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A systematic review of the use of mobile alerting to inform the public about emergencies and the factors that influence the public response

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Abstract

During an emergency, it is necessary to quickly disseminate messages to the public. These communications often provide information about the emergency as well as guidance or advice aimed at ensuring the safety of the population. Successful emergency communication depends upon how rapidly and reliably a message can be disseminated, but also on how people respond to the message that they receive. To assist emergency planners tasked with developing message sets for future incidents, in this paper we report a systematic review of all studies that assessed the impact of mobile telephone alerting systems on intended and actual behaviour, to identify factors that affect their likely impact. We searched multiple databases and conferred with topic experts, resulting in a total of 22 studies which met the inclusion criteria. Our results indicate that limited data exist on how people respond to text-based warning messages and that much of the data is poor quality, indicating a need for more real-world studies.

KEYWORDS

emergency alerts, mobile alerting, notification system, SMS messaging

1 | INTRODUCTION

Major incidents and emergencies require a prompt public response to reduce adverse outcomes. Providing fast, effective public communication about an emergency and how people should respond can be essential to saving lives and reducing negative impacts on a population (Rubin et al., 2012). To achieve this, official agencies have tested multiple ways of rapidly warning people of emergencies. Several techniques such as the use of sirens, alarms and landline telephones have been in existence for many years and can be effective, but the amount of information that they can provide to

people is limited (Fakhruddin & Chivakidakarn, 2014). More recently, the proliferation of mobile phones has provided a quick and reliable way to disseminate more detailed advice, using cell broadcasting to target messages to all phones within a specific location (Bean et al., 2016). The use of mobile phone networks in this way has been beneficial but poses new challenges to understand and overcome. In particular, the development and deployment of text-based warning systems in recent years has outpaced research into the effectiveness and potential limitations of the alert messages that they convey (Bean et al., 2015; Gutteling et al., 2018; Wood et al., 2015). While the speed with which messages are delivered to the public is crucial in an

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emergency, the success of the messaging is also determined by whether and how people act on the information that they receive (Lee et al., 2013; Sutton et al., 2014).

To make messages as effective as possible in guiding people to take action, we need to understand numerous factors. What, for example, is the best wording for each message? How many messages should be sent in an incident? Are there specific criteria for what type of incidents should trigger a message? These are empirical questions, for which evidence is required.

While some previous review work has investigated public alert and warning systems, these have generally focussed on American studies and have not solely investigated the impact of text-based emergency alert messages on behaviour (Kuligowski & Doermann, 2018; National Academies of Sciences, Engineering, and Medicine, 2018; Sadiq et al., 2022). The current review is therefore unique, in that it looks solely at the impact of emergency alert messages on behaviour and includes studies regardless of geographic location. To assist emergency planners tasked with developing message sets for future incidents, in this paper we report a systematic review of all studies that assessed the impact of location-specific, text-based mobile emergency alert messages on intended and actual behaviour, to identify factors that affect their likely impact.

2 | METHODS

2.1 | Search strategies

We searched the following electronic databases from inception to 14th March 2022: Medline, Embase, PsycInfo, Publons and Scopus. Databases were searched for articles containing MeSH terms or keywords relating to mobile alerting (e.g., 'notification system', 'mobile alert', 'public messaging'), text messages (e.g., 'SMS message', 'text message') and a type of emergency event (e.g., 'chemical spill', 'tornado', 'swine flu', 'shooting'). Full details of our searches are available in Supporting Information Material. Reference sections of any pertinent studies and reviews were also examined for further potential references.

2.2 | Inclusion criteria

This review included studies if they were published in English (no date restrictions), contained original research, related to an emergency (e.g., natural hazards, infectious disease outbreak, terrorism), studied the use of a location-specific mobile telephone alerting system and included a direct measure of actual behaviour, or a direct measure of how people report that they would behave in either a real or hypothetical situation involving the alerting system. Both qualitative and quantitative studies were included. There are many studies which investigate things such as the percentage of phones that receive an alert, but do not delve into the actual behavioural response of the recipient. In this review we looked only at those

studies that directly investigated how people responded to either actual or hypothetical messages. Also excluded were those which looked at emergency alerts via social media or any medium other than text-based mobile messages as responses to these information channels may differ (Schultz et al., 2011). We also excluded studies that contained only location data (e.g., from mobile phone data), measuring where in space people were located rather than what they were doing, as this data is not a direct measure of either intended or actual behaviour. We also excluded studies that used crowd density measurements where social distancing within the crowd could not be determined. Studies were also excluded if multiple types of messaging channel were used and results not separated according to type.

2.3 | Study selection

All titles and abstracts were screened by the first author using Endnote software to identify potentially eligible studies and record decisions. A subset of 500 titles and abstracts were additionally screened by a second reviewer (the second author) to ensure that the inclusion criteria were applied consistently and accurately. Full texts were then screened by the first author and shared with the last author to resolve any uncertainties through discussion. A list of related literature has been included in Supporting Information: Appendix 1, which details reasons for exclusion from the review.

2.4 | Data extraction and risk of bias

The first author extracted data from all the included studies using a narrative synthesis approach. This method is an established way of using text to collate study findings in mixed systematic reviews where a meta-analysis is not appropriate due to methodological and statistical variability (Campbell et al., 2018). Study and participant characteristics were noted, including study design, study populations, sample size, type of emergency, mobile alert details and behavioural outcomes.

Studies were assessed for quality using the Mixed Methods Appraisal Tool (MMAT), which is designed to appraise the methodological quality of qualitative research, randomised controlled trials, nonrandomised studies, quantitative descriptive studies, and mixed methods studies (Hong et al., 2019).

3 | RESULTS

3.1 | Search results

In total, 5703 titles or abstracts were identified and examined, from which 53 articles were selected as potentially relevant to the review. Of these, 38 were excluded for not studying an emergency alert ($n = 11$), not including a measure of behaviour ($n = 9$), focusing solely

on evaluating the feasibility of the alert system ($n = 9$), not conducting original research ($n = 6$), being a duplicate record of an already included publication ($n = 2$), and not being published in English ($n = 1$). This left a total of 15 studies which met the inclusion criteria (see Figure 1 PRISMA flowchart). Twenty-two studies that were not previously included were flagged for inclusion during peer review. When assessed, seven were deemed to meet the inclusion criteria, bringing the full number of included studies to 22. Of these, four had a qualitative design. The other 18 studies used a variety of quantitative methods including cross-sectional surveys ($n = 7$), mixed methods ($n = 5$), and experimental design ($n = 6$). The majority of studies were conducted in the United States ($n = 14$), but other countries included the UK ($n = 3$), South Korea ($n = 2$), Canada ($n = 1$), China ($n = 1$) and the Netherlands ($n = 1$). A variety of behavioural responses were measured by the studies, such as sharing of

information and following recommended behaviours, either reported or intended.

3.2 | Quality of studies

The MMAT was used to rate the quality of each study. This tool evaluates studies on five dimensions which vary based on study methodology. To enable more detailed description of risk of bias in the study, we scored studies out of two on each of the five dimensions, resulting in a total score out of 10. To aid interpretation of results, studies were rated as poor quality if they scored five or under; moderate quality if they scored six or seven; and good quality if they scored eight or over. Studies had a median score of 7, with a range of 4–9 (Figure 2). Overall, studies were of moderate quality, but

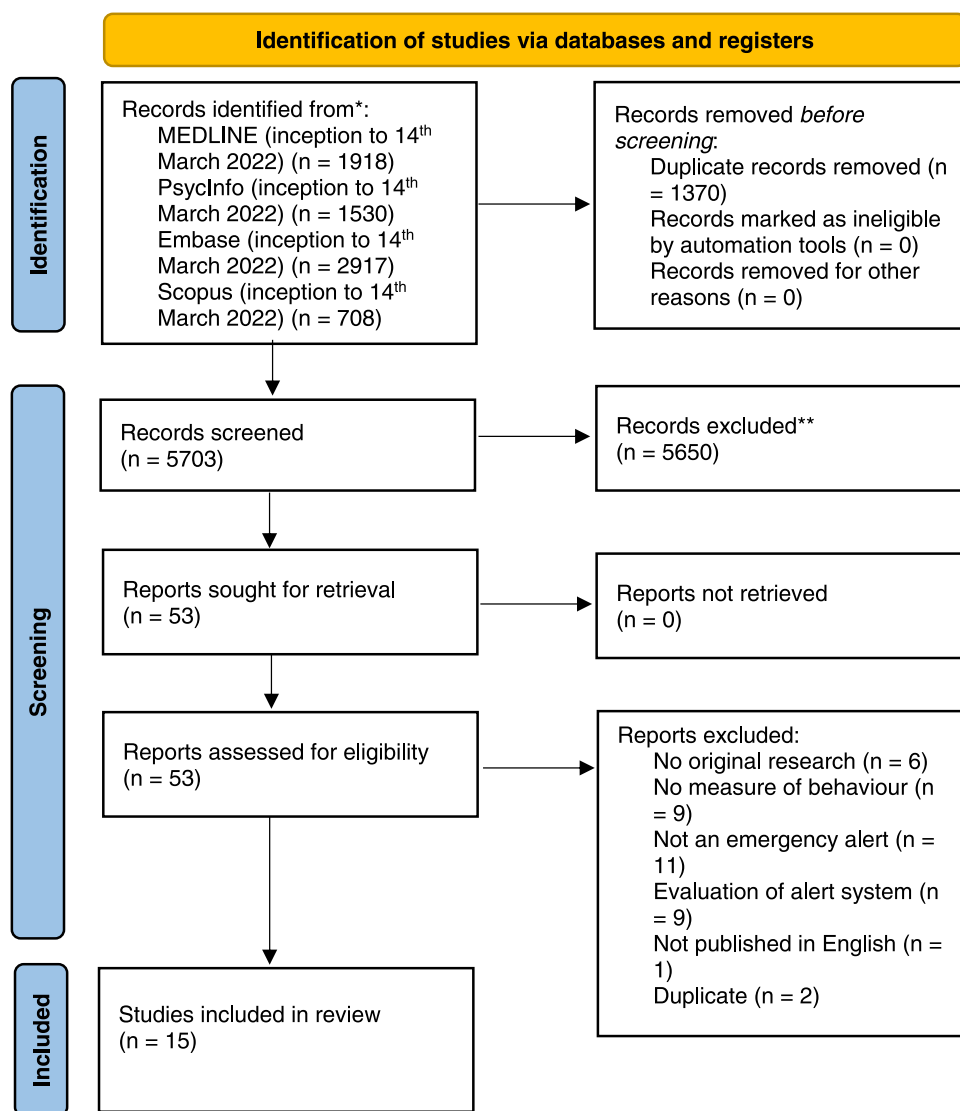


FIGURE 1 Mixed methods appraisal tool scores by study.

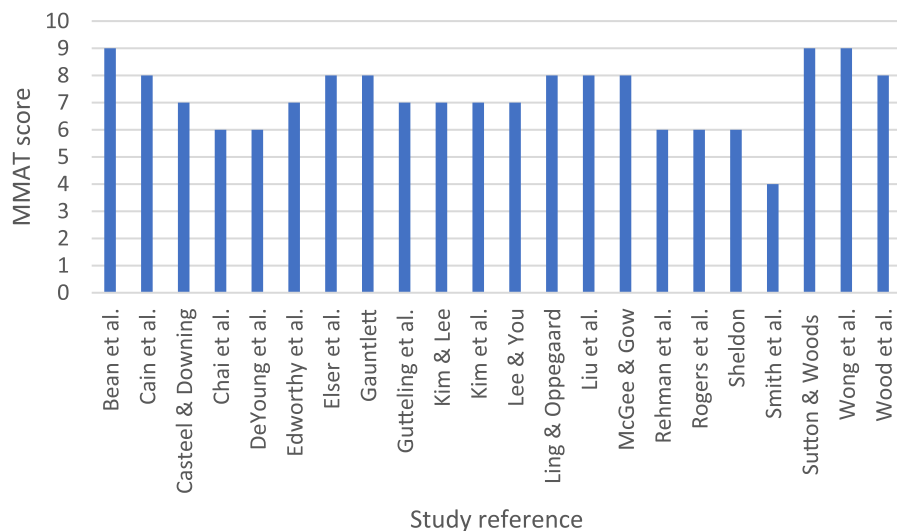


FIGURE 2 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only. *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). **If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools. From: Page et al. (2021). For more information, visit: <http://www.prisma-statement.org/>.

often lacked detail about aspects such as randomisation procedures, confounding variables, or full outcome data.

3.3 | Qualitative studies

Table 1 provides a summary of the qualitative studies that we identified.

The first study aimed to understand how members of the American general public interpret Wireless Emergency Alerts (WEAs) and Twitter-length messages for a mock improvised nuclear device detonation (Bean et al., 2016). Participants first took part in a think-aloud telephone interview where they were asked to read and respond to one of four potential alert messages. Two of the messages were 90-character WEAs and the other two messages were 140-character tweets. Subsequent to the interview, all participants took part in a focus group where they examined two of the four mock messages and discussed their understanding and beliefs about the messages, as well as perceived personal impact and intended behavioural responses. Most participants felt that both the WEAs and tweets lacked clarity and would have benefited from further information about the hazard, as well as greater details about the protective action to be taken and the specific area that was affected. Inclusion of a map helped participants to determine whether the hazard was impacting them specifically and belief in the message was influenced by whether participants thought they had opted-in to receiving alert messages. Overall, about a third of participants reported the intention to take shelter immediately after receiving the messages, although the 140-character tweets were perhaps slightly better at reducing milling behaviour. This could have been a consequence of the longer message, or the way in which it was worded.

A study conducted with Canadian university students in 2009, focusing on three potential emergency situations which included a tornado, a fire or a threatening message towards the university (McGee & Gow, 2012). Focus group discussions examined how

students living on campus might respond to an emergency alert about one of the three scenarios. In the week before the focus groups, participants met with researchers and were given three sealed envelopes, each with the text of one SMS message relating to one of the emergency scenarios. Several days later they were sent a text message by the researchers telling them to open only one of the envelopes and read the message inside. Each message provided information about the emergency situation and protective behaviours that participants should engage in (either sheltering in place or leaving campus). Participants were asked to write down initial thoughts and responses before attending a focus group where they discussed their experiences, understanding of the message and their intended behavioural responses. Most students felt that the emergency alert messages were easy to understand, but expressed uncertainty about how and where to evacuate, particularly in response to the unspecified threat. Belief in the messages was high as participants were aware that the university had a warning system in place, but most students reported that they would confirm the veracity of the message with friends, staff, or other sources before acting. The protective behaviours that participants were asked to consider were deemed to be feasible, but some participants reported that they would employ a 'wait and see' approach as they had concerns about missing classes or exams.

A study, conducted with members of the general public in America in 2014 aimed to examine how message sense making supports individual risk processing and message interpretation regarding tsunamis (Sutton & Woods, 2016). Participants took part in focus groups where they were presented with a tsunami warning message. This message was taken from a real tsunami alert, with only the date altered to match the focus group. Participants were asked to imagine that they were on vacation in an area which has previously experienced tsunamis, when the alert message appeared on their phone. Participants tended to make sense of the messages by making comparisons to media accounts they had seen of tsunamis, as well as drawing on personal experiences with other hazard warnings, particularly tornadoes. Participants generally expressed belief in the

TABLE 1 Characteristics of mobile alerting studies using qualitative methodology.

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Bean et al. (2016)	Nuclear device detonation	Not stated	Four focus groups and 31 think aloud interviews; 31 participants completed an interview and a focus group); USA	Two 90-character WEA messages, two 140-character Tweets. Each participant saw only one message.	Participants initially completed a think aloud interview by telephone, seeing one message by email and described their thoughts while reading it aloud. The same participants then took part in a focus group exploring their understanding, beliefs, thoughts and intentions around two of the messages.	Understanding: all messages were seen as lacking clarity about the hazard, protective action guidance, affected area, and timings Beliefs: this was influenced by whether participants thought they had opted-in to receiving alert messages and whether the source was seen as trustworthy Personalisation: many participants were unsure whether or not the hazard was impacting them specifically and inclusion of a map helped clarity this Behavioural intentions: 11 participants overall said they would immediately take shelter; of these three saw the 90-character WEAs and eight saw the 140-character tweets, suggesting the tweets may have slightly reduced participant milling behaviour
McGee and Gow (2012)	Tornado, fire, threatening message	October 2009	Four focus groups; 24 university students; Canada	three SMS emergency messages: one about a tornado, one threatening message towards the university, one fire. Each participant saw only one SMS message.	In the week before the focus group, participants met with researchers to find out about the study being given three envelopes with cue cards in. They were then sent an SMS message telling them to open one of the three envelopes and asked to read the card which contained a warning message. The message gave information about the emergency and protective behaviours. Participants were asked to write down initial thoughts and how they might respond. The focus group was held several days later to discuss experiences, understanding, responses.	Understanding: messages were seen as easy to understand but needed more clarity about where to go when evacuating. Beliefs: most participants said they would view the messages as real, but some said they would ignore them if they were unaware of the alerting system. Personalisation: environmental risks were perceived to be greater if they were visible at the time of the message. Confirmation: participants would all seek further information after the alert to verify/confirm it. Decision making and protective actions: sheltering or leaving campus were

(Continues)

TABLE 1 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Sutton and Woods (2016)	Tsunami	October 2014	Four focus groups; 31 participants; USA	One complete warning message, presented in 12 smaller sets of text.	Each focus group saw a real tsunami message (only the date altered so it matched the focus group date) and were asked to imagine they were on vacation in an area that has previously experienced tsunamis when the message appeared on their cell phone. The message was discussed in small sets and at the end participants were given a paper copy and asked to circle statements they did not fully understand.	<p>seen as reasonable actions by participants, but there was uncertainty about when to adopt the behaviours. Some participants said they would try to protect others by telling them about the alert. Some participants would 'wait and see' before sheltering/leaving and worried about missing classes or exams.</p> <p>Understanding: mixed levels of understanding, for instance, size of wave was discussed as being hard to comprehend; more information wanted about damage it could cause, specificity about location impacted for those unfamiliar with the area. Language around impact and protective actions needs to be clear and convey urgency.</p> <p>Belief in message: participants believed the message was reliable and from a credible source and that recommended actions would keep them safe. Believing the message meant participants would take the intended action of leaving the area, but many would also search for more information.</p> <p>Personalisation of message: participants expressed a need for more information about specific locations affected, feeling particularly concerned as they were somewhere unfamiliar to them. This anxiety compelled many participants to say they would plan to take action by</p>

TABLE 1 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Wong et al. (2018)	Flooding, unexploded WW2 bomb	30 April to 6 July 2015	Seven focus groups; 33 12–18 year olds; UK	Two sets of sample SMS messages about flooding and an unexploded WW2 bomb. Each set had four SMS messages shown to participants one by one to simulate receiving them on their phone.	Focus group initially discussed mobile alerting systems and experiences. Participants then shown 2 sets of sample SMS messages and asked to write down thoughts, feelings and likely responses. Participants then shared what they had written.	<p>leaving the area or seeking more information.</p> <p>Risk information processing: participants discussed gaps in knowledge and how they were filling these to make sense of the threat, impact and consequences. They often discussed past vicarious experiences with hazards they deemed similar.</p> <p>Intention to comply: most participants were willing to comply with advice, but it may depend on how much danger they felt they were, with greater compliance if in greater danger. Type of incident influenced how much risk they felt, but no consensus over which scenario was more risky.</p> <p>Trust: greater trust in messages if from government agency and used infrequently.</p> <p>Information needs: wanted clear instructions about how to respond; would check additional sources to verify alert message</p> <p>Style of message: more formal language made it feel more official and more likely to follow advice</p> <p>Typical text message behaviours: most would immediately read an alert message, but might ignore or delete if not aware of alert system</p>

message and this led them to take the intended protective action of leaving the area, but many also explained that they would search for further information. Specifically, participants wanted more information about specific affected locations to relieve their anxiety about being in an unfamiliar place.

Another study, conducted in 2015 with UK teenagers sought to identify factors that influence how young people might respond to emergency text messages about flooding or an unexploded World War Two bomb (Wong et al., 2018). Participants took part in a focus group where they were shown two sets of four sample SMS messages which gave them information about the emergency and told them what to do. Participants then wrote down their initial thoughts, feelings and likely behavioural responses before engaging in a group discussion. Intention to comply with advice was high, but participants reported that they would be more likely to engage in recommended protective behaviours if they were already familiar with the alerting system, if the messages came from a trusted source, if messages were only sent in serious events, if multiple messages were sent and if the messages were short and formal in style.

3.4 | Quantitative and mixed methods studies

Table 2 provides a summary of the quantitative and mixed methods studies that we identified.

3.4.1 | Experimental design

In the single randomised controlled trial that we identified, the researchers tested the effectiveness of SMS messaging to improve knowledge, attitudes and self-reported preventive behaviours about influenza A/H1N1 (Chai et al., 2013). Using a single-blind method, a random sample of community residents in China received 3 weeks of either H1N1 prevention SMS messages, or tobacco cessation SMS messages. Before messages were sent, participants completed a survey collecting data about their demographics as well as knowledge, attitudes and behaviours regarding H1N1 prevention and control. After a total of 10 SMS messages had been received over a 3-week period, participants completed another survey containing the same measures, but also assessing acceptability of the SMS messaging system. Both study groups saw a significant increase in self-reported engagement with recommended preventive behaviours, however the H1N1 group was significantly more likely to report having had an H1N1 vaccination post-SMS messaging.

Five further studies used an experimental design. The first study sought to examine how the use of maps can clarify who should take protective action in an emergency, and whether maps affect risk perception, intended action and trust in the message source (Cain et al., 2021). Participants were American university students who were randomised to either a school shooting or armed robbery incident. Participants initially answered a questionnaire to assess their knowledge of campus emergency alerts. Then they were

randomised to a study condition and saw a message which either provided text-only information about the type of hazard, location and protective measures to be taken, or a message that provided the text, plus a short or long distance map of the affected location. After viewing the message participants completed questions about emotions, risk perceptions, crisis efficacy, behavioural intentions, message understanding and trust. Participants in the school shooting scenario had significantly higher responses across most measures, including intentions to follow protective behaviours. Although those who were exposed to a short distance map reported greater perceived risk compared to participants who only received text based information, the map had no significant effect on perceptions of risk severity, behavioural intentions, crisis efficacy, understanding or trust in message source.

Another American university based experimental study aimed to explore responses to text-only tornado warning messages compared to messages which also incorporated warning polygons (very specific locations affected by the alert) or radar images (Casteel & Downing, 2016). University students were given information about WEAs and were then told to imagine that they were on a trip and while driving, received a tornado warning message. Messages were divided into 4 categories which included text only, text and national weather service warning polygon, text and radar image, and text, warning polygon and radar image. All participants initially completed two practice warning messages before seeing all 26 study messages in a computer randomized order. After each message they were asked about risk perceptions and severity, as well as intentions to inform loved ones about the incident. Results indicated that decisions to inform loved ones did not differ between types of warning message. Including greater amounts of information also did not increase perceptions of risk or severity.

A 2015 study explored which factors influence information transmission when emergency messages describing various chemical hazards are passed from person to person (Edworthy et al., 2015). Five messages were passed along a chain of participants from the UK general population using five modes of communication, including SMS messaging, email, paper, phone and face-to-face. Five groups of 10 participants each passed all five messages between them. Each participant had to try to remember enough of the message to pass it to the next participant while a researcher observed the process. In the SMS condition, the message was sent directly to the phone of the first participant, and they then created and sent a text message to pass the information on to the next participant. Written messages were transmitted more accurately than verbal messages, with a paper format being the most accurate, followed by SMS. Message accuracy deteriorated down the chain of participants. The researchers suggested that written messages survive better as it is possible for participants to reread them and take more time formulating their own message. However, 'location', 'advice' and 'substance' (e.g., gas release, chemical fertilizer, weak acid) survived well regardless of communication channel.

Another study aimed to test how at-risk groups in the United States respond to warning messages with and without maps (Liu

TABLE 2 Characteristics of mobile alerting studies using quantitative or mixed methodology.

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Cain et al. (2021)	School shooting; armed robbery	Not stated	Experimental; 404 university students; USA	Messages were based on existing alerts for imminent hazards and were presented as messages sent to personal cell phones. Messages communicated either an armed robbery or shots fired scenario and gave text information about the type of hazard, location, protective measures and updates. Some messages also included a map after the text.	Participants first answered questions about their knowledge of campus emergency alerts. They were randomly assigned to a study condition. After viewing the message they completed questions about emotions, risk perceptions, crisis efficacy, behavioural intentions, understanding and trust.	The school shooting scenario produced significantly higher responses for negative emotions, risk susceptibility and severity, behavioural intentions and crisis efficacy than the armed robbery scenario (all $p = .00$). Participants exposed to a short distance map reported significantly higher levels of perceived risk susceptibility compared to text-only ($p = .05$), however maps had no significant effect on perceptions of risk severity, behavioural intentions, crisis efficacy, understanding or trust in message source.
Casteel and Downing (2016)	Tornado	Not stated	Experimental; 64 university students; USA	26 WEA tornado warning messages divided into four message conditions: text only alert; text and national weather service warning polygon; text and radar image; text, warning polygon and radar image	Participants were introduced to WEA messaging and told it was geographically targeted. They were told to imagine they were on a trip outside the study location and while driving their cell phone received the tornado WEA. Each participant completed two practice messages and then saw all 26 messages in a computer randomized order. Participants were asked about perceived risk, severity and intentions to inform loved ones and their responses were timed.	Responses to questions about perceived risk, perceived severity and likelihood to contact a loved one did not differ significantly as a function of type of warning message (all p 's < .81). There were also no differences in response times as a function of warning type (all p 's < .54). Ratings on the likelihood to contact a loved one did not differ as a function of weather knowledge.
Chai et al. (2013)	H1N1	January to February 2010	Single-blinded, RCT; 995 H1N1 group and 997 tobacco	10 SMS messages on H1N1 prevention and control, or tobacco cessation	Pre-SMS messaging survey collecting data on demographics, knowledge, responses were timed.	Knowledge: H1N1 message group had higher H1N1 knowledge (4.2% higher, $p < .001$).

(Continues)

TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
DeYoung et al. (2019)	Ballistic missile/nuclear emergency	2018	Mixed methods with online survey and open-ended questions; 186 participants from the general	Accidental emergency SMS on 13 January 2018 to population of Hawaii about a false nuclear threat	Participants completed an online survey with a large portion of open-ended questions. Primary focus was to capture perceptions about information in the warning message, protective actions	Attitudes toward recommended prevention measures: H1N1 groups had greater change in individual attitudes to H1N1 (9.4% higher, $p < .001$). Self reported behaviour: Average individual self report of recommended preventive behaviours (mask wearing, handwashing, social distancing) score increased significantly within each group between pre- and post-SMS messaging (within the H1N1 group, by 12.1%, $p < .001$; tobacco group, by 11.4%, $p < .001$), average individual scores did not differ between H1N1 and tobacco groups (95% CI = -0.8% to 2.2%). Uptake of H1N1 vaccination: H1N1 group 1.77 times higher odds (95% CI = 1.39-2.26) of reporting receipt of a 2009 H1N1 vaccination versus tobacco group post-SMS messaging. Symptom reporting: H1N1 group had 0.12 times smaller odds of reporting influenza-like illness ($p < .001$).
						Emotions: most participants reported negative feelings of fear, anger and worry; mostly associated with social connections. Information and trust: most participants reported seeking

TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Edworthy et al. (2015)	Various chemical hazards for example, gas release, chemical fertilizer release, weak acid release	Not stated	Experimental design; 50 participants from the general population; UK	Five messages (one paper, one email, one SMS, one face-to-face, one phone)	There were five groups of 10 participants. Each group passed all five messages between them in a designated participant order. Each participant had to try to remember enough information to pass the message on to the next participant while the experimenter observed. In the SMS condition, the message was sent to the first participants phone and they created and sent a text to the next participant to pass on the information.	<p>further information to confirm veracity of the message; many reported doing this while simultaneously taking protective action such as sheltering in place.</p> <p>Protective actions: many participants reported taking no action to protect themselves, displaying fatalism about the event and seeing action as pointless. Some participants said the event would make them prepare to take action in the future for example, purchasing iodine tablets. Many participants reported confusion or uncertainty about appropriate action to take, but many chose to shelter in place even if unsure about how useful it would be.</p>

Transmission accuracy: Paper messages were most accurately transmitted, ($M = 1.13$) followed by SMS ($M = 1.01$), email ($M = 0.91$), face-to-face ($M = 0.69$) and phone ($M = 0.65$). Significant differences were found between paper and all other channels (all at $p < .001$ except between paper and SMS, $p < .05$) and between SMS and both phone and face-to-face ($p < .001$).

Communication down the chain: A two-way communication channel position ANOVA showed a main effect for

(Continues)

TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
						channel ($F [4, 37] = 27.3, p < .01$), a main effect for position ($F [9, 37] = 17.14, p < .01$) but no significant interaction between the two ($F [36, 160] = 1.38, p = .094$). Performance generally fell as position in the chain increased, and performance was better using some channels than others. At position 1, there was a significant effect of communication channel ($F [4] = 5.1$) with significant differences between paper and face-to-face ($F [1] = 28.4, p < .01$), paper and phone ($F [1] = 12.31, p < .01$) and paper and SMS ($F [1] = 12.4, p < .01$). At position 2, there was again a significant effect of communication channel ($F [4] = 5.25, p < .01$), with significant differences between paper and face-to-face ($F [1] = 50.1, p < .01$), paper and phone ($F [1] = 21.5, p < .01$) and paper and SMS ($F [1] = 7.4, p = .053$). At position 3 there was still a significant effect of channel ($F [4] = 3.56, p < .01$) with significant differences between paper and face-to-face ($F [1] = 68, p < .01$) and paper and phone ($F [1] = 16.7, p < .01$). At position 4, there was no effect of communication channel ($F [4] = 1.83, p = .172$, neither was there at position 5 ($F [4] = 2.11, p < .01$), position 6 ($F [4] = 2.05, p < .01$) or beyond.

TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Elser et al. (2021)	COVID-19	14 March to 1 April 2020	Online, cross-sectional social media survey; 17,543 participants from the general population; USA	Shelter-in-place order by SMS message on March 16, 2020	Online survey conducted between 14 March to 1 April, 2020 measuring self reported changes in social distancing behaviour, experienced difficulty with daily activities, and level of concern regarding COVID-19.	<p>Social distancing: increase in proportion of respondents practicing social distancing 'all of the time' after SMS message in the Bay Area (9.2%, 95% CI: 6.3, 12.1) and elsewhere (3.4%, 95% CI: 2.0–4.9).</p> <p>Sheltering in place: increase in proportion of respondents sheltering in place 'most of the time' after SMS message in the Bay Area (5.7%, 95% CI: 2.3–9.0) and elsewhere (8.5%, 95% CI: 6.8–10.3).</p> <p>Difficulty with daily activities: increased difficulty obtaining hand sanitizer, medications and obtaining food in the Bay Area (13.3%, 95% CI: 10.4–16.3) and elsewhere (8.2%, 95% CI: 6.6–9.7).</p> <p>Concern: only small changes in level of concern regarding COVID-19.</p>

Gauntlett (2020)	Ballistic missile/nuclear emergency	October to November 2018	Online, cross-sectional survey; 454 participants from the general population; USA	Accidental emergency SMS on 13 January 2018 to population of Hawaii about a false nuclear threat	Each participant completed a single survey asking them about preparedness, preincident communication preferences, adherence, belief in message, awareness, risk perceptions, trust, prior information received and perceived preparedness effort.	<p>Adherence with protective instructions: 85% were found to be incidentally adherent to instructions to seek immediate shelter, while only 13% were deliberately adherent.</p> <p>Respondents were less likely to have been incidentally adherent if they had children over 18 living at home (OR 0.39 [0.13–0.89]), were native Hawaiian (OR 0.39 [0.18–0.86]) or were educated to degree level (OR 0.36 [0.17–0.74]). Having been outdoors upon receiving</p>
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TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
						the alert was significantly associated with incidental adherence (OR 0.00 [0.00–0.01]), but not with deliberate adherence. Being of mixed (OR 3.16 [1.31–7.61]) or other (OR 4.29 [1.35–13.29]) ethnicity was significantly associated with deliberate adherence. Those believing an attack to be imminent were more likely to be deliberately adherent (OR 5.14 [2.31–11.42]). Taking no action or carrying on with what they were doing was reported by 19% (n = 87). Those who selected this response offered four key reasons as to why they took no action. These were categorised as: fatalism, denial, unawareness and uncertainty.
						Individuals of mixed ethnicity (OR 3.32 [1.21–9.14]) and those first alerted to the warning via emergency siren (OR 18.30 [1.04–322.25]) were significantly more likely to believe an attack imminent as well as adhere to protective instructions, whilst individuals who believe Hawai'i to be partially protected by the military (OR 0.34 [0.12–1.01]) were less likely to believe an attack was imminent or to adhere with the instruction to shelter than those who believe Hawai'i to be fully protected by the military.

TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Gutteling et al. (2018)	Two hazardous industrial fires; one large city centre fire	January 2013, June 2013, October 2013	Cross-sectional telephone survey; 643 participants who were members of the general population total (175 incident 1; 181 incident 2; 287 incident 3); Netherlands	One SMS message providing advice about emergency situation and advising to close windows and doors and turn off ventilation	Potential participants randomly contacted within 48 h of SMS message and asked about first responses, then invited to complete online survey capturing data on behaviour, perceived threat, efficacy beliefs, affective reaction, social norms, information need and perceived message quality.	Self reported adaptive behaviour: could be predicted by the set of variables moderately well ($p < .001$). Emotion ($p < .001$), social norms ($p < .01$) and perceived message quality ($p < .05$) were significant predictors of adaptive behaviour. Self-reported behavioural avoidance: could be predicted by the set of variables moderately well ($p < .001$). Perceived threat ($p < .001$), emotion ($p < .001$) and social norms ($p < .001$) predicted behavioural avoidance significantly.

Kim et al. (2019)	Active shooter, explosion	2015	Randomised laboratory experiments with surveys and qualitative interviews; 150 participants in Experiment 1, 102 participants in Experiment 2, all were university students; USA	Six SMS emergency messages (three active shooter, three explosion)	Participants were not initially aware that the SMS messages were not real. They completed a pretest questionnaire assessing psychological attributes and demographic characteristics, then received a warning message and were observed for 1 min before completing a post-test survey assessing behaviour responses. Participants were interviewed after the study to expand on the findings.	Behavioural response: alerting the RA was influenced by belief in the message (OR = 1.19, $p = .031$, CI (1.02–1.39)), with higher belief predicting higher odds of alerting the RA. For both Experiments 1 and 2, experimental condition was not a significant predictor of protective action behaviour. This suggests that behavioural responses, at least immediately after receiving a text-based warning message, do not significantly differ based on message content (active shooter, explosion) or message length (90, 160, and 280 characters). Qualitative interviews suggested that desensitisation to emergency alerts through previous experience may reduce protective actions. They also
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TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Kim and Lee (2021)	COVID-19	September 25 to October 16, 2020	Cross-sectional study using self-reported online or paper questionnaire; 489 participants who were 310 members of the general public and 179 migratory workers; South Korea	Regular/ongoing SMS messages about preventive measures to slow transmission of COVID-19	Each participant completed a single survey in September/October 2020, capturing data on demographic characteristics, self-reported compliance with measures, perceptions of the role of SMS messages in compliance with measures and overall feelings toward SMS messages.	Self-reported compliance with preventive measures (e.g., handwashing, mask wearing, cough etiquette, symptom reporting): Compliance was higher in migratory workers than in Koreans ($p < .001$) and higher in females than males ($p < .001$). Females recognized need to comply with measures more ($p < .019$) and had a more positive attitude towards compliance ($p < .014$). Participants with poor health status perceived SMS messages as more helpful for complying with measures ($p < .001$) and preventing infection ($p < .002$) and had more positive attitudes to compliance ($p < .001$).
Lee and You (2021)	COVID-19	March 25 to 27 2020	Cross-sectional web-based survey; 990 participants from the general population; South Korea	Regular/ongoing SMS messages about preventive measures to slow transmission of COVID-19	Each participant completed a single survey capturing data on demographic characteristics, self-reported preventive and social distancing behaviours, perceived susceptibility, perceived severity and response efficacy.	Reading SMS messages: overall, 49.2% of participants reported always reading emergency SMS messages and visiting the linked website for further information. Self-reported behaviour: participants who always read the SMS messages wore facial masks more ($p < .01$), avoided crowded places more ($p < .01$) and cancelled or postponed social gatherings more frequently ($p < .001$) than those who did not read the messages.

found that participants might be waiting for environmental or social cues before taking protective action.

TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Ling & Opegaard (2021)	Ballistic missile/nuclear emergency	January 28 to February 28, 2018	Mixed methods with online survey and open-ended questions; 418 participants from the general population of Hawaii; USA	Accidental emergency SMS on 13 Jan 2018 to population of Hawaii about a false nuclear threat	Participants completed an online survey with a large portion of open-ended questions. Primary focus was to capture experience of residents in the wake of the event.	Only 28% of participants reported their initial response as believing the message and about a quarter did not believe the alert. Those who were unsure were more likely to reported checking the information with another source such as TV or radio. Many participants said they checked validity with close family/friends. Some participants reported changing their usual behaviour until the message was verified, for example, by staying home, sheltering under a table, reaching out to family and friends.

Liu et al. (2017)	Tsunami, active shooter, radiological disaster	Not stated	Experimental: 1317 (Experiment 1 n = 767; Experiment 2 n = 550) members of the general population; USA	Experiment 1 included tsunami, active shooter and radiological disaster messages of 90, 140 and 1380 character lengths. Experiment 2 was tsunami messages of 280 characters with maps.	Participants were randomized to conditions and viewed the assigned message on a computer screen that visualized the message on a mock smart phone screen. Next they were told to imagine how they would feel if they had received the message on their phone and were asked about information seeking, emotion, compliance, decision clarity, information sharing behaviour and use of maps.	<p>Compliance with warnings is driven by emotional reaction and publics' clarity of understanding of the messages they receive. Clarity seems to be affected by publics' technology access, but not to the extent that emotion impacts clarity. Additionally, though information seeking consistently contributes meaningfully to information sharing, information seeking also is largely driven by emotional responses, with the impact of maps (as tested here) having insignificant effects. Furthermore, information seeking consisted of two constructs focusing on technology use and information milling capacity.</p>
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Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Rehman et al. (2020)	Mining disaster: fire, cave-in, explosion	2019	Field study with in-person survey; 37 participants who were all miners; USA	Identical messages were sent by SMS or in-person. Each scenario had 4 messages of increasing detail.	Premessaging, participants completed a survey gathering demographic data. After each message, participants completed a survey to understand how they would react and what they would do in response to different details in the alerts.	Decision making behaviour: message content was significantly associated with participants decision making in all scenarios (fire $p < .0000$; cave-in $p < .0000$; explosion $p < .0006$). Miners were more likely to investigate or seek further information in the cave-in scenario when messages were provided in person rather than by SMS ($p < .0329$).

Rogers et al. (2020)	Robbery, active shooter, building fire, hazmat, riot/violent protest, air quality advisory, health advisory	March 2017 to February 2018	Cross-sectional, online survey; 1529 university students; USA	A total of seven SMS emergency messages were sent to each participant (one for each scenario).	Online survey collecting data on demographic characteristics. After each scenario SMS message, the survey asked participants questions about preferences, perceptions and behavioural intentions.	Behavioural intentions: 66.1% of participants reported an intention to rapidly comply with SMS information without verification and 24.5% intended to verify it first then comply. Active shooter scenario elicited greatest intention to comply (84.2%). Higher attitude score were associated with rapid compliance in all 7 scenarios (AOR range = 1.06-1.12; 95% CI = 1.01-1.17). Higher perceived behavioural control scores were only associated with rapid compliance in the air quality advisory notification scenario (AOR = 1.07; 95% CI = 1.03-1.12). Higher threat appraisal scores were only associated with rapid compliance in the building fire emergency notification scenario (AOR = 1.02; 95% CI = 1.00-1.05); whereas, higher response efficacy scores were associated with rapid compliance
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TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Sheldon, 2017	Tornado, active shooter	Not stated	2 × 2 within subject experiment; 172 university students; USA	Two SMS emergency messages (one tornado, one active shooter), two social media messages (one tornado, one active shooter)	After reading each of the four messages (two SMS, two social media), participants completed a questionnaire collecting data on perceived severity and intentions to share crisis communication.	<p>in robbery, active shooter, and building fire scenarios (AOR range = 1.06-1.08; 95% CI = 1.02-1.13).</p> <p>Behavioural intentions: the channel used to notify students had a significant effect on the perceived threat, $F(1, 171) = 39.45, p < .0001$, but not secondary crisis communication, $p = .37$, indicating that text messages were perceived to be more serious than warning messages sent through social media. The overall regression model was significant only for the shooting message sent through social media, $F(1, 171) = 94.56, p = .000$, and results indicated that the more serious the warning message about the shooting was perceived, the higher the likelihood that it would be shared with others ($\beta = .60, SE = 0.06, p = .000$). Those who have experienced tornado warnings ($N = 150$) were also less likely to share the text message alert with people sitting around them ($M = 4.10, SD = 1.21$), compared to those that have not experienced it before ($M = 4.73, SD = 0.46$), $t(170) = -2.42; p = .016$. Those who had experienced warnings about the shooting before ($N = 24$) were less likely to share the text</p>

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TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
Smith et al. (2022)	Flooding	2021	Mixed methods combining focus group sharing, responsive writing and participatory polling; 80 university students; UK	Three separate SMS messages in each workshop, but all related to a severe flooding emergency.	A series of three workshops in one day. Each workshop involved the same questions and tasks for the cohort to complete but had different emergency message scenarios based on real flood events.	<p>message with their parents ($M = 3.58$, $SD = 1.53$), compared to those that had not experienced it before ($M = 4.27$, $SD = 0.46$), $t(170) = -2.42$; $p = .016$.</p> <p>Behavioural intentions: From the eight themes identified in responses, four occurred more frequently than others: prepare for evacuation, assess veracity/risk, contact people and click the link, accounting for 92% ($n = 137$) of all reported actions.</p> <p>Participants aged 18–21 were more likely than other groups to engage in milling by assessing the veracity of the message, and women were slightly more likely to prepare for evacuation than men, although differences were not significant. Participants with past experience of flooding were twice as likely to report preparing for evacuation than non-flooded participants (87% of all flooded participants vs 35% of all participants). Although each workshop was shown a different emergency scenario, there was no significant difference in anticipated actions between the groups ($F(2, 21) 0.937$, $p = .4$).</p>
Wood et al. (2018)	Explosion of an improvised nuclear device	2013	Mixed methods design with laboratory experiment and	Four separate SMS messages were used. All messages were about the same threat, but they differed	Experiment participants were each presented with one of the four randomly assigned SMS messages and then	In post hoc analysis, the enhanced high information message resulted in significantly higher understanding ($M = 5.07$) than

TABLE 2 (Continued)

Reference	Type of emergency	Date(s) of data collection	Design, sample and country	Details of mobile alerts used	Data collection procedure	Outcomes examined and effect of intervention (significant effects in bold, no significant effect unless stated, effect sizes given for significant effects where known)
	interviews and focus groups; 155 members of the general public took part in the experiment, 44 members of the general public took part in interviews/focus groups; USA			in length: standard 90 characters, enhanced low information 90 characters, enhanced medium information 140 characters, enhanced high information 1380 characters	asked to complete a survey collecting data about message understanding, belief, risk personalisation, deciding how to react and milling behaviour intentions. Interviews were by phone and participants had been emailed 1 of the messages. Focus groups were in person and each group focused on 1 of the messages.	the standard low ($M = 3.86$, $p < .001$), enhanced low ($M = 4.21$, $p = .005$), and enhanced medium ($M = 4.24$, $p = .014$) information messages. The enhanced high information message ($M = 4.70$) also resulted in significantly higher deciding than the standard low ($M = 3.38$, $p < .002$) and enhanced medium information ($M = 3.61$, $p = .025$) messages. Finally, the enhanced high information message ($M = 3.98$) resulted in lower intended milling (i.e., less response delay) compared with the standard low ($M = 5.08$, $p = .003$), enhanced low ($M = 4.98$, $p = .005$), and enhanced medium ($M = 5.01$, $p = .007$) information messages. The qualitative analysis confirmed the quantitative findings and yielded three important themes: (a) high information messages had better message outcomes, (b) high information messages did not eliminate milling completely, and (c) respondent opinions about high information messages were divergent.

et al., 2017). Hazard scenarios included tsunami, active shooter and radiological disaster, with each participant randomised to a condition. In the first experiment, each of the three scenarios had messages of 90, 140 or 1380 character length, while the second experiment was tsunami only and messages were 280 characters, plus a map. Participants viewed the mock phone message on a computer screen and were then told to imagine how they would feel to receive the message and answered questions about information seeking, emotion, compliance, decision clarity, information sharing behaviour and the use of maps. Findings showed that maps did not change understanding and potential compliance with protective behaviours in this study.

The final experimental study was a simulated evacuation exercise in the United States which sought to evaluate the effect of increasing levels of detail in emergency SMS messages on underground miners' evacuation decisions (Rehman et al., 2020). Three emergency scenarios had been developed which included a fire, a cave-in, or an explosion. For each scenario there were four messages of increasing detail, and these were randomly sent either by SMS message, or delivered in-person. Following each message, participants completed a survey to understand how they would react and what they would do in response to differing levels of detail in the alerts. The authors reported that the content of the messages had a significant effect on miners' decisions, with more miners choosing to evacuate when more detail about the incident was provided. The channel of communication did not significantly affect evacuation decisions.

3.4.2 | Mixed methods

Five studies employed a mixed methods approach. The first was conducted in 2018, shortly after the accidental release of a ballistic missile warning message to the population of Hawaii (DeYoung et al., 2019). The purpose of this study was to capture perceptions about the warning message, protective actions taken and drivers of protective actions. Members of the general population completed an online survey which also contained open-ended questions. Participants reported mixed beliefs about the veracity of the message and seeking further information was common, though some participants said they sought this information while simultaneously taking protective action. While many participants said they did not take protective actions, some did say the event has led them to prepare for taking action in the future.

An American study, focused on understanding how people respond immediately after receiving emergency alert text messages (Kim et al., 2019). Having arrived at the laboratory to take part in a study described to be about multitasking, participants completed a pretest assessing various psychological attributes, and then received an unexpected warning message either about an active shooter or an explosion. They were observed by the researcher for 1 min before completing a post-test survey of their behavioural responses to the warnings. Participants also took part in a qualitative interview about

their responses. Most participants did not react to the message at all, and type of emergency was not a significant predictor of protective action behaviour, though those who mainly spoke English at home were more likely to engage in protective behaviour than those who spoke only a language other than English at home. The qualitative analysis suggested that desensitisation to emergency alerts through previous experience may reduce protective actions. The qualitative work also found that participants might have been waiting for environmental or social cues before acting.

Another study of the accidental ballistic missile alert message sent to the Hawaiian population was conducted several weeks after the incident to capture the experiences of the population (Ling & Oppegaard, 2021). Similar to the earlier study, this was an online survey which contained numerous open-ended questions for members of the general public to complete. Belief in the veracity of the message was low, though many participants reported checking the information with another media source or with close family and friends. Some participants reported engaging in protective behaviours such as staying home or sheltering until they had confirmed whether the message was real.

A UK study looking at hypothetical flooding also used a mixed methods approach to understand how members of the public would respond to emergency SMS messages (Smith et al., 2022). Participants received SMS messages regarding a flood emergency and were involved in a series of workshops where they collaborated in groups to answer questions, complete tasks, and take part in a focus group. Participants often talked about the need to check the veracity of the messages. Those who had a past experience of flooding were twice as likely to report preparing for evacuation if they received an SMS (87% vs. 35%).

The final mixed methods study, based in the United States, focused on the hypothetical explosion of an improvised nuclear device (Wood et al., 2018). Four separate SMS messages were used, providing different amounts of information. Each participant was presented with one of the four randomly assigned messages and then asked to complete a survey which collected data about their understanding, beliefs, risk personalisation, how they would react and milling behaviour intentions. Milling is a psychological process whereby someone does not engage in a behaviour immediately as they are checking the veracity of the message and seeing how others will respond to a novel event. A smaller, separate group of participants took part in telephone interviews or in-person focus groups. Again, each interviewee or group saw only one randomly assigned message. The combination of quantitative and qualitative data suggested that messages with more information reduced the inclination to search for and confirm information, though they did not eliminate the delay to action completely.

3.4.3 | Cross-sectional

Three cross-sectional studies focused on COVID-19 emergency messaging. The first used an online survey to measure self-reported

changes in social distancing behaviour following a shelter-in-place SMS message (Elser et al., 2021). Participants were from the general population and the researchers compared those living in the San Francisco Bay area where the alert message took place, with those living elsewhere in the United States. Participants in both locations reported an increase in both their social distancing behaviour and sheltering in place behaviour, though there was no significant difference between the groups. Although this study focused on the Bay area shelter-in-place order, during the study time period, other areas also issued similar orders making it difficult to determine the effect of the messaging.

Another cross-sectional COVID-19 study surveyed members of the general public in South Korea as well as a group of migratory workers to assess how effective the government-driven SMS messages were for public compliance with COVID-19 protective measures (Kim & Lee, 2021). Participants had all been receiving regular messaging from the national emergency SMS service regarding COVID-19 and protective measures such as handwashing, coughing etiquette, mask wearing and the reporting of symptoms. Each participant completed a single survey which captured self-report data about compliance with 30 different behaviours. Participants with poor health status perceived SMS messages as more helpful for complying with measures and preventing infection and had more positive attitudes to compliance than those with a better health status. Differences between the general public and migratory workers were minimal, though migratory workers were more likely to suggest that messages should be provided in English as not all migratory workers spoke Korean and translation of messages was difficult.

The third cross-sectional study looking at COVID-19 also aimed to determine the effectiveness of emergency SMS messages on individual practice of COVID-19 protective behaviours (Lee & You, 2021). This online survey asked members of the general population in South Korea to provide self-report data on the preventive behaviours of mask wearing, hand hygiene and social distancing. Participants who always read the SMS messages wore facial masks more, avoided crowded places more, and cancelled or postponed social gatherings more frequently than those who did not always read the messages.

One cross sectional study focused on a potential nuclear emergency, using an online survey to understand how participants felt about preincident communication, message preferences, adherence, beliefs, risk perceptions and trust (Gauntlett, 2020). This study was also able to ask participants about their behavioural response to the accidental ballistic missile alert in Hawaii. Participants were generally found to report high levels of adherence to the protective alert telling people to 'find shelter', though certain factors such as being of mixed or other ethnicity, being outdoors when receiving the message and believing an attack to be imminent were most likely to impact adherence. Among those who did not take cover, key reasons for nonadherence included fatalism, denial, unawareness and uncertainty.

Another study that looked at real emergency messages was a telephone survey about SMS messages alerting the general population to large scale or industrial fires in the Netherlands (Gutteling et al., 2018). Messages had been sent to everyone within a certain

distance of each fire and included requests to avoid areas, close windows and doors and turn off ventilation systems. Participants were randomly selected within 2 days of the messages being sent and were asked about beliefs, reactions, information needs and behaviours. People were more likely to report engaging in protective behaviours when they rated their own affective reaction to reading the message as higher (e.g., more anxious, concerned, angry), when some social pressure was perceived and when the quality of the message was perceived to be higher.

An online study assessed the use of health behaviour theory to predict compliance to emergency text notifications across a wide range of scenarios (Rogers et al., 2020). College students in the United States were sent seven SMS messages, relating to different emergency scenarios, such as the presence of an active shooter to health advisories. Messages gave brief information about the threat as well as protective behaviours such as sheltering in place, avoiding certain areas or seeking healthcare. Following each message, participants were asked to complete questions about their message preferences, perceptions and behavioural intentions. Most participants reported an intention to comply with the advice straight away without verification, particularly in the active shooter scenario. There were some differences between scenarios, with perceived behavioural control being most important with rapid compliance to an air quality alert scenario and higher response efficacy being associated with rapid compliance in robbery, active shooter and fire scenarios.

Finally, a study of American college students tested the impact of emergency text versus social media notifications on threat assessments and behaviour (Sheldon, 2018). The scenarios were either an active shooter or a tornado and for each scenario there were two messages: one SMS and one social media. After participants had read each message, they completed questions about the perceived severity of the incident and their intentions to share the messages that they had received. Text messages were perceived to be more serious than warning messages sent through social media, though there was no significant difference in terms of message sharing. The more serious the message was perceived to be, the more likely it was to be shared with others. However, those participants who had experienced a tornado warning before were less likely to share the tornado warning message with those around them, and those who had previously experienced a shooting warning were less likely to share the shooting warning message.

4 | DISCUSSION

During a major incident it is important that the public receive clear, timely information about the threat as well as advice about appropriate protective behaviours. Despite the speed with which warning messages can be sent, evidence we reviewed suggests that many people do not react immediately to an emergency alert. Instead, they often engage in 'milling' behaviour. This means they spend time checking the message or interacting with others to determine how to behave in unfamiliar circumstances—several

studies in the papers we reviewed showed this effect (Bean et al., 2016; Casteel & Downing, 2016; Kim et al., 2019; McGee & Gow, 2012; Rogers et al., 2020; Smith et al., 2022; Wong et al., 2018; Wood et al., 2018). This corresponds well to evidence on 'milling' in relation to other forms of emergency alert, which shows that checking the credibility of emergency messages is common (Wood et al., 2018). Interestingly, studies of an emergency alert sent in error indicated that although people sought further information to verify the message, many also reported taking protective action at the same time (DeYoung et al., 2019; Ling & Oppegaard, 2021), perhaps highlighting a difference between hypothetical versus real-life responses. Indeed, to reduce the negative impact of a major incident, there is a need to understand how we can encourage people to act on a message as soon as possible and it is important to understand how and when people seek further information and engage in protective behaviours.

From our review, there appear to be several factors that influence the behavioural response to SMS alerts. These can be categorised as relating to the characteristics and past experiences of the message recipient(s), the nature of the incident, or the features of the message. First, behaviour can be influenced at an individual level. This includes specific factors such as the language spoken at home versus in the message (Kim et al., 2019) and type of affective reaction to the message (Gutteling et al., 2018; Ling & Oppegaard, 2021; Liu et al., 2017). Several studies also determined that prior exposure to warning messages was an important predictor of behavioural engagement. In several studies, those who had received messages previously either in a real incident or as a drill had potentially become desensitised to the warnings (Kim et al., 2019; Sheldon, 2018; Wong et al., 2018), which aligns with previous studies showing that people experience alert fatigue when numerous messages are received (Baseman et al., 2013; Lee et al., 2013; Perry et al., 2013). However, one study did find that those who had prior experience of flooding were twice as likely to report being prepared for evacuation compared to those with no experience of flooding (Smith et al., 2022), while another reported that those who had previously experienced a tornado warning were more likely to share a subsequent alert message (Sheldon, 2018). Those who had received the erroneous ballistic missile message also reported intentions to prepare themselves for potential future incidents (DeYoung et al., 2019; Ling & Oppegaard, 2021). In addition, a study of tsunami messaging found that participants drew on personal experiences of other hazards to inform their response to the existing message (Sutton & Woods, 2016). Potentially, while alerts that are not followed up by any particular impact on an individual result in a degree of desensitisation, incidents which do impact the individual have the opposite effect.

Situational factors include the 'milling' behaviour discussed earlier, but also the various environmental and social cues that can influence how a person responds to an incident. Participants in some studies described looking for visual or auditory cues that would confirm the message and encourage them to engage in protective behaviours (DeYoung et al., 2019; Gauntlett, 2020; Kim et al., 2019;

McGee & Gow, 2012). These cues were used by participants to inform their own assessments about risk severity. Unsurprisingly, people who reported a more emotional reaction to the warning message or greater perceptions that there is some societal pressure to respond in a certain way were more likely to engage in protective behaviours (Gutteling et al., 2018; Liu et al., 2017; Wong et al., 2018), in line with previous work (Rod et al., 2012). However, if perceived threat or external pressures are too high, people seem inclined to avoid following warning messages (DeYoung et al., 2019; Gauntlett, 2020; Gutteling et al., 2018), perhaps practicing behavioural avoidance as a coping mechanism (Witte & Allen, 2000). It is also likely that perceptions of threat and emotional reactions will differ in studies asking people to imagine a potential future incident, compared to studies asking them about a real-life incident which they have experienced (Nordgren et al., 2011), thus highlighting the need for more real-world studies in this area.

Finally, message characteristics also influence message credibility and engagement with protective behaviours. Message style influenced behaviour, with more formal language making messages feel more official and therefore more credible (Wong et al., 2018). In addition, messages from an official, recognised source, such as a government agency, were more likely to elicit a behavioural response (Gutteling et al., 2018; McGee & Gow, 2012; Wong et al., 2018), as suggested by previous research (Freberg, 2012; Kuligowski & Doermann, 2018), while another study suggests that the order in which information is presented can influence behaviour (Wood et al., 2015). Though one study seemed to indicate that people generally preferred short, simple messages (Wong et al., 2018), results from other studies were mixed (Kim et al., 2019; Wood et al., 2018). Two reported that milling behaviour was reduced among those who had received longer, more detailed messages (Bean et al., 2016; Wood et al., 2018), while another found no significant difference in behavioural responses based on message length (Casteel & Downing, 2016; Kim et al., 2019; Liu et al., 2017). Studies which investigated the inclusion of maps as additional information to help participants make sense of warning messages had mixed results with some finding no significant effect on behaviour (Cain et al., 2021; Casteel & Downing, 2016; Liu et al., 2017), though two did find that a map resulted in higher levels of perceived risk susceptibility (Bean et al., 2016; Cain et al., 2021). Therefore, it seems that there is a difficult balancing act to be performed between providing short, succinct messages, but also giving sufficient information for people to feel confident in the message.

4.1 | Limitations

Several limitations should be considered for this systematic review. First, our conclusions may be limited due to the paucity of available literature. It is obvious from this review that plenty of scope exists for future work to expand this literature and improve our understanding of behavioural responses to text-based warning messages. Second, studies based on real-world incidents are needed, but it is also

important to note that the majority of studies conducted to date have relied on self-reporting of behaviour. It is possible that self-report may reflect actual behaviour, but it can also be heavily influenced by numerous other factors, such as social desirability of reporting 'good' behaviour and recall bias. In addition to self-report, most studies measured behavioural intentions, or asked people what they would do in a hypothetical incident, but this may differ to real-world scenarios. Third, it is important to recognise that our review may be affected by publication bias, whereby there is a tendency to publish only those studies which demonstrate statistically significant results. In reality, it is possible that additional research has been conducted to explore our topic, but has gone unpublished as it has been deemed of less interest or importance. Fourth, the studies included in our review are heterogeneous in their characteristics such as study design, location, population and type of emergency. Thus, it is key that we highlight that our results may not be generalisable across these domains.

While we made every attempt to search widely for relevant studies across numerous databases, it is possible that we missed some studies which used terminology relating to text-based mobile alerting that were not included in our search. Finally, our searches were limited to English language papers, and it is possible that research has been published on alerting systems in countries where English is not the first language.

5 | CONCLUSIONS

The findings from the systematic review align with those produced by others, using an expert panel process (Sutton & Kuligowski, 2019). Limited data exist on how people respond to text-based warning messages and much of the data that does exist is poor quality. To reduce the negative impact of major incidents, we need a better understanding of the factors that affect behavioural responses to such messages. In particular, we need more experimental studies and evaluations of the behavioural impact of warning messaging in real world settings. For now, based on the results of the included studies, several practical recommendations are posed for those considering rolling out such systems. It is recommended that emergency planners using mobile telephone alerting systems adhere to the following:

1. Provision of clear, actionable information as to what recipients need to do when they receive an alert message, with clear explanation regarding the effectiveness of the recommended action.
2. Specific details about the emergency (e.g., threat type and location) should be included due to the role of risk perception and perceived threat/urgency in adherence to alerts.
3. Accurate, consistent and timely information should be available via other communication channels and alert messages should signpost (e.g., a link or search recommendation) to further information to confirm message veracity or severity because recipients will likely seek further information from other sources before deciding to take action.
4. A preincident public information campaign about the emergency alert system should be delivered so that in the event of a major incident, recipients are confident that the source is trustworthy and credible.
5. Alerts should be used infrequently and only when there is a real need to inform the public about the messaging system or an incident to avoid desensitisation.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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