



Deliverable D1.1

Findings from Systematic Review of Public Perceptions and Responses

Due date of deliverable: 31/12/2019

Actual submission date: 12/03/2021

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Project details

Project acronym	PROACTIVE
Project full title	PR eparedness against CBRNE threats through cO mmun Approaches between security pra CT itioners and the V ulneran blE civil society
Grant Agreement no.	832981
Call ID and Topic	H2020-SU-SEC-2018, Topic SU-FCT01-2018
Project Timeframe	01/05/2019 – 30/04/2022
Duration	36 Months
Coordinator	UIC – Grigore Havarneanu (havarneanu@uic.org)

Document details

Title	Findings from Systematic Review of Public Perceptions and Responses
Work Package	WP1
Date of the document	12/03/2021
Version of the document	05
Responsible Partner	PHE
Reviewing Partner	All
Status of the document	Final
Dissemination level	Public

Document history

Revision	Date	Description
01	17/12/2019	First Draft
02	18/12/2019	Draft reviewed by CBRNE Ltd
03	19/12/2019	Draft reviewed by UIC and CBRNE Ltd
04	20/12/2019	Final version
05	12/03/2021	Update following mid-term periodic review

Consortium – List of partners

Partner no.	Short name	Name	Country
1	UIC	UNION INTERNATIONALE DES CHEMINS DE FER (COORDINATOR)	France
2	CBRNE	CBRNE LTD	UK
3	PPI	POPULATION PROTECTION INSTITUTE (MINISTRY OF THE INTERIOR OF THE CZECH REPUBLIC)	Czech Republic
4	DB	DEUTSCHE BAHN AG	Germany
6	UMU	UMEA UNIVERSITET	Sweden
7	DHPOL	DEUTSCHE HOCHSCHULE DER POLIZEI	Germany
8	RINISOFT	RINISOFT LTD	Bulgaria
9	WMP	WEST MIDLANDS POLICE AND CRIME COMMISSIONER	UK
10	ETICAS	ETICAS RESEARCH AND CONSULTING SL	Spain
11	SESU	STATE EMERGENCY SERVICE OF UKRAINE	Ukraine
12	PHE	DEPARTMENT OF HEALTH	UK
13	SPL	STATE POLICE OF LATVIA	Latvia
14	AGS	AN GARDA SÍOCHÁNA – NATIONAL POLICE FORCE IRELAND	Ireland
15	FFI	FORSVARETS FORSKNINGSINSTITUTT	Norway
16	NPH	KOMENDA GŁÓWNA POLICJI	Poland

List of acronyms

Acronym	Definition
EU	European Union
CBRNe	Chemical, Biological, Radiological, Nuclear, and explosive
T	Task
M	Month
D	Deliverable
WP	Work Package
NHS	National Health Service
KI	Potassium Iodide
Po	Polonium
NW	Natalie Williams
LG	Louis Gauntlett
CH	Charlotte Hall
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Executive summary

The following deliverable is the first of the three set for the PROACTIVE project for WP1 – Human factors analysis of preparedness and response. In line with the activities of Task 1.1 and the requirements of D1.1, this deliverable presents the findings from a review of academic literature relating to public perceptions of pre-incident preparedness, and during-incident response (e.g., management strategies), for CBRNe events (including terrorism). Specifically, this review details: (i) the baseline level of knowledge and understanding of CBRNe prevention and management strategies within the general population; (ii) identify factors that are associated with effective pre-incident public information campaigns for CBRNe terrorism; (iii) understand factors that may increase public compliance with both recommended prevention measures (prior to an incident occurring) and recommended protective measures (during an incident); (iv) identify and understand insights from literature concerning other types of incidents which may be of relevance for CBRNe preparedness.

A synthesis of data and outcomes from 41 papers enabled the authors to identify the ‘state of the art’ and extract common themes to answer the key questions associated with Task 1.1. Following the synthesis of results, it became apparent that the general public’s current understanding of CBRNe prevention and management strategies is very low. Across literature there was consensus that official protective and preventative recommendations are often misunderstood, complex and confusing to the public. Effective pre-incident communication was characterised by being easy to understand with the use of non-complex language, disseminated across multiple platforms, delivered by a credible source, and incorporate psychological constructs that aim to reduce threat and anxiety. Factors which have the potential for increasing willingness to engage in pre-incident and preparedness information, included: demographics, prior knowledge and psychosocial factors. Factors which have the potential of increasing compliance with official instruction during an incident, included: trust, provision of information, emotional responses; efficacy and relationships. Sources listed within the discussion section provide support for these outcomes across a range of other types of incidents (e.g. pandemics, evacuations and natural hazard based disasters). Additionally, there are focused sections which draw from wider research which compliments the outputs of this review in terms of importance of trust, legitimacy and information sharing in CBRNe incidents.

On the basis of these outcomes, the Discussion details several provisional recommendations, alongside potential gaps for further research. For example: pre-incident information should be communicated in a culturally appropriate way, whilst being easy to understand, accessible and factual; and, communication during an incident should be delivered by a trustworthy spokesperson, present useful and needed information, and incorporate facts or proof to provide robustness. These recommendations will be further explored when the outcomes from D1.1 are synthesised with D1.2 for presentation within D1.3.

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1. INTRODUCTION

Chemical, biological, radiological, nuclear, and explosive (CBRNe) incidents, whether accidental or terrorist-based, can have a high impact on society. These events may be hard to detect or invisible and may induce potentially delayed contamination symptoms and negative health effects. As a result, CBRNe risks are typical of 'dread' risks, defined by lack of perceived control, catastrophic potential, and fatal consequences [1, 2], which can influence public anxiety. Furthermore, technological advances and an increased willingness for terrorists to use more unconventional weapons has resulted in greater likelihood of these incidents occurring in recent years [3]. As a result, it is essential that the public are familiar with, and knowledgeable about, correct measures to be taking to ensure effective action if an incident were to occur.

Pre-incident information campaigns such as 'Run, Hide, Tell' [4] (which provide knowledge of marauding terrorist fire arm attacks), 'Report, Remove, Rinse' [5], and 'See it, say it, sorted' [6] (which both provide instruction to be followed in the event of a hazardous material or CBRNe incident) have recently been released and aim to increase public knowledge in relation to CBRNe incidents. However, the implementation of such public information campaigns is recent, and there has been little work conducted to assess, collate, and synthesise the evidence concerning the effectiveness of these pre-incident information campaigns for compliance and preparedness. Indeed, the authors of this deliverable are only aware of one additional recent review focused on collating evidence concerning pre-incident information campaigns, which was focused explicitly on acid attacks (Carter et al., under review). Further research is therefore sorely needed to collate available evidence concerning the effectiveness of pre-incident and preparedness information, from both CBRNe contexts and beyond, to help ensure that such information is created to be maximally effective for ensuring public preparedness.

As part of PROACTIVE Work Package (WP) 1, focused on a human factors analysis of preparedness and response relating to CBRNe terrorism in Europe and beyond, Deliverable 1.1 aims to address this lacuna. Specifically, this deliverable presents the results of a recent systematic review identifying research relating to strategies for prevention and preparedness for CBRNe incidents, and public perceptions of such strategies. This review provides a comprehensive overview and appraisal of current literature in order to improve understanding of: the baseline level of knowledge and understanding of CBRNe prevention and management strategies within the general population; factors that are associated with effective pre-incident public information campaigns for CBRNe terrorism and; factors that may increase public compliance with both recommended prevention measures (prior to an incident occurring) and recommended protective measures (during an incident). Furthermore, this review also draws on insights from literature concerning other types of incidents which may be of relevance for CBRNe preparedness. Following presentation of the methodology and results of the review, this deliverable provides a preliminary assessment of the gaps in the literature and some initial recommendations for the development of future pre-incident material. These outcomes will subsequently be synthesised with the outcomes from Deliverable 1.2 in order to provide the synthesis due within Deliverable 1.3.

2. METHOD

In order to provide a systematic and structured method it was decided that the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework [7] would be followed. This results in the method section describing and explaining the process of criteria selection, use of information sources, the search strategy, study selection, data selection, quality assessment and the analytical method used during the review.

2.1. Selection Criteria

The criteria were developed to reflect the requirements of the PROACTIVE work package. The rationale, aims and objectives of the review were developed whilst maintaining the requirements of the grant. The final inclusion and exclusion criteria are presented in Table 1. To be included within the review, articles must have met at least one of the first four criteria listed (i.e. examine the effect of CBRNe prevention and management strategies on public knowledge, understanding and behaviour prior to or during an incident, examine the effect of pre-incident information for improving public knowledge, examine factors associated with willingness to engage in pre-incident information, or examine factors which affect public willingness and ability to engage with pre-incident information or take part in preventative action), whilst only including original data (whether quantitative or qualitative) and being available in English. Furthermore, papers which examined the effect of pre-incident information on professionally trained responders would be excluded from the review to allow emphasis on public or layperson preparedness. Articles including animal data were also excluded due to the work package focusing on human factors. Lastly, articles published prior to 2001 were excluded from this review due to the large frequency of published papers focusing on decontamination procedure following the 9/11 USA terrorist attacks.

2.2. Information sources

Initial searches were conducted across both healthcare and psychologically-focused literature databases (a decision taken to reflect the Work Package emphasis on human factors as they relate to public health incidents (e.g., CBRNe). These searches were designed to identify the most relevant literature sources, resulting in final searches conducted using EMBASE, MEDLINE, PubMed, PsycINFO and PsychARTICLES on the 14th of August 2019.

2.3. Search

Following the guidelines from Carter et al. (under review), an initial search strategy was developed. This included terms relating to the timing of the information and strategies provided (e.g. pre-incident), terms relating to the type of information and strategies provided (e.g. educat*) and terms relating to the type of incident (CBRNe). All initial terms were developed by Natalie Williams (NW) and were sent to consortium project partners for review. Potential search terms were also investigated by running initial searches on Embase, PsycINFO, Web of Science Core Collection, and PubMed. Additional search terms were added by project partners and by using the thesaurus function to identify similar terms. Based on this consultation with project partners, terms such as radiological, nuclear, and biological were added to the search to increase hits on incidents that were not chemical thereby increasing the focus on all elements of CBRNe incidents.

Due to gaining a substantial number of hits (196,370; from searches conducted across Embase, PsycARTICLES, PsycINFO, PubMed and Scopus), the initial search terms were refined to maximise the relevance of identified abstracts for the current review and to ensure the task was manageable within available resources. As detailed in the preceding “Selection Criteria” section the decision was taken to restrict papers to the following: using human participants, published in the English language, published after 2001, and only peer reviewed articles. The full search strategies carried out on each database are available in Appendix A.

Table 1: Final inclusion and exclusion criteria used for full text screening.

Include	Exclude
Include articles which examine the effect of CBRNe prevention and management strategies on public knowledge, understanding and behaviour, both prior to and during an emergency or disaster	Exclude articles which examine the effect of training/ pre-incident information on responder (first responder, healthcare staff, government official etc) preparedness or response to disasters/ workers can be included, as long as they have not been professionally trained.
Include articles which examine the effect of pre-incident information for improving public knowledge of actions/ confidence in taking protective actions during an emergency or disaster/ more rapid recovery/ improved wellbeing	Exclude articles which do not contain original data
Include articles which examine factors associated with public perceptions of pre-incident information	Exclude articles which pertain to animal not human data
Include articles which examine factors that affect public ability/ willingness to engage with pre-incident information or take preventative action prior to an emergency or disaster	Exclude articles published prior to 2001
Include original data, whether qualitative or quantitative	
Are available in English	

2.4. Study Selection

Once the search had been carried out by NW, the yielded records were subject to selection. Firstly, any duplicate articles were identified and removed from the results by Louis Gauntlett (LG). The remaining articles were firstly title screened and sorted into 'include' and 'exclude' sections by LG. Those which passed into the 'include' section were abstract screened, and again sorted into 'include' and 'exclude' sections by LG. Further, the PROACTIVE consortium reviewed and discussed a selection of abstracts during the 1st PROACTIVE Progress Meeting which took place in Paris on the 17th of September 2019. Discussions during this meeting subsequently fed in to the overall abstract screening process. Following this process, the remaining papers were subjected to full text review by Charlotte Hall (CH), and a decision was made as to whether it met any of the exclusion criteria. The paper was read a second time by CH, to ensure the inclusion criteria were met and that the paper was of relevance to the review. Papers were again either 'included' or 'excluded'. To provide robustness, the full text review was conducted by both CH and one other individual drawn from across two project partners (UIC (one representative), RINISOFT (two representatives)) or the research team at Public Health England. Following the second full-text review, the inclusion/exclusion decision was compared with the initial reviewers result and discrepancies between the two reviews were identified. Discrepancies between reviews were either re-evaluated by CH, or, in the case of continued discrepancy, were subject to a third review. Third review was conducted by Dale Weston (DW) or LG, and the majority decision was taken (a table detailing this process, and the decisions made by each reviewer, can be found in Appendix B).

2.5. Data collection

A standardised data extraction process was carried out on all the papers used within the review to extract the following information: authors; date of publication; institution location of the first author (to ascertain study origin); location of study; methodological design; incident described (if applicable); sample information (consisting of *N*, male to female ratio and age data) and specific sample characteristics; results; main outcome; and any restrictions or limitations. CH extracted data from all included papers as standard. A second member of the PHE team (LG) extracted data from 25% of the papers to provide robustness in the process. Papers were then divided randomly between two project partners (DHPOL and UIC), who were also tasked with extracting data to provide further robustness. Due to the iterative process of inclusion and exclusion, and the tight timescales for all stages of the review, four papers were subsequently included after the double data-extraction process had begun. Data from these papers were therefore excluded by one author (CH). These papers are marked with an Asterix in the citation list (found in Appendix C). The remaining 37 other included papers were subjected to full data extraction by at least two parties.

CH compared the initial data extraction and the project partners extraction data, paper by paper, and common information was added to a final master copy. Any information that was uncommon (i.e. only written by one author) but was perceived as relevant to meeting the aims of the review was checked for correctness in the original paper before addition to the master data. Again, any discrepancies within the extracted data were also checked against the original manuscript and the correct data was extracted. Ultimately, data was extracted with the inclusion criteria and protocol aims in mind (i.e. data which related to CBRNe prevention and management strategies on public

knowledge, effectiveness, and public perception and engagement with these strategies) to ensure that data was relevant for meeting the aims of the review. Extracted data is available on request.

2.6. Quality Assessment Tool

Quality assessment was carried out on each individual study used within the review using the online Understanding Health Research tool (<https://www.understandinghealthresearch.org/about-us/what-is-the-understanding-health-research-tool-8>). The tool required the user to answer a number of questions relating to the quality of the research. The precise nature of these questions varied as a function of the methodological approach used in the paper (e.g., interviews, randomised controlled trials, etc.), thus making the tool appropriate for this review where considerable variation in methodological approach was expected. As recommended by the tool, when a study consisted of a mixed method, the most prominent methodological approach was chosen for the quality assessment. The outcome of the tool resulted in positive, neutral and negative scoring for statements relating to study quality (e.g. includes a conflict of interest statement, mentions ethical procedures, and provides a description of focus group or questionnaire structure). A percentage of positive scores was created in order to assess studies fairly which differed in methodological approach and therefore had different numbers of questions answered. These overall scores and common low-quality concerns across included papers are reported in the Results section.

2.7. Analytical Method

As studies used within this review are highly varied and non-comparable, meta-analysis was not attempted. Instead, a narrative synthesis of the included papers was conducted. This involved the following stages. Firstly, to best meet the objectives of the review, data was organised in relation to each of the aims: 1. to understand the level of knowledge and understanding of CBRNe prevention and management strategies within the general population, 2. To identify factors that are associated with effective pre-incident public information campaigns for CBRNe terrorism, 3. To understand factors that may increase public compliance with both recommended prevention measures (prior to an incident occurring) and recommended protective measures (during an incident). Secondly, data relating to insights from other literature was incorporated into the first three aims. Thirdly, once sorted, thematic analysis following the guidelines proposed by Braun and Clarke [8] was carried out on the data which resulted in the emergence of themes apparent to each aim, which was used to structure the results.

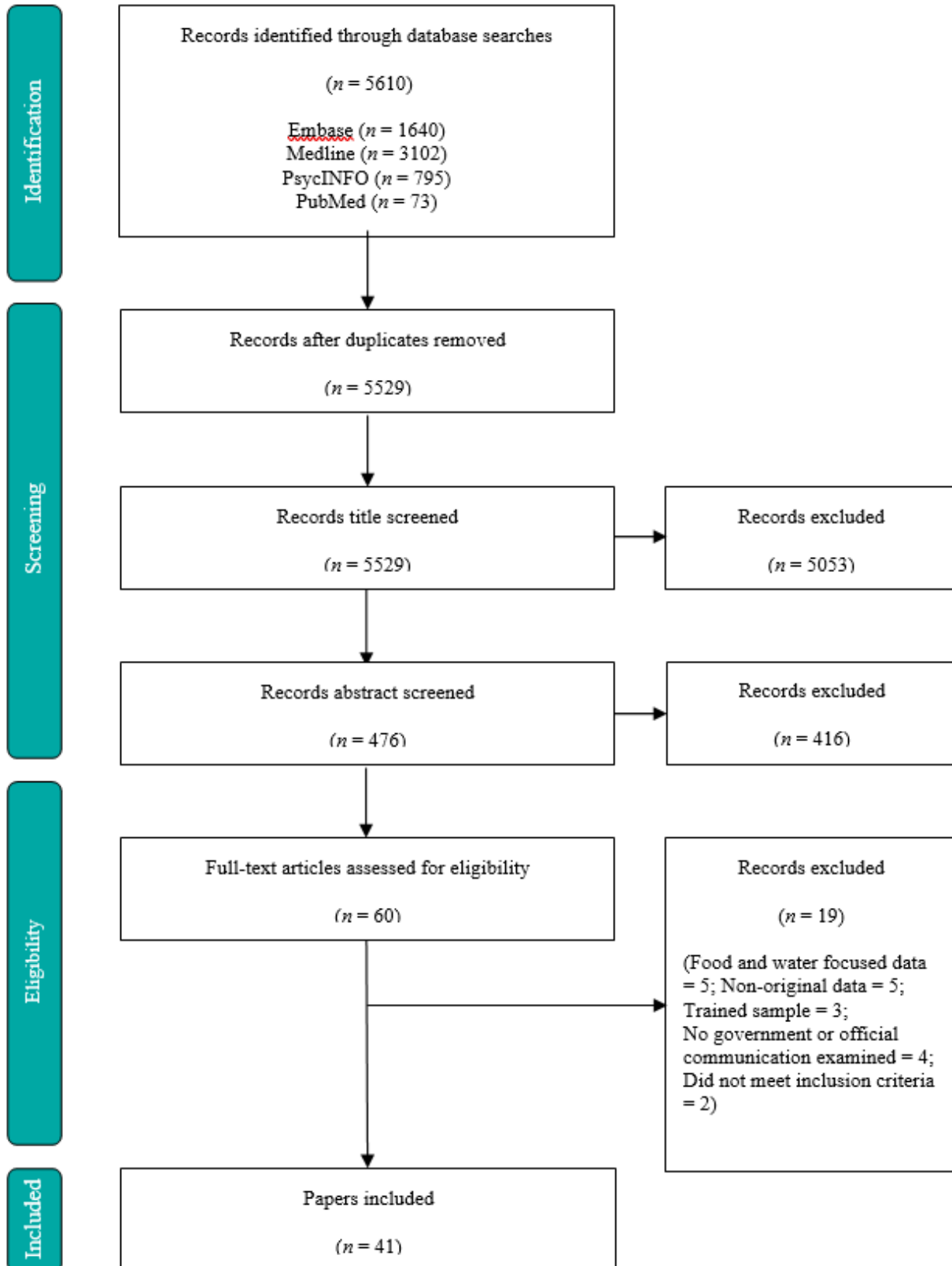


Fig. 1 PRISMA diagram detailing the stages of the review process.

3. RESULTS

3.1. Study selection

The final database search run on the 14th of August 2019 yielded 5,610 records. Post duplication screening, 5,529 records remained. 5,053 papers were excluded during title screening, and 416 during abstract screening, resulting in 60 papers which were retained for full-text review. Initially, full text review by CH revealed 40 papers which were eligible to be used within the review (with 20 exclusions). Following second review from project partners and the PHE team, 17 discrepancies were identified. Two of these were reconsidered by CH, with one initially included being excluded, and one initially excluded being included. The remaining 15 papers were subject to a third full text review and this resulted in inclusion of five papers, and exclusion of ten.

A PRISMA diagram can be found in Figure 1, demonstrating the full screening process. A final list of the included (41) and excluded (19) papers was created and as a result, 41 papers were retained and included in the qualitative synthesis.

3.2. Notable Inclusion and Exclusion Decisions

Despite application of distinct and defined inclusion and exclusion criteria in a robust and methodical manner, emphasised by the use of a third reviewer, some subjectivity was inevitably involved in the selection of papers. To provide transparency, this section will discuss some of the decisions made which were subject to third review and explain the ultimate decision regarding inclusion or exclusion of the paper(s).

Pre-incident information and communication released during an incident does not necessarily originate from an accidental incident (e.g. chemical spill), an acute naturally occurring disaster (e.g. an earthquake) or a purposefully created (e.g. terrorist attack) CBRNe incident, some incidents occur from gradual, naturally occurring events with no acute incident or cause, which are still targeted by authorities in the release of pre-incident information, for example using education programmes. To comply with the aims of the review, it was decided that papers which originated from the examination of a CBRNe incident with a distinct cause, or from non-terrorist incidents which most closely mirror the process of a terrorist attack (e.g. an acute incident or accident with a defined cause), would be retained for analysis within this review. However, papers that involved preparedness for, or response to, more general environmental hazards were excluded. Therefore, this excluded papers relating to potentially harmful contamination via ingestion and exposure: Arsenic in water [9-11], dioxin in pork [12], and toxin chemical exposure from the environment [13].

Another notable decision within the exclusion and inclusion of papers surrounds the criteria of excluding workers which have been professionally trained. One study examined both public and trained professionals in relation to radioactive terrorist events [14], this paper was included within the review, but data was only extracted in relation to those not professionally trained (i.e. the public). Papers which mainly related to trained professionals were excluded [15], similarly those which focused wholly on professionals were also excluded [16] as per the exclusion criterion. Two papers were difficult to decide on due to both being carried out on workers which were subject to minor levels of training. The first aimed to improve the knowledge and behaviour of workers in relation to

chemical exposure in a nail salon [17], this paper was excluded as workers are trained in knowledge and behaviours around chemicals as standard. The second aimed to examine factors which impacted on compliance shown by herbicide sprayers [18], this paper was included as workers did not receive official training and the paper also states that due to a large staff turnover many workers do not even get the option for training.

Papers were also included within this review despite not explicitly examining pre-incident or during incident communication released by official sources. These papers instead examined future-incident preparedness and evaluated factors which may increase public compliance were a future CBRNe incident to happen (e.g. [19-21]). As these papers still met the inclusion criteria, despite not focusing explicitly on a prevention or management strategy, they were included within the review as they will aid in the discovery of factors which are effective in communicating pre and during incident information.

3.3. Study Characteristics

Ultimately, 41 papers were retained after title, abstract and full text screening (a full list can be found in Appendix C). This section of the review encompasses data relating to date of publication, country of origin, study design, incident described and study size and specific characteristics. All extracted data is available upon request.

3.3.1. Date of Publication

No papers included within the review were published prior to 2001, as per the exclusion criterion. Papers included in this review were first published in 2003, with a subsequent gradual increase of papers published annually or biannually in the lead up to 2016 (27 papers [14, 18, 19, 22-45], Figure 2), where the number of papers peaked at seven [20, 46-51]. From 2016-2019 there were seven papers published in total [21, 52-57]. There is no specific CBRNe incident common across the papers published in 2016, but the growing amount of papers published in recent years suggests that public perceptions of information given pre and during CBRNe incidents is a growing area of interest.

3.3.2. Country of origin

To display the geographical spread of the papers used within this review, data were extracted relating to the location of the first authors institute at the time of publication. Nearly half of the papers originated from the USA (17 papers [14, 22-24, 26, 28-30, 33, 42, 43, 45-47, 49, 52, 55], ten from the UK [20, 27, 31, 32, 34, 35, 37-39, 54], six from Japan [21, 40, 44, 48, 51, 57], two from Belgium [36, 56], one from Canada [19], one from India [41], one from Romania [25], one from South Africa [18] and one from Korea [53], which displays a potential Western bias in the research field.

3.3.3. Study design

There were several different methodological approaches apparent throughout the retained papers. Over half of the conducted research used questionnaires or surveys (22 papers), and these were carried out in a variety of ways; in person [27, 36, 42, 52], via telephone [22, 29, 33, 47, 55], online [20, 34, 45, 48, 56], postal [21, 26, 57], in-house semi-structured [41], self-administered [40], using pencil and paper [32], during lecture time [51] and one used both in person and online questionnaires [25]. Other methods used included: focus groups [14, 24, 30, 37, 43, 54]; interviews in person [49]

and via telephone [19]; exploratory case studies [44, 50], an observational report [23] and a field experiment [38]. Lastly, five studies used a mixed method design [18, 31, 35, 39, 46].

3.3.4. Incident Described

There were examples of all CBRNe incidents involved within this review; there was a higher proportion of incidents consisting of chemical (27.9%; [18, 24, 27, 28, 30, 31, 34, 38, 45, 49, 52, 54], radiological (22.0%; [14, 25, 29, 35, 37, 41-43, 46]) and nuclear events (23.3%; [21, 32, 39, 40, 44, 48, 50, 53, 56, 57]), in comparison to biological events, (2.3%; [20]; see table 3 for more information about the incidents described and the type of information assessed). One paper also specified a biological or nuclear device (2.3%; [22]). Of the papers categorised as a radiological event, 44% were both explosive and radiological (e.g. dirty bomb or a radiological dispersal device; [14, 37, 43, 46]). Some papers used within the review did not relate to a specific incident and instead assessed public perceptions and preparedness for future incidents [19, 47, 51, 55]; for example, through the evaluation of Potassium Iodide pill distribution campaigns [23, 26, 33, 36]. As can be seen from the summary of incident types detailed in Table 2, this review includes studies with both short kinetics (e.g., an explosion) and long kinetics (e.g., a nuclear incident).

3.3.5. Study sample

There was substantial variation in the study characteristics across the included papers. Sample size highly differed between studies, ranging from $n = 30$ [49] to $n = 9249$ [48]. Thirteen papers, which equates to 31.7% of the studies, claimed to be representative of a wider population, which included: Belgium [36, 56], Canada [19], London [31, 54], US ([22, 29], including specific areas in US, [42, 52]), and areas within Japan [21, 41]. One paper was representative of both the UK and Poland [34], and one paper claims to have a representative sample of participants but does not specify what they are representative of [37]. However, the remaining 68.3% of papers present non-representative samples. Of these, it is important to note that one study claims to be a general public survey [26], and despite one study having $n = 9,249$ participants which have similar characteristic distribution to various prefectures in Japan, it does not claim to be representative [48]. A table displaying extracted data in relation to sample size and characteristics, including unique characteristics and gender distribution can be found in Appendix D.

3.3.6. Narrative Synthesis

As noted above, the data was organised to relate to each aim of the review. Therefore, results will now be presented in three sections: understanding the level of knowledge and understanding of CBRNe prevention and management strategies within the general population; identification of factors which are associated with effective pre-incident public information campaigns for CBRNe terrorism; and understanding factors that may increase public compliance with both recommended prevention and protective measures.

Table 2: Information relating to what type of incident was described within the study, CBRNe categorisation, and what type of information was communicated or assessed within the paper.

Study Citation	Incident described	CBRNe	Pre-Incident	During	Future Incident Preparedness
Rogers, 2013	Radiological dispersal device	Radiological / Explosive	X	X	
Hellier, 2014	Nuclear emergency preparedness	Nuclear	X		X
Andrade-Rivas, 2015	Exposure to herbicide	Chemical	X		
Bass, 2016	Dirty bomb / radiological terrorist event	Radiological / Explosive	X		
Bisconti, 2011	Radiation from nuclear power plants	Radiological	X		
Hambach, 2011	Chemical risk	Chemical	X		
Hildebrand, 2007	3 chemical release scenarios	Chemical	X		
Latré, 2018	Nuclear accident	Nuclear	X		
Ross, 2016	Accident at a Chemical Weapon Storage and Incinerator	Chemical	X		
Tampere, 2016	Fukushima accident	Nuclear	X		
Boscarino, 2003	Major terrorist attack	Biological or Nuclear		X	X
Nyaku, 2014	Release of radioactive material	Radiological		X	X
Bass, 2015	Dirty bomb	Radiological / Explosive		X	
Becker, 2004	Radiological dispersal device	Radiological / Explosive		X	
Burrer, 2017	Chemical spill	Chemical		X	
Carter, 2014	Mass decontamination field experiment	Chemical		X	
Carter, 2018	Release of a non-caustic liquid contaminant	Chemical		X	
Goodwin, 2012	Fukushima accident	Nuclear		X	
Henderson, 2004	VX terrorist threat	Chemical		X	
Lee, 2017	Fukushima accident	Nuclear		X	
Nakayama, 2019	Fukushima accident	Nuclear		X	
Ohno, 2015	Fukushima accident	Nuclear		X	
Pearce, 2013	Radiological attack	Radiological		X	
Pearce, 2013	Chemical spill	Chemical		X	
Rubin, 2011	²¹⁰ Po poisoning	Chemical		X	
Savoia, 2015	Drinking water contamination	Chemical		X	
Wray, 2008	Agent-specific scenario	Biological		X	
Alshehri, 2016	Biological disaster	Biological			X
Blando, 2007	KI pill distribution	No incident			X
Carney, 2003	KI pill distribution	No incident			X
Heath, 2016	Residents living in a petrochemical manufacturing community	No incident			X
Heath, 2018	Residents living in a petrochemical manufacturing community	No incident			X
Kanda, 2014	Fukushima accident	Nuclear			X
Kuroda, 2018	Fukushima accident	Nuclear			X
Lee, 2009	CBRNe terrorism incident(s)	No incident			X
Makkar, 2014	Mayapuri Radiation Accident	Radiological			X
Mihai, 2005	Radiation Risk	Radiological			X
Murakami, 2016	Fukushima accident	Nuclear			X
Perko, 2013	KI pill distribution	No incident			X
Yoshida, 2016	Supplementary texts following Fukushima	No incident			X
Zwolinski, 2012	KI pill distribution	No incident			X

Note: KI represents Potassium Iodide, ²¹⁰Po represents Polonium.

3.4. Understanding the level of knowledge and understanding of CBRNe prevention and management strategies within the general population

3.4.1. Public perceptions and understanding of CBRNe incidents and management

Some studies concerning knowledge and understanding within the general population reported that the public felt a sense of fear, worry and concern associated with CBRNe incidents, whether hypothetical in nature [14] or potential future incidents [22]. Studies reported differences regarding baseline public awareness of CBRNe incidents. A small number of studies demonstrate relatively high levels of understanding [26, 56]; for example, Mihai et al. (2005) concluded that 79% of participants who were aware of emergency plans could provide correct examples of emergency measures. Furthermore, studies provided information that participants were aware of taking some precautionary measures and demonstrating preparedness prior to information reception, for example having an emergency kit prepared [42]. However, preparedness was not a consistent finding across studies as very low levels of engagement with preparedness were also apparent [22]. Some studies highlighted that there were many misconceptions around the presentation and potential of radiological incidents [35, 43], and these commonly consisted of perceptions that dirty bombs were not perceived as a common threat or current concern [35, 43].

3.4.2. Knowledge and understanding of specific CBRNe prevention and management strategies

The studies examined several prevention and management strategies, including shelter-in-place, the Homeland Security Colour System, Potassium Iodide (KI) distribution campaigns, warning signals, information sheets, and leaflets. Research revealed that the strategies were highly confusing for participants, and there was not enough awareness or knowledge of the strategies. Specifically, shelter-in-place as a concept was considered confusing across studies [14, 28], with some concluding that despite having knowledge of the concept, the strategy could still not be fully described [43]. Confusion was also apparent regarding the Homeland Security Colour System [14], and Potassium Iodide (KI) pills distributed via campaigns; as there was an apparent lack of understanding in how individuals can obtain a KI pill in the case of an emergency [26], and when KI should be taken [33]. Warning signals had the potential to result in both the taking of unnecessary actions (e.g. recommended behaviours carried out in unaffected areas; [45]) and failure to take necessary actions (e.g. knowing to tune into the Emergency Alert System upon hearing the 3-minute signal; [33]). Information sheets and leaflets, for instance a Nuclear Safety Information Leaflet distributed by a nuclear site operator [39], were often hard to understand [39, 51], ineffective [27] and poorly remembered [39]. Ultimately, there was a consensus apparent across the literature which suggests that the public have a limited knowledge of CBRNe prevention and management strategies, as they are often viewed as confusing [14, 26, 28, 39, 51] and unclear [33, 43, 45].

In summary, review of the research concluded that the public are worried about potential CBRNe incidents. There are also varied levels of preparedness displayed throughout research; but most studies demonstrate that there is still room for improvement in current public protective methods. Furthermore, the public often view official prevention and management strategies as confusing and unclear due to complexity and a lack of knowledge.

3.5. Identification of factors which are associated with effective pre-incident public information campaigns for CBRNe terrorism

When synthesising data from the studies which examined effective factors associated with pre-incident information, four themes emerged concerning factors associated with effective pre-incident information: ease of understanding; credibility of spokesperson; mode of dissemination; and psychological constructs. These are considered in turn in the following sub-sections.

3.5.1. Ease of Understanding

Pre-incident CBRNe information is commonly disseminated using leaflets and informational texts (as shown in [27, 39, 51]). However, these have been criticised for being difficult to understand (often expressed as low informational recall following reading; Hellier, 2014) and containing complex wording which is not suitable for many populations [41, 51]. Recommended changes to informational texts and leaflets are relatively consistent across studies, with guidelines often consisting of rewording [30, 51] and the use of visual material [51] to assist in making the resource user friendly [30]. These recommendations have been showcased to be effective using multi-phase studies, in which participants are asked to review a currently existing leaflet, and feedback is subsequently used to aid in the creation of an adapted leaflet or informational text (e.g. [39, 46]). For example, Hellier et al. (2014), created a leaflet which: was highly approved by the participant group; was shorter in length; presented a lower reading age, and; used definite and explicit language. Ability to recall information from the leaflet (i.e. recommended advisories to be taken in the case of an event) was also improved after reading the adapted leaflet in comparison to the original [39]. Additionally, successful pre-incident information has been novel in quality (e.g. featuring a cartoon character as a spokesperson), specific, easy to understand [55], and incorporated well versed analogies to allow information to be more applicable to the public [29].

3.5.2. Credibility

Credibility of information is becoming more important to the public as trust in media and previously trusted sources (e.g. next-door neighbours) has decreased over time [47], suggesting that more credible sources are preferred when information is communicated to the public. Furthermore, aiding in the shift away from pre-conceptualised beliefs (e.g. negative effects relating to the radiological impact of living near a nuclear reactor) held by the public is possible, but is more effective when messages are delivered through credible sources [29]. Research is mixed as to the importance of source credibility when communicating information to the public. Some studies suggest that, while different sources (e.g. scientists, authorities and the nuclear industry) are perceived as more or less credible, they are nevertheless, equally effective in communicating mitigation actions to the public [56]. However, a higher proportion of studies recommend having a credible spokesperson delivering information [14, 29, 37].

3.5.3. Mode of Dissemination

The majority of studies within this review disseminated pre-incident information to the public using forms of written communication (i.e. leaflets [37, 39], informational sheets [18, 30, 46], booklets [27], and instructions with kits [49]). Other methods used included a television news segment [56] and a spokesperson [29].

The use of written communication (i.e. leaflets and informational texts) was perceived positively by members of the public, as they are tangible and therefore are harder for the government to retract [35]. Additionally, leaflets have been deemed by some to be successful in communicating pre-incident information, especially when developed following feedback from the public (e.g. shorter with less complex information [37]). However, within some literature, the effectiveness of written communication has been questioned as distribution needs are not always met when releasing information (i.e., with vast reports of non-receipt; [27, 39]). Furthermore, findings that demonstrate effectiveness of written communication are largely captured under controlled research settings [28, 37]; real life studies of such communications have yielded low percentages of participants claiming to have read and remembered various distributed pre-incident information, including a booklet [27], and a leaflet [39].

Ensuring campaigns are adequately disseminated is important to ensure the public are aware of pre-incident information and campaigns available to them. As demonstrated by Zwolinski et al. (2012), despite bulk mailing vouchers, using media advertising and informational web postings only a small percentage of the intended population were aware of the campaign. However, support was shown by Carney et al. (2003) who supported the importance of advocating campaigns across multiple platforms, including posters, information packets and newspaper articles as five months into the current more than 1,000 individuals had requested and received a KI pill. It may, therefore be, that the use of multiple modes of dissemination are most appropriate to overcome issues with alleged non-receipt and awareness.

3.5.4. Psychological constructs

Research has supported the use of pre-incident information to incorporate both emotional and rational appeal [29] when educating the public. For radiological and nuclear incidents specifically, it is also helpful to explain the benefits associated with the nuclear industry as it aids familiarity and reduces threat [29]. The use of 'Safety in Place Kits', which consisted of items which would be used in the event of an accident at a chemical storage facility, were highly effective in increasing symbolic safety and trust in officials whilst reducing anxiety in relation to a potential future incident [49].

In summary, review of the research revealed that in order to be effective, pre-incident information should: be easily understandable; delivered by a credible source; be disseminated via multiple platforms; and incorporate psychological constructs which reduce anxiety and provide emotional and rational appeal.

3.6. Understanding factors that may increase public compliance with both recommended prevention and protective measures

When synthesising studies which aimed to understand factors that may increase public compliance, data was split into two categories: studies that recommended preventative measures (i.e. prior to incident) and studies that recommended protective measures (i.e. communication during an incident).

3.6.1. Public compliance with preventative measures

In relation to data which concerned factors which increased compliance with recommended prevention measures, three themes emerged: demographics, prior knowledge and psychosocial factors.

3.6.1.1. Demographics

Demographic characteristics including gender, location and level of education may affect the rate of compliance with preventative measures in relation to CBRNe incidents. Females are reported to display more compliant behaviours [22], and young males do not always comply with instruction [18]. Having lived in a location more likely to experience CBRNe incidents, for example, living near a nuclear installation [36] or living in an urban area influenced knowledge on incidents and concern with potential incidents [28]. Additionally, those who have a higher level of education have been reported to have a higher levels of both understanding [51] and recall [36] of pre-incident information, and are therefore more likely to engage in taking preventative measures prior to an incident occurring.

3.6.1.2. Prior Knowledge

Prior knowledge has been identified as a factor which may increase public compliance with recommended preventative measures. For example, if people do not have a certain level of knowledge, communicated messages will not trigger the needed attention to be heard or recalled [36]. Similarly, watching television, reading newspapers and internet use (i.e. gaining knowledge) has been associated with higher levels of understanding of supplemental texts informing about radiation featuring complex wording [40, 51]. A lack of prior knowledge also contributes to the likelihood of individuals misunderstanding information. For example, when asked how a KI pill would be received following a radiological disaster only 19% of participants were able to identify the correct source [26] (Blando et al., 2007) and only 60% of participants would comply with not taking a KI pill until instructed to through official communication [26]. An initial understanding of the effectiveness of the strategy shelter-in-place is also apparent as it is believed to merely be a method which would calm people down in the event of an incident [49], which may result in non-compliance with official instruction.

The level of knowledge can be increased through training and education: as workers who have not received the adequate training (due to literacy, language and instruction format issues) were significantly more likely to display non-compliant behaviours when working [18]; and engagement with more informational resources led to a better level of understanding of complex texts [51]. Therefore, when communicating recommended preventative measures with the public it is necessary to refrain from adopting a one size fits all strategy which may not be applicable and comprehensible to all populations [46].

3.6.1.3. Psychosocial factors

Research revealed that public compliance with recommended preventative methods may be affected by the emotions associated with CBRNe incidents [49]. For example, if a sense of hopelessness is apparent and there is a sense that nothing could be done if an incident did occur [49], the willingness to comply with official instruction may be limited.

Motivation to carry out preventative measures is also increased if there is a sense of dread associated with a potential incident [47, 55]. Furthermore, research has highlighted that perceived risk is indicative of whether compliance will be shown within a working context [18] (i.e. the higher the perceived risk, the more likely an individual is to comply with official instruction and preventative measures).

In summary, review of the research revealed that demographic factors, including a higher level of education, being female and living in an area more likely to experience a CBRNe incident were all positively associated with engagement in preventative measures. Additionally, higher levels of knowledge concerning why preventative measures are necessary is associated with an increase in public compliance, and this can be effectively raised through the use training and education interventions. Psychosocial factors such as a sense of hopelessness may negatively influence compliance with protective measures, whereas a sense of dread or increased risk will positively influence public compliance with preventative measures.

3.6.2. Public compliance with protective measures

In relation to data which concerned factors that increased compliance with recommended protective measures, five themes emerged: trust; provision of information; emotional responses; efficacy; and relationships. These are considered in turn in the following sub-sections.

3.6.2.1. Trust

The response to information (e.g., positive or negative) is influenced by the level of trust associated with both the spokesperson and source [24, 43, 47]. Furthermore, the level of risk awareness is also negatively correlated with trust in industry officials; that is, the higher the perceived risk of a situation, the lower trust associated with industry officials [47]. Research has also concluded that there is concern as to whether spokespersons communicating official information would tell the truth, or whether their aim would just be to keep the public calm [43]. There are also low levels of trust associated with public health professionals (which affected the likelihood of an individual being willing to shelter-in-place; [42]); with television and news reports (which lead to young males stating they would seek local information from well trusted sources including neighbours; [43]); and all official sources including the police, the Mayor and the federal government [24, 43]. Ultimately, across studies, there is a preference for local resources (i.e. hazard groups and health departments; [42, 43]).

Compliance with recommended protective measures was also motivated by the level of trust associated with the spokesperson and source [14, 34, 38]. Remaining inside when asked in the event of a chemical incident was significantly associated with higher levels of trust [34], and compliance within a mass decontamination experiment was significantly associated with the extent participants trusted emergency responders [38]. Trust in protective measures was also apparent, as individuals were more willing to engage in tried and tested methods [14].

3.6.2.2. Provision of Information

Research indicates that people become more compliant with instruction from authority when sufficient information is provided [37, 38]. A mass decontamination study concluded that participants who received more information about the decontamination process, and why it was necessary, were

more willing to comply in comparison to those given basic or no information at all [38]. This was also apparent within both wet and dry decontamination conditions even though dry decontamination was considered significantly less effective by participants than wet decontamination [38]. Therefore, once individuals are made aware of information which makes compliance easier, i.e. what they should do, and why they should do it, people are more willing to comply with official instruction [38]. Research indicates that the public are willing to seek information and gain knowledge through their own means following an incident when they feel undereducated [44]. Additionally, willingness to comply post-education has also been shown in a hypothetical context as participants are more receptive to official advice from authority following education from a leaflet [37].

3.6.2.3. Emotional Responses

Anxiety towards incidents can have a strong impact on willingness to comply, and studies have concluded that anxiety can have a negative effect on willingness [34, 42]. For example, people are more willing to comply with shelter-in-place strategies when they are in their home in comparison to an unfamiliar environment [34]. Additionally, those who had been previously subject to evacuation, whether compulsory or not were found to be more anxious and have a higher sense of risk of a future incident than those who did not evacuate [48, 57]. Anxiety levels were also affected by having children [57], and higher levels of fear were associated with a low trust in government [32].

Fear towards incidents also has a potential effect on the willingness to comply with instruction. If instruction was paired with fear of sickness, contamination or death [35, 38, 45], participants were more willing to engage in various protective measures. Compliance has also been reviewed to continue following announcement that contamination was no longer apparent, under the belief of 'better safe than sorry' [52]. Additionally, the use of evidence-based risk communication has the ability to increase levels of knowledge as well as allowing the public to make their own decisions regarding the risk and protective measures [48]. However, some research is inconclusive in regards to the impact of fear on public behaviour, with fear being associated with both the likelihood of fleeing regardless of information given to affected individuals and also with careful evaluation of any information given [22].

Fear as a construct was more common for women [20, 22], those living in an urban area [20, 22, 28], and those who are lowly educated [22].

3.6.2.4. Efficacy

Both self-efficacy and response efficacy were associated with compliance with shelter-in-place instruction [34]. The ability to cope, i.e. coping appraisal is also reported to be a key predictor of compliance in both familiar and unfamiliar environments [34]. Confusion toward the incident also has the effect that participants may not follow the strategy fully due to a lack of knowledge [54].

3.6.2.5. Relationships

There was a consensus across research that the rate of compliance would be highly affected by ensuring the safety of family, pets and friends [14, 34, 37, 42, 43], and this was applicable to shelter-in-place official notices. Collecting children from school [34], finding parents [14, 43] and ensuring pets safety [14, 42] were key reasons for non-compliance with official communication.

In summary, review of the research revealed that trust in both spokesperson and source are associated with increased compliance during an event, with an apparent preference for local sources over governmental or official communication. Additionally, the more information made available to the public during an incident, regarding why and how they should comply, will increase the level of compliance shown. Anxiety can negatively affect the willingness to comply, whereas fear can motivate the public to comply with official instruction. Self-efficacy, response-efficacy and the ability to cope with the situation at hand were all associated with how much compliance would be shown by the public. Lastly, the desire to seek out loved ones during an incident and ensure their safety has a large effect on public willingness to comply with protective measures.

4. DISCUSSION

This review aimed to assess the level of public preparedness relating to CBRNe incidents. In relation to the aims, the review sought to: determine the public's current level of knowledge and understanding of CBRNe prevention and management strategies; identify factors which are associated with effective pre-incident public information campaigns; understand factors that have potential to increase public compliance with preventative and protective measures; and to identify and understand insights from literature concerning other types of incidents which may be of relevance for CBRNe preparedness. The 41 papers included within this review were published between 2003 and 2019, with a cluster of publications in 2016 (there was no apparent commonality between these papers). Studies were predominantly Western in origin, with over half of the total papers published by first authors from institutions located in the USA or UK, suggesting a bias in the research field. Various study designs were used within the papers: over half of the methods consisted of questionnaires or surveys administered in different ways (e.g. via telephone, in person and online), focus group research was also common as was utilising a mixed method. All types of CBRNe incidents were incorporated within the included studies, with an apparent preference for chemical, radiological, and nuclear incidents in comparison to biological incidents. Furthermore, many papers included samples that were not representative of a wider population (e.g. students [38, 51], use of a low literacy sample of participants [46]). As a result, there is substantial methodological variation present across the included papers.

Results which related to the current level of knowledge and understanding of CBRNe prevention and management strategies indicated that initial levels of preparedness apparent among the public vary between populations used within research. For example, many were aware of correct emergency plans [25], and some had an assembled emergency kit [35], whereas others displayed low levels of engagement with preventative measures [22] and were misinformed about radiological incident presentation [35, 43].

Furthermore, understanding in relation to CBRNe prevention and management strategies is currently very low. There was a consensus toward management and prevention strategies (e.g. Shelter-in-Place, The Homeland Security Colour System and KI distribution campaigns) being viewed by the public as confusing, and often without meaning [14, 26, 28, 33, 43].

Effective pre-incident public information campaigns were characterised by four factors: ease of understanding, credibility, mode of dissemination and psychological constructs. Sources which

ensured that the information was presented in a user-friendly way (i.e. non-complex, novel and explicit in instruction [47, 55]) were highly effective at encouraging public engagement with the material [39, 46]. Dissemination of information using a credible source also aided in effectiveness [14, 29, 37]. The use of written communication is viewed positively by the public [35], but when disseminated the effectiveness is questionable (i.e. due to claimed non-receipt and effectiveness only shown through the use of control trials [27, 28, 37, 39]). Taken together, research has therefore demonstrated that pre-incident information is most effective when advocated across multiple platforms over a long-time period to allow user engagement and awareness [23, 33]. Furthermore, pre-incident information should seek to reduce anxiety by providing familiarity with potential incidents and provide emotional and rational appeal [29, 49].

Factors associated with public compliance with recommended preventative measures prior to an incident included: demographics, prior knowledge, psychosocial factors and trust. Demographic factors include: gender (females reported to be more compliant in comparison to males [22]); education level (those with a higher level of education are more likely to engage in the uptake of preventative measures [36, 51]); and location (those who are in closer proximity to a site which has the potential to cause a CBRNe incident are more likely to have higher levels of concern and knowledge of incidents [36] [28]). Prior knowledge is essential in ensuring the public can understand, remember, and recall information [36, 40, 51]. Additionally, psychosocial factors were also identified as having variable associations with compliance [47, 55]. For example, a sense of hopelessness is negative associated with compliance with official instructions [49].

Lastly, factors associated with potential public compliance with recommended protective measures during an incident include: trust, provision of information, emotional responses, efficacy and relationships. For example, providing a trustworthy source is highly effective in influencing compliance with official communication during an incident [14, 34, 38]. During an incident, the more information made available to the public (e.g. how and why official instruction should be followed), the higher the rate of compliance [37, 38]. Anxiety and fear as emotional responses to an incident influence public compliance; anxiety is indicative of a higher level of noncompliance [34, 42], whereas fear is indicative of a higher level of compliance [35, 38, 45]. Self-efficacy, response-efficacy and coping ability were all associated with compliance with official instruction [34]. Ensuring the safety of loved ones was also suggestive of low levels of compliance with official instruction [14, 34, 37, 42, 43].

4.1. Lessons learnt from other incidents

A systematic review carried out by Carter, Drury and Amlôt [58] focused on the creation of recommendations for improving engagement with CBRN pre-incident public information. The review incorporated 44 studies which examined the effect of pre-incident information on public preparedness, public ability to take protective actions, or examined factors which sought to improve efficacy of pre-incident communication. The 44 studies included a wide range of different disaster types (including but not limited to: infectious diseases; natural disasters; terrorist attacks; evacuation procedures, and; CBRN incidents more generally). The systematic review concludes that education provided pre incident mainly resulted in an increase in preparedness knowledge, behaviour or protective intentions in comparison to providing no information at all. The recommendations made by Carter, Drury and Amlôt [58] based on the findings of their review provide an insight into what

makes pre-incident materials effective for CBRN and other types of major incidents (e.g. natural disasters, evacuations).

In relation to what information should be included within pre-incident information, Carter, Drury and Amlôt [58] recommended that the materials should contain:

- Information about potential consequences of CBRNe incidents;
- The ways in which CBRN agents may be transmitted;
- The actions that people can take to protect themselves and others during a CBRN incident;
- The efficacy of protective measures that people can take to protect themselves and others during CBRN incidents and the importance of taking such actions.

The academic literature cited within this systematic review produced similar outcomes. There was a preference for the public to be provided with factual information, both in relation to pre-incident materials [37] and during incident communication (e.g. mechanisms through which someone could be affected by radiation [35]) [14, 43]. Additionally, the findings from the review also align with the recommendations to provide actions that people can take to protect themselves and others, and the efficacy and importance of taking these protective measures [34, 14, 28].

In terms of how pre-incident information is provided, Carter, Drury and Amlôt [58] also recommend that: “pre incident information for CBRN incidents should be provided using multiple methods, all of which should contain consistent information”. This recommendation is also a key finding established from the academic literature cited within this deliverable [33, 37].

Additional factors that were recommended by Carter, Drury and Amlôt [58] to consider when pre-incident information is developed include: “consideration should be given to using higher intensity interventions (e.g. training courses and video games) to deliver pre-incident information for CBRN incidents, when possible”. Similarly, this recommendation is also supported by the findings presented in this deliverable, as incorporation of novelty elements [47, 55] and educational programs were deemed to be beneficial in reducing anxiety [21] and improving knowledge [37, 51] within the academic literature used within this review.

The review by Carter, Drury and Amlôt [58] included a wealth of different incident types (e.g. infectious diseases, natural disasters, terrorist attacks, evacuation procedures and CBRN incidents) in comparison to this review which focused on CBRNe events (e.g. chemical spills and contamination, dirty bombs, and nuclear accidents). Nevertheless, the conclusions and recommendations of each review are complimentary and supportive of one another, which suggests the recommendations provided as a key output of this deliverable are applicable in both CBRNe incidents and other types of incidents (e.g. pandemic diseases, building evacuations, natural disasters, etc.).

4.1.1. COVID-19

While considering literature relating to preparedness for non CBRNe terrorist incidents, it is important to consider the recent COVID-19 pandemic and the wealth of current and relevant work which details recommendations for harnessing human factors during incident response.

A recent review of reviews conducted by Weston, Ip and Amlôt [59] which aimed to examine the application of behaviour change theories in the context of infectious disease outbreaks and emergency response resulted in several recommendations for applying behavioural science and human factors in practice.

Primarily, the researchers recommended that those working in the context of infectious disease and emergency response, should: a) draw on the available theoretical literature and; b) work with experts in behavioural science to inform both empirical work to understand behaviour, and the design and implementation of interventions to affect behaviour. This recommendation is supported by a several sources which stress the importance of behavioural change theories (e.g. [60], which states behaviour change theories and constructs should be used to inform the development of policy and practice for increasing uptake of self-protective behaviours).

Recent work from Michie, West, Amlôt and Rubin [61] established 5 key behaviour change principles for the slowing down the COVID-19 outbreak. These consisted of the following steps:

- Create a mental model (e.g. ensure the public has an accurate mental model of the transmission process, provide a strong rationale for what they need to do to prevent it);
- Create social norms (e.g. by using media campaigns to target people's self-identity);
- Create the right level and type of emotion (i.e. couple all anxiety provoking messaging with actions that people can do to protect themselves);
- Replace one with another (e.g. keep your hands below shoulder level instead of touching your face);
- Make the behaviour easy (i.e. build it into an established routine).

Additionally, Weston, Ip and Amlôt [59] also recommend considering the application of the COM-B (Capability, Opportunity, Motivation and Behaviour; [62]) model when both conducting research or delivering research into practice. The COM-B model seeks to target capability, opportunity and motivation in order to evoke a desired change in behaviour. This model has been advocated when aiming to reduce the transmission of COVID-19 during the pandemic [60]. Recent work from Michie, West and Amlôt [63] provides context of the potential of COM-B model use when aiming to reduce transmission, for example: the importance of focusing on a small number of key behaviours rather than a long list which will be hard to remember (also supported by: [60, 61]).

Additional sources have indicated other methods of using human factors within the COVID-19 response, for example: to work with community members to ensure accessibility and appropriateness of advice and support to those from different backgrounds to increase, and promote a sense of community effort in beating COVID-19 [64]; to provide evidence based care to pregnant women, as well as ensuring both healthcare professions and the women are well informed about public health recommendations and current guidance [65]; to focus on common interests and identity to engage people in commitments that need to be made [66]; and, the importance of listening to and recognising community support groups and allow them to sustain themselves over time [67].

The COVID-19 pandemic has highlighted the importance of human factors and behavioural intervention in combatting and overcoming infectious disease outbreaks. The current review

ascertained that psychological constructs which reduce anxiety and provide emotional and rational appeal should be used within communication with the public. Therefore, the insights derived from the COVID-19 pandemic reinforce the outputs of this systematic review in real life context.

4.2. Importance of trust, legitimacy and information sharing in CBRNe incidents

The outputs of this review highlight the importance of establishing trust and legitimacy towards emergency responders and agencies from a public perspective in relation to both CBRNe preparedness and response (e.g. providing a trustworthy source is highly effective in influencing compliance with official communication during an incident [14, 34, 38]). Additionally, the current review established that the more information made available to the public during an incident (e.g. how and why official instruction should be followed), the higher the rate of compliance [37, 38].

These key findings compliment wider research conducted in the context of emergency preparedness and response. For example, research carried out by Carter, Drury, Amlôt, Rubin & Williams [68] investigated the importance of responder communication strategies in a multiagency (Fire and Rescue Service, Police and the Ambulance Service) mass decontamination field exercise. The scenario used in this exercise involved deliberate release of an unidentified chemical in a large room full of people attending a conference. This research found that effective responder communication strategies and the provision of practical information had the ability to significantly increase the level of compliance shown by the public [68]. Additionally, this same piece of research also established that the most efficient strategy for providing communication to the public is to include both health-focused explanations paired with practical information, as this has resulted in having the fewest cases of confusion and noncompliance in a decontamination trial [68]. These findings are in line with the outcomes of this deliverable (i.e. the more information made available to the public (e.g. how and why official instruction should be followed), the higher the rate of compliance [37, 38], and self-efficacy, response-efficacy and coping ability were all associated with compliance with official instruction [34]).

Furthermore, research into communication in CBRNe incidents has provided recommendations in how responders should aim to communicate with the public [69,70,71]:

- Responders should understand that the way in which they manage an incident will impact on the way in which members of the public behave;
- Effective communication strategies should be developed which are designed to enhance public compliance and cooperation;
- Responders should communicate openly and honestly about the nature of the incident and provide regular updates about actions being taken; Responders should demonstrate respect for public needs;
- Communication should emphasise the health benefits of taking recommended protective actions; provide information in a timely way; and, provide sufficient practical information to enable members of the public to take appropriate actions.

The findings from studies which focus on responder communication (i.e. [67, 68, 69, 70, 71] paired the findings from this systematic review therefore provide complimentary evidence that both public perception of trust and legitimacy in agencies and responders are important factors in CBRNe preparedness and response, as these can have a positive influence on public compliance and cooperation.

4.3. Suggestions for future communication

As a result of the literature synthesised within this review, several recommendations can be made for increasing effectiveness of both future pre-incident campaigns and peri incident communications with the public. At this stage, these recommendations should be considered preliminary. Following the integration of this review with the review of guidance documentation conducted for deliverable D1.2 (findings from systematic review of current policy for mitigation and management of CBRNe terrorism), a finalised series of recommendations will be included within deliverable D1.3 (guidelines and recommendations for mitigation and management of CBRNe terrorism).

4.3.1. Pre-Incident information

Pre-incident information should be delivered to the public using multiple sources [33, 37]. It should be culturally appropriate [20], easy to understand, and noncomplex [37, 39, 51]; allowing the information to be accessible for all [41]. Additionally, pre-incident information should meet the needs of the intended audience [37, 46], incorporate factual proof [37] and use a credible spokesperson (e.g. a specialist) [29] to account for the preference for information received via higher sources [47]. Furthermore, incorporation of novelty has been effective in dissemination of pre-incident information (e.g. using a cartoon character [47, 55]), which may provide an additional route for effective delivery of pre-incident information.

Furthermore, it may prove beneficial to implement more educational programs or to implement methods to raise awareness (i.e. interventions) as research indicates these are effective at: reducing anxiety [21], improving knowledge; [37, 51], and raising education, to allow members of the public to effectively attend to, and remember, information [36].

Alongside the importance of pre-incident information and education, it is also necessary to consider that there is a possibility of provoking worry in members of the public that are not currently worried when circulating pre-incident information regarding CBRNe incidents [19, 34], so this should be done so mindfully. It is also important to remember that pre-incident information is not a substitute or replacement for real-time information for an ongoing incident [37].

4.3.2. During Incident Communication

Communication should focus on ensuring the protection of the public's health [14], and should aim to influence the perceived efficacy of recommended behaviours [34]. To advocate effective communication with the public in the event of a CBRNe incident, officials should: utilise a trusted spokesperson [14, 43], whilst tailoring the spokesperson to what is preferred by the population at hand (e.g. local sources [42, 43]); accompany information with facts or proof to provide robustness [14, 43] (e.g. mechanisms through which someone could be affected by radiation and the known geographical spread of any risk [35]); meet the needs of the intended audience (e.g. publish information in multiple languages [14, 24] to aid vulnerable groups [54]); and incorporate answers to

popular questions regarding CBRNe incidents, for example: what to do when driving in a car [14, 28], and [if applicable] what the incident or contaminant was [14, 38].

4.4. Gaps in the literature

Throughout the process of conducting this review, several gaps were identified in the current literature. Firstly, there was a bias towards Western research in the included literature, with a small amount of papers relating to non-Western countries. Therefore, further research is warranted into pre-intervention CBRNe information and education in non-Western populations.

There was a preference indicated towards research concerning chemical, radiological and nuclear events. Biological incidents were under researched in the areas of pre-incident and during incident communication (in the current review $n = 3$). Therefore, further research should seek to evaluate the current level of knowledge regarding biological incidents across populations.

There were methodological limitations apparent across a high proportion of the papers used within this review, which can be targeted when future research is conducted. For example, the included papers have demonstrated that more research should aim to utilise a large, and therefore generalisable sample, as roughly only one in three papers claim to be representative of a wider population (Appendix D). Additionally, many of the papers used a questionnaire or survey to collect data, which did not allow for the in-depth appraisal of pre-incident information which could have been provided through qualitative methods. As a result, it is suggested that more papers seek to use a mixed method design which allowed for both quantitative and qualitative measures to be encompassed (in the current review, $n = 5$).

4.5. Limitations and Future Considerations

Although this review does present thorough, robust, and methodically sound evaluation of the literature concerning current knowledge and understanding of, and factors influencing adherence to, CBRNe prevention and preparedness strategies among the general population, it is important to consider that there were some limitations.

Firstly, although the search terms used in this review do include literature concerning CBRNe incident response (See Table 2), the search terms used emphasise pre-incident and preparedness information. This emphasis is entirely consistent with the PROACTIVE project emphasis on preparedness information, and as such the review focuses on public perceptions of prevention and preparedness strategies. Nevertheless, it is worth considering that there may be a broader literature concerning CBRNe response which is not covered herein. For readers interested in this literature, it is worth noting that the following reviews, specifically focused on CBRNe response, may be of relevance: [72, 73]. Furthermore, PROACTIVE deliverable D1.2 provides an analysis of tools, policy and guidance documents relating to CBRNe response, which may provide further detail.

Secondly, this deliverable does not include non-published 'grey' literature, and so there may be additional non-published research that could contribute to the recommendations detailed herein. Nevertheless, the review does represent a comprehensive search of the published literature, conducted using databases across multiple academic disciplines. Further work to incorporate the 'grey' literature available from previous project deliverables, in order to inform recommended outcomes, will be conducted as part of the review synthesis in D1.3.

5. CONCLUSION

This systematic review identified 41 papers which pertained to the inclusion/exclusion criteria. By extracting a range of data including: the location of first author, sample characteristics, methodological procedure, and the type of incident described, this research was able to identify common themes apparent throughout the 'state of the art' research concerning pre-incident information.

Following the synthesis of results, it became apparent that the general public's current understanding of CBRNe prevention and management strategies is very low. Across literature there was consensus that official protective and preventative recommendations are often misunderstood, complex and confusing to the public. Effective pre-incident communication was characterised by being easy to understand with the use of non-complex language, disseminated across multiple platforms, delivered by a credible source, and incorporate psychological constructs that aim to reduce threat and anxiety. Factors which have the potential for increasing willingness to engage in pre-incident and preparedness information, included: demographics, prior knowledge and psychosocial factors. Factors which have the potential of increasing compliance with official instruction during an incident, included: trust, provision of information, emotional responses; efficacy and relationships.

On the basis of these outcomes, several provisional recommendations are detailed, alongside potential gaps for further research. For example: pre-incident information should be communicated in a culturally appropriate way, whilst being easy to understand, accessible and factual; and, communication during an incident should be delivered by a trustworthy spokesperson, present useful and needed information, and incorporate facts or proof to provide robustness. Gaps in the research were apparent due to a lack of consideration for biological incidents, and a lack of papers using a non-Western sample. These recommendations and gaps will be further explored when the outcomes from D1.1 are synthesised with D1.2 for presentation within D1.3.

6. REFERENCES

1. Slovic, P., What's fear got to do with it-It's affect we need to worry about. *Mo. L. Rev.*, 2004. 69: p. 971.
2. Slovic, P., et al., The affect heuristic. *European Journal of Operational Research*, 2007. 177: p. 1333-1352.
3. Schneidmiller, C., Nuclear smuggling shows terrorist WMD threat persists: State Department. *Global Security Newswire*, 2012, August 1.
4. City of London Police., Run, Hide, Tell. 2017; Available from: <https://www.cityoflondon.police.uk/advice-and-support/countering-terrorism/Pages/stay-safe.aspx>.
5. NHS England., Report, Remove, Rinse. 2017; Available from: <https://www.england.nhs.uk/2017/08/new-help-for-acid-attack-victims-following-recent-rise-in-demand-for-nhs-help/>.
6. British Transport Police., See it. Say it. Sorted. 2016; Available from: <https://www.cityoflondon.police.uk/advice-and-support/countering-terrorism/Pages/stay-safe.aspx>.
7. Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G., Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. . *Annals of Internal Medicine*, 2009. 151(4): p. 264-269.
8. Braun, V. and V. Clarke, Using Thematic Analysis in psychology. *Qualitative research in psychology*, 2006. 3(2): p. 77-101.
9. Hanchett, S., et al., Increasing awareness of arsenic in Bangladesh: lessons from a public education programme. *Health policy and planning*, 2002. 17(4): p. 393-401.
10. Renaud, J., et al., Evaluation of the effectiveness of arsenic screening promotion in private wells: A quasi-experimental study. *Health Promotion International*, 2011. 26(4): p. 465-475.
11. Khan, K., et al., Evaluation of an Elementary School-based Educational Intervention for Reducing Arsenic Exposure in Bangladesh. *Environmental health perspectives*, 2015. 123(12): p. 1331-1336.
12. Kennedy, J., et al., Public perceptions of the dioxin incident in Irish pork. *Journal of Risk Research*, 2010. 13(7): p. 937-949.
13. Mello, S. and S.R. Hovick, Predicting Behaviors to Reduce Toxic Chemical Exposures Among New and Expectant Mothers: The Role of Distal Variables Within the Integrative Model of Behavioral Prediction. *Health education & behavior: the official publication of the Society for Public Health Education*, 2016. 43(6): p. 705-715.

14. Becker, S.M., Emergency communication and information issues in terrorist events involving radioactive materials. *Biosecurity and bioterrorism : biodefense strategy, practice, and science*, 2004. 2(3): p. 195-207.
15. Chess, C. and L. Clarke, Facilitation of risk communication during the anthrax attacks of 2001: The organizational backstory. *American Journal of Public Health*, 2007. 97(9): p. 1578-1583.
16. Lovelace, K., et al., All-hazards preparedness in an era of bioterrorism funding. *Journal of public health management and practice : JPHMP*, 2007. 13(5): p. 465-468.
17. Quach, T., et al., Improving the knowledge and behavior of workplace chemical exposures in Vietnamese-American nail salon workers: a randomized controlled trial. *International archives of occupational and environmental health*, 2018. 91(8): p. 1041-1050.
18. Andrade-Rivas, F. and H.-A. Rother, Chemical exposure reduction: Factors impacting on South African herbicide sprayers' personal protective equipment compliance and high risk work practices. *Environmental research*, 2015. 142: p. 34-45.
19. Lee, J.E.C. and L. Lemyre, A social-cognitive perspective of terrorism risk perception and individual response in Canada. *Risk Analysis*, 2009. 29(9): p. 1265-1280.
20. Alshehri, S.A., Y. Rezgui, and H. Li, Public perceptions and attitudes to biological risks: Saudi Arabia and regional perspectives. *Disasters*, 2016. 40(4): p. 799-815.
21. Kuroda, Y., et al., Association between health literacy and radiation anxiety among residents after a nuclear accident: Comparison between evacuated and non-evacuated areas. *International Journal of Environmental Research and Public Health*, 2018. 15 (7) (no pagination)(1463).
22. Boscarino, J.A., C.R. Figley, and R.E. Adams, Fear of terrorism in New York after the September 11 terrorist attacks: implications for emergency mental health and preparedness. *International journal of emergency mental health*, 2003. 5(4): p. 199-209.
23. Carney, J.K., et al., Enhancing nuclear emergency preparedness: Vermont's distribution program for potassium iodide. *J Public Health Manag Pract*, 2003. 9(5): p. 361-7.
24. Henderson, J.N., et al., Chemical (VX) terrorist threat: public knowledge, attitudes, and responses. *Biosecurity and bioterrorism : biodefense strategy, practice, and science*, 2004. 2(3): p. 224-228.
25. Mihai, L.T., et al., Ionizing radiation - Understanding and acceptance. *Health Physics*, 2005. 89(4): p. 375-382.
26. Blando, J., et al., Assessment of potassium iodide (KI) distribution program among communities within the Emergency Planning Zones (EPZ) of two nuclear power plants. *Health Physics*, 2007. 92(2 SUPPL. 1): p. S18-S26.
27. Hildebrand, S. and A. Bleetman, Comparative study illustrating difficulties educating the public to respond to chemical terrorism. *Prehospital and disaster medicine*, 2007. 22(1): p. 35-41.

28. Wray, R.J., et al., Communicating with the public about emerging health threats: lessons from the Pre-Event Message Development Project. *Am J Public Health*, 2008. 98(12): p. 2214-22.
29. Bisconti, A.S., Communicating with stakeholders about nuclear power plant radiation. *Health physics*, 2011. 100(1): p. 97-102.
30. Hambach, R., et al., Workers' perception of chemical risks: A focus group study. *Risk Analysis*, 2011. 31(2): p. 335-342.
31. Rubin, G.J., R. Amlôt, and L. Page, The London polonium incident: lessons in risk communications. *Health physics*, 2011. 101(5): p. 545-550.
32. Goodwin, R., et al., Modelling psychological responses to the Great East Japan earthquake and nuclear incident. *PloS one*, 2012. 7(5): p. 1.
33. Zwolinski, L.R., M. Stanbury, and S. Manente, Nuclear power plant emergency preparedness: results from an evaluation of Michigan's potassium iodide distribution program. *Disaster Med Public Health Prep*, 2012. 6(3): p. 263-9.
34. Pearce, J.M., et al., Communicating public health advice after a chemical spill: results from national surveys in the United Kingdom and Poland. *Disaster medicine and public health preparedness*, 2013. 7(1): p. 65-74.
35. Pearce, J.M., et al., Communicating with the public following radiological terrorism: results from a series of focus groups and national surveys in Britain and Germany. *Prehospital and disaster medicine*, 2013. 28(2): p. 110-119.
36. Perko, T., et al., Communication in nuclear emergency preparedness: a closer look at information reception. *Risk Anal*, 2013. 33(11): p. 1987-2001.
37. Rogers, M.B., R. Amlôt, and G.J. Rubin, The impact of communication materials on public responses to a radiological dispersal device (RDD) attack. *Biosecurity and bioterrorism: biodefense strategy, practice, and science*, 2013. 11(1): p. 49-58.
38. Carter, H., et al., Effective responder communication improves efficiency and psychological outcomes in a mass decontamination field experiment: Implications for public behaviour in the event of a chemical incident. *PLoS ONE*, 2014. 9 (3) (no pagination)(e89846).
39. Hellier, E., et al., Evaluating the application of research-based guidance to the design of an emergency preparedness leaflet. *Appl Ergon*, 2014. 45(5): p. 1320-9.
40. Kanda, H., et al., Internet usage and knowledge of radiation health effects and preventive behaviours among workers in Fukushima after the Fukushima Daiichi nuclear power plant accident. *Emergency Medicine Journal*, 2014. 31(e1): p. e60-e65.
41. Makkar, N., et al., Evaluating awareness and practices pertaining to radioactive waste management among scrap dealers in Delhi, India. *PLoS ONE*, 2014. 9 (3) (no pagination)(e91579).

42. Nyaku, M.K., et al., Assessing radiation emergency preparedness planning by using community assessment for public health emergency response (CASPER) methodology. *Prehosp Disaster Med*, 2014. 29(3): p. 262-9.
43. Bass, S.B., et al., Attitudes and perceptions of urban African Americans of a "dirty bomb" radiological terror event: results of a qualitative study and implications for effective risk communication. *Disaster medicine and public health preparedness*, 2015. 9(1): p. 9-18.
44. Ohno, K. and K. Endo, Lessons learned from Fukushima Daiichi nuclear power plant accident: efficient education items of radiation safety for general public. *Radiation protection dosimetry*, 2015. 165(1-4): p. 510-512.
45. Savoia, E., et al., Public response to the 2014 chemical spill in West Virginia: knowledge, opinions and behaviours. *BMC public health*, 2015. 15: p. 790.
46. Bass, S.B., et al., How Do Low-Literacy Populations Perceive "Dirty Bombs"? Implications for Preparedness Messages. *Health security*, 2016. 14(5): p. 331-344.
47. Heath, R.L. and J. Lee, Chemical manufacturing and refining industry legitimacy: Reflective management, trust, precrisis communication to achieve community efficacy. *Risk Analysis*, 2016. 36(6): p. 1108-1124.
48. Murakami, M., J. Nakatani, and T. Oki, Evaluation of risk perception and risk-comparison information regarding dietary radionuclides after the 2011 Fukushima nuclear power plant accident. *PLoS ONE*, 2016. 11 (11) (no pagination)(e0165594).
49. Ross, J.A., T.H. Deshotels, and C.J. Forsyth, Fantasy objects: The perception of safety of emergency shelter in place kits. *Deviant Behavior*, 2016. 37(6): p. 692-708.
50. Tampere, P., K. Tampere, and V. Luoma-Aho, Facebook discussion of a crisis: Authority communication and its relationship to citizens. *Corporate Communications*, 2016. 21(4): p. 414-434.
51. Yoshida, M., et al., Availability of Japanese Government's supplemental texts on radiation reflecting the Fukushima Daiichi Nuclear Power Plant accident for elementary and secondary education from dental students' understanding. *Journal of Environmental Radioactivity*, 2016. 155-156: p. 7-14.
52. Burrer, S.L., et al., Assessment of impact and recovery needs in communities affected by the elk river chemical spill, West Virginia, April 2014. *Public Health Reports*, 2017. 132(2): p. 188-195.
53. Lee, D., et al., Factors associated with the risk perception and purchase decisions of Fukushima-related food in South Korea. *PloS one*, 2017. 12(11): p. 1.
54. Carter, H., et al., Public perceptions of emergency decontamination: Effects of intervention type and responder management strategy during a focus group study. *PLoS One*, 2018. 13(4): p. e0195922.

55. Heath, R.L., et al., Risk communication emergency response preparedness: Contextual assessment of the protective action decision model. *Risk Analysis*, 2018. 38(2): p. 333-344.
56. Latré, E., T. Perko, and P. Thijssen, Does it matter who communicates? The effect of source labels in nuclear pre-crisis communication in televised news. *Journal of Contingencies and Crisis Management*, 2018. 26(1): p. 99-112.
57. Nakayama, C., et al., Lingering health-related anxiety about radiation among Fukushima residents as correlated with media information following the accident at Fukushima Daiichi Nuclear Power Plant. *PLoS ONE*, 2019. 14 (5) (no pagination)(e0217285).
58. Carter, H., et al., Social identity and intergroup relationships in the management of crowds during mass emergencies and disasters: recommendations for emergency planners and responders. *Policing: A Journal of Policy and Practice*, 2020. 14(4), 931-944.
59. Weston, D., et al., Examining the application of behaviour change theories in the context of infectious disease outbreaks and emergency response: a review of reviews. *BMC public health*, 2020. 20(1), 1-19.
60. West, R., et al., Applying principles of behaviour change to reduce SARS-CoV-2 transmission. *Nature Human Behaviour*, 2020. 4(5), 451-459.
61. Michie S., Slowing down the covid-19 outbreak: changing behaviour by understanding it. *BMJ Opinion*. 2020; <https://blogs.bmj.com/bmj/2020/03/11/slowing-down-the-covid-19-outbreak-changing-behaviour-by-understanding-it/>. Accessed 11 Feb 2020.
62. Michie S., The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci*, 2011. 6.
63. Michie, S., Behavioural strategies for reducing covid-19 transmission in the general population, 2020; <https://blogs.bmj.com/bmj/2020/03/03/behavioural-strategies-for-reducing-covid-19-transmission-in-the-general-population/>. Accessed 11 Feb 2021.
64. Yardley, L., et al., Share strategies to enhance community engagement and cooperation during the covid-19 pandemic, 2020; <https://blogs.bmj.com/bmj/2020/03/17/how-can-we-involve-communities-in-managing-the-covid-19-pandemic/> Accessed 11 Feb 2020
65. Brooks, S. K., et al., Psychological impact of infectious disease outbreaks on pregnant women: Rapid evidence review. *Public Health*, 2020. 189, 26-36.
66. Drury, J., et al., Public behaviour in response to the COVID-19 pandemic: understanding the role of group processes. *BJPsych open*, 2021. 7(1).
67. Carter, H., et al., Perceived responder legitimacy and group identification predict cooperation and compliance in a mass decontamination field exercise. *Basic and Applied Social Psychology*, 2013. 35(6), 575-585.

68. Carter, H., et al., Effective responder communication improves efficiency and psychological outcomes in a mass decontamination field experiment: implications for public behaviour in the event of a chemical incident. *PloS one*, 2014. 9(3), e89846.
69. Carter, H., et al., Effective responder communication, perceived responder legitimacy, and group identification predict public cooperation and compliance in a mass decontamination visualization experiment. *Journal of Applied Social Psychology*, 2015. 45(3), 173-189.
70. Carter, H., et al., Applying crowd psychology to develop recommendations for the management of mass decontamination. *Health security*, 2015. 13(1), 45-53.
71. Carter, H., et al., Communication during mass casualty decontamination: highlighting the gaps. *International Journal of Emergency Services*, 2013. 2(1): p. 29-48
72. Carter, H. & R. Amlôt., Mass Casualty Decontamination Guidance and Psychosocial Aspects of CBRN Incident Management: A Review and Synthesis. *PLOS Currents Disasters.*, 2016. 8.

7. APPENDICES

7.1. Appendix A: Search strategy

EMBASE	Search strategy
1	pre-incident.ab. or pre-incident.ti. or pre-emergency.ab. or pre-emergency.ti. or prior.ab. or prior.ti. or prevent*.ab. or prevent*.ti. or plan*.ab. or plan*.ti. or "emergency preparedness".ab. or "emergency preparedness".ti.
2	education.ab. or education.ti. or information.ab. or information.ti. or "risk management".ab. or "risk management".ti. or management.ab. or management.ti. or knowledge.ab. or knowledge.ti. or perception.ab. or perception.ti. or opinion.ab. or opinion.ti. or communication.af. or communication.af.
3	chemical.ab. or chemical.ti. or "chemical agent".ab. or "chemical agent".ti. or "chemical injury".ab. or "chemical injury".ti. or "chemical terrorism".ab. or "chemical terrorism".ti. or "chemical warfare".ab. or "chemical warfare".ti. or biological.ab. or biological.ti. or "biological warfare".ab. or "biological Warfare".ti. or nuclear.ab. or nuclear.ti. or "nuclear accident".ab. or "nuclear accident".ti. or "fukushima nuclear accident".ab. or "fukushima nuclear accident".ti. or "nuclear terrorism".ab. or "nuclear terrorism".ti. or radiological.ab. or radiological.ti. or CBRN.ab. or CBRN.ti. or CBRNe.ab. or CBRNe.ti. or "radiological terrorism".ab. or "radiological terrorism".ti.
4	public.ab. or public.ti. or layperson.ab. or layperson.ti. or citizen.ab. or citizen.ti. or community.ab. or community.ti.
5	1 and 2 and 3 and 4
6	limit 5 to (human and english language and yr="2001 -Current" and article)

PsycArticles and PsycInfo	Search strategy
	noft((pre-incident. OR pre-emergency. OR prior.ab. OR prevent*. OR plan*. OR "emergency preparedness" .)) AND noft((education information OR "risk management" OR management OR knowledge OR perception OR opinion OR communication)) AND noft((chemical OR "chemical agent" OR "chemical injury" OR "chemical terrorism" OR "chemical warfare" OR biological OR "biological warfare" OR nuclear OR "nuclear accident" OR "fukushima nuclear accident" OR "nuclear terrorism" OR radiological OR CBRN OR CBRNe OR radiological terrorism)) AND noft((public OR layperson OR citizen OR community))

PubMed	Search strategy
	(((((pre-incident.[Title/Abstract] OR pre-emergency.[Title/Abstract] OR prior.ab.[Title/Abstract] OR prevent*.[Title/Abstract] OR plan*.[Title/Abstract] OR "emergency preparedness" .)[Title/Abstract])) AND ((education information[Title/Abstract] OR "risk management"[Title/Abstract] OR management[Title/Abstract] OR knowledge[Title/Abstract] OR perception[Title/Abstract] OR opinion[Title/Abstract] OR communication)[Title/Abstract])) AND ((chemical[Title/Abstract] OR "chemical agent"[Title/Abstract] OR "chemical injury"[Title/Abstract] OR "chemical terrorism"[Title/Abstract] OR "chemical warfare"[Title/Abstract] OR biological[Title/Abstract] OR "biological warfare"[Title/Abstract] OR nuclear[Title/Abstract] OR "nuclear accident"[Title/Abstract] OR "fukushima nuclear accident"[Title/Abstract] OR "nuclear terrorism"[Title/Abstract] OR radiological[Title/Abstract] OR CBRN[Title/Abstract] OR CBRNe[Title/Abstract] OR radiological terrorism)[Title/Abstract])) AND ((public[Title/Abstract] OR layperson[Title/Abstract] OR citizen[Title/Abstract] OR community)[Title/Abstract]))

MEDLINE	Search strategy
	noft((pre-incident. OR pre-emergency. OR prior.ab. OR prevent*. OR plan*. OR "emergency preparedness" .)) AND noft((education information OR "risk management" OR management OR knowledge OR perception OR opinion OR communication)) AND noft((chemical OR "chemical agent" OR "chemical injury" OR "chemical terrorism" OR "chemical warfare" OR biological OR "biological warfare" OR nuclear OR "nuclear accident" OR "fukushima nuclear accident" OR "nuclear terrorism" OR radiological OR CBRN OR CBRNe OR radiological terrorism)) AND noft((public OR layperson OR citizen OR community))

7.2. Appendix B: Table of Acceptance/Rejection of papers

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Alshehri, A. A., et al. (2016).	Public perceptions and attitudes to biological risks: Saudi Arabia and regional perspectives		N/A	N/A	N/A		N		N/A	N/A	
Bass, S. B., et al. (2015).	Attitudes and Perceptions of Urban African Americans of a "Dirty Bomb" Radiological Terror Event: Results of a Qualitative Study and Implications for Effective Risk Communication		N/A	N/A	N/A	N/A	N		N/A	N/A	
Bass, S. B., et al. (2016).	How Do Low-Literacy Populations Perceive "Dirty Bombs"? Implications for Preparedness Messages		N/A	N/A		N/A	N		N/A	N/A	
Becker, S. M. (2004).	Emergency Communication and Information Issues in Terrorist Events Involving Radioactive Materials		N/A	N/A		N/A	N		N/A	N/A	
Bisconti, A. N. (2011).	Communicating with Stakeholders about Nuclear Power Plant Radiation		N/A	N/A		N/A	N		N/A	N/A	
Blando, J., et al. (2007).	Evaluation of Potassium Iodide Prophylaxis Knowledge and Nuclear Emergency Preparedness: New Jersey 2005		N/A	N/A		N/A	Y	Third Review	N/A		

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Blando, J., et al. (2007).	Assessment of Potassium Iodide (KI) Distribution Program Among Communities Within the Emergency Planning Zones (EPZ) of Two Nuclear Power Plants		N/A	N/A		N/A	Y	Third Review	N/A		
Boscarino, J. A., et al. (2003).	Fear of Terrorism in New York After the September 11 Terrorist Attacks: Implications for emergency Mental Health and Preparedness		N/A		N/A	N/A	N		N/A	N/A	
Buck, A. J., et al. (2010).	Communicating serum chemical concentrations to study participants: follow up survey		N/A		N/A	N/A	Y	Third Review	N/A		
Burrer, L. S., et al. (2017).	Assessment of Impact and Recovery Needs in Communities Affected by the Elk River Chemical Spill, West Virginia, April 2014		N/A		N/A	N/A	N		N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Carney, J. K., et al. (2003).	Enhancing Nuclear Emergency Preparedness: Vermont's Distribution Program for Potassium Iodide	CH	N/A	NM	N/A	N/A	Y	Third Review	DW	N/A	Outcome
Carter, H., et al. (2014).	Effective Responder Communication Improves Efficiency and Psychological Outcomes in a Mass Decontamination Field Experiment: Implications for Public Behaviour in the event of a Chemical Incident	CH	N/A	N/A	GM	N/A	N		N/A	N/A	Outcome
Carter, H., et al. (2015).	Applying Crowd Psychology to Develop Recommendations for the Management of Mass Decontamination	CH	N/A	N/A	N/A	DW	N		N/A	N/A	Outcome
Carter, H., et al. (2018).	Public Perceptions of emergency decontamination: Effects of intervention type and responder management strategy during a focus group study.	CH	LP	N/A	N/A	N/A	N		N/A	N/A	Outcome

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Chess, C. & Clarke, L. (2007).	Facilitation of Risk Communication During the Anthrax Attacks of 2001: The Organisational Backstory			N/A	N/A	N/A	Y	Third Review		N/A	
Goodwin, R., et al. (2012).	Modelling Psychological Responses to the Great East Japan Earthquake and Nuclear Incident		N/A		N/A	N/A	N		N/A	N/A	
Goto, A., et al. (2014).	Leveraging public health nurses for disaster risk communication in Fukushima City: a qualitative analysis of nurses' written records of parenting counselling and peer discussions		N/A		N/A	N/A	Y	Third Review		N/A	
Hambach, R., et al. (2011).	Workers perception of chemical risks: A Focus Group Study		N/A	N/A	N/A		N		N/A	N/A	
Hatchett, S., et al. (2002).	Increasing awareness of arsenic in Bangladesh: lessons from a public education programme		N/A	N/A	N/A		N		N/A	N/A	
Heath, R. H. & Lee, J. (2016).	Chemical Manufacturing and Refining Industry Legitimacy: Reflective Management, Trust, Precrisis Communication to Achieve Community Efficacy		N/A	N/A	N/A		N		N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Heath, R. L., et al. (2018).	Risk Communication Emergency Response Preparedness: Contextual Assessment of the Protective Action Decision Model			N/A	N/A	N/A	N		N/A	N/A	
Hellier, E., et al. (2014).	Evaluating the application of research-based guidance to the design of an emergency preparedness leaflet		N/A	N/A		N/A	Y	Third Review	N/A		
Henderson, J. N., et al. (2004).	Chemical (VX) Terrorist Threat: Public Knowledge, Attitudes, and Responses		N/A	N/A		N/A	N		N/A	N/A	
Hildebrand, S. & Bleetman, A. (2007).	Comparative Study Illustrating Difficulties Educating the Public to Respond to Chemical Terrorism		N/A		N/A	N/A	N		N/A	N/A	
Kanda, H., et al. (2014).	Internet usage and knowledge of radiation health effects and preventative behaviours among workers in Fukushima after the Fukushima Daiichi nuclear power plant accident		N/A	N/A	N/A	N/A	N		N/A	N/A	
Kennedy, J., et al. (2010).	Public Perceptions of the dioxin incident in Irish pork			N/A	N/A	N/A	Y	Third Review		N/A	
Khan, K., et al. (2015).	Evaluation of an Elementary School-based Educational Intervention for Reducing Arsenic Exposure in Bangladesh			N/A	N/A	N/A	N		N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Kuroda, Y., et al. (2018).	Association between Health Literacy and Radiation Anxiety among Residents after a Nuclear Accident: Comparison between Evacuated and Non-Evacuated Areas			N/A	N/A	N/A	N		N/A	N/A	
Latre, E. et al. (2017).	Does It Matter Who Communicates? The Effect of Source Labels in Nuclear Pre-Crisis Communication in Televised News			N/A	N/A	N/A	N		N/A	N/A	
Law, R. K., et al. (2013).	National surveillance for radiological exposures and intentional potassium iodide and iodine product ingestions in the United States associated with the 2011 Japan radiological incident		N/A	N/A		N/A	Y	Third Review	N/A		
Lee, D., et al. (2017).	Factors associated with the risk perception and purchase decisions of Fukushima-related food in South Korea			N/A	N/A	N/A	Y	Third Review		N/A	
Lee, J. E. & Lemyre, L. (2009).	A Social-Cognitive Perspective of Terrorism Risk Perception and Individual Response in Canada		N/A	N/A		N/A	N		N/A	N/A	
Lemyre, L., et al. (2010).	Psychological considerations for mass decontamination			N/A	N/A	N/A	N		N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Lord, E. J. (2001).	Exercises Involving an Act of Biological or Chemical Terrorism: What are the Psychological Consequences?		N/A	N/A	N/A		N		N/A	N/A	
Lovelace, K., et al. (2007).	All-hazards Preparedness in an Era of Bioterrorism Funding		N/A		N/A	N/A	N		N/A	N/A	
Makkar, N., et al. (2014).	Evaluating awareness and practices pertaining to radioactive waste management among scrap dealers in Delhi, India		N/A	N/A	N/A		N		N/A	N/A	
Meit, M., et al. (2011).	Rural and Suburban Population Surge Following Detonation of an Improvised Nuclear Device: A new Model to Estimate Impact		N/A		N/A	N/A	Y	Third Review		N/A	
Mello, S. & Hovick, S. R. (2016).	Predicting Behaviours to Reduce Toxic Chemical Exposures Among New and Expectant Mothers: The Role of Distal Variables Within the Integrative Model of Behavioural Prediction		N/A		N/A	N/A	Y	Third Review		N/A	
Mihai, L, T., et al. (2005).	Ionising Radiation - Understanding and Acceptance			N/A	N/A	N/A	N		N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Murakami, M., et al. (2016).	Evaluation of Risk Perception and Risk-Comparison Information Regarding Dietary Radionuclides after the 2011 Fukushima Nuclear Power Plant Accident		N/A	N/A	N/A	N/A	N		N/A	N/A	
Nakayama, C., et al. (2019).	Lingering health-related anxiety about radiation among Fukushima residents as correlated with media information following the accident at Fukushima Daiichi Nuclear Power Plant			N/A	N/A	N/A	N		N/A	N/A	
Nyaku, M. K., et al. (2014).	Assessing Radiation Emergency Preparedness Planning by Using Community Assessment for Public Health Emergency Response (CASPER) Methodology			N/A	N/A	N/A	N		N/A	N/A	
Ohno, K. & Endo, K. (2015).	Lessons learned from Fukushima Daiichi Nuclear Power Plant Accident: Efficient Education Items of Radiation Safety for General Public		N/A	N/A		N/A	N		N/A	N/A	
Pearce, J. M., et al. (2013).	Communicating Public Health Advice After a Chemical Spill: Results From National Surveys in the United Kingdom and Poland			N/A	N/A	N/A	N		N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Pearce, J. M., et al. (2013b).	Communicating with the Public Following Radiological Terrorism: Results from a Series of Focus Groups and National Surveys in Britain and Germany		N/A		N/A	N/A	N		N/A	N/A	
Perko, T., et al. (2013).	Communication in Nuclear Emergency Preparedness: A Closer Look at Information Reception		N/A		N/A	N/A	N		N/A	N/A	
Quach, T., et al. (2018).	Improving the knowledge and behavior of workplace chemical exposures in Vietnamese-American nail salon workers: a randomized controlled trial		N/A	N/A		N/A	Y	Third Review	N/A		
Renaud, J., et al. (2011).	Evaluation of the effectiveness of arsenic screening promotion in private wells: a quasi-experimental study		N/A	N/A		N/A	N		N/A	N/A	
Rivas, A. F. & Rother, H. A. (2015).	Chemical exposure reduction: Factors impacting on South African herbicide sprayers' personal protective equipment compliance and high risk work practices			N/A	N/A	N/A	N		N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Rogers, M. B., et al. (2007).	Mediating the social and psychological impacts of terrorist attacks: The role of risk perception and risk communication		N/A		N/A	N/A	Y	Third Review		N/A	
Rogers, M. B., et al. (2013).	The Impact of Communication Materials on Public Responses to a Radiological Dispersal Device (RDD) Attack			N/A	N/A	N/A	N		N/A	N/A	
Ross, J. A., et al. (2016).	Fantasy Objects: The Perceptions of Safety of Emergency Shelter in Place Kits		N/A	N/A		N/A	N		N/A	N/A	
Rubin, G. J., et al. (2011).	The London Polonium Incident: Lessons in Risk Communications		N/A	N/A		N/A	Y	Third Review	N/A		
Savoia, E., et al. (2015).	Public response to the 2014 chemical spill in West Virginia: knowledge, opinions and behaviours		N/A		N/A	N/A	N		N/A	N/A	
Tampere, P. & Tampere, K. (2015).	Facebook discussion of a crisis: authority communication and its relationship to citizens		N/A	N/A	N/A		Y	Reconsidered	N/A	N/A	

Authors	Title	Screened By					Disagree	CH (reconsidered)	Third Reviewer (DW)	Third Reviewer (LG)	Outcome
		CH	LP	NM	GM	DW					
Tuyet-Hanh, T. T., et al. (2016).	Dioxin risk reduction programme at the most severe dioxin hot spot in Vietnam: Residual knowledge, attitude and practices five years post intervention		N/A	N/A	N/A		N		N/A	N/A	
Vyncke, B., et al. (2016).	Information Sources as Explanatory Variables for the Belgian Health-Related Risk Perception of the Fukushima Nuclear Accident		N/A	N/A	N/A		Y	Reconsidered	N/A	N/A	
Wray, R. J., et al. (2008).	Communicating With the Public About Emerging Health Threats: Lessons From the Pre-Event Message Development Plan		N/A	N/A	N/A		N		N/A	N/A	
Yoshida, M., et al. (2016).	Availability of Japanese Government's supplemental texts on radiation reflecting the Fukushima Daiichi Nuclear Power Plant accident for elementary and secondary education from dental students' understanding		N/A		N/A	N/A	N		N/A	N/A	
Zwolinski, L. R., et al. (2012).	Nuclear Power Plant Emergency Preparedness: Results From an Evaluation of Michigan's Potassium Iodide Distribution Program		N/A	N/A	N/A	N/A	N		N/A	N/A	

Note: green corresponds to accepted, red corresponds to rejected.

7.3. Appendix C: Citation list of included studies

- Alshehri, S.A., Y. Rezgui, and H. Li, Public perceptions and attitudes to biological risks: Saudi Arabia and regional perspectives. *Disasters*, 2016. 40(4): p. 799-815.
- Andrade-Rivas, F. and H.-A. Rother, Chemical exposure reduction: Factors impacting on South African herbicide sprayers' personal protective equipment compliance and high-risk work practices. *Environmental research*, 2015. 142: p. 34-45.
- Bass, S.B., et al., Attitudes and perceptions of urban African Americans of a "dirty bomb" radiological terror event: results of a qualitative study and implications for effective risk communication. *Disaster medicine and public health preparedness*, 2015. 9(1): p. 9-18.
- Bass, S.B., et al., How Do Low-Literacy Populations Perceive "Dirty Bombs"? Implications for Preparedness Messages. *Health security*, 2016. 14(5): p. 331-344.
- Becker, S.M., Emergency communication and information issues in terrorist events involving radioactive materials. *Biosecurity and bioterrorism: biodefense strategy, practice, and science*, 2004. 2(3): p. 195-207.
- Bisconti, A.S., Communicating with stakeholders about nuclear power plant radiation. *Health physics*, 2011. 100(1): p. 97-102.
- Blando, J., et al., Assessment of potassium iodide (KI) distribution program among communities within the Emergency Planning Zones (EPZ) of two nuclear power plants. *Health Physics*, 2007. 92(2 SUPPL. 1): p. S18-S26.
- Boscarino, J.A., C.R. Figley, and R.E. Adams, Fear of terrorism in New York after the September 11 terrorist attacks: implications for emergency mental health and preparedness. *International journal of emergency mental health*, 2003. 5(4): p. 199-209.
- Burrer, S.L., et al., Assessment of impact and recovery needs in communities affected by the elk river chemical spill, West Virginia, April 2014. *Public Health Reports*, 2017. 132(2): p. 188-195.
- Carney, J.K., et al., Enhancing nuclear emergency preparedness: Vermont's distribution program for potassium iodide. *J Public Health Manag Pract*, 2003. 9(5): p. 361-7.
- Carter, H., et al., Effective responder communication improves efficiency and psychological outcomes in a mass decontamination field experiment: Implications for public behaviour in the event of a chemical incident. *PLoS ONE*, 2014. 9 (3) (no pagination)(e89846).
- Carter, H., et al., Public perceptions of emergency decontamination: Effects of intervention type and responder management strategy during a focus group study. *PLoS One*, 2018. 13(4): p. e0195922.

- Goodwin, R., et al., Modelling psychological responses to the Great East Japan earthquake and nuclear incident. *PLoS one*, 2012. 7(5): p. 1.
- Hambach, R., et al., Workers' perception of chemical risks: A focus group study. *Risk Analysis*, 2011. 31(2): p. 335-342.
- Heath, R.L. and J. Lee, Chemical manufacturing and refining industry legitimacy: Reflective management, trust, precrisis communication to achieve community efficacy. *Risk Analysis*, 2016. 36(6): p. 1108-1124.
- Heath, R.L., et al., Risk communication emergency response preparedness: Contextual assessment of the protective action decision model. *Risk Analysis*, 2018. 38(2): p. 333-344.
- Hellier, E., et al., Evaluating the application of research-based guidance to the design of an emergency preparedness leaflet. *Appl Ergon*, 2014. 45(5): p. 1320-9.
- Henderson, J.N., et al., Chemical (VX) terrorist threat: public knowledge, attitudes, and responses. *Biosecurity and bioterrorism : biodefense strategy, practice, and science*, 2004. 2(3): p. 224-228.
- Hildebrand, S. and A. Bleetman, Comparative study illustrating difficulties educating the public to respond to chemical terrorism. *Prehospital and disaster medicine*, 2007. 22(1): p. 35-41.
- Kanda, H., et al., Internet usage and knowledge of radiation health effects and preventive behaviours among workers in Fukushima after the Fukushima Daiichi nuclear power plant accident. *Emergency Medicine Journal*, 2014. 31(e1): p. e60-e65.
- Kuroda, Y., et al., Association between health literacy and radiation anxiety among residents after a nuclear accident: Comparison between evacuated and non-evacuated areas. *International Journal of Environmental Research and Public Health*, 2018. 15 (7) (no pagination)(1463).
- Latré, E., T. Perko, and P. Thijssen, Does it matter who communicates? The effect of source labels in nuclear pre-crisis communication in televised news. *Journal of Contingencies and Crisis Management*, 2018. 26(1): p. 99-112.
- Lee, D., et al., Factors associated with the risk perception and purchase decisions of Fukushima-related food in South Korea. *PLoS one*, 2017. 12(11): p. 1.
- Lee, J.E.C. and L. Lemyre, A social-cognitive perspective of terrorism risk perception and individual response in Canada. *Risk Analysis*, 2009. 29(9): p. 1265-1280.
- Makkar, N., et al., Evaluating awareness and practices pertaining to radioactive waste management among scrap dealers in Delhi, India. *PLoS ONE*, 2014. 9 (3) (no pagination)(e91579).
- Mihai, L.T., et al., Ionizing radiation - Understanding and acceptance. *Health Physics*, 2005. 89(4): p. 375-382.

- Murakami, M., J. Nakatani, and T. Oki, Evaluation of risk perception and risk-comparison information regarding dietary radionuclides after the 2011 Fukushima nuclear power plant accident. PLoS ONE, 2016. 11 (11) (no pagination)(e0165594).
- Nakayama, C., et al., Lingering health-related anxiety about radiation among Fukushima residents as correlated with media information following the accident at Fukushima Daiichi Nuclear Power Plant. PLoS ONE, 2019. 14 (5) (no pagination)(e0217285).
- Nyaku, M.K., et al., Assessing radiation emergency preparedness planning by using community assessment for public health emergency response (CASPER) methodology. Prehosp Disaster Med, 2014. 29(3): p. 262-9.
- Ohno, K. and K. Endo, Lessons learned from Fukushima Daiichi nuclear power plant accident: efficient education items of radiation safety for general public. Radiation protection dosimetry, 2015. 165(1-4): p. 510-512.
- Pearce, J.M., et al., Communicating public health advice after a chemical spill: results from national surveys in the United Kingdom and Poland. Disaster medicine and public health preparedness, 2013. 7(1): p. 65-74.
- Pearce, J.M., et al., Communicating with the public following radiological terrorism: results from a series of focus groups and national surveys in Britain and Germany. Prehospital and disaster medicine, 2013. 28(2): p. 110-119.
- Perko, T., et al., Communication in nuclear emergency preparedness: a closer look at information reception. Risk Anal, 2013. 33(11): p. 1987-2001.
- Rogers, M.B., R. Amlôt, and G.J. Rubin, The impact of communication materials on public responses to a radiological dispersal device (RDD) attack. Biosecurity and bioterrorism : biodefense strategy, practice, and science, 2013. 11(1): p. 49-58.
- Ross, J.A., T.H. Deshotels, and C.J. Forsyth, Fantasy objects: The perception of safety of emergency shelter in place kits. Deviant Behavior, 2016. 37(6): p. 692-708.
- Rubin, G.J., R. Amlôt, and L. Page, The London polonium incident: lessons in risk communications. Health physics, 2011. 101(5): p. 545-550.
- Savoia, E., et al., Public response to the 2014 chemical spill in West Virginia: knowledge, opinions and behaviours. BMC public health, 2015. 15: p. 790.
- Tampere, P., K. Tampere, and V. Luoma-Aho, Facebook discussion of a crisis: Authority communication and its relationship to citizens. Corporate Communications, 2016. 21(4): p. 414-434.
- Wray, R.J., et al., Communicating with the public about emerging health threats: lessons from the Pre-Event Message Development Project. Am J Public Health, 2008. 98(12): p. 2214-22.
- Yoshida, M., et al., Availability of Japanese Government's supplemental texts on radiation reflecting the Fukushima Daiichi Nuclear Power Plant accident for elementary and

secondary education from dental students' understanding. *Journal of Environmental Radioactivity*, 2016. 155-156: p. 7-14.

Zwolinski, L.R., M. Stanbury, and S. Manente, Nuclear power plant emergency preparedness: results from an evaluation of Michigan's potassium iodide distribution program. *Disaster Med Public Health Prep*, 2012. 6(3): p. 263-9.

7.4. Appendix D: Sample characteristics

Study Citation	N	Male / Female	Age	Claims to be Representative	Of?	Location Carried out	Sample Specifics
Alsehri et al., 2016	n = 1,164	69% male 31% female		Unclear: listed as: National Survey		Saudi Arabia	
Andrade-Rivas, F. & Rother, H. A. 2015	n = 34 (workers) n = 13 (contractors)	(Workers) Male = 15, Female = 19 (Contractors) Male = 11, Female = 2		No		South Africa	
Bass et al., 2015	n = 37	67.6% male	Range - 18-67 80% between 18-50	No	N/A	USA	African American (94.6%)
Bass, et al., 2016	n = 50	42% male	13-35 = 42% 36-50 = 22% 50-65 = 20% 65-88 = 16%	No		USA	Low literacy participants 80% African American
Becker, 2004	n = 163	48% male	42.6	No	N/A	USA	
Bisconti, 2011	n = 1000			Yes	Nationally representative of US	USA	
Blando et al., 2007	n = 729	General public survey (99% spoke English)		No		USA	

Study Citation	N	Male / Female	Age	Claims to be Representative	Of?	Location Carried out	Sample Specifics
Boscarino, et al 2003	<i>n</i> = 1001	51.3% female	46.8 (SD = 19).	Yes	Weighted sample to achieve data comparable to the US census for New York	USA	61% White
Burrer et al, 2017	<i>n</i> = 171	Male = 140, Female = 148		Yes	Representative of households in the sampling frame	USA	Households
Carney et al, 2003	N/A	N/A	N/A	N/A	N/A	USA	
Carter, et al., 2014	<i>n</i> = 111 university students			No		UK	
Carter, et al., 2018	<i>n</i> = 62 members of the public	48% male	Range: 18-65	Yes	London	UK	
Goodwin, R., et al. 2012	<i>n</i> = 844			No		Japan	University students 59% of respondents were male in Miyagi compared to 41% in Western Japan and 39% in Tokyo/Chiba
Hambach, R., et al. 2011	<i>n</i> = 58	Primarily male sample - one focus group consisted of only women (Male = 48 Female = 10)		No		Belgium	Representative of the gender split for chemical workers

Study Citation	N	Male / Female	Age	Claims to be Representative	Of?	Location Carried out	Sample Specifics
Heath, 2018	$n = \sim 400$ per year across four years	No less than 40% males or females in sample of quadrant of the city		No		USA	
Heath, R. H. & Lee, J. 2016	$n = \sim 400$ per year across four years	No less than 40% males or females in sample of quadrant of the city		No		USA	
Hellier, et al., 2014	(1) $n = 631$ (2) $n = 50$ (3) $n = 57$ (4) $n = 302$	(1) 42.6% male 2.1% gender not specified (2) 50% male	(1) $\mu = 53.2$ (2) $\mu = 43.5$ (4) $\mu = 39.5$	No	N/A	UK	
Henderson, J. N., et al. 2004	13 focus groups with 8-12 ppts in each			No		USA	conducted in several regions, included rural and urban, and a range of population groups and different language main speakers.
Hildebrand, S. & Bleetman, A. 2007	$n = 200$	(UK) 41% male (Israel) 53% male	(UK) $\mu = 35$ (Israel) $\mu = 46$	No		UK & Israel	$n = 100$ UK $n = 100$ Israel
Kanda, et al., 2014	$n = 1119$			No		Japan	who took part in one or more health seminars hosted by the Fukushima Occupational Health Promotion Centre

Study Citation	N	Male / Female	Age	Claims to be Representative	Of?	Location Carried out	Sample Specifics
Kuroda et al., 2018	n = 777	(No evacuation) 46% male (Evacuation) 43.9% male		Yes	Evacuation areas in relation to Fukushima	Japan	
Latre, et al., 2017	n = 1031			Yes	Country (Belgium)	Belgium	
Lee & Lemyre, 2009	n = 1502			Yes	Country (Canada)	Canada	(1159 English, 343 French)
Lee et al, 2017	n = 1045	Males = 502, Females = 543	20s = 17.9% 30s = 22.8% 40s = 24.3% 50s = 23.4% 60+ = 11.7%	No		Japan	
Makkar, N., et al. 2014	n = 209	All male	Range = 16-83	Yes	Representative of all regions, and of respondents both within and outside Mayapuri	Japan	
Mihai, et al., 2005	n = 293 (177 from the general public).	<i>of the 293 total</i> 106 males 181 females	<i>of the 293 total</i> 40.51	No		Romania	26% were not professionally exposed to radiation and should not be considered)
Murakami, et al., 2016	n = 9249	52.38% male	Range - 20-69, Most common age group was 40s (29.2%)	No		Japan	

Study Citation	N	Male / Female	Age	Claims to be Representative	Of?	Location Carried out	Sample Specifics
Nakayama, C., et al. 2019	n = 861	49.5% male	$\mu = 51.6$	No		Japan	
Nyaku, et al., 2014	n = 192 households			Yes	County (Oakland)	USA	
Ohno & Endo, 2015	n = 372 questions	<i>(no participants, just online questions)</i>		N/A		N/A	Only questions relating to Fukushima
Pearce, et al., 2013a	(1) n = 52 British, n = 35 German (2) n = 1000B & 1005G (3) n = 70 British, n = 63 German	(2) Male = 889, Female = 1116	(2) $\mu = 50.1$	No		UK & Germany	
Pearce, et al., 2013b	n = 1203			Yes	Country x2 (UK / Poland)	UK & Poland	
Perko, et al., 2013	n = 1031			Yes	Country (Belgium)	Belgium	
Rogers, et al., 2013	(1) n = 22 (2) n = 24			Yes	No details given	UK	
Ross, et al., 2016	n = 30	<i>"Almost perfectly split between men and women."</i>	<i>"Youngest in their late teens, most senior in her eighties."</i>	No		USA	

Study Citation	N	Male / Female	Age	Claims to be Representative	Of?	Location Carried out	Sample Specifics
Rubin et al, 2011	(1) <i>n</i> = 86 (2) <i>n</i> = 1000			Yes	General public used was representative of the adult London population	UK	
Savoia, E., et al. 2015	<i>n</i> = 592	47.4% male	Most common age range = 55-64		Population based sample size	USA	with oversampling in areas of minority (low socio-economic position)
Tampere et al, 2016	<i>n</i> = 605 (<i>media comments</i>)	N/A	N/A	N/A		N/A	
Wray, R. J., et al. 2008	<i>n</i> = 1013	65% women	$\mu = 44$	No		USA	
Yoshida, et al., 2016	<i>n</i> = 40 first year students <i>n</i> = 44 fourth year students <i>n</i> = 41 sixth year students	(First year) male = 26, female = 14 (Fourth year) male = 27, female = 17 (Sixth year) male = 25, female = 17		No		Japan	All dental students
Zwolinski, et al., 2012	<i>n</i> = 153	40% male	$\mu = 61.7$ 54% were aged 60 or older	No		USA	

Note: Empty cells indicate that information was missing. When used a multi-phase methodology each trial is assigned to a number (e.g. (1)) in numerical order as shown in the paper.

7.5. Appendix E: Quality table (using the Understanding Health Research Tool)

Authors	Green	Grey	Red	Sum (Exc. Grey)	Percentage Green (Exc. Grey)
Alshehri et al. (2016)	11	2	3	14	78.6
Andrade-Rivas & Rother (2015)	14	2	4	18	77.8
Bass et al. (2015)	21	2	2	23	91.3
Bass et al. (2016)	19	3	10	29	65.5
Becker (2004)	18	2	6	24	75.0
Bisconti (2011)	8	3	4	12	66.7
Blando et al. (2007)	9	1	6	15	60.0
Boscarino et al. (2003)	10	2	3	13	76.9
Burrer et al. (2017)	11	3	2	13	84.6
Carney et al. (2003)	N/A	N/A	N/A	N/A	N/A
Carter et al. (2014)	23	2	6	29	79.3
Carter et al. (2018)	22	2	2	24	91.7
Goodwin et al. (2012)	18	4	6	24	75.0
Hambach et al. (2011)	18	4	4	22	81.8
Heath & Lee (2016)	16	4	13	29	55.2
Heath et al. (2018)	8	4	7	15	53.3
Hellier et al. (2014)	17	4	12	29	58.6
Henderson et al. (2004)	17	4	9	26	65.4
Hildebrand & Bleetman (2007)	8	1	7	15	53.3
Kanda et al. (2014)	16	3	11	27	59.3
Kuroda et al. (2018)	21	3	6	27	77.8
Latre et al. (2017)	14	2	3	17	82.4
Lee & Lemyre (2009)	18	3	10	28	64.3
Lee et al. (2017)	14	4	9	23	60.9
Makkar et al. (2014)	23	3	10	33	69.7
Mihai et al. (2005)	15	4	9	24	62.5
Murakami et al. (2016)	21	3	6	27	77.8
Nakayama et al. (2019)	11	1	3	14	78.6
Nyaku et al. (2014)	15	2	2	17	88.2
Ohno & Endo (2015)	N/A	N/A	N/A	N/A	N/A
Pearce et al. (2013a)	18	1	2	20	90.0
Pearce et al. (2013b)	21	2	9	30	70.0
Perko et al. (2013)	8	4	3	11	72.7
Rogers et al. (2013)	21	2	8	29	72.4
Ross et al. (2016)	10	2	8	18	55.6
Rubin et al. (2011)	9	3	14	23	39.1
Savoia, 2015	12	2	1	13	92.3
Tampere et al. (2016)	N/A	N/A	N/A	N/A	N/A
Wray (2008)	19	2	8	27	70.4
Yoshida et al. (2016)	17	2	12	29	58.6
Zwolinski et al. (2012)	21	4	7	28	75.0