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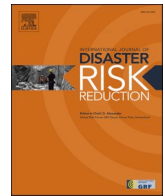
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Review Article

Recommendations for improving public engagement with pre-incident information materials for initial response to a chemical, biological, radiological or nuclear (CBRN) incident: A systematic review

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ABSTRACT

The risk of chemical, biological, radiological and nuclear (CBRN) incidents has increased in recent years, due to advances in technology, and increased willingness of terrorists to use unconventional weapons. There are basic actions which can reduce or prevent harm during such incidents. The speed with which these actions can be taken may be enhanced by providing pre-incident public information about how to undertake such actions. However, limited research has been carried out to identify potential benefits of providing pre-incident information in relation to preparing for and responding to terrorist attacks, including those involving CBRN agents. This paper presents findings from a systematic literature review which aimed to: examine potential efficacy of pre-incident information campaigns for improving public preparedness for CBRN incidents; identify what information should be included within public preparedness campaigns for CBRN incidents; and identify the best method(s) of providing pre-incident information for CBRN incidents. The review was carried out using Ovid, and selection and screening of papers followed a PRISMA framework. Findings showed that providing a pre-incident educational intervention generally resulted in an improvement in preparedness, compared to not providing any information. However, the majority of studies focused on improving preparedness behaviour in the immediate or short-term (<1 month). It is therefore unclear whether any improvement in preparedness is sustainable over the medium to longer-term. Further research is required to examine to what extent public information campaigns can improve public preparedness over the longer-term, and how best to enhance preparedness for CBRN incidents specifically.

1. Introduction

The risk of incidents involving chemical, biological, radiological and nuclear (CBRN) agents is ever-increasing, due to advances in technology, and the increased willingness of terrorists to use unconventional weapons [1,2]. CBRN threats fall into the category of 'dread' risks [3,4], because they are often invisible, the consequences of contamination are unknown, and they may have catastrophic potential. They may therefore be particularly frightening for members of the public.

Recent examples of incidents involving CBRN agents include the attempted assassination of a former Russian spy in Salisbury using Novichok (a nerve agent) [5], as well as numerous small-scale attacks involving acid [6]. There are basic actions which, if taken rapidly, can

reduce or prevent harm to victims of such attacks. These include removing contaminated clothing (providing it isn't stuck to skin), using available absorbent materials (providing the contaminant is not acidic), and rinsing with water [7]. The faster these actions are taken, the more lives will be saved [8].

One way to enhance the speed with which these actions can be taken is by providing pre-incident public information about how to undertake such actions [9]. The aim of providing this information is to enable members of the public to take actions to reduce their own risk, prior to the arrival of any emergency responders. Such pre-incident information is routinely provided by governments and emergency response organisations in order to help people to prepare for and respond to natural hazards (e.g. flooding, earthquakes, wildfires etc.). Pre-incident

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information may be provided online, through targeted local campaigns, or as part of the school curriculum, and evidence suggests that such information may be effective in enabling people to protect themselves and their families during a disaster [10,11]. As well as enabling people to take action quickly to protect themselves and others, this information may also promote a sense of self-efficacy, and facilitate speedier recovery [12].

Provision of pre-incident information may also help to establish shared norms and expectations between authorities and members of the public prior to an incident occurring. For example, in the US, there is a shared understanding between authorities, emergency responders and the public that all members of the public must be prepared to take care of themselves and their families for the first 72 h following a disaster [13]. As part of this understanding, emergency responders actively engage communities in disaster planning and exercising. Provision of such pre-incident information therefore enables people to be more prepared to take action to help themselves and their loved ones. In addition, establishing shared norms prior to an incident occurring may promote identification between members of the public and emergency responders, thus making it easier for responders to communicate effectively with members of the public during an emergency [14].

While there has been a substantial amount of research into pre-incident preparedness for natural hazards, research into the effectiveness of pre-incident information for terrorist attacks, including those involving CBRN agents, is limited. Furthermore, the evidence that is available is mixed. Some research suggests that provision of such information will not be effective, because people will not want to engage with the material prior to an incident, or will not remember the information when they need it [15]. In contrast, more recent evidence suggests that provision of pre-incident information about actions to take during CBRN incidents may increase public knowledge and confidence in taking such actions, which could increase the speed with which protective actions are initiated, and could therefore save lives during a real incident [16,17]. In order for preparedness information to be effective, the natural, technical and social context must be taken into consideration [18].

Policy makers increasingly advocate the involvement of the public in planning for disasters and emergencies [19–21], and this includes incidents involving CBRN agents [22]. Existing campaigns include the ‘Run, Hide, Tell’ campaign [23] designed to provide information around marauding terrorist fire arms attacks, the ‘See it, Say it, Sorted’ campaign designed to increase vigilance to potential threats across rail networks [24], and the ‘Report, Remove, Rinse’ campaign designed specifically for hazardous materials incidents involving caustic chemicals [25]. The information within these campaigns is designed to provide pre-incident information regarding protective actions that people can take, and is distributed to members of the public using various methods, including television adverts, electronic boards in crowded places (e.g. metro stations, transport hubs), and online.

During a CBRN incident, the actions that people may be asked to take to reduce their risk (e.g. removing clothing, undergoing a decontamination shower) might be embarrassing or uncomfortable. Providing pre-incident information for these types of incidents might increase both people’s knowledge and confidence in taking such actions, and their perceptions of the effectiveness of such actions, therefore increasing their willingness to take these actions [16]. Given the potential benefits of providing pre-incident public information for CBRN incidents, and the current lack of research in this area, there is a need for further research to establish both the type of information that members of the public will need prior to a CBRN incident, and the best method of providing this information.

A systematic literature review was carried out to identify research relating to pre-incident information campaigns for disasters and emergencies generally, as well as CBRN incidents specifically. Rather than focusing solely on CBRN incidents, broader disasters were included to enable potentially transferable lessons for CBRN incidents to be

identified. The aims of this review were to: examine the potential efficacy of pre-incident information campaigns for improving public preparedness for CBRN incidents; identify what type of information should be included within public preparedness campaigns for CBRN incidents; and identify the best method(s) of providing pre-incident information for CBRN incidents.

2. Method

We carried out a review, using Ovid to search three databases: Embase, PsychInfo and Medline. The review was originally carried out in October 2018 and included any papers published before that date. An update to the review was carried out in June 2019, to capture any relevant papers published within the previous 6 months. A broad search was carried out, which included three more focused searches. Search 1 included terms relating to the timing of information provided, such as “pre-incident”, “pre-emergency”, and “prior”. Search 2 included terms relating to the type of intervention, such as “educat*”, “inform*”, and “communicat*”. Search 3 included terms relating to the type of emergency, such as “chemical”, “CBRN”, “disaster”, and “flood”. See S1 Appendix for the full search strategy.

Articles were eligible for inclusion within the review if they: examined the effect of pre-incident information on levels of public preparedness prior to an emergency or disaster; examined the effect of pre-incident information for improving public ability to take effective protective actions during mass emergencies and disasters; examined factors that improve the efficacy of pre-incident information; included original data, whether qualitative or quantitative; were available in English; were published in peer-reviewed journals. Articles were not eligible for inclusion if they: examined the effect of information provided during or after a disaster or emergency on public behaviour or response; examined the effect of training or pre-incident information on responder (first responder, healthcare staff, Government officials etc) disaster preparedness or response; focused on provision of preparedness information in a warning context; were not available in English; did not contain original data; were not published in peer-reviewed journals (i.e. grey literature).

Selection and screening of papers followed a systematic search method following a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework [26]. All title, abstract, and full-text screening was carried out by the first author. Where the first author was unsure as to whether an abstract met the inclusion criteria, the abstract was then screened by a second researcher. This resulted in 20% of abstracts being subjected to additional screening by a second researcher. The first author and second researcher then discussed any abstracts for which uncertainty remained, before agreeing on whether to include or exclude each one.

The online critical appraisal tool ‘Understanding health research’ (<https://www.understandinghealthresearch.org/about-us/what-is-the-understanding-health-research-tool-8>) [27] was used to assess the quality of included papers. The scoring system in this tool is based on a series of questions about the research, some of which are determined based on earlier answers, and positive and negative scores. Criteria that studies are assessed by include: who carried out the research; who funded the research; ethical procedures; clarity of research aims; whether studies were quantitative, qualitative, or mixed (and additional questions depending on type of study); and any conflict of interest. A cut off for inclusion was set at 50% positive scores out of the total number of responses (a percentage cut off was used because the number of questions varied based on the type of research).

3. Results

The initial search generated 20,319 articles. After de-duplication, 19,598 records remained. Title screening resulted in 1982 papers being accepted for abstract screening, after which 62 papers remained.

The full text for each of the remaining papers was reviewed and following this 30 papers were accepted for inclusion within the review. Reference searching of these 30 papers identified 9 further references. A further five studies were identified from other sources (i.e. literature identified when developing the rationale and protocol for the review). Combining these with the 39 relevant studies identified from the initial search resulted in the inclusion of 44 studies in this review. See Fig. 1 for a PRISMA flow diagram containing full details of studies included and excluded at each stage. Critical assessment of the articles revealed that all papers scored above 50%, with the lowest score being 56.25% (n = 3) [28–30]. All papers were therefore included in the review.

Of the 44 studies identified, 32 employed quantitative methods, 6 employed qualitative methods, 3 employed mixed (i.e. quantitative and qualitative) methods, and 3 employed systematic reviews of existing literature. The 44 studies identified examined public preparedness to a variety of different disasters and threats, including: general disaster preparedness (n = 14); earthquakes (n = 10); chemical, biological, radiological, and/or nuclear (CBRN) threats (n = 14); floods and/or weather-related disasters (n = 5); fires (n = 3); terrorist attacks (n = 2); mass shootings (n = 1); and landslides (n = 1).

In the majority of studies (n = 29), the target audience for the

preparedness interventions developed was the general adult population (various countries). Other target audiences were: children/teenagers (n = 6); Latino participants (n = 3); children with special healthcare needs (n = 2); adults with special healthcare needs (n = 1); college students (n = 1); pregnant women (n = 1); and veterans (n = 1). The papers included populations from various different countries, including: the US (n = 18); the UK (n = 5); Belgium (n = 2); Australia (n = 2); Japan (n = 1); Iran (n = 1); Netherlands (n = 1); Italy (n = 2); Turkey (n = 1); China (n = 1); Tajikistan (n = 1); Canada (n = 1); New Zealand (n = 2); and Israel (n = 1). Five studies took place in two different countries: UK and Israel (n = 1); UK and Denmark (n = 2); Belgium and Slovenia (n = 1); and Japan and US (n = 1).

Twenty nine of the studies identified directly tested the effectiveness of an educational intervention to improve preparedness, seven studies investigated how public response to disaster-related pre-incident information affects preparedness, using a cross-sectional design, six studies examined effective ways to design an intervention, and three studies were systematic reviews.

See Table 1 for full details of each of the included studies.

Results will be presented in four sections, examining: whether pre-incident education is effective; what type of information should be

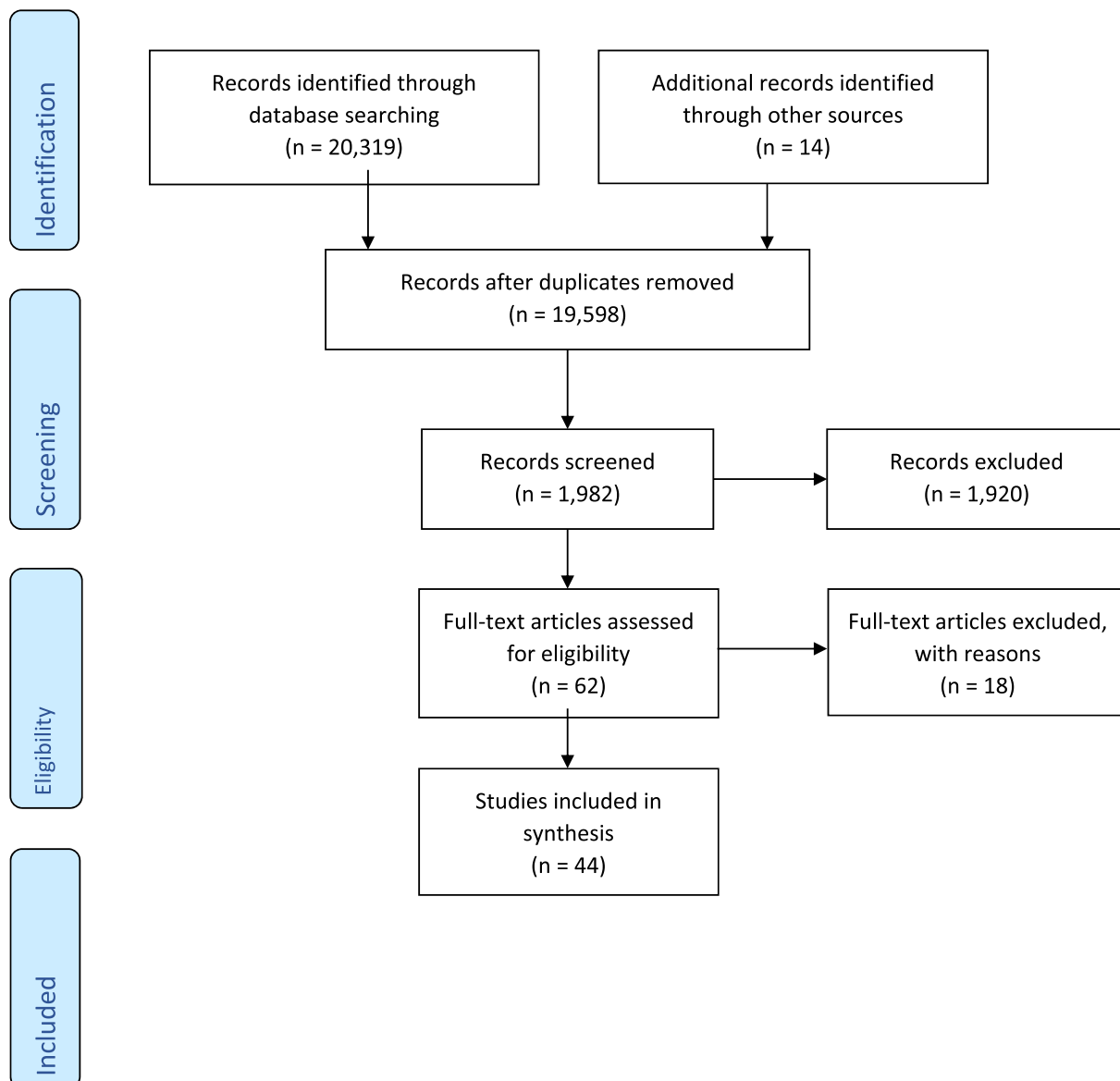


Fig. 1. PRISMA flow diagram showing number of included and excluded papers at each stage. Records after duplicates removed (n = 19,598).

Table 1
Details of included studies.

Author, Year, Country, Quality	Population	Sample size	Disaster type	Intervention type	Preparedness outcomes	Study type
Ardalan et al., 2013, Iran, 86%	General public	Urban intervention, n = 5562, urban control, n = 6123, rural intervention, n = 3638, rural control, n = 3887	Floods and earthquakes, and all-hazards	Face-to-face one-to-one	Household awareness and readiness scores, individual disaster risk perception	Intervention test
Baker & Cormier, 2013, US, 71%	Families of children with special healthcare needs	Florida, n = 114, Alabama, n = 96	All-hazards	10–20-min face-to-face training	Level of family preparedness	Intervention test
Baker et al., 2012, US, 63%	Families of children with special healthcare needs	Pre-test, n = 238, post-test, n = 121	All-hazards	Face-to-face one-to-one training	Level of family preparedness	Intervention test
Becker, 2004, US, 65%	General public	N = 163	Radiation/nuclear	Pre-event communication development	Public perceptions of pre-incident communication materials	Intervention development
Carter et al., 2018, UK, 76%	General public	N = 62	CBRN	Small discussion groups	Knowledge and confidence in taking protective actions during CBRN incidents	Intervention test
Carter et al., 2019, UK, 76%	General public	N = 44	CBRN	Small discussion groups	Knowledge and confidence in taking protective actions during CBRN incidents	Intervention development, intervention test
Chittaro & Sioni, 2015, Italy, 64%	General public	N = 44	Terrorist attacks	A virtual reality video game depicting a terrorist attack involving a series of explosions in a train station	Knowledge and confidence in taking appropriate protective actions	Intervention test
Codreanu et al., 2014, Australia, 83%	Teenagers	14 studies	All-hazards	Any educational intervention designed to improve preparedness of teenagers	Change in preparedness and mitigation behaviour; enhancement and retention of disaster-related knowledge and skills	Review
De Boer et al., 2015, Netherlands, 82%	General public	N = 1887	Floods	Four educational scenarios, varying by hypothetical location (risky vs. less risky), type of risk information provided, and information about efficacy of precautions in preventing flood damage	Preparedness for flooding	Intervention test
De Dominicis et al., 2014, Italy, 64%	General public	N = 444	Floods	Intervention based on principles of Vested Interest Theory	Flood preparedness behaviour	Intervention test
Eisenman et al., 2014, US, 71%	Adults with IDD living independently in the community	N = 46 (intervention group), n = 45 (control group)	Earthquake, fire safety, and all-hazards	Four 2-h courses taught by a health educator and trained peer mentors, delivered over two weeks	General disaster preparedness and earthquake knowledge	Intervention test
Eisenman et al., 2009, US, 78%	Latinos	N = 187	All-hazards	Media intervention (pamphlet, laminated card), and 1-h session led by trained providers	Improvement in stockpiling disaster supplies, and in family communication plans	Intervention test
Eisenman et al., 2009, US, 78%	Latino participants	N = 100	All-hazards	Various interventions	Improved understanding of participants' perceptions, understandings, facilitators, barriers to disaster preparedness	Intervention development
Faupel et al., 1992, US, 71%	General public	N = 198	Earthquakes	Workshop sponsored by Earthquake Education Center	Household preparedness and adaptive response	Cross-sectional
Feng et al., 2019, New Zealand, 69%	General public	N = 87	Earthquakes	A virtual reality serious game educating people about effective building evacuation during an earthquake.	Knowledge of behaviours to take during earthquake evacuation.	Intervention test
Foster & Barnby, 2018, US, 71%	Children aged between 10 and 13	N = 61	Weather-related disasters	One-hour educational session taught by nursing students, including a lecture and interactive group activities	Knowledge and confidence in taking appropriate actions during a disaster	Intervention test
Fraustino & Ma, 2015, US, 64%	College students	N = 232	All-hazards	Four interventions, varying media type (traditional vs. social), and message style (humorous vs. non-humorous)	Intentions to engage in emergency preparedness activities	Intervention test
Gauntlett et al., 2018, UK, 91%	Various	41 studies	Radiation	Various	Preferences for information type and source relating to provision of information around radiological incidents	Review
Glik et al., 2004, US, 65%	General public	N = 93	Botulism	Intervention development	Emotional responses, knowledge and beliefs,	Intervention development

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Table 1 (continued)

Author, Year, Country, Quality	Population	Sample size	Disaster type	Intervention type	Preparedness outcomes	Study type
Glik et al., 2008, US, 71%	General public	N = 73	Botulism	15, 30, or 45 s radio clip, 3-min narrated television clip, 2-page fact sheet	behavioural intent, information preferences Perceptions of different types and sources of information	Intervention development
Glik et al., 2014, US, 85%	Latinos	N = 187	All-hazards	One-hour face-to-face discussion groups vs. mailed, culturally competent print materials	Whether people had heard of a family communication plan or disaster kit, and their perceptions of such a kit	Intervention test
Hellier, 2013, UK, 67%	General public	First study, n = 631, experiment, n = 302	Nuclear	Informational leaflet	Intended compliance, understanding, readability, completeness	Intervention test
Hildebrand & Bleetman, 2007, UK and Israel, 73%	General public	N = 200 (UK = 100, Israel = 100)	Chemical	Government information leaflet	Knowledge of actions to take in the event of a chemical incident and intentions to take different protective actions	Cross-sectional
Karanci et al., 2005, Turkey, 63%	General public	Experiment group, n = 400, control group, n = 400	Earthquakes, floods and landslides	Eight-hour training intervention	Preparedness behaviour, disaster expectation, worry about future disasters and loss estimation	Intervention test
Kruvand & Silver, 2013, US, 56%	General public	Whole population	All-hazards	CDC Zombie apocalypse campaign	Amount of traffic to CDC website, Twitter data, and publicly available comments	Intervention test
Latre et al., 2017, Belgium, 75%	General public	N = 1031 (industry – 253; authority – 254, scientists – 268)	Nuclear	Intervention provided by three different types of communicator: scientist, authorities, industry	Recall of information, acceptance of proposed mitigation actions	Intervention test
Li et al., 2013, China, 69%	General public	N = 994	All-hazards	Intervention involving various stages: mass media information; information in community areas; face to face training in homes; lectures; drills.	Knowledge and skills for responding to various public health emergencies	Intervention test
Mohadjer et al., 2010, Tajikistan, 57%	Children aged 14–15	N = 43	Earthquakes	Educational curriculum including six science activities on physical earthquake processes, hazard and mitigation strategies	Knowledge of basic earth science, ability to think critically when receiving and sharing earthquake-related information, empowerment to protect self and others	Intervention test
Morrongiello et al., 2012, Canada, 57%	Children aged 3 - 6	N = 76	Fire safety/evacuation	Video game intervention	Knowledge of fire safety actions	Intervention test
Mulilis & Lippa, 1990, US, 61%	General public	N = 111	Earthquakes	Sixteen interventions, based on four manipulated variables: earthquake probability (high vs. low); earthquake severity (high vs. low); efficacy of earthquake preparedness (high vs. low); capability of earthquake preparedness (high vs. low)	Earthquake preparedness measure (Mulilis-Lippa Earthquake Preparedness Scale)	Intervention test
Pearce & Lindekilde et al., 2019, UK and Denmark, 85%	General public	N = 3003	Mass shootings	Tested efficacy of 'Run, Hide, Tell' campaign. Three different interventions: no information; information presented via a leaflet; information presented via a film.	Trust, coping appraisal, and intention to take recommended protective behaviours.	Intervention test
Pearce & Parker et al., 2019, UK and Denmark, 85%	General public	N = 1505 (UK), 1500 (Denmark)	Terrorist attacks	Tested three interventions: 'See it, say it' information; 'See it, say it, sorted' information; and no information control.	Intention to take recommended actions.	Intervention test
Perko et al., 2013, Belgium, 83%	General public	N = 1031	Nuclear	Various interventions, including: personal letters, local community meetings, leaflets, tv, radio and newspaper adverts, press conferences, internet pages, posters, and expert meetings	Recall of information, specific knowledge, confidence in authorities	Cross-sectional
Perko et al., 2012, Belgium/Slovenia, 71%	General public	N = 1031	Nuclear	Two communication campaigns: 1) public education on iodine tablets (Belgium); campaign around radioactive waste (Slovenia)	Acceptance of communicated messages, perception of communicated risks, perception of radiation risks, confidence in authorities, attitude towards nuclear energy or waste	Cross-sectional

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Table 1 (continued)

Author, Year, Country, Quality	Population	Sample size	Disaster type	Intervention type	Preparedness outcomes	Study type
Rohrmann, 1999, Australia, 67%	General public	N = 110	Bushfires	Community fireguard programme	Reception, understanding, acceptance, and implementation of recommended measures	Intervention test
Ronan & Johnston, 2003, New Zealand, 80%	Children aged 11–13	N = 115 (experimental), n = 104 (control)	All-hazards	Six-week module including information on hazard mitigation and emergency response	Knowledge about mitigation and response, hazard adjustments, knowledge of preparing for and responding to various different hazards	Intervention test
Rubin et al., 2012, UK, 91%	General public	29 studies	CBRN	Various	Information people want to receive prior to a CBRN attack, preferred information sources, factors that determine trustworthiness of a person or source	Review
Santos et al., 2007, US, 81%	Veterans	N = 55	Anthrax, plague, smallpox	Development of information campaign for smallpox, plague, anthrax	Perceptions of veterans' information needs prior to an outbreak	Intervention development
Soffer et al., 2010, Israel, 73%	School students	N = 2544	Earthquakes	Lecture on earthquake preparedness; earthquake drills; lecture and earthquake drill	Knowledge about earthquakes and aftershocks, practical knowledge relating to appropriate actions people should take during an earthquake	Intervention test
Tanaka, 2005, Japan/US, 82%	General public	N = 361 (Fukui), n = 190 (San Francisco)	Earthquakes	Three different methods of information provision: print, broadcast, and community meeting	Level of earthquake preparedness	Cross-sectional
Tanes, 2017, US, 73%	General public	N = 50 (repetitive-play), n = 49 (single-play), n = 49 (no-play)	Earthquakes	Earthquake preparedness video game	Knowledge of what to do during and after an earthquake	Intervention test
Wood et al., 2012, US, 74%	General public	N = 2811	All-hazards	General preparedness information received	Type, source, and channel of preparedness information sought, knowledge of others preparedness actions, preparedness actions taken, milling about preparedness actions	Cross-sectional
Yasunari et al., 2011, Japan, 84%	Pregnant women	N = 226 (intervention group), n = 1010 (control group)	All-hazards	Information on importance of preparedness, contact methods with families, evacuation sites and routes, items to prepare in case of emergency	Measures of preparedness awareness and preparedness behaviour	Intervention test
Zwolinski et al., 2012, US, 74%	General public	N = 153	Nuclear	Distribution of information and vouchers for obtaining potassium iodide prior to a nuclear emergency	Knowledge of living near a nuclear facility, preparedness actions taken, what actions people would take on hearing a nuclear alarm.	Cross-sectional

included within pre-incident education interventions; the best method of providing pre-incident education; and how pre-incident information for CBRN incidents specifically compares to pre-incident education for emergencies generally. Details of the preparedness outcome(s), type(s) of information, and method(s) of providing information included within each study can be found in Table 2.

3.1. Is pre-incident education effective?

Thirty-six studies either directly examined the effect of pre-incident education on improved preparedness for mass emergencies and disasters (educational intervention test) (n = 29) or examined how public response to disaster-related information affects preparedness (cross sectional design) (n = 7). Within these studies, six different preparedness outcomes were examined, including: public knowledge of preparedness or protective actions (n = 23); actually taking preparedness actions (e.g. creating a disaster kit) (n = 17); public intentions or willingness to take preparedness actions (n = 13); public confidence or self-efficacy in taking preparedness or protective actions (n = 7); engagement with pre-incident preparedness campaigns (n = 1); and emotional coping in relation to future disasters (n = 1).

The majority of these studies found that the provision of pre-incident disaster education had some efficacy for improving preparedness. This was particularly the case when it came to improving public knowledge of preparedness or protective actions, with almost all studies finding that providing an educational intervention of some type improved participants' knowledge compared to no intervention. However, findings were more mixed when it came to improving actual preparedness behaviour or preparedness intentions.

The majority (n = 19) of studies that tested a pre-incident educational intervention were either followed up immediately post-intervention (n = 11) [38,43,45,50,59,62–64,66–68] or were followed up within 1-month post-intervention (short-term) (n = 8) [28,29,32,33,35,42,47,55]. Only 10 studies involved either medium-term follow-up (between 1 and 12 months post-intervention) (n = 7) [16,17,31,37,39,40,65] or longer-term follow-up (over 12 months post-intervention) (n = 3) [30,46,48].

The 9 studies that examined intervention development or reviewed existing literature indicated that people were positive about the importance of providing pre-incident information, feeling that the provision of such information would enable them to take care of themselves and their loved ones.

Table 2
Study information relating to preparedness outcome, type of information, and method of providing information.

Preparedness outcomes	Type of information	Method of providing information
Knowledge [15–17,28,29,31,35,39–43,45,48,49,55–57,59,61,64–66]	Information about preparedness/protective actions [15–17,28–33,35,36,38–43,45,46,48,50–61,64,66–68]	Leaflets or handouts [15,31–33,37,39,40,42,52,55,56,58,68]
Taking preparedness actions [28,31–33,35,37,39,41–44,46,47,49,55,61,65]	Information about disaster effects [16,17,28,31–36,39,45,48,51–58,64,66,67]	School modules/educational classes [28,35,42–44,46,48,64]
Intention/willingness to take action [15,28,38,39,45,50,59,61–63,65,67,68]	Information about efficacy of actions [17,36,41,42,45,47,51–53,55,60,64,66]	Small group discussions [16,17,36,37,39]
Self-efficacy [16,17,45,50,64,66,68]	Information about disaster severity [17,38,47,53,55,60,62,63,66]	Face-to-face one-to-one intervention [31–33,40]
Engagement [30]	Information about disaster likelihood [38,47,53,56,60,62,63]	Traditional media [15,38,40,41,49,51,53,54,56,59,61,68]
Emotional coping [43]	Information about self-efficacy [47,50,60,63,66]	Online information/social media [30,38,51–53,56,61]
	Information about likely stress reactions [64]	Posters [15,17,40,56]
	Information about overcoming barriers [33,36]	Video games [29,45,50,66]
	Information about others' preparedness actions [41]	Drills [40,48]
	Sources of further information [52,53,58]	Group lectures [31,40,49,53,56,61]
		Information from others who had taken preparedness action [41,51]

3.2. What type of information should be included?

The 29 studies that tested the efficacy of a pre-incident educational intervention or interventions included various different types of information. The different types of information could be grouped into eight main themes: information about the preparedness and protective actions that people can take during disasters (n = 24); information about the effects of different types of disasters (n = 14); information about the efficacy of different prevention or protection measures, and the importance of taking such measures (n = 8); information designed to increase perceptions of the severity of different types of disasters (n = 7); information designed to increase perceptions of likelihood of different types of disasters (n = 4); information designed to increase self-efficacy in relation to taking preventative or protective actions (n = 4); information about likely stress reactions to disasters (n = 1); and information about how to overcome different barriers to taking preparedness actions (n = 1).

Given that studies typically provided more than one different type of information, it is difficult to draw firm conclusions about the relative efficacy of any one particular type of information. Five studies provided all three of the most commonly provided types of information (protective actions people can take, efficacy of taking protective actions, and information about the effects of disasters) [17,45,55,64,66]. These studies all found improvements in the outcomes that they measured, including knowledge of protective actions, confidence in taking protective actions, behavioural intentions, willingness to take recommended actions, and self-efficacy. In contrast, papers that included only one or two of these three types of information were more mixed in their findings, particularly when examining impact on preparedness outcomes other than knowledge (e.g. actual behaviour, behavioural intentions etc). In some cases, provision of an intervention improved intentions to adopt protective health behaviours, but was not effective for reducing potentially risky behaviours [68]. In other cases, the intervention resulted in improvement in preparedness or behavioural intentions, but level of preparedness overall remained low [32,38]. A possible reason given for this is that it may be easier to change

hazard-related cognitions than to change behaviour [46].

Of the 7 studies that used a cross sectional design to examine how public response to disaster-related pre-incident information affects preparedness, 5 reported some detail about the types of information that people were provided with or reported receiving relating to pre-incident preparedness [15,41,56,57,61]. Such information included: information about preparedness actions to take (n = 5); information about disaster-related effects (n = 2); information about the relative likelihood of a disaster occurring (n = 1); information about efficacy of preparedness actions (n = 1); and knowledge about preparedness actions that others have taken (n = 1). The majority of these cross-sectional studies (5 out of 7) indicated that where people reported receiving some form of pre-incident information or education, this resulted in improved preparedness outcomes [41,44,49,56,57]. However, these studies provided less detail about the nature of the information that people reported receiving than did the studies that directly tested the efficacy of pre-incident interventions.

Nine studies examined what type of information should be included in pre-incident educational interventions, using either a qualitative design (n = 6), or a systematic review of existing literature (n = 3). The 6 qualitative studies examined the types of pre-incident information that people wanted to receive. Findings broadly supported the findings from the quantitative studies, with reported information needs including: information about the effects of a disaster (n = 6); information about protective actions that people can take (n = 6); information about efficacy of protective measures (n = 4); sources of further information (n = 2); information about the severity of the risk (n = 2); information about the likelihood of a disaster (n = 1); and information about facilitating preparedness actions or overcoming barriers (n = 1). The three systematic literature reviews also detailed preparedness information that people should be provided with prior to a CBRN incident [34,52,60]. Two reviews highlighted the need to provide people with information about actions that they can take to protect themselves and others, and to explain how such actions will be effective [52,60]. In addition, the reviews emphasised the need to provide information about the effects of such incidents [34,52], links to sources of further information [52],

information about the likelihood and severity of such incidents [60], and information designed to enhance self-efficacy [60].

3.3. What is the best method of providing information?

Four of the 29 studies testing pre-incident educational interventions provided information within an experimental laboratory setting, and therefore did not use a particular method of delivering this information [47,62,63,67]; these studies were therefore excluded from the analysis relating to methods of providing information. The remaining 25 studies that examined the effectiveness of an educational intervention used various different methods of providing such information. These included: leaflets or handouts (n = 9); school modules or educational classes (n = 7); small group discussions (n = 4); face-to-face one-to-one interventions (n = 4); traditional media (e.g. tv/radio/newspapers) (n = 4); online information or social media (n = 2); posters (2 studies); video games (n = 4); drills (n = 2); and group lectures (n = 2).

Only 5 studies directly compared the effectiveness of two or more different methods of providing pre-incident information. The comparisons included: traditional media vs. social media (n = 1) [38]; leaflet/handout vs. small group discussion (n = 2) [37,39]; leaflet/handout vs. traditional media (n = 1) [68]; and school module/educational class vs. drill vs. educational class and drill (n = 1) [48]. These studies typically found that the higher the intensity of the intervention, the more effective it was for improving preparedness. The two studies comparing a handout with a small discussion group found that while both types of intervention improved preparedness over a three-month period, there was significantly greater improvement in preparedness among those who had received the small group intervention than among those who had received the leaflet. Likewise, the study that compared educational class with a physical earthquake preparedness drill found that those who had received the class and the drill (the highest intensity intervention) showed the greatest theoretical and practical knowledge one year later compared to those who had received only the class or the drill. The study comparing an informational leaflet with an educational film found that the film had significantly more impact on preparedness than did the leaflet, but that both conditions significantly improved preparedness compared to a no information control. The study comparing social media with traditional media found no difference in preparedness between those who received the social media message and those who received the traditional media message.

Of the 7 cross sectional studies, 6 collected information about the sources of information that had been used to deliver pre-incident education [15,41,44,49,56,61]. Sources of information used included: traditional media (n = 5); public meetings/lectures (n = 3); online resources/social media (n = 2); leaflets/handouts (n = 2); posters (n = 2); educational workshops (n = 1); and others who had taken preparedness actions (n = 1). Two of these studies compared the effect of being provided with information from different sources, with one study comparing traditional media sources with public meetings, and the other comparing traditional media sources with receiving information from others who had initiated preparedness actions. In both cases, information received from traditional media sources was associated with less effective preparedness than information received from another source.

Seven out of the 9 studies that used a qualitative or review design reported the sources that people would want to receive information from [36,51–54,58,60]. The sources that people wanted to receive information from mirrored those examined in the experimental and cross-sectional studies and included: traditional media (n = 3); online resources/social media (n = 3); close others (n = 1); small discussion groups (n = 1); community meetings/lectures (n = 1); and leaflets/handouts (n = 2). Two studies specifically reported that people would want to receive information from multiple sources [53,60].

3.4. Studies examining CBR and N threats specifically

Fourteen of the studies identified examined preparedness in relation to CBRN threats specifically. These threats included: radiation/nuclear threats (n = 7) [51,52,55–57,59,61]; general CBRN threats (n = 3) [16,17,60]; biological threats (n = 3) [53,54,58]; and chemical threats (n = 1) [15]. Of the studies looking at preparedness for CBRN threats, four studies directly tested the effectiveness of an educational intervention to improve preparedness [16,17,55,59], five studies looked at ways of developing pre-incident preparedness interventions [17,51,53,54,58], four studies investigated how public response to CBRN-related pre-incident information affects preparedness, using a cross-sectional design [15,56,57,61], and two studies were systematic literature reviews [52,60].

Similar to the studies examining non-CBRN threats, the 4 studies examining the effectiveness of pre-incident information for CBRN threats found that overall, pre-incident information campaigns were effective for improving individuals' preparedness for CBRN incidents, particularly in terms of improving knowledge and confidence in taking protective actions. The studies that examined the development of pre-incident information interventions found that there was often considerable confusion among members of the public about the effects of different types of CBRN agents, and the different protective actions that people should take in response to different CBRN threats [17,51,53,54,58]. These studies therefore recommended that pre-incident information for CBRN threats should include information about effects of different types of CBRN agents, different methods of transmission, and appropriate protective measures.

4. Discussion

Overall, findings showed that providing a pre-incident educational intervention generally resulted in an improvement in preparedness knowledge, behaviour, and/or intentions, compared to not providing any information. From this review, several recommendations can be made for the development of effective pre-incident education campaigns for incidents involving CBRN agents. These are discussed under three key headings below: what type of information should be provided; how should information be provided; specific considerations for CBRN incidents (as distinct from other types of disaster preparedness).

4.1. What information should be included?

Information about protective actions that people can take. In almost all types of emergencies and disasters, there are actions that people can take to protect themselves and others. These include actions that can be taken in advance of an incident occurring (e.g. developing a disaster preparedness kit, putting in place an evacuation plan etc) and actions that can be taken during the disaster itself. The findings from this review show that it is essential to provide people with information about protective actions that they can take in order to improve both physical preparedness prior to a disaster, and knowledge and confidence about actions to take during a disaster. As noted in the introduction, during incidents involving CBRN agents it will be essential that people take action as quickly as possible [8]; providing people with pre-incident information about protective actions they can take will enhance the speed with which actions can be taken [9]. Findings from the qualitative studies reported here showed that participants reported that this was one of the key pieces of information that they would want prior to an emergency or disaster. These findings were consistent across studies examining non-CBRN and CBRN threats. A key starting point for any pre-incident information campaign for CBRN incidents will therefore be to provide people with information about the protective actions that they can take to protect themselves and others.

Efficacy of taking protective actions. In addition to providing people with information about protective actions that they can take, it will also

be important to explain why these actions are necessary, and how they are effective. The studies that included this information alongside information about protective actions that people can take resulted in improved willingness to take recommended actions and improved confidence. Findings from the qualitative studies supported this point, with information about the efficacy of protective actions being highlighted as a key piece of information that people would want prior to a disaster. Whilst providing people with information about actions they can take to protect themselves is an important first step in improving preparedness, findings presented here suggest that provision of information relating to the efficacy of such actions may improve confidence in taking recommended actions [17,45,66] and willingness to take recommended actions [17,55]. This was again in line with findings from previous related reviews [52,60]. Information about the efficacy of protective actions was shown to be important for both non-CBRN and CBRN threats. This information should therefore be included in any pre-incident information campaigns for CBRN incidents, alongside information about the protective actions that people can take.

Information about the effects of different types of disasters. Provision of information about the effects of different types of disasters, alongside information about protective actions that people can take, and the efficacy of such actions, resulted in improved preparedness. In addition, findings from the qualitative studies indicated that this was a key piece of information that people would want to receive prior to an emergency or disaster.

It is likely that provision of information about the effects of different types of disasters will be even more important when communicating with members of the public about CBRN threats. Findings from the qualitative studies examining pre-incident information needs for CBRN threats suggest that there is considerable confusion about the differences between different types of CBRN agents [17,51,58]. This includes lack of understanding of the effects of different CBRN threats, confusion around methods of transmission, and misperceptions regarding protective actions. It is vital that pre-incident information for CBRN threats addresses such misperceptions in order to help members of the public understand the effects of different types of CBRN agents, and the different ways such threats can be managed. This is discussed in greater detail in the section relating specifically to CBRN threats, below.

Other types of information. As noted above, studies that provided more different types of information (e.g. information about protective actions people can take, information about the efficacy of such actions, and information about the effects of disasters) were more consistent in showing a positive effect on preparedness than studies that only provided one or two different types of information. This is in line with the findings from two previous reviews examining public information needs during CBRN incidents [52,60].

Other types of information that were provided by studies in this review included information relating to the potential severity of a particular disaster and the likelihood of such a disaster occurring. Generally, these studies showed that presenting a disaster as more likely to occur, and the consequences as being more severe, resulted in greater disaster preparedness [17,38,47,55,62,63,66]. However, it is important that this information is included alongside information relating to efficacy of recommended actions; emphasising disaster likelihood and severity without enhancing efficacy can result in denial of the threat or rejection of information [69,70]. This may be particularly important during CBRN incidents which score highly in terms of dread risk, and may therefore result in a greater sense of fatalism (compared to other types of disasters) [71]. Further research is therefore required to understand how the inclusion of information relating to severity and likelihood can be incorporated into pre-incident information campaigns for CBRN incidents.

4.2. How should information be provided?

A variety of methods of information provision were used, with some

appearing to show more promise than others. In particular, those studies that compared a high intensity intervention (e.g. small discussion groups) with a low intensity intervention (e.g. leaflet/handout) found that, as expected, the higher intensity intervention resulted in greater improvement in preparedness. This is in line with a recent review of research into factors affecting the efficacy of fire drills [72]. In addition, studies in which more than one type of intervention was provided showed that those who had received more than one type of educational intervention were more prepared than those who had received only one type of intervention. In terms of improving preparedness, it may therefore be beneficial to provide higher intensity interventions in order to facilitate increased preparedness. However, the higher the intensity of the intervention, the greater resource it will require. A method that shows potential, in terms of improving preparedness but requiring relatively low resource, is video games. However, the novelty of such interventions means only four studies examined the effectiveness of these [29,45,50,66]. Overall, the small minority of studies comparing the effectiveness of two or more interventions (5 out of 44), and the lack of medium-to-long-term follow up, makes it difficult to draw firm conclusions about the best method of providing information in order to ensure longer term improvements in preparedness.

4.3. Factors to consider when developing CBRN information campaigns

It should be noted that only around a third of the studies identified ($n = 14$) focused on incidents involving CBRN agents. However, pre-incident information campaigns appeared to be as effective for CBRN incidents as for other types of emergencies. In general, findings relating to the efficacy of pre-incident information were similar across a broad range of emergencies and disasters. This suggests that it is the way in which pre-incident information is designed and delivered that affects preparedness, rather than the type of emergency per se (though preparedness did tend to be higher in areas that were at high risk from a particular type of disaster e.g. earthquakes). Overall, this similarity across different types of emergency provides reassurance that findings will be equally applicable to incidents involving CBRN agents.

Despite this, there are some additional considerations that should be taken into account when designing pre-incident communication for CBRN incidents. The first is that, in comparison to other types of emergencies and disasters, public knowledge of different CBRN threats tended to be low. The studies identified in this review indicated that people frequently demonstrated confusion regarding the effects of CBRN agents, and the different protective measures that might need to be taken in relation to different types of CBRN agents [17,51,58]. It may therefore be even more important to provide people with information about different types of CBRN agents when developing pre-incident information for these types of incidents. Further work is needed to understand current public perceptions of CBRN agents, in order to address any common misconceptions when designing public information campaigns for these types of incidents.

A second aspect to bear in mind is that CBRN threats score highly in terms of 'dread' risk, defined by a lack of perceived control, and unknown consequences [3,4]. For this reason, some evidence suggests this may result in a sense of fatalism, which may be a barrier to people engaging with preparedness actions [52]. Communicating about the nature of these risks and providing people with information about actions they can take to reduce their risk will reduce perceptions that the risk is unknown (they have been informed about it) and uncontrollable (they have been given information about actions they can take to control it), thus reducing the sense of fatalism and empowering people to take action to protect themselves and others.

Relatedly, a final factor to consider is the extent to which people will actually be able to use any additional knowledge they have gained from pre-incident information campaigns in the event of a real incident; to what extent will any fear and anxiety experienced during the incident outweigh any benefits associated with increased pre-incident

knowledge? It is certainly possible that any anxiety experienced during an incident may reduce public ability to recall specific information. However, as noted above, effective pre-incident information campaigns will reduce factors associated with increased anxiety (e.g. lack of knowledge about the risk, perception that the risk is uncontrollable) and so should help to counteract anxiety and empower people to take appropriate actions. Additionally, having a certain level of pre-incident knowledge should facilitate public engagement with official advice during an incident [73].

To ensure that pre-incident information campaigns are as effective as possible in empowering people to take appropriate actions in the event of an incident, information should: be as clear and concise as possible (to inform people about the risks, increase perceived control, and reduce public anxiety) and; be reiterated regularly (to assist ease of recall during an incident). Whilst fear and anxiety associated with an incident may make it more difficult for people to recall pre-incident information, they are likely to have a much better chance of taking appropriate actions if they have been provided with pre-incident information about appropriate actions to take.

4.4. Further research

The findings presented here suggest that it is possible to develop effective pre-incident education campaigns, for both non-CBRN and CBRN threats. However, the majority of studies identified in this review focused on improving preparedness behaviour in the immediate or short-term (<1 month), with only 3 studies examining improved preparedness over one year or more. It is therefore unclear whether any improvement in preparedness is sustained over the medium to longer term. Further research is required to examine how best to increase preparedness over the longer term, for example testing the efficacy of two or more interventions for improving preparedness over a medium-to long-term time frame. Further research should also examine public misperceptions in relation to different types of CBRN agents, so that these can be specifically addressed when designing pre-incident education campaigns.

4.5. Limitations

While every attempt was made to ensure that this review was as comprehensive and systematic as possible, there are certain limitations that should be borne in mind when interpreting the results. The first is that, despite every attempt to apply the inclusion and exclusion criteria systematically and objectively, there is inherently some subjectivity involved in paper screening and selection. To attempt to overcome this, a second researcher reviewed a sample of 20% of the selected abstracts, and the first author discussed any papers around which there was uncertainty with other members of the research team. However, due to time and resource constraints, it was not possible to achieve multiple-review for all papers included at the full text stage. A second limitation is that only papers published in English were included in the review, again due to time and resource constraints. This inevitably creates a western bias in the papers that were included, resulting in a degree of cultural homogeneity. For example, 34 studies were carried out in the UK, Europe or North America, with a further 4 being carried out in Australia or New Zealand. As noted in the introduction it is therefore essential that any pre-incident information campaign take into account the natural, technical and social context [18].

5. Conclusion and recommendations

This review brings together evidence relating to the development of effective pre-incident information campaigns for a broad range of major incidents and emergencies, in order to generate recommendations for the development of pre-incident information for CBRN incidents. While the review highlights the need for further research to establish the

optimum method of providing pre-incident information, there are some recommendations that can be drawn from the current review. This recommendations section highlights some initial recommendations for developing pre-incident information campaigns for CBRN incidents, as well as recommendations for further research.

5.1. Recommendations for pre-incident information campaigns for CBRN incidents

- Pre-incident public information for CBRN incidents should contain information about:
 - o The potential consequences of CBRN incidents
 - o The ways in which CBRN agents may be transmitted
 - o The actions that people can take to protect themselves and others during a CBRN incident
 - o The efficacy of protective measures that people can take to protect themselves and others during CBRN incidents and the importance of taking such actions
- Pre-incident information for CBRN incidents should be provided using multiple methods, all of which should contain consistent information.
- Consideration should be given to using higher intensity interventions (such as discussion groups, training courses, video games etc) to deliver pre-incident information for CBRN incidents, when possible.

5.2. Recommendations for future research

- Researchers should examine public perceptions of hazardous materials/CBRN incidents, to help address any common misperceptions when designing public information interventions.
- Research should examine the best method of providing pre-incident information for CBRN incidents and should specifically compare two or more pre-incident information interventions to establish the most effective method of delivery.
- Research should examine the potential of pre-incident information to improve preparedness for CBRN incidents over the medium-to long-term (over 3 months following an intervention), with careful consideration of the outcome measures used to determine whether preparedness information has been retained, and/or whether any changes in behaviour have been maintained.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2020.101796>.

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