering of local culture; and not understanding the causes of an event. Experience of uncertainty changes across the time course of an event that includes uncertainty regarding: impact of event; future of schools and village/ town; and decisions about rebuilding.	Afifi (2014); Alipour (2015); Duchêne (2004) FR	Moderate	Overlapping findings by 3 studies, individually appraised as high (1), moderate (1), and low (1)

Uncertainty	QL	In Australia, Japan, the United Kingdom, and the United States, for earthquake, flood, tornado, and infectious disease, for all phases, and including for school children, lack of information increases experience of uncertainty and information from authorities reduces this uncertainty. Authorities must provide information speedily, timely, and reliably. People actively seek information to reduce their uncertainty, especially through social media, and the authorities too should use this medium for information dissemination.	Acar (2011); Afifi (2014); Bird (2012); Taylor-Robinson (2009)	High	Overlapping findings by 4 studies, all individually appraised as moderate.
Uncertainty	QL	In the United States, for bioterrorism, general public health, and tornado events, for all four phases, and including for low SES minorities population, contradictory and inconsistent information in the media may be seen as uncertain information, which leads to several outcomes including: experience of uncertainty; lack of trust in authorities and recommended actions; confusion and fear; reduced intentions for health protective behaviors such as vaccination; and reduced attention to health risk news.	Afifi (2014); Quinn (2008); Taylor-Clark (2007)	Moderate	Overlapping findings by 3 studies, individually appraised as high (1) and moderate (2).
Uncertainty	QL	In Canada, China, several European countries, and the United States, for bioterrorism, flood, general public health, and infectious disease, for preparation, onset, and containment phases as well as evaluation, and including for low SES minorities, pregnant women, children, and people with chronic disease populations, there is general agreement among experts and researchers that communication by authorities to the public should include explicit information about uncertainties associated with events. It is important to ensure that the information provided is consistent and not contradictory, and is presented clearly and in an easy to understand manner.	Holmes (2009); Pappenberger (2013); Quinn (2008); Taylor-Clark (2007); Massé (2011) FR; Qian (2010) CH	Moderate	Overlapping findings by 6 studies, individually appraised as high (2), moderate (3), and low (1).
Uncertainty	QL	In France, Russia, and the United States, for flood, hurricane, and general public health events, and for preparation and onset phases as well as evaluation, uncertainty information provided in messages as predictor is associated with the outcomes of: confidence in forecasts; reduction in circulation of	Morss (2010b); Duchêne (2004) FR; Gryzunova (2012) RU	Moderate	Overlapping findings by 3 studies, individually appraised as high (1), moderate (1), and low

		misinformation; and improved risk management. However, the uncertainty about specific parameters of an event may sometimes leave not have enough time to prepare property or move belongings to a safe location. Also, the phrasing of the uncertainty information may sometimes be interpreted negatively, which may affect response to future risk communication.			(1)
Uncertainty	QL	In the United States, for flood event, and for onset phase, how experts make decisions about forecasting and warnings under conditions of uncertain data is a complex process. Experts have to use (scientifically) uncertain data, and in rapidly evolving situations where multiple actors have to make interrelated decisions under uncertainty, there is a greater danger of risk assessment propagating across individuals in unintended ways. Although uncertainty can be reduced by actively seeking and obtaining data from multiple sources, there is a need to improve experts' decision-making under conditions of uncertain data in the context of their interactions with others.	Morss (2015)	Moderate	Finding based on one study, appraised as high.
Uncertainty	MM, CS	In Russia and the United States, for flood and general public health events, and for preparation phase, there are several types of uncertainty information that can be put in messages by authorities. In particular, these include knowledge uncertainty (limitations of scientific understanding of complex natural processes and future changes) and sampling uncertainty (uncertainty in estimates calculated using limited data samples from naturally variable processes). The uncertainties can also be about results of checks and examinations of event control mechanisms and health affecting properties of dangerous materials produced by industry. It should be noted that often uncertainty becomes confounded with values issues, which deal with the appropriate standards of public protection.	Downton (2005); Podkorytov (2014) RU	Moderate	Overlapping findings by 2 studies, both individually appraised as high.
Uncertainty	MM, CS	In Chile and Indonesia, for flood and landslide events, for preparation phase, and including for low SES people, for authorities to develop messages that	Aldunce (2007); Voorst (2015)	Moderate	Overlapping findings by 2 studies, both individually

		contain uncertainty information, it is important to keep in mind the whole living environment of the intended audience, which may be full of uncertainties due to poverty. It should be recognized that issues of development and environment are just as central to reduced uncertainty as messages from authorities.			appraised as moderate.
Uncertainty	MM, CS	In Chile, Finland, Singapore, South Africa, and New Zealand, for air pollution, earthquake, infectious disease, industrial accident, landslide, and general public health events, for all phases as well as evaluation, uncertainty experienced by the public as an outcome is associated with the following predictors: disaster management, coordination, and cooperation at the local level; disaster management plan that is interactive with the public, and that includes all mass and social media; integrated management of official response to event across all mass and social media and other domains; regular and timely information, including via social media; detailed information disseminated, including through personal networks (doctors, nurses, community leaders); regular updates about the event progression through the mass media; information about the probability and consequences of events; and differing levels of risk perceptions.	Aldunce (2007); Dabner (2012); Karan (2007); Skinner (2014); Barengo (2011) SP; Francescutti (2007) SP; Vallejos-Romero (2013) SP	Moderate	Overlapping findings by 7 studies, individually appraised as high (4), moderate (1), and low (2)
Uncertainty	MM, CS	In Canada and France for an infectious disease event, and for onset and containment phases, uncertainty about an event conveyed by mass media coverage through rapidly changing, contradictory, and conflicting information, especially that differs from official information from authorities, increases uncertainty and fear in the public, and puts a constraint on health/medical workers ability to address the public's uncertainty.	Rousseau (2008)	Moderate	Finding based on one study, appraised as moderate.
Uncertainty	MM, CS	In Canada, France, and Israel, for infectious disease event, and for onset and containment phases, and for medical/ health care workers and policy makers. As a result of absent or contradictory and inconsistent information from authorities, medical/ health care workers and policy makers	Gesser-Edelsburg (2014); Rousseau (2008)	Moderate	Overlapping findings by 2 studies, both individually appraised as moderate.

		experience uncertainty and the organizational decision making regarding communication to the public becomes uncertain. Instead of providing transparent communication regarding the uncertainty surrounding an emergent event, if authorities rush to declare a “fact” about the event without adequate information, it can lead to compromised decision making and efforts by organizations.			
Uncertainty	MM, CS	In Austria, Belgium, Canada, Norway, Russia, South Africa, the United Kingdom, and several European countries, for flood, infectious disease, industrial accident, and general public health, and for all four phases as well as evaluation, uncertainty information in messages provided by authorities as predictor is associated with the following outcomes: reduced experienced uncertainty; reduced uncertainty about protection actions; avoidance of information void; reduced misinformation; prevention of rumors; reduced indifference; reduced reliance on sensationalized stories; increased sense that situation is under control; and efficiency, quality, and value of forecasts. The uncertainty information should be timely, full, and unbiased.	Ramos (2010); Skinner (2014); Jakubowski (2004) FR; Lord (2009) FR; Pozdnyakov (2011) RU	Moderate	Overlapping findings by 5 studies, individually appraised as high (4) and low (1).
Uncertainty	MM, CS	In the United States, for food contamination event, and for preparation phase, experts/scientists indicate that providing information about scientific uncertainty will have a negative impact on the extent to which the public trusts science, scientists, and scientific institutions; their view is that the general public is unable to conceptualize uncertainties associated with risk management processes and so providing the public with information about uncertainty will cause panic and confusion regarding the extent and impact of a particular event.	Frewer (2003)	Moderate	Finding based on one study, appraised as high.
Uncertainty	MM, CS	In several European countries and the United States, for flood events, and for preparation phase as well as evaluation, uncertainty of data and knowledge influences decision making and interactions within and among groups of experts and between experts and policy/ decision makers. It is important	Downton (2005); Morss (2010a); Ramos (2010)	High	Overlapping findings by 3 studies, all individually appraised as high.

		to see a final policy decision as the end point of a chain of decisions that includes a flow of uncertainty information. It is also important to assess how different people in the decision chain perceive and understand uncertainty, and tend to act in face of uncertain information. For example, policy/ decision makers may not fully understand scientific uncertainty and may default to their intuitions and experience to make decisions. Additionally, uncertain scientific knowledge is entwined with values issues (appropriate standards for public protection), which makes the decision chain process more complex.			
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Findings from individual studies, both English and other UN languages, were put into four method streams, quantitative comparison group, quantitative descriptive survey, qualitative, and mixed method/ case study. The findings within each method stream were synthesized using thematic analysis. An individual study could support more than one synthesized finding. Most synthesized findings were supported by multiple studies though a few were supported by only one study.

There was one synthesized finding in the quantitative comparison group stream. It was supported by a single study. The country covered was the United States. Infectious disease event was covered; the phases covered were onset and containment. No vulnerable populations were studied. The evaluation of certainty in the finding ranged from low to moderate.

There were six synthesized findings in the quantitative descriptive survey stream. Two findings were supported by only a single study whereas the rest were supported by multiple studies. The countries covered included China, India, Mexico, New Zealand, Thailand, the United Kingdom, the United States, and general global. Bioterrorism, cyclone, earthquake, foodborne illness, hurricane, industrial accident, infectious disease, volcanic, and wildfire events were covered. All four phases of an event were covered, with emphasis on preparation. Vulnerable populations were covered in two findings. The evaluation of certainty in the findings included high (1), moderate (2), and low (3).

There were six synthesized findings in the qualitative stream. One finding was supported by only a single study whereas the rest were supported by multiple studies. The countries covered included Australia, Canada, China, general European Union countries, France, Iran, Japan, Russia, the United Kingdom, and the United States. Bioterrorism, earthquake, flood, hurricane, infectious disease, tornado, and general public health events were covered. All four phases were covered, with emphasis on preparation and onset, along with evaluation. Vulnerable populations were covered in three findings. The evaluation of confidence in the findings were high (1) and moderate (5).

There were eight synthesized findings in the mixed methods/ case study stream. Two findings were supported by only a single study whereas the rest were supported by multiple studies. The countries covered included Canada, Chile, general European Union countries, Finland, France, Indonesia, Israel, New Zealand, Russia, Singapore, South Africa, and the United States. Air pollution, earthquake, flood, foodborne illness, industrial accident, infectious disease, landslide, and general public health events were covered. All four phases of an event were covered, with emphasis on preparation, along with evaluation. Vulnerable populations were covered in one of the findings. The evaluation of certainty/ confidence in the findings was high (1) and moderate (7).

4.6 Synthesis of Findings Across Methodological Streams

Key to Table

Citations-Language: English has no suffix; Arabic (AR); Chinese (CH); French (FR); Russian (RU); Spanish (SP)

Certainty/ Confidence Evaluation: QN-CG (GRADE) – High; Moderate; Low; Very low
 QN-DS (GRADE Adapted) – High; Moderate; Low; Very low
 QL (CERQual) – High; Moderate; Low; Very low
 MM, CS (as appropriate) – High; Moderate; Low; Very low

Phenomenon of Interest/ Outcome	Synthesized Finding Across Method Streams (with subgroup analysis of type, phase, and country of disaster, and vulnerable population)	Citations (first author) Supporting Synthesized Finding Across Method Stream	Evaluation of Certainty/ Confidence Note: Only English language studies from Section 4.5 considered
Uncertainty	There are several different types/ components of uncertainty associated with an event, related to both uncertainties experienced by the public and also uncertainty information that can be put in messages, that authorities need to keep in mind. As some examples, uncertainty can be regarding: safety of person, home, and close others; event knowledge, sampling, data, and outcome; and influx of non-local people. Experience of uncertainty changes across the time course of an event that includes, for example, uncertainty regarding impact of event (onset, containment) and future of schools and village/ town and decisions about rebuilding (containment, recovery). It should be noted that, particularly for authorities, uncertainty can become confounded with values issues, which deal with the appropriate standards of public protection. The countries covered include France, Iran, New Zealand, Russia, Thailand, the United Kingdom, and the United States. Events include earthquake, flood, food contamination, industrial accident, tornado, volcanic, wildfire, and general public health. Preparation and recovery phases are covered along with evaluation. No vulnerable populations are included.	Afifi (2012); Afifi (2014); Alipour (2015); Downton (2005); Doyle (2011); Janmaimool (2014); Miles (2003); Duchêne (2004) FR; Podkorytov (2014) RU	QN-CG (GRADE): --- QN-DS (GRADE Adapted): Low to High QL (CERQual): Moderate to High MM, CS: Moderate to High
Uncertainty	The public's experience of uncertainty is due to lack of information. Uncertainty is reduced by greater information and	Acar (2011); Afifi (2012);	QN-CG (GRADE):

	the public actively seeks out information to reduce its uncertainty. Thus, information from authorities can reduce the public's uncertainty. People seek both general and specific information, and there are demographic and mass medium differences in information seeking; people also seek information (and coping support) from personal networks to reduce uncertainty and its impact on mental health. The uncertainty experienced by the public as an outcome is associated with other predictors as well, that, as examples, include: disaster management, coordination, and cooperation at the local level; disaster management plan that is interactive with the public, and that includes all mass and social media; integrated management of official response to event across all mass and social media and other domains; speedy, regular, timely, reliable, and detailed information about event progression, including via social media and personal networks (doctors, nurses, community leaders); regular updates about the event progression through the mass media; and differing levels of risk perceptions. The countries covered include Australia, Chile, China, Finland, Japan, Mexico, New Zealand, Singapore, South Africa United Kingdom, and the United States. Events include air pollution, earthquake, floods, hurricane, industrial accident, infectious disease, landslide, tornado, wildfire and general public health. All four phases of an event are covered along with evaluation. School children as vulnerable populations included.	Afifi (2014); Aldunce (2007); Bird (2012); Burke (2009); Dabner (2012); Karan (2007); Skinner (2014); Spence (2007); Taylor-Robinson (2009); Barengo (2011) SP; Francescutti (2007) SP; Muniz (2011) SP; Vallejos-Romero (2013) SP	--- <i>QN-DS (GRADE Adapted):</i> Low to High <i>QL (CERQual):</i> Moderate to High <i>MM, CS:</i> Moderate
Uncertainty	There is general agreement among experts and researchers that communication by authorities to the public should include explicit information about uncertainties associated with events. It is important to ensure that the information provided is consistent and not contradictory, and is presented clearly and in an easy to understand manner. However, in contrast, some experts/ scientists indicate that providing information about scientific uncertainty can have a negative impact on the extent to which the public trusts science, scientists, and scientific institutions; they view the general public as unable to conceptualize uncertainties associated with risk management processes and so providing the public with information about uncertainty will cause panic and confusion regarding the extent and impact of a particular event. Countries covered include Canada, China, European Union countries, New Zealand, Thailand, the United States, and general globally. Events include bioterrorism, floods, foodborne illness, industrial accident, infectious disease, volcanic, and general public health. Preparation, onset, and containment phases are covered, with emphasis on preparation, along with evaluation. Low SES minorities, pregnant women, children, and people with chronic disease vulnerable populations are included.	Doyle (2011); Frewer (2003); Holmes (2009); Janmaimool (2014); Pappenberger (2013); Quinn (2008); Taylor-Clark (2007); FAO/WHO (2011) FR; Massé (2011) FR; Qian (2010) CH	<i>QN-CG (GRADE):</i> --- <i>QN-DS (GRADE Adapted):</i> Low to Moderate <i>QL (CERQual):</i> Moderate <i>MM, CS:</i> Moderate
Uncertainty	To develop messages that contain uncertainty information, it is important to keep in mind the whole living environment of the intended audience. People's lives may be full of uncertainties due to poverty and not just because of a particular hazard. It should be recognized that issues of development and environment are just as central to reduced uncertainty regarding an event as messages from authorities. Countries covered include Chile and Indonesia. Events are flood and landslide, and the phase is	Aldunce (2007); Voorst (2015)	<i>QN-CG (GRADE):</i> --- <i>QN-DS (GRADE Adapted):</i> ---

	preparation. Low SES vulnerable populations are included.		<i>QL (CERQual):</i> --- <i>MM, CS:</i> Moderate
Uncertainty	Uncertainty information in messages provided by authorities is generally associated with desirable outcomes but the possibility of some undesirable outcomes needs to be kept in mind. Some positive outcomes include: Reduced experienced uncertainty; reduced uncertainty about health protection actions; reduced information void, circulation of misinformation and rumors, and reliance on sensationalized media stories; improved efficiency, quality, and value of forecasts; and improved response to future warnings. However, openly acknowledging uncertainties in messages may reduce trust in authorities. But, this decrease is only for a small proportion of the total number of message recipients; for the vast majority of message recipients, there is no change in their level of trust. Additionally, the uncertainty about specific parameters of an event may sometimes leave the public not have enough time to prepare property or move belongings to a safe location. Also, the phrasing of the uncertainty information may sometimes be interpreted negatively, which may affect response to future risk communication.	Janmaimool (2014); Johnson (2015); McClure (2015); Miles (2003); Morss (2010b); Sharma (2012); Ramos (2010); Skinner (2014); Vaughan (2012); Duchêne (2004) FR; Gryzunova (2012) RU; Jakubowski (2004) FR; Lord (2009) FR; Pozdnyakov (2011) RU	<i>QN-CG (GRADE):</i> Low to Moderate <i>QN-DS (GRADE Adapted):</i> Low to Moderate <i>QL (CERQual):</i> Moderate <i>MM, CS:</i> Moderate to High
Uncertainty	The public's understanding of some uncertainty information associated with event likelihood estimates is error prone. This error is true of experts (scientists, non-scientists) as well. The likelihood of event occurrence is rated higher in later intervals than in earlier intervals of a time window; the likelihood of event occurrence is not understood as being uniform throughout a time window. For example, the likelihood of an event occurrence in a 3-day time window is rated higher toward the end interval and lower in the first interval of the window, as opposed to uniform across all periods in the time window. Additionally for experts, translation of verbal descriptions of event likelihood uncertainty to numerical terms was not fully accurate. Country covered is New Zealand. Events are earthquake and volcanic. Phase covered is preparation. No vulnerable populations are include.	Doyle (2011); Doyle (2014); McClure (2015)	<i>QN-CG (GRADE):</i> --- <i>QN-DS (GRADE Adapted):</i> Low to Moderate <i>QL (CERQual):</i> --- <i>MM, CS:</i> ---
Uncertainty	Uncertainty of data and knowledge influences interactions within and among groups of experts and between experts and policy/ decision makers and this the decision-making process in complex ways. It is important to see a final decision (e.g., evacuation warning) as the end point of a chain of decisions that includes a flow of uncertainty information. Experts have to use (scientifically) uncertain data, and in rapidly evolving situations where multiple actors have to make interrelated decisions under this uncertainty, there is a greater danger of risk assessment propagating across individuals in unintended ways. Different people in the decision chain perceive and understand uncertainty, and tend to act in face of uncertain information,,	Downton (2005); Morss (2010a); Morss (2015); Ramos (2010)	<i>QN-CG (GRADE):</i> --- <i>QN-DS (GRADE Adapted):</i> --- <i>QL (CERQual):</i> Moderate

	differently. For example, policy/ decision makers may not fully understand scientific uncertainty and may default to their intuitions and experience to make decisions. Additionally, uncertain scientific knowledge is entwined with values issues (appropriate standards for public protection), which makes the decision chain process even more complex. Countries covered include several European countries and the United States. Event is floods, and preparation and onset phases are covered along with evaluation. No vulnerable populations are included.		<i>MM, CS:</i> Moderate to High
Uncertainty	Mass media coverage of an event that emphasizes rapidly changing, contradictory, and conflicting information, especially that differs from official information from authorities, increases uncertainty in the public, which in turn can lead to several undesirable outcomes. These include: lack of trust in authorities and recommended actions; confusion and fear; reduced intentions for health protective behaviors such as vaccination; and reduced attention to health risk news. Such media coverage also puts a constraint on the ability of frontline health/medical workers to address the public's uncertainty. Countries covered are Canada, France, and the United States. Events are bioterrorism, infectious disease, tornado, and general public health. All four phases are covered. Low SES minorities vulnerable population included.	Afifi (2014); Quinn (2008); Rousseau (2008); Taylor-Clark (2007)	<i>QN-CG (GRADE):</i> --- <i>QN-DS (GRADE Adapted):</i> --- <i>QL (CERQual):</i> Moderate to High <i>MM, CS:</i> Moderate
Uncertainty	As a result of absent or contradictory and inconsistent information from authorities, medical/ health care workers and policy makers experience uncertainty and the organizational decision making regarding communication to the public becomes uncertain. Instead of providing transparent communication regarding the uncertainty surrounding an emergent event, if authorities rush to declare a "fact" about the event without adequate information, it can lead to compromised decision making and efforts by organizations. Countries covered are Canada, France, and Israel. Event is infectious disease. Onset and containment phases are covered. No vulnerable populations are included.	Gesser-Edelsburg (2014); Rousseau (2008)	<i>QN-CG (GRADE):</i> --- <i>QN-DS (GRADE Adapted):</i> --- <i>QL (CERQual):</i> --- <i>MM, CS:</i> Moderate

There were total 9 synthesized findings across the four method streams. Of these, one synthesized finding was based on all four method streams, three synthesized findings were based on three method streams, two synthesized findings were based on two method streams, and two synthesized findings were based on just one method stream. The across-method synthesis sought to identify commonalities in themes across the method streams but at the same time it allowed for findings that were unique to not get subsumed under more general themes; this resulted in two synthesized findings that drew only from one method stream.

The quantitative comparison group within-method synthesized finding appeared in one across-method synthesized finding, quantitative descriptive survey within-method synthesized findings appeared in three across-method findings, qualitative within-method synthesized findings appeared in three across-method synthesized findings, and mixed method/ case study within-method synthesized findings appeared in four across-method findings.

There was coverage of a large number of countries, but countries in Africa and South America were not represented at all. The coverage of different types of events was adequate and all four phases of an event (preparation, onset, containment, and recovery) along with evaluation were covered. Vulnerable populations appeared in all the findings.

The findings identify the following for the phenomenon of uncertainty, as experienced by the public and as information put in a message, during public health emergency events: There are several different types/ components of uncertainty associated with an event, related to both uncertainties experienced by the public and also uncertainty information than can be put in messages, that authorities need to keep in mind; the public's experience of uncertainty is due to lack of information; thus, information from authorities can reduce the public's uncertainty; there is general agreement among experts and researchers that communication by authorities to the public should include explicit information about uncertainties associated with events, but it is important to ensure that the information provided is consistent and not contradictory, and is presented clearly and in an easy to understand manner; to develop messages that contain uncertainty information, it is important to keep in mind the whole living environment of the intended audience as people's lives may be full of uncertainties due to life circumstances and not just because of a particular hazard; uncertainty information in messages provided by authorities as predictor is generally associated with desirable outcomes but the possibility of some undesirable outcomes needs to be kept in mind; the public's understanding of some uncertainty information associated with event likelihood estimates is error prone and this error is true of experts as well; uncertainty of data and knowledge influences interactions within and among groups of experts and between experts and policy/ decision makers and thus decision making in complex ways; mass media coverage of an event that emphasizes rapidly changing, contradictory, and conflicting information, especially that differs from official information from authorities, increases uncertainty in the public, which in turn can lead to several undesirable outcomes, such as lack of trust in authorities and recommended actions; and as a result of absent or contradictory and inconsistent information from authorities, medical/ health care workers and policy makers experience uncertainty and the organizational decision making regarding communication to the public becomes uncertain. All these findings, as a whole, need to be taken into account when developing communication strategies.

4.7 Media Reports

No media reports were included in the review for lack of data-based findings. Two media reports were identified for the review objective in the search for English-language news stories. Both reports were press releases and did not report any data.

5.0 DISCUSSION

5.1 *Summary of Results*

5.1.1 *Overall Summary*

For the synthesis of evidence on uncertainty, as experienced by the public and as information put in a message, during public health emergency events, 46 studies (33 English language, 13 other UN languages) were included. The studies were appraised for quality, the data were extracted from them for constructing synthesized findings within four methodological streams, these findings were evaluated for certainty/confidence and then synthesized across methods.

The country coverage of the reviewed literature showed mostly high and middle-income countries in Asia, Europe, North America, and Oceania. Only one country was covered in Africa and two countries in Central and South America. The event most covered was infectious disease, in both English language and other UN languages studies. Other relatively common events included flood and earthquake. All four event phases were covered though there was heavy emphasis on the preparation phase, followed by onset and containment phases; relatively there was much less coverage of the recovery phase. There were several studies that undertook evaluation as well.

Total seven studies (four English language, three other UN languages) explicitly examined at-risk/vulnerable populations. In general, the individual-study findings from these populations do not differ from those generated from general populations. The individual-study findings do, however, show that all vulnerable groups do not process uncertainty information the same way. The findings note, for example, the differences between urban African American and Hispanic minorities in the United States with regards to uncertainty information in messages. The primary finding to keep in mind is that the life circumstances of vulnerable groups, such people from low SES backgrounds, might have myriad uncertainties stemming from poverty, chronic illness, among other factors, and as such the uncertainty associated with a public health emergency event might be just source of uncertainty among many others.

The final set of nine across-method synthesized findings provide an understanding of uncertainty in health and related authorities during public health emergency events and the message and activities that can be undertaken to communicate and reduce uncertainty in this situation. Overall, the synthesized findings illuminate multiple aspects of the phenomenon of uncertainty during public health emergency events. The findings, broadly, can be summarized as four aspects of uncertainty that authorities should keep in mind. First, uncertainty as a lived experience and as a characteristic of information is multifaceted. Second, the public's experience of uncertainty and the public's response to uncertainty information in messages constitute two different though overlapping aspects. Third, experts' (both scientists and non-scientists) handling of uncertainty information in forecasting, warning, and other similar decision-making is a complex process. Fourth, mass media's handling of contradictory and inconsistent information can negatively contribute to uncertainty faced by the public and experts. Authorities should carefully consider these, and other, aspects of uncertainty when developing the best ways to communicate uncertainties to the general public, at-risk/vulnerable populations, and stakeholders.

5.1.2 *Results Vis a Vis Findings from Existing Reviews*

There were four existing reviews of high and moderate quality whose findings were extracted. The results from the present review generally overlap with and extend these findings, and also provide new findings.

The present findings broadly replicate and extend the previous findings about the conceptualization of uncertainty and identification of its different aspects. Similar to the previous findings, the present review did not find a definitive view of uncertainty in the literature. Although there are several conceptualizations of uncertainty, there seems to be no consensus on the best view for a public health emergency event. Likewise, although several types/ components of uncertainty are noted in the present results, there is no clear agreement on a list that would be the most applicable to the public health emergency event situation. Additionally, the present findings also show that the format for presenting the likelihood information for occurrence of events influences how the information is understood.

Some new findings are highlighted in the present review. The present findings firmly distinguish between uncertainty as experience and as information. Although the two are related, uncertainty information can decrease/ increase experience of uncertainty or uncertainty experience can modulate how uncertainty information is interpreted, they are clearly two separate concepts. Both concepts are essential to fully understanding the nature of uncertainty in public health emergency events. Another new finding relates to experts' decision making under conditions of uncertainty regarding data and knowledge that they have and how this uncertainty gets propagated through the chain of decisions that lead to a public forecast or warning announcement. Another new finding is the role of absent, contradictory, and inconsistent information in the mass media, which can increase uncertainty in both the public and medical/ health workers as well as negatively influence the decision-making in organizations and impede their efforts.

5.2 Research Gaps

The present review identified seven main gaps in the literature on the phenomenon of uncertainty during public health emergency events. First, there should be a comprehensive examination of the various conceptualizations and components of uncertainty, separately as well as jointly for uncertainty experience and uncertainty information. There are studies that investigated different sets of components, but the review did not identify any study that comprehensively examined all relevant components and concepts, and tested their relationships with outcome and predictor variables of interest.

Second, there is a paucity of studies examining message designs, such as linguistic choices and visual formats, that can augment understanding of uncertainty information. There do exist studies that have investigated this, but the vast majority have been conducted with college students in laboratories. Such studies need to be conducted in the field with populations affected or likely to be affected by public health emergency events.

Third, there is insufficient comparative research across countries, especially across low and high income countries. To fully understand how the characteristics of low income countries, especially in terms of infrastructure, history, and political climate, might influence uncertainty processes differently relative to high income countries, there needs to be comparison of such countries. If practices of health authorities need to be different across low and high income countries, key specific factors and relationships among the factors that contribute to uncertainty processes should be compared across countries.

Fourth, there is not enough attention paid to the most vulnerable and disadvantaged populations. These are often the populations who have the least access to information resources and exposure to official information before, during, and after an event, and as such face the most uncertainty. Uncertainty is alleviated through information and when there is insufficient access to traditional and new media sources, information may be predominantly sought from interpersonal networks. There are not enough studies that investigate information seeking processes in such media access-poor populations.

Fifth, completely absent in the literature are longitudinal studies. It is not always necessary to have randomized comparison group research design, which may be precluded due to the nature of public health emergency events, to draw out causal relationships. Such linkages between variables of interest, such as health protection behavior as an outcome of uncertainty information in a message, can also be examined using a longitudinal research design where data of interest are measured at multiple time points. Such a research design can better reveal how uncertainty dynamically varies during the phases of an event; even if say, preparation and recovery phases are only used for data collection, this will still provide insight into how uncertainty information affects different variables across the phases. Such a design can also provide knowledge about how uncertainty experience varies and how it interacts with uncertainty information through the course of an event.

Sixth, there is insufficient research on how uncertainty information is determined and processed by experts and then disseminated to their colleagues within and across organizations. Although some research exists, it has not been conducted for decision-making processes in a wide variety of public health emergency events, organizations, and scientific/ technical areas and disciplines. It is commonly assumed that all experts in all domains accurately understand and in turn correctly disseminate uncertainty information. The sample of studies addressing this topic in the present review, though small in number, suggests otherwise.

Seventh, there is an absence of integrative model building and theory construction. Uncertainty is a much theorized concept in various disciplines, especially communication and psychology, but the data-based primary research covered in the present review did not substantively utilize it. Uncertainty information in messages can have desirable outcomes as well as undesirable ones. A theory-based approach can help tease out the conditions, such as different verbal-visual information formatting, under which such outcomes can be expected. To develop effective strategies for communicating uncertainty information, effective theory development needs to take place as otherwise a set of empirical facts of relationships between variables will not add up to accurate predictions about these relationships that can assist with planning and management.

5.3 Limitations of the Present Review

The present review has two main limitations. First, the other UN languages articles and reports were not fully translated into English, which may have led to some information to be missed. Second, the coding, data extraction, and findings synthesis was done only by one person which prevented the calculation of inter-coder reliability as a check for consistency of these data. Additionally, presently there are no agreed upon quality appraisal or risk of bias tool for big data studies and so no quality assurance was done for such studies.

5.4 Authors' Conclusions

Uncertainty related to public health emergency events is a complex phenomenon. Its study requires a distinction between uncertainty experience and uncertainty information. The two concepts are intertwined and to fully understand the nature of uncertainty, it is not advisable to investigate one without the other. The two concepts, their various components, and the relationships among them quite likely behave similarly, if not identically, in the general public and in communities of experts. That is, it is likely that uncertainty is experienced in the same general ways by the public and experts, and uncertainty information is understood and misunderstood by the general public and experts alike.

Perhaps cautiously, then, the metaphor of a chain of decision-making by experts within organizations and the propagation of uncertainties, both experience and information, along this chain can be fruitfully extended to include the public. That is, the decision-making chain does not end with the decision of a forecast or warning message by the authorities but it continues to include the decisions the public makes under experienced and informational uncertainty. One can even theorize the chain connecting back to the organizations and authorities as they make new decisions in response to the decisions made by the public. One advantage of such a systems view of uncertainty in public health emergency events might assist authorities construct messages communicating uncertainty with greater specificity and nuance in relation to the life circumstances of the intended audience.

Uncertainty in public health emergency events is a multi-faceted concept with multiple components and closely related concepts, all of which may vary differently. There is general agreement among experts and researchers, though with some exceptions, that communication by authorities to the public should include explicit information about uncertainties associated with events. It is important to ensure that the information provided is consistent and not contradictory, and is presented clearly and in an easy to understand manner. Messages conveying uncertainty information that disregard this will fail to work.

The experience of uncertainty may be a defining feature of a public health emergency event not only for the public and experts, but for the media as well. The mandate of the media is to report all relevant information, including information that might be contradictory/ inconsistent and thus uncertain, to the public in a timely manner. The media may struggle with whether to report such uncertain information or not, but typically it does get covered. Thus, it is imperative for authorities to effectively coordinate with various media outlets, both traditional and new/ Internet, to assist them with their decision-making regarding contradictory and inconsistent uncertain information because such media information negatively influences both the public and frontline medical/ health workers.

6.0 FUNDING

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7.0 FULL LIST OF INCLUDED STUDIES, EXISTING REVIEWS, AND OTHER REFERENCES

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8.0 APPENDIXES

8.1 Adjustments to the GRADE Process for Quantitative Descriptive Surveys (Cross-sectional; No comparison groups for outcomes of interest)

A. Levels of quality of study findings

High quality: It is highly likely that new evidence will not substantially modify the study findings.

Moderate quality: It is somewhat likely that new evidence will not substantially modify the study findings.

Low quality: It is somewhat likely that new evidence will substantially modify the study findings.

Very low quality: It is highly likely that new evidence will substantially modify the study findings.

B. Factors that can reduce the quality of study findings

1. Limitations in study design or execution

We are more confident about the high quality of study results, when we have:

- . High validity and reliability of measurement of variables
- . Attention to minimization of confounding variables, through, for example, use of control variables

2. Inconsistency of results

We are more confident about the high quality of study results, when we have:

- . Homogeneity in the results across disaster types, national/cultural boundaries, etc.
- . Heterogeneity of results, if present, has a plausible explanation

3. Indirectness of evidence

We are more confident about the high quality of study results, when we have direct evidence, which is:

- . Direct - data are from affected populations, currently or in the past.
 - Less direct - data from populations who may be likely to be affected in the future.
 - Least direct - data from populations unlikely to be affected in the future
- . Study variables directly speak to question of interest and outcomes of interest

4. Imprecision of results

We are more confident about the high quality of study results, when results are more precise, which is:

- . Results are statistically significant
- . Sample size is at least 90 for single group

5. Publication bias * (for a finding collated across multiple quantitative studies)

We are more confident about the high quality of results collated as a finding across individual studies, when:

- . There is at least one study that shows nonsignificant/null results

8.2 Quality Appraisal of and Extracted Findings from English Language Individual Data-based Primary Studies (Quantitative-Comparison Group Method)

Key to Table

Method: Quantitative-Comparison Groups (QN-CG)

Relevancy: Direct; Indirect; Partial; Unclear

Quality: QN-CG – High (low risk of bias); Moderate (minor risk of bias); Low (some risk of bias); Very low (significant risk of bias)

<i>Citation (first author); Method; Relevancy; Quality Appraisal Rating; Study Description</i>	<i>Findings</i>	<i>Statistical Information</i>
<i>Citation:</i> Johnson (2015) <i>Method:</i> QN-CG <i>Relevancy:</i> Direct <i>Quality Appraisal Rating:</i> Low (some risk of bias) to Moderate (minor risk of bias) <i>Study Description:</i> The general public has been informed that the quarantine period for Ebola-exposed people is 21 days. However, there is a small (12% maximum) likelihood that such people might exhibit symptoms, which indicates infectiousness, beyond 21 days. Two online experiments in the United States investigated whether openness in communication to the public about this post-21-day infection likelihood influences public's trust in authorities and risk perceptions. The results suggest that informing the research participants about the small likelihood of post-21-day Ebola	. Trust in authorities, as indicated by the mean of rating scales, decreased as a result of a message openly acknowledging uncertainty. However, the mean ratings remained above the midpoint of the rating scales, and the decrease was very small and was observed in both the treatment group that received the message noting the uncertainty and the control group that did not receive such a message. The level of decrease was slightly more in the treatment group relative to the control group. . The mean level of trust in CDC showed a significant decrease pre to post message in both treatment and control groups. In addition, only in the control group there was significant decreases in trust for local health authorities, the Obama administration, and Congress. . For over 80% of participants, in both treatment and control group, there was no change in level of trust in authorities pre to post message. . Overall, health authorities can provide nuanced messages, which acknowledges uncertainty, as the vast majority of message recipients trust in authorities will not be affected. Open communication about uncertainty can protect people against misperceptions about disease transmission.	<u><i>Study 1</i></u> Pre-post design with treatment ($N = 1260$) and control ($N = 153$) groups, but participants not randomly assigned to the two groups. Both groups read Message 1 about enhanced screening and monitoring for 21 days of anyone with close contact with Ebola patients in West Africa. The treatment group only read Message 2 that noted the risk that a person exposed to Ebola might develop symptoms after 21 days; control group did not see Message 2 or any substitute message. Risk perception and trust questions (scale 1-5, with 5 = higher trust) were collected after Message 1 in both groups, and then again after Message 2 in treatment group and same intervening time interval in control group. <i>Mean Change from Pre to Post:</i> . Trust CDC: Treatment pre to post change $M = 3.28$ to 3.18, $p < .05$; Control pre to post change $M = 3.38$ to 3.37, $p > .05$; Treatment vs. Control post only $M = 3.18$ vs. 3.37, $p < .05$. Trust Local Health Authorities: Treatment pre to post change $M = 2.89$ to 2.86, $p < .05$; Control pre to post change $M = 2.89$ to 2.88, $p > .05$; Treatment vs. Control post only $M = 2.86$ vs. 2.88, $p > .05$. Trust Obama Administration:

symptoms did not increase perceived risk and distrust. Thus, communication to the public may want to include unpleasant facts about infectious diseases before these are reported by the media.		Treatment pre to post change $M = 2.61$ to 2.58, $p < .05$; Control pre to post change $M = 2.71$ to 2.75, $p > .05$; Treatment vs. Control post only $M = 2.58$ vs. 2.75, $p > .05$ <i>Majority Response (% of N) Post Only</i> . Trust CDC: Treatment vs. Control - no change in response 86.3% vs. 94.8%, $p < .001$. Trust Local Health Authorities: Treatment vs. Control - no change in response 87.4% vs. 94.7%, $p > .05$. Trust Obama Administration: Treatment vs. Control - no change in response 91.6% vs. 95.4%, $p < .05$ <u>Study 2</u> Pre-post design with treatment ($N = 224$) and control ($N = 201$) groups, with participants randomly assigned to the two groups. Both groups answered questions about trust in authorities (scale 1-5, with 5 = higher trust) and risk perceptions as baseline. Treatment group only read Message 1, which was a proactive communication that explained reasoning behind the 21-day monitoring/ quarantine period and openly mentioned the small probability of post-21-day symptoms; control group did not see Message 1 or any substitute message. Only the treatment group answered the trust and risk questions again. After this, both groups read Message 2, which was a mock news article about a nurse who had experienced a 21-day quarantine without symptoms after treating an Ebola patient, then manifested symptoms on the 30th day, and returned to quarantine. After this both groups responded to the trust and risk questions again.
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		<i>Mean Change from Baseline to Post-Message 2</i> . Trust CDC: Treatment pre to post change $M = 3.42$ to 3.32, $p < .05$; Control pre to post change $M = 3.24$ to 3.05, $p < .05$. Trust local health authorities: Treatment pre to post change $M = 3.11$ to 3.05, $p > .05$; Control pre to post change $M = 2.98$ to 2.87, $p < .05$. Trust Obama administration: Treatment pre to post change $M = 2.40$ to 2.34, $p > .05$; Control pre to post change $M = 2.19$ to 2.11, $p < .05$. Trust Congress: Treatment pre to post change $M = 1.84$ to 1.88, $p > .05$; Control pre to post change $M = 1.79$ to 1.73, $p < .05$. Trust State Governor: Treatment pre to post change $M = 2.19$ to 2.20, $p > .05$; Control pre to post change $M = 2.02$ to 1.99, $p > .05$ There were no significant effects treatment vs. control. <i>Majority Response (% of N)</i> . Trust CDC: Treatment vs. Control - no change in response 79.9% vs. 80.1%, $p > .05$. Trust local health authorities: Treatment vs. Control - no change in response 76.3% vs. 81.1%, $p > .05$. Trust Obama administration: Treatment vs. Control - no change in response 82.6% vs. 87.1%, $p > .05$. Trust Congress: Treatment vs. Control - no change in response 87.1% vs. 89.1%, $p > .05$. Trust State Governor: Treatment vs. Control - no change in response 83.0% vs. 84.6%, $p > .05$
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8.3 Quality Appraisal of and Extracted Findings from English Language Individual Data-based Primary Studies (Quantitative-Descriptive Survey, Qualitative, and Mixed-Method/ Case Study Methods; Organized by Method)

Key to Table

Method: Quantitative-Descriptive Survey (QN-DS); Qualitative (QL); Mixed-Method/ Case Study (MM, CS)

Relevancy: Direct; Indirect; Partial; Unclear

Quality: QN-DS – Strong; Moderate; Low

QL – High; Moderate; Low; Very low

MM, CS – High; Moderate; Low; Very low

<i>Citation (first author)</i>	<i>Method</i>	<i>Relevancy</i>	<i>Quality Appraisal Rating</i>	<i>Findings</i>
Afifi (2012)	QN-DS	Indirect	Moderate	. In the United States, people who had been recently affected by wildfires showed three types of uncertainty: personal safety, safety of home, and safety of close others. All three types of uncertainty were associated with lower mental health scores for those who were not evacuated, whereas only two types of uncertainty (home, close others) were linked to lowered mental health for those who were evacuated. . Communal coping played a moderating role for the uncertainty-mental health association for two of the three types of uncertainty (personal, home) among those who were evacuated. For those who were not evacuated communal coping did not play a moderating role for the uncertainty-mental health association for any of the uncertainty types.
Burke (2009)	QN-DS	Indirect	Weak	. In China, for residents in rural areas affected by earthquake more information helped reduce uncertainty. Because a high level of uncertainty is a defining characteristic of disaster, individuals seek information to reduce uncertainty. . No sex differences in information seeking. Younger respondents were more likely to desire information concerning food and water distribution and who else was affected; higher income brackets were more likely to seek out information on government responses; lower income levels were less likely to desire information about the larger impact of the earthquake.
Doyle (2011)	QN-DS	Partial	Weak	. In New Zealand, volcanic experts (scientists, non-scientists) noted that communication should include information about the associated uncertainty in the knowledge, data, and outcome. . Respondents attempts to translate verbal uncertainty to numerical terms were with problems. Consistency with the IPCC guidelines was low, especially for verbal phrases that conveyed more extreme probabilities. Scientists were somewhat more consistent than non-scientists. . Respondents did not view the likelihood of a volcanic eruption as being uniform throughout a time window

				(today vs. 10-years-time); they viewed the likelihood of an event today as being lower and in 10-years as being higher as opposed to uniform across all periods in the time window. . Use of 'within' instead of 'in' for a time period (e.g., 'within next 24 hours' vs. 'in next 24 hours') may mitigate this effect.
Doyle (2014)	QN-DS	Partial	Weak	. In New Zealand, volcanic experts (scientists, non-scientists) did not view the likelihood of a volcanic eruption as uniform throughout a time window of three days, but rather viewed the likelihood of eruption today as being lower and later in the time window as being higher. The same pattern was observed for a 1-year time window as well. Use of 'within' instead 'in' for the time window did not mitigate this effect. There were generally no differences between scientists and non-scientists.
Janmaimool (2014)	QN-DS	Indirect	Weak	. In Thailand among the public living adjacent to an industrial area, lay understanding of risk assessment uncertainty and event outcome uncertainty was related to trust in public authorities. Trust in industrial agencies was related to only lay understanding of risk assessment uncertainty but not event outcome uncertainty. This might be because people do not rely on industrial agencies in terms of receiving health protection, as industrial agencies do not have any direct responsibility for providing health care. . While information related to uncertainty is available to the public, it is not explicitly communicated to lay people. Explicit communication of uncertainty could increase perceived transparency of environmental risk management, thereby contributing to social trust. Janmaimool (2014)
McClure (2015)	QN-DS	Direct	Weak	. In New Zealand, given an expert assessment of earthquake likelihood over a time window, general public respondents rated earthquake likelihood higher in later intervals than in earlier intervals of the time window. This pattern was observed at both research cities and occurred despite the fact that the scientific statements presented to the respondents did not imply that the earthquake risk changed across the time window. . The judgment that the likelihood of an earthquake or aftershock is higher at later time intervals is not reflected in the likelihood of increasing preparedness, except for those low in preparedness.
Miles (2003)	QN-DS	Direct	Weak	. In the United Kingdom, views about food contamination in the general public showed seven types of uncertainty: uncertainty about who is affected, temporal uncertainty (uncertainty about past and future states), measurement uncertainty, uncertainty due to scientific disagreement, uncertainty about the risk to humans after measurements with animals, uncertainty about the extent (or 'size') of the risk, and uncertainty

				about how to deal with (specifically, how to reduce) the risk. However, all seven types loaded on to a single dimension in factor analysis. So communication efforts can focus on utilizing a 'broad' definition of uncertainty, rather than attempting to employ different types of uncertainty. . Public perception of seriousness of risk for themselves, and for other people was examined for different types of uncertainty, for five different food hazards. The results indicated that participants responded to the different types of uncertainty in a uniform way, suggesting that perception of risk associated with uncertainty is not affected by the type of uncertainty. The results further indicated that the seriousness of risk, in the presence of statements of uncertainty, was perceived to be greater for pesticides and genetic modification compared to BSE, high fat diets, and Salmonella. It was argued that this could be due to the perceptions of low personal control, and high societal responsibility to protect people and societal control over exposure to the potential risks of pesticides and genetic modification.
Sharma (2012)	QN-DS	Direct	Moderate	. In India for a rural population in the path of annual cyclones, communicating uncertainty can improve the credibility of a warning message. This is particularly important as the experience about the credibility of the message in a current hazard event can affect the response to warning in the next future event. Greater the experience of false alarms, lesser is the tendency to respond to warnings. This normally happens because the forecasts and the associated warnings do not contain information about uncertainty of occurrence of the natural hazard. Forecasts and warnings often get communicated as "certainty" in predictions and when the event does not occur as predicted, it leads to a lack of trust and confidence in the warning or the forecast for the next time.
Spence (2007)	QN-DS	Partial	Moderate	. In the United States, hurricane evacuees showed that staying informed (with general and very specific information) reduced uncertainty and brought predictability and order to an otherwise chaotic situation. After a crisis, individuals experienced high levels of uncertainty, due to lack of information, feeling of loss of control, and associated stress. Uncertainty in a time of crisis can motivate individuals to engage in information seeking, which can alleviate the uncertainty.
Vaughan (2012)	QN-DS	Direct	Moderate	. In the United States for a bioterrorism event scenario with urban minority African American and Hispanic populations showed that after hearing bioterrorism messages about uncertainties in decontamination efforts or reoccupancy decisions preexisting trust in government officials to fairly and competently manage the consequences of a terrorist act (as well as prior risk perceptions about the terrorism threat in general)

				predicted whether individuals reported feeling reassured or fearful. If participants believed that officials would be honest and forthcoming with negative information, they tended to feel less reassured (i.e., more fearful) by the acknowledgment of risk uncertainties. . When government officials' messages openly referred to risk uncertainties, for African Americans, greater confidence/ trust that officials would provide accurate and timely information was associated with a greater likelihood of feeling reassured. In contrast, among Hispanics/ Latinos, more confidence that risk information would be accurate and timely was associated with greater reported fear when risk messages acknowledged uncertainties.
Acar (2011)	QL	Partial	Moderate	. In Japan, after an earthquake people in directly affected areas tend to tweet about their unsafe and uncertain situation while people in remote areas post messages to let their followers know that they are safe. . Government should spread reliable and true information immediately on social media after an event to reduce uncertainty.
Afi (2014)	QL	Indirect	Moderate	In the United States, rural residents recently affected by a tornado experienced changing uncertainty depending upon the stage of the disaster they were describing, but in all cases was rooted in their inability to control outcomes. Leading up to the tornado they had a false sense of control but which changed when the severity of the oncoming event was realized. During the tornado, sensory experiences fed shifting uncertainties about the potential impact of the tornado. In the aftermath, there were multiple uncertainties about the future of the town, the school, and the townspeople's decisions about rebuilding or not. Uncertainty in this stage was due to either a lack of information or inconsistent information. Perhaps more than in any other period, communal coping was critical to manage uncertainties during the recovery phase. . The changing focus of uncertainty across the time course of an event is often missing from analysis of uncertainty. An examination of uncertainty across the stages of a natural disaster helped elucidate the many foci of uncertainty during this experience.
Alipour (2015)	QL	Indirect	High	. In Iran, for people living in earthquake prone rural areas, there was significant uncertainty about the future. The uncertainty was related to: disruption of roles and responsibilities; employment uncertainty; influx of nonnative population; reconstruction without considering the culture. In general, lack of a comprehensive plan for effective recovery post-event led to uncertainty.
Bird (2012)	QL	Partial	Moderate	. In Australia, during floods, Facebook can serve as a means of information sharing, which can reduce uncertainty.

Holmes (2009)	QL	Partial	Moderate	. In Canada, regarding infectious disease, a majority of public communication experts emphasized the need to communicate uncertainty, believing that the public wants, deserves, and indeed can well handle such information. Their view was that to develop and retain trust, spokespeople must acknowledge what they do not know.
Morss (2010b)	QL	Indirect	Moderate	. In the United States in the general public in hurricane areas, hurricane forecasts have medium to high confidence, with somewhat higher confidence in 3-day than 5-day forecasts. However, the uncertainty regarding the exact storm track can lead people not have enough time to prepare their property or move belongings to a safe location. . Use of “certain death if you stay” warning in evacuation orders was interpreted positively and negatively. For those who interpreted it negatively, it may affect their response to future risk communication.
Morss (2015)	QL	Indirect	High	. In the United States, flash flood experts noted that a major challenge for all flash flood warning system professionals is evaluating the severity of a threat and making warning decisions quickly under significant uncertainty. However, waiting for clearer evidence in a rapidly evolving, highly uncertain situation costs lead time and may even lead to a missed warning for an event, when it occurs. Uncertainty can be reduced by actively seeking and obtaining data from multiple sources. . Although uncertainty can be reduced, there will always be limits in observational and predictive capabilities for flash flooding. With multiple actors making interrelated decisions under uncertainty, risk assessments can propagate through the warning system in unintended ways. Thus, managing uncertainty system-wide is important. This suggests the need to analyze propagation of uncertainty through the warning system, to improve how individuals make decisions under uncertainty in the context of their interactions with others.
Pappenberger (2013)	QL	Indirect	Moderate	. In Europe, flood experts are in agreement that communicating the uncertainty associated with scientific forecasts to decision makers and the public is as important for risk management as is increasing forecast accuracy and timeliness. However, there is no overarching agreement among the experts on how to display probabilistic forecasts and the essential information that should accompany plots and diagrams. Tools are required to translate this information into clear and effective visualizations that might be easily communicated to specialist decision makers and the general public.
Quinn (2008)	QL	Indirect	Moderate	. In the United States, a bioterrorism event with postal workers and public health professionals showed uncertainty and conflicting opinions about the vaccine

				created confusion for postal workers that was further aggravated when public health agencies disagreed on recommendations about the vaccine. Individual decision making became more complex as postal workers found contradictory opinions about the vaccine, which added to the confusion and fear. . The media presented the doubts about the vaccine expressed by various organizations and the disagreements about definitive recommendations among public health experts, which led to the respondents having uncertainty and distrust of the vaccine. When the vaccine was offered to the respondents, many unanswered questions about the vaccine remained and public health officials had already lost trust and credibility. . In times of great uncertainty and with highly diverse audiences, having multiple voices may be useful. However, professionals or agencies in disagreement should join together to discuss in public the rationale and processes by which they come to their conclusions to build trust.
Taylor-Clark (2007)	QL	Direct	High	. In the United States, low socio-economic status (SES) minorities noted several challenges to seeking and processing environmental health risk information effectively: information overload, frequent dissemination of contradictory information given the uncertain nature of science, and complex language. Many respondents stated that they no longer pay attention to health risk information or news because of regularly occurring contradictions. . Where scientific uncertainty exists, respondents called for transparent messages that provide only the facts about known environmental health risks.
Taylor-Robinson (2009)	QL	Indirect	Moderate	. In the United Kingdom, school children confronted with an infectious disease suggested that there was uncertainty about whether it was appropriate to attend school on the Monday morning, and that this should have been addressed with appropriate communication over the weekend. They noted that speed, timeliness, and usefulness of information can reduce uncertainty.
Aldunce (2007)	MM, CS	Indirect	Moderate	. In Chile, rural residents living in landslides prone areas noted that better disaster management, coordination, cooperation at the local level can lead to less uncertainty about all phases of an event.
Dabner (2012)	MM, CS	Indirect	High	. In New Zealand, after an earthquake university students, staff, and faculty noted that social media served to disseminate regular and timely information, which reduced uncertainty . Need to better integrate social media in the overall communications strategy to disseminate information in a timely manner.
Downton (2005)	MM, CS	Partial	High	. In the United States, regarding floods, uncertainty influences decision making and interactions within and among groups of experts. Scientific and technical

				uncertainty is integrally entwined with uncertainty due to values and other issues in decision making. There is a crucial role of expert judgment in bridging the gap between uncertain scientific knowledge and decision makers' need for information they can act on. In these settings, uncertainty can become confounded with values issues (the appropriate standard of protection). Flood management decisions might benefit if scientific estimates provided to decision makers were accompanied by a clear statement about the level of confidence in the estimates and how uncertainty has been handled in developing strategy alternatives. . There is a distinction between knowledge uncertainty (refers to limitations of scientific understanding of complex natural processes and future changes) and sampling uncertainty (refers to the uncertainty in estimates calculated using limited data samples from naturally variable processes). Sampling uncertainty cannot be eliminated, but it can be reduced by collecting more data over time or space.
Frewer (2003)	MM, CS	Partial	High	. In the United States, in a food contamination outbreak, experts/scientists indicated that they felt that providing information about scientific uncertainty has had and will have a negative impact on the extent to which the public trusts science, scientists, and scientific institutions. There was a widespread belief that the general public were unable to conceptualize uncertainties associated with risk management processes. Many scientists thought that providing the public with information about uncertainty would increase distrust in science and scientific institutions, as well as cause panic and confusion regarding the extent and impact of a particular hazard.
Gesser-Edelsburg (2014)	MM, CS	Partial	Moderate	. In Israel, during an infectious disease event, policy makers and health care workers experienced lot of uncertainty due to lack of information. During the initial stages of the pandemic, when decisions such as buying the vaccine needed to be made, the WHO and CDC provided few answers, and this uncertainty affected decision making. Health care workers either followed the pandemic and vaccine guidelines without being troubled by uncertainty, or they followed the WHO and CDC guidelines with feelings of ambivalence, believing that many questions had been left unanswered. . The main criticism was that instead of providing transparent communication regarding the uncertainty surrounding the new virus, there was a rush to declare a pandemic without adequate information.
Karan (2007)	MM, CS	Indirect	High	. In Singapore during an outbreak of an infectious disease (SARS), integrated management of responses across media and other domains significantly reduced uncertainties.
Morss (2010a)	MM, CS	Indirect	High	. In the United States, experts predicting floods have to consider the uncertainty regarding their predictions.

				Information about predictive uncertainty was not communicated by forecasters nor understood by decision makers. Instead, local officials relied primarily on experience, intuition, and observations of the flood to decide what high-water level to protect their communities. Given predictive uncertainty, decision makers' confidence and trust in the forecasters' who are providing predictions influenced decision making and outcomes. It was difficult for local officials to interpret and use predictive uncertainty information given the high stakes involved in a potential extreme event.
Ramos (2010)	MM, CS	Indirect	High	. In Europe, flood experts note that flood forecasting is a chain that has a flow of uncertainties and decisions. A full uncertainty analysis is needed to track all sources of uncertainty and to estimate both their relative importance in the system and the total uncertainty from the combination of each component. . Uncertainties are communicated to other experts and the public with the help of confidence indices, risk level estimations, interpercentile intervals or likelihood of occurrence of an event. It is acknowledged that ignoring uncertainty in the formulation of forecasts affects the efficiency of the forecasting process, as well as the quality and value of the forecasts. The basis for an efficient communication of a final forecast lies in the quantification of uncertainty, but also on the assessment of how users perceive and understand uncertainty, and tend to act in face of uncertain information.
Rousseau (2008)	MM, CS	Indirect	Moderate	. In Quebec Canada and France, during an infectious disease event (H1N1), medical information phone line personnel noted that rapid changes in information, conflicting information, and gap between information conveyed by the media and the health authorities about immunization led to the personnel unable clear the public's uncertainties. Rousseau (2008) . The overall confusion about the contradictory information in the media and between the media and health authorities increased feelings of fear linked to uncertainty.
Skinner (2014)	MM, CS	Indirect	Low	. In South Africa, people living in the vicinity of an industrial area noted that sharing of information with the public or institutions about the probability and consequences of harmful events enables the public to respond to the crisis and reduce the uncertainty and possibility of misinformation. A disaster management plan that is interactive with the public and other stakeholders, and that includes all media including social media, can reduce uncertainty about protection actions.
Voorst (2015)	MM, CS	Partial	Moderate	. In Indonesia, for low SES people living in flood prone areas, there is a need to take into account the whole living environment which is uncertain due to poverty;

				risk for flood is just one among many other risks. In such uncertain living circumstances, it would be unrealistic to interpret their behaviour as a direct response to a single, acute hazard.
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