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An Experimental Study of Message Strategies for Mobile Alerts and Warnings

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Abstract: Dr. Dennis Mileti devoted his career to the study of public warnings disseminated through mass media, word of mouth, and, later, mobile technologies. To date, research on mobile public warnings has focused on standardized elements of messages (e.g., the common alerting protocol). During this same period, however, a variety of private, public, and governmental organizations have adopted mobile alert technologies to disseminate a diverse variety of free-form (nonstandardized) messages. We investigated how the evidence-based guidance developed for mobile public warnings applies to this broader class of free-form mobile alerts and warnings (FMAWs). This study reports an experimental comparison of US residents' ($N = 299$) reactions to notional free-form mobile messages about a safety risk. Experimental conditions compared messages that included safety instructions, ways to seek additional information, expressions of empathy, and emphasizing choice ("choice forward"). Results indicated that message efficacy was greater for FMAWs that gave safety instructions rather than just notifications. Choice-forward FMAWs produced both message efficacy and safety efficacy, or confidence that the person could make a good safety decision for the situation. Application: When the location, timing, and severity of an emergent risk are ambiguous, or when for public safety organizations, they have not yet reached a threshold appropriate for wireless emergency alert messages, a free-form message disseminated through mobile technologies or social media could use choice-forward language and links to more detailed information about possible self-protective action to facilitate just-in-time pre-event education and preparedness. **DOI: 10.1061/NHREFO.NHENG-1721.**

Practical Applications: Thanks to the scholarship of Dr. Dennis Mileti, guidance for mobile public warnings, such as wireless emergency alert (WEA) messages, works. This guidance helps make people feel safer, and it is becoming standardized through technologies and practices, such as the common alerting protocol. Existing guidance applies to a specific set of circumstances: Experts have identified an imminent threat and can accurately predict its severity, location, and the single best way that people at risk can protect themselves. For many other situations, mobile alert technologies and social media messages may still be useful. These messages would be "free-form," meaning not following a template or common alerting protocol, so understanding how existing wisdom about warnings applies is key. This study further suggests that free-form messages should empower recipients to seek additional information about a range of self-protective actions and to make the best choice for their individual situation.

Author keywords: Message efficacy; Safety efficacy; Mobile; Warnings; Alerts.

Introduction

Dr. Dennis Mileti's research on hazard warnings is foundational to our collective understanding of how hazard warnings can be used to promote public safety. His work helped to progress scholarship from postdisaster case studies of single disasters to meta-analyses, cross-sectional studies, and experimental studies related to the multiple factors that may influence public risk perception, including characteristics of the risk messaging itself and characteristics of message recipients (e.g., Mileti and Beck 1975; Mileti and Darlington 1997; Mileti et al. 1975; Mileti and Fitzpatrick 1991; Mileti and O'Brien 1992; Mileti and Peek 2000; Mileti and Sorenson 1990; Sorensen and Mileti 1988; Wood et al. 2018).

For example, over the decades, Mileti and colleagues partnered with government agencies, offering subject-matter expertise and recommendations for the development of the Federal Emergency Management Agency's (FEMA) integrated public alert and warning system (IPAWS) and wireless emergency alert (WEA) messages (Mileti 2018). WEA messages are public warning messages issued to mobile devices, such as smartphones, as text messages (FEMA 2020). They warn of an imminent threat and provide guidance for self-protective action (e.g., "evacuate now"), and they are issued to devices that are geolocated in regions of highest risk (FCC 2022).

The present study draws on the message design aspects of Mileti's work, with consideration for his work on how organizational systems manage uncertainties related to message content and dissemination (Mileti and Sorenson 1990; Sorensen and Mileti 1987; Mileti and Peek 2000; Mileti 2018; Wood et al. 2018). Since the adoption of the IPAWS system, government agencies that are authorized to issue WEA messages have standardized many elements of mobile public warning messages (Kuligowski and Doermann 2018; National Academies of Science, Engineering, and Medicine 2018). In response to substantial research, the length of WEA messages was expanded (Mileti 2018; Wood et al. 2018), and key elements have been established as fillable fields in the common

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alerting protocol (CAP), such as the message source, type of hazard, location, time frame, and protective action advised (FEMA 2022). This evidence-based work has successfully met the moment of mass adoption of text-enabled mobile phones and smart devices (Doermann et al. 2021; Kim et al. 2019; Sutton and Kuligowski 2019).

During the same period, however, mobile alert technologies have continued to develop and have been adopted by a wide variety of public and private organizations (Bean 2019; Mileti 2018). A public school may send alerts to students' families about school delays or cancellations. An airline may send alerts to ticketed passengers about a gate change for an upcoming flight. Colleges and universities comply with The Clery Act by notifying stakeholders about violent crimes that occur on or near campus (Clery Center 2022). Alongside these alerts, social media users may set notifications to sound, buzz, or appear on their mobile devices when messages are published on social media platforms such as Twitter. Public safety organizations, including those authorized to disseminate WEA messages, must also consider which additional platforms they will use: Twitter, Facebook, or opt-in, private mobile messaging systems like CodeRED or B-WARN! (Bean 2019). These mobile alert platforms offer greater flexibility and less standardization than WEA messages (Doermann et al. 2021). They were designed for a broad array of purposes, whereas the WEA system was designed to prompt self-protective action in the face of a severe, and precisely geolocated, imminent threat.

At the same time, mobile public warning research has grown substantially over the past 10 years (Bean 2019; Mileti 2018). This research has prioritized the development of evidence-based norms and standards for mobile public warnings, with less attention to how message recipients respond to free-form mobile alerts and warnings. Guided by the protective action decision model (Lindell and Perry 2004; Sutton and Kuligowski 2019), this study reports the results of an experiment designed to investigate US adults' reactions to FMAWs, namely, those nonstandardized and non-CAP-compliant messages that can be written freely in privately developed mobile alert technologies or social media platforms.

The article begins by comparing and contrasting theoretical and practical assumptions associated with mobile public warnings and free-form mobile alerts and warnings. Based on this theorizing, we highlight message efficacy and, potentially, safety efficacy as important outcomes, we make the case for three features of messages likely to influence these outcomes: (1) the focus on safety directions (e.g., "Do not attempt to drive on flooded roads"); (2) choice-forward messages (e.g., "You can choose to change your plans or drive a different route"); and (3) empathy (e.g., "It can be difficult to change plans or delay activities due to a weather emergency"). We then report the results of an experimental evaluation of messages by a sample of US residents ($N = 299$). The experiment compared (1) messages designed to notify with messages designed to give specific safety instructions; and (2) empathetic and choice-forward messages.

Overall, the results of the study suggest the promise of choice-forward messages in situations of an emergent but not-yet-imminent threat. Our results confirmed that safety instructions produce greater interest in self-protective behavior than do notifications, but we also found that the choice-forward message strategy enhanced the positive association between interest in self-protective behavior (message efficacy) and confidence in one's ability to figure out how to stay safe in the situation described (individual-specific safety efficacy). In other words, choice-forward messages enhanced safety efficacy, particularly when message recipients were initially reluctant to take the risk seriously.

This study advances the scholarship on audience responses to mobile alerts and warnings (Mileti 2018; Sutton and Kuligowski 2019; Wood et al. 2018) by demonstrating the importance of safety efficacy as an effect of free-form mobile alerts and warnings, shaped by message design. Results also identify circumstances in which hazard type, as well as the use of notification versus prescription, are likely to enhance recipients' intention to take self-protective action. For practical application, the study's results identify more and less persuasive message content for free-form messages that might supplement IPAWS and WEA messages (Mileti 2018), whether using nongovernmental mobile alert technologies or social media platforms. We also propose a reframing of milling (Mileti 2018; Mileti and Peek 2000; Wood et al. 2018), specifically under nonimminent conditions, as a period of receptivity to pre-event education and preparedness.

In this article, we begin by arguing for the importance of safety efficacy as a meaningful outcome in the study of audience responses to mobile alerts and warnings. The assumptions underlying research and practice related to mobile public warnings (MPWs) (Mileti 2018; Mileti and Peek 2000) differ from those that apply to the broader category of FMAWs. Then, we propose research questions and hypotheses to better understand the influence of message direction and particular message strategies on the preliminary outcome of message efficacy and the target outcome of safety efficacy. We describe the experimental design and measures used, and then we describe the study's results. Finally, we discuss implications of the results for message design. In the end, we advocate for the promotion of productive milling (i.e., pre-event education and preparedness) in situations in which the location, severity, or timing of a risk do not meet the threshold for a WEA message. We aim to build on the work of Mileti and colleagues by extending his legacy to guidance for FMAWs.

Intended Outcomes: What Alert Originators Expect Mobile Alerts and Warnings to Do

In the foundational work of Dr. Dennis Mileti and colleagues, public warnings were defined as messages designed to tell people who faced an imminent, hazard-related safety risk what they should do immediately, without delay, to protect themselves (Mileti and Sorenson 1990). The central mission of Mileti's work was to determine how to disseminate a warning in such a way that everyone in harm's way would receive the warning, understand it, believe it, see how it applied to them personally, and quickly take the recommended self-protective action (Mileti and Beck 1975; Mileti and Fitzpatrick 1991; Mileti and O'Brien 1992; Mileti and Peek 2000; Mileti and Sorenson 1990; Sorensen and Mileti 1988; Wood et al. 2018).

In practice, as in Mileti's research program, the intended outcome of public warning messages is that recipients take the self-protective action prescribed, such as taking shelter, evacuating, or avoiding hazardous areas. When studying a hypothetical disaster or crisis, as most social scientific research does, researchers have used a proxy outcome: message recipients' self-reported intentions to comply with notional messages' safety instructions (e.g., Liu et al. 2017; Johansson et al. 2021; Kim et al. 2019; Stephens et al. 2015; Sellnow et al. 2017b; Wood et al. 2018). This study includes messages that do and do not give instructions about how to stay safe in a hazard situation; thus, we adapted the spirit of compliance intention, as it relates to messages, into *message efficacy*, i.e., the degree to which the message makes the recipient take an interest in self-protective behavior. Taking an interest in self-protective behavior might include multiple phases of protective

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action decision-making, such as taking the risk seriously and considering possible self-protective actions (Lindell and Perry 2004). In the study of MPWs, message efficacy is of central concern because the principal goal of MPWs is activating a process that culminates in the decision to act (Lindell and Perry 2004; Sutton and Kuligowski 2019; Doermann et al. 2021).

Researchers have also used the term "efficacy" to describe the respondents' belief that they can do what the message advocates (Ajzen 1991; Hastell and Knobloch-Westwick 2013). In this study, we use the term "safety efficacy" to refer to the recipients' sense that they can comply; we also contend that the broader study of mobile alerts and warnings should account for message efficacy and safety efficacy. The following sections review the literature to explicate message and safety efficacy as important outcomes in research on MPWs as well as FMAWs.

Safety and Message Efficacy in Response to Alerts and Warnings

Message efficacy has been the focus of extensive mobile public warning research (Johansson et al. 2021; Kim et al. 2019; Liu et al. 2017; Mileti and Beck 1975; Mileti and Darlington 1997; Mileti and O'Brien 1992; Wood et al. 2018), and its centrality in this research makes sense given the assumptions of MPW research. In recent years, Mileti and colleagues have focused particularly on messages designed to be distributed by the public-facing element of the federal IPAWS, namely, WEA messages, which became fully operational in 2012 (FEMA 2020). Recommendations related to mobile warning messages have drawn on four key assumptions about MPWs (see Table 1):

1. MPWs will only be issued within hours or minutes of an imminent threat to human safety;
2. MPWs will only be distributed to people in particular geographical region that technical experts have designated as exceeding some threshold of imminent risk;
3. MPWs should be formatted as directives, because their purpose is to instruct people to take immediate self-protective action; and
4. The directives given should represent the most essential safety advice that technical experts would recommend for persons facing that particular type of hazard (i.e., a single recommendation, not a set of contingencies with multiple recommendations).

Per these assumptions, the purposes of MPWs are to get people to reject a sense of normalcy and take the protective action recommended in the message as quickly as possible (Mileti 2018; Mileti and Beck 1975; Mileti and O'Brien 1992). Notional MPWs guided by these assumptions tend to generate greater intention to comply with recommended self-protected actions (Wood et al. 2018). The assumptions and recommendations related to MPWs work well for the context from which they have emerged, i.e., hazards, often natural disasters, that pose a severe threat to a portion of the public and for which the location, timeline, and severity of risk can be forecast by the technical experts.

The Case for Safety Efficacy as an Additional Outcome of Interest

Recipients' beliefs that they *can* take the action advocated in a message will also affect their intentions, which in turn will affect behavior, i.e., what message recipients actually do. Fundamental theories of message effects, such as the Theory of Reasoned Action and Planned Behavior make this point clear by focusing on perceived behavioral control. Perceived behavioral control describes individuals' assessment of whether they are able to adopt a target behavior. Perceived behavioral control differs from self-efficacy in

Table 1. Contrasting assumptions of mobile warnings and alerts

Category of mobile alerts and warnings	Examples	Threat Focus	Geography	Direction	Recommendation
Mobile public warnings (MPWs)	*Wireless emergency alerts* (WEAs), amber alerts	Imminent threat to safety	Specific: people in a particular geographical region designated as exceeding risk threshold	Prescription: formatted as directives that instruct people to take immediate self-protective action	Specific and singular: a single recommendation that embodies the most essential safety advice
Free-form mobile alerts and warnings (FMAWs)	School mobile alert systems, smartphone app-based alerts	Possible impetus for non-routine action that may or may not relate to a threat to human safety	Varied: location defined by pre-existing governmental districts or the association between recipient and organization that originated the alert (e.g., opt-in alerts)	Notification: information about an emergent situation that may or may not prescribe any particular course of action other than information seeking	Open and contingent: a set of contingencies with one or multiple recommendations that may prompt additional information-seeking to determine the need to act

that it is not a trait that individuals bring to situations (Bandura 2004, 2012); rather, it is an incremental evaluation about the ease or difficulty of adopting a specific behavior shaped by situational cues and, in the case of mobile alerts and warnings, the message itself. In the context of mobile alerts and warnings, this sense of the ability to act to be safe may be conceptualized as safety efficacy. Safety efficacy is the recipients' belief in their ability to do what is needed to stay safe in a particular situation based on situational cues as well as individual values and preferences.

Safety efficacy takes on more importance given the broader use of mobile alert technologies where messages may or may not direct the recipient to take any specific action (Bean et al. 2015). The FMAWs possible with current technology may still aim to prompt protective action (message efficacy) but can offer more flexibility in messaging that broadens the range and number of protective actions that may be targeted, the form and length of contents, the ability to modify or ignore templates, the use of communication norms such as hashtags, and so forth. Bean and colleagues characterized this broader range of warning and alert platforms as "mobile alert technologies" that can be used to distribute text-based MPWs (Bean et al. 2015, p. 73). They wrote, "Alerts [. . .] are designed to direct people's attention, whereas warnings are designed to provide additional information about what has happened and what to do about it" (p. 73). Alert systems may be used to issue specific prescriptions, as is the intent of the WEA system (Mileti 2018), or they may be used to issue more general informative messages that may vary in their time sensitivity, location or target audience specificity, and call to action.

How the Assumptions of Free-Form Mobile Alerts and Warnings Differ from Those of Mobile Public Warnings

The previously outlined assumptions of MPWs do not apply to many situations in which a local public or private organization might contact stakeholders using mobile alert technologies (see Table 1). Instead, persons receiving a mobile alert that is not a mobile public warning (i.e., not a WEA message) are likely to assume:

1. The message may or may not relate to a threat to human safety. Rather, it will relate to an unforeseen change in conditions that might prompt the recipient to take nonroutine action.
2. The message will relate to a location defined by preexisting governmental districts (e.g., a county), and the association between recipient and location was most likely established by the recipient's registration or consent to opt-in to receive mobile messages from the organization that originated the alert.
3. The message will provide information about an emergent situation, but it may not prescribe any particular course of action.
4. The message may or may not provide sufficient information for the recipient to choose a course of action. Additional information-seeking may be needed to determine whether there is any real need to disrupt routines.

For example, the importance of these contrasting assumptions about the specificity of the call to action is clear in National Weather Service messages that use incremental levels of "watch" and "warning." "Watch" messages assume that weather in a particular jurisdiction could produce hazardous conditions. The implied instruction is to watch, be aware, and pay attention to developing conditions and emerging information. For a given location, it is too soon to say whether the threat is imminent enough to require self-protective action. These assumptions are typical for nonhazard-related messages as well as for the preliminary stages of situations that defy precise predictions of severity or geolocation.

Instrumental Alerts and Warnings: Prescription versus Notification

Message efficacy is an important outcome for MPWs; it may also be important for FMAWs in general, but understanding safety efficacy is especially important under the second set of assumptions because safety efficacy gets at the degree to which messages help recipients envision what they could do to respond to emerging or changing conditions. The MPW assumptions emphasize a single best course of self-protective action, for which the recipient's choice is to comply or not. Under FMAW assumptions more generally, no single best course of action applies to all message recipients because of uncertainty about the location, severity, and imminence of the threat. The MPW assumptions sought to eliminate the urge to seek additional information, especially the tendency to check with other people to identify a social norm, thus delaying action (i.e., milling). Mileti's early-career work identified the dangerous prevalence of individuals delaying self-protective action (Mileti and Sorenson 1990; Sorensen and Mileti 1988). His later work applied the term "milling" and sought to better understand how to reduce or eliminate it, especially in the context of WEAs (e.g., Mileti and Peek 2000; Wood et al. 2018). In contrast, mobile alert assumptions accept and may even promote information-seeking and milling.

Comparing the assumptions of MPWs and FMAWs, the nature of the direction or call to action given in these messages is a key difference. The instrumental focus of the messages may be to give a specific instruction or to prompt more information gathering. That is, messages may prescribe specific, immediate self-protective action. Messages may also provide information but stop short of prescribing any particular course of action. To investigate this contrast, we asked the following research questions:

RQ1a: Will messages that direct people to seek information (notifications) affect message efficacy differently than messages that direct people to take self-protective action (prescriptions)?

RQ1b: Will messages that direct people to seek information (notifications) affect safety efficacy differently than messages that direct people to take protective action (prescriptions)?

This contrast focuses on the type of direction, notification versus prescription, typical in MPWs and FMAWs. The differing MPW and FMAW assumptions also point to messaging strategies that may heighten the effects of direction type. This study focused on two related messaging strategies: choice and empathy.

Choice and Empathy

Public warning scholarship takes as an assumption the urgent need to communicate about an imminent hazard. In contrast, risk communication scholarship assumes that risks may be ongoing and may need to be managed over time; however, events can make latent risks erupt into crises (Mileti and Sorenson 1990; Reynolds and Seeger 2005; Veil et al. 2008). Risk communication campaigns may use constellations of messages and multiple points of engagement. The overarching goal is to persuade individuals to take protective action but with greater latitude in the range of choices that could represent appropriate protective action. This communication involves greater emphasis on choice and the agency of individuals to choose appropriate protective action, given a range of options and an individual set of preferences among the options' perceived advantages and disadvantages. Persons have the right to choose, and the communicators' goal is to provide publics with accurate, sufficient, and accessible information so that individuals can make a meaningful choice, a perspective captured in the ethic of significant choice (Nilsen 1966; Sellnow et al. 2012). When the threat cannot be well known or the warnings targeted, or when multiple protective actions would be reasonable, this perspective points to message strategies inconsistent with MPWs. As such, empowering recipients to make choices is thus a key messaging strategy related to what is possible through FMAWs.

Choice-forward messages are messages that verbalize recipients' ability to choose what they perceive to be the best course of action. In the public warning literature, Protective Action Decision-making Theory (e.g., Kuligowski and Doermann 2018; Sutton and Kuligowski 2019), Emergent Norm Theory (e.g., Wood et al. 2018), and the persistence of milling (e.g., Kim et al. 2019) point to an acknowledgment that individuals will choose whether and how they will engage in self-protective action. Similar to the single-best-course-of-action assumption of MPWs, Liu et al.'s study of terse public health messaging in response to a crisis found that terse messages tended to focus on a narrow set of safety directives and to overlook a broader set of logical protective actions that an individual might take (2015). The ethic of significant choice suggests that an organization can show respect for its stakeholders by validating their agency as decision-makers (Sellnow et al. 2012; Ulmer and Sellnow 1997). To do so also frames the organization's role as providing unbiased information that people can use to inform their decisions (Seeger 2006).

Along similar lines, empathetic messages, or messages that use a more conversational, empathetic style is a second messaging strategy of importance given this comparison between MPWs and FMAWs. Crisis communication experts advise communicating compassion in public relations and risk communication (Seeger 2006). The need to take nonroutine action constitutes a disruption that message recipients may resent. An empathetic style can acknowledge possible perceived costs of disrupting one's routine to engage further with the process of deciding what to do. Choice-forward messages would affect message and safety efficacy by empowering participants. Empathetic messages would affect message and safety efficacy by acknowledging the difficulty of taking nonroutine action. As such, empathetic and choice-forward messages may have similar effects but for different reasons. To assess the effects of these messaging strategies, we asked:

RQ2a: Will instrumental-only, empathetic, or choice-forward messages produce the greatest message efficacy?

RQ2b: Will instrumental-only, empathetic, or choice-forward messages produce the greatest safety efficacy?

Instrumental messages will prescribe action or give notice, and empathetic and choice-forward messaging strategies represent message additions that aim to bolster the effectiveness of those messages. Following this logic, we also asked:

RQ3a: Will message strategy (instrumental, empathetic, choice-forward) moderate the effect of direction type (notification, prescription) on message efficacy?

RQ3b: Will message strategy (instrumental, empathetic, choice-forward) moderate the effect of direction type (notification, prescription) on safety efficacy?

Last, per the aforementioned theorizing, messages with higher efficacy should also encourage greater safety efficacy. As such, we hypothesized that:

H1: Message efficacy will be positively associated with safety efficacy.

We also contended that safety efficacy should be a particularly important outcome for FMAWs because current mobile alert technologies allow for flexibility in message content. We examined this idea by investigating if either direction type or messaging strategies would moderate the relationship between message efficacy and safety efficacy. We therefore asked:

RQ4a: Will direction type (notification, prescription) moderate the relationship between message efficacy and safety efficacy?

RQ4b: Will message strategy (instrumental only, empathetic, choice-forward) moderate the relationship between message efficacy and safety efficacy?

An interaction between message design and message efficacy on safety efficacy would provide support for the theoretical importance of safety efficacy in the context of FMAWs.

Methods

To examine the effects of message design on message and safety efficacy, we conducted 2×3, post-test-only, multiple message experiment. The first factor compared the type of direction, contrasting prescriptions to take specific action and notifications with a suggestion to seek additional information. The second factor compared instrumental-only message designs (prescription only or notification only) with messages that added either empathetic or choice-forward message elements. Across the conditions, the message features, in combination, were (1) prescription only (specific safety instructions); (2) prescription plus empathy; (3) prescription plus choice; (4) notification only (seek information, with notional hyperlink); (5) notification plus empathy; and (6) notification plus choice (see Tables 2 and 3). The experiment also included two message replications: a set related to flooded roads and another related to household water contamination (i.e., a boil-water advisory). The purpose of the message replications was to control for confounds between the phenomena under study and the particular message stimuli used (Jackson 1992; O'Keefe 2015).

Table 2. Experimental conditions with messages replication 1: flooded roads

Construct	Instrumental-only	Empathy	Choice
Prescription	Some roads are blocked by flooding. Avoid unnecessary travel. Do not attempt to drive through standing water.	Some roads are blocked by flooding. Avoid unnecessary travel. Do not attempt to drive through standing water. Changing your plans might be difficult, but it's better to wait for the water to go down than to get stranded out on the road.	Some roads are blocked by flooding. Avoid unnecessary travel. Do not attempt to drive through standing water. You are the best judge of whether you really need to travel today . . . and which route you should take.
Notification	Some roads are blocked by flooding. Before traveling, visit yourtown.gov/road conditions to see flood maps.	Some roads are blocked by flooding. Before traveling, visit yourtown.gov/road conditions to see flood maps. Changing your plans might be difficult, but it's better to wait for the water to go down than to get stranded out on the road.	Some roads are blocked by flooding. Before traveling, visit yourtown.gov/road conditions to see flood maps. You are the best judge of whether you really need to travel today . . . and which route you should take.

Table 3. Experimental conditions with messages replication 2: contaminated water

Construct	Instrumental-only	Empathy	Choice
Prescription	Your town water has issued a boil water advisory due to potential contamination. Tap water should be boiled before drinking, brushing teeth, preparing or cooking food, preparing infant formula, or giving water to pets.	Your town water has issued a boil water advisory due to potential contamination. Tap water should be boiled before drinking, brushing teeth, preparing or cooking food, preparing infant formula, or giving water to pets. Boiling water may seem like a chore, but it's a simple way to protect everyone in your family.	Your town water has issued a boil water advisory due to potential contamination. Tap water should be boiled before drinking, brushing teeth, preparing or cooking food, preparing infant formula, or giving water to pets. You can choose to protect your family and yourself by using boiled tap water or bottled water for any kind of water consumption.
Notification	Your town water has issued a boil water advisory due to potential contamination. Boil tap water (or use bottled water) for any kind of human or pet consumption. Details and updates at yourtownhealthdepartment/drinkingwater.	Your town water has issued a boil water advisory due to potential contamination. Boil tap water (or use bottled water) for any kind of human or pet consumption. Details and updates at yourtownhealthdepartment/drinkingwater. Boiling water may seem like a chore, but it's a simple way to protect everyone in your family.	Your town water has issued a boil water advisory due to potential contamination. Boil tap water (or use bottled water) for any kind of human or pet consumption. Details and updates at yourtownhealthdepartment/drinkingwater. You can choose to protect your family and yourself by using boiled tap water or bottled water for any kind of water consumption.

Participant Characteristics

Participants ($N = 299$) ranged in age from 18 to 77 years, with a mean age of 36 ($SD = 12.6$). Participants identified their gender as male (36%), female (63%), nonbinary (less than 1%), or preferred not to say (less than 1%). Participants reported the highest level of education they had attained: some high school or completed high school (20%), some college (30%), completed associate's degree (10%), completed bachelor's degree (23%), and some or completed graduate or professional education (17%). Participants described the size of the community in which they currently lived: 11% in a rural setting (population under 5,000); 25% in a small town (5,000 to 25,000); 31% in a midsize city (25,000 to 100,000); 16% in a large city (100,000 to 500,000); and 16% in a major metro (500,000+). In comparison with US census data, the sample slightly overrepresented females and persons with college education; however, the distribution of residents of different types of communities was close to the US in general (Parker et al. 2018).

Sampling, Sample Size, and Power

After study procedures and informed consent materials were reviewed and approved by the Central Michigan University Institutional Review Board, participants were recruited by Survey Monkey, a provider of panel data. The provider compensated individuals who completed a requisite number of questionnaires, for multiple clients, with modest gift certificates from an online retailer. Inclusion criteria were that participants must be US residents of at least 18 years of age who were mobile phone users. Survey Monkey maintains a panel of participants meant to represent the general United States and the region of the country in which the person resided was not part of the sampling strategy. Participants could come from any region of the United States; participants were also randomly assigned to conditions to control for participant differences, including regional differences. Recruitment ended once 50 participants had completed each condition (25 participants within each message replication). We classified effect sizes following guidance from Cohen (1988), categorizing effects as small (partial $\eta^2 = 0.01$), moderate (partial $\eta^2 = 0.06$), or large (partial $\eta^2 = 0.14$). Given the overall sample size ($N = 299$) and the design, an F-test of an ANOVA with random factors had sufficient power (0.98) to find moderate effects (assuming $\alpha = 0.05$).

Measures

After seeing a message, participants completed a brief, eight-item questionnaire with items that measured message and safety efficacy. Message efficacy items were adapted from measures intended to measure behavioral intentions to undertake protective action (Sellnow et al. 2017b; note: no comparable indicator of reliability is available from the Sellnow et al. study, because that study used individual items for analyses). Four items measured participants' intentions to comply ($\alpha = 0.76$) on a scale of strongly agree (5) to strongly disagree (1): "If I got this message, I would do what the message says I should do to stay safe"; "This message would catch my attention"; "This message would NOT make me think about changing my daily routine to stay safe" (reverse-coded for analyses); and "This message would make me take the safety risk seriously."

A measure of safety efficacy was developed for this study. Four items measured participants' perception of their agency to choose and make a good decision about how to stay safe in the situation described in the message ($\alpha = 0.87$) on a scale of strongly agree (5) to strongly disagree (1): "I feel confident that I could make good decisions about keeping myself safe in a situation like this"; "This message reminded me that I can make good choices about my safety"; "Ultimately, the decision about what to do to stay safe is up to me"; and "I feel sure that I could figure out the best thing to do for my safety in a situation like this."

Experimental Conditions and Design

Participants were randomly assigned to one of 12 conditions ($2 \times 3 \times 2$): Prescription versus notification (2); instrumental-only, empathy, and choice (3); replicated in two messaging contexts, road flooding and water contamination (2). Each participant viewed only a single message. Tables 2 and 3 summarize the experimental manipulations, and the Appendix provides an example of a notional message presented to participants. Messages were modeled after free-form protective action instructions found on the National Weather Service and the Centers for Disease Control websites. No scenario was presented, only an image of the message with the instruction, "Imagine that you receive this alert on your cell phone" (Appendix).

Analytical Strategy

We conducted analyses of variance (ANOVAs) to assess the differences between experimental conditions, relationships among covariates, and interaction effects. All analyses were completed using IBM SPSS version 28.0.1. As a preliminary step, we checked our assumptions that none of the demographic characteristics of the sample nor the message replications would produce differences in the outcome variables. It turned out that participant gender and education were associated with differences in reported message efficacy and safety efficacy. Participants who identified as female reported higher levels of message efficacy than those who identified as male, across all message strategies and treatments [$t(272) = 2.55$, $p < 0.050$, $M_{\text{females}} = 4.26$, $M_{\text{males}} = 4.00$]. Participants whose highest level of education ranged from "some college" to a graduate or professional degree reported higher levels of message efficacy than participants with no postsecondary education [$t(276) = -2.99$, $p < 0.050$, $M_{\text{college}} = 4.22$, $M_{\text{highschool}} = 3.85$]. The random assignment of participants to conditions controlled for such differences, but they should be noted in generalizing the findings. In addition, we found that response patterns for the two message replications did differ in some ways. Because neither of these phenomena were the focus of the research, we explored differing response patterns by message replication in post hoc analyses.

To address the research questions and hypothesis, first, we estimated a model for message efficacy (RQ1a, RQ2a, and RQ3a). Second, we estimated a model for safety efficacy that included message efficacy as a covariate (RQ1b, RQ2b, and RQ3b, H1, R4). Each of these models included the message replication as a random factor nested within message strategy (instrumental-only, empathetic, choice-forward). This analytical approach used the variation in specific message replications to focus the analysis on the message features of interest rather than the specific messages under study (Jackson 1992; O'Keefe 2015). The models are summarized in Table 5. Third, we completed post hoc analyses to explore the main effects and interactions. When analyses identified significant interactions, we focused on the interaction rather than main effects by visualizing them (Aiken and West 1991). We also explored differences in the message replications when analysis made clear that participants responded to them differently.

Results

A typical participant spent approximately 3 min completing the study. All participants completed the study. We removed a single response that selected the middle response option for all items, even when illogical (i.e., "straight lining"), even when illogical. There were no missing data, but we treated misaligned responses to the reverse-coded message efficacy item as missing data in 21 cases. Across the conditions, participants reported a high degree of message efficacy ($M = 4.15/5.00$, $SD = 0.82$) and similar perceptions of their safety efficacy ($M = 4.17/5.00$, $SD = 0.76$). We organized the following reporting of the substantive results by research question and hypothesis per the theoretical framing.

Direction Type (RQ1)

The first pair of research questions asked if messages that direct people to seek information (notifications) would affect message and safety efficacy differently than messages that direct people to take self-protective action (prescriptions). Direction type had a small main effect on message efficacy overall ($F[1,271] = 5.22$, $p = 0.023$, partial $\eta^2 = 0.02$). Direction type also had a moderate main effect on safety efficacy ($F[1,61.43] = 6.40$, $p = 0.014$, partial $\eta^2 = 0.09$). Prescriptions produced greater safety efficacy ($M_p = 4.26/5.00$ versus $M_n = 4.09/5.00$) and message efficacy ($M_p = 4.25/5.00$ versus $M_n = 4.08/5.00$) (see Table 5). The findings also indicated an interaction between direction type and message efficacy, which we discuss later in this text.

Instrumental-Only, Empathetic, and Choice-Forward Messaging Strategies (RQ2)

The second pair of research questions asked if instrumental-only, empathetic, or choice-forward messages would produce greater levels of message and safety efficacy. (See Table 4 for all descriptive statistics.) Modeling indicated no significant main effects of differences among these strategies in message efficacy ($F[4,271] = 1.31$, $p = 0.266$, partial $\eta^2 = 0.02$) (see Table 5). The strategies did have differing effects on safety efficacy [$F(4,294) = 3.54$, $p = 0.018$, partial $\eta^2 = 0.331$]; however, findings indicated an interaction between messaging strategy and message efficacy, which we further discuss.

Table 4. Descriptive statistics by condition

	Flooded roads replication			Water-contamination replication			Overall		
Variable	*I-O*	*E*	*C*	*I-O*	*E*	*C*	*I-O*	*E*	*C*
				Prescription					
N	27	26	23	23	25	27	50	51	50
Mean SE	4.065	4.173	4.250	4.304	4.260	4.482	4.175	4.216	4.375
SD	0.678	0.862	0.707	0.559	0.846	0.532	0.631	0.847	0.623
N	26	24	22	20	21	22	46	45	44
Mean ME	4.106	4.125	4.171	4.438	4.214	4.500	4.250	4.167	4.335
SD	0.637	0.787	0.746	0.782	0.784	0.686	0.715	0.778	0.727
				Notification					
N	21	22	28	29	28	20	50	50	48
Mean SE	3.691	3.932	4.268	4.241	4.071	4.250	4.010	4.010	4.260
SD	0.925	0.678	0.495	0.663	1.156	0.612	0.822	0.969	0.541
N	21	21	27	26	28	20	47	49	47
Mean ME	3.500	3.726	3.963	4.577	4.256	4.213	4.096	4.031	4.069
SD	0.959	0.891	0.730	0.586	0.992	0.745	0.938	0.977	0.739

Note: This table reports the number of participants and mean and standard deviation values for safety efficacy (SE) and message efficacy (ME) in each condition organized by message replication and instrumental-only (I-O), empathetic (E), and choice-forward (C) message strategies.

Table 5. ANOVAs for message and safety efficacy treating message replications as a random factor

Variable	F	df_{between}	df_{within}	p	Partial $\eta 2$
		Message efficacy			
Intercept	357.064	1.000	1.000	0.340	0.997
Replication	16.516	1.000	4.013	0.015	0.805
Message strategy (replications)	1.310	4.000	271.000	0.266	0.019
Message direction	5.223	1.000	271.000	0.023	0.019
		Safety efficacy			
Intercept	5,557.323	1.000	1.156	0.005	1.000
Replication	0.191	1.000	4.139	0.684	0.044
Message strategy (replications)	3.537	4.000	28.580	0.018	0.331
Message direction	6.396	1.000	61.433	0.014	0.094
Message efficacy	7.229	13.000	64.244	<0.001	0.594
Interaction of message strategy and message direction	0.603	5.000	194.000	0.698	0.015
Interaction of message strategy and message efficacy	2.065	47.000	194.000	<0.001	0.333
Interaction of message direction and message efficacy	2.147	10.000	194.000	0.023	0.100

Interactions between Direction Type and Message Strategy (RQ3)

The third pair of research questions asked if message strategy (instrumental-only, empathetic, choice-forward) would moderate the effect of direction type (notification, prescription) on safety or message efficacy. The models indicated no such interaction effects for message efficacy ($F[5{,}266] = 1.44$, $p = 0.209$, partial $\eta^2 = 0.03$) or safety efficacy ($F[5{,}194] = 0.60$, $p = 0.698$, partial $\eta^2 = 0.02$) (see Table 5).

Examining the Relationship between Safety and Message Efficacy (H1 and RQ4)

We hypothesized that message efficacy would be positively associated with safety efficacy. In general, there was a positive, linear relationship between message efficacy and safety efficacy ($r = 0.601$, $p < 0.001$), supporting H1. We also asked if direction type or message strategy would moderate the relationship between message efficacy and safety efficacy (RQ4). Analyses indicated a moderating effect of direction type on the relationship between message and safety efficacy ($F[10{,}194] = 2.15$, $p = 0.023$, partial $\eta^2 = 0.10$). Prescriptions increased the positive, linear relationship between message efficacy and safety efficacy above the values for notification messages. As message efficacy increased, prescription messages produced greater safety efficacy than notification messages (see Fig. 1).

Analyses also indicated a moderating effect of message strategy (instrumental, empathy forward, or choice forward) on the relationship between message and safety efficacy ($F[47{,}194] = 2.07$, $p < 0.001$, partial $\eta^2 = 0.333$). Follow-up analyses revealed that this interaction was largely driven by the relationship between message efficacy and choice-forward messages. As message efficacy increased, the relative advantage of choice-forward messages in influencing safety efficacy decreased. Another way to interpret this result is that, when message efficacy was low, choice-forward messages had a strong positive influence on safety efficacy. When message efficacy was high, safety efficacy was also high, but there was little difference between choice-forward messages and other message strategies under those conditions (see Fig. 2).

Post Hoc Analyses

The modeling indicated that relationships under study operated differently in the message replications. Message replications did not differ in safety efficacy ($F[1, 4.139] = 0.19$, $p = 0.684$, partial $\eta^2 = 0.04$), but replications produced a strong main effect on message efficacy ($F(1, 4.013) = 16.52$, $p = 0.015$, partial $\eta^2 = 0.81$). Participants reported higher levels of message efficacy for the water contamination condition ($M = 4.37/5.00$, $SD = 0.78$) than for the flooded roads condition ($M = 3.95/5.00$, $SD = 0.81$). To investigate potential differences, we completed post hoc analyses of the message replications separately.

Modeling the flooded-roads message replication condition indicated a significant main effect for the message direction variable ($F[1, 5.697] = 9.14$, $p < 0.01$). When the topic was flooded roads, prescriptions produced significantly higher message efficacy ($M = 4.13/5.00$) than alerts ($M = 3.75/5.00$); however, direction

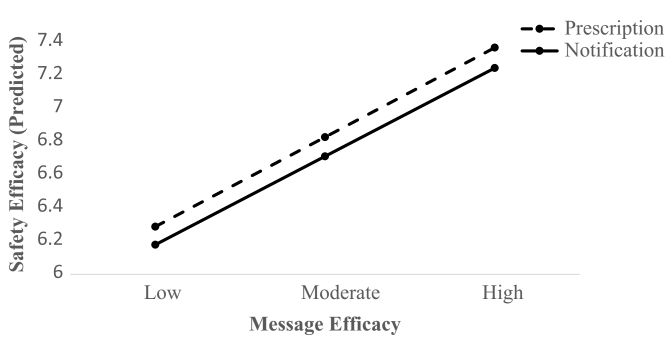

Fig. 1. Prescriptions produce slightly higher safety efficacy overall.

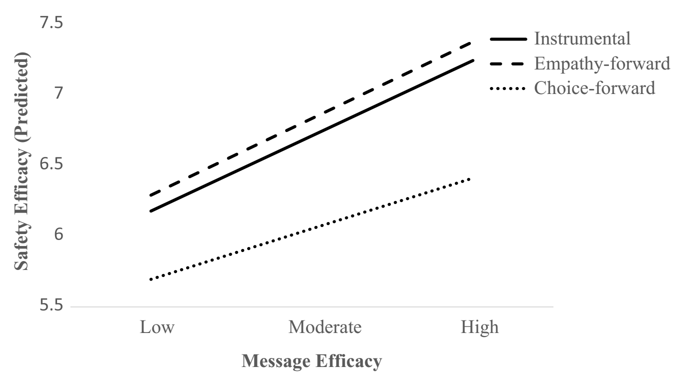

Fig. 2. Message efficacy influences safety efficacy more for instrumental and empathetic messages than for choice-forward messages.

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type did not produce a main effect in the water contamination conditions ($F[1, 0.040] = 0.66$, $p = 0.798$), where message efficacy was generally higher overall ($M = 4.370$, $SD = 0.778$).

Across replications, the mean safety efficacy scores are as follows: instrumental-only messages ($M = 4.09$, $SD = 0.73$); empathetic messages ($M = 4.11$, $SD = 0.91$); and choice-forward messages ($M = 4.32$, $SD = 0.58$). Empathetic messages seemed to suppress safety efficacy more in the flooded roads condition than in the water contamination condition (see Fig. 3). A post hoc comparison showed that choice-forward messages produced higher safety efficacy scores than did instrumental-only messages ($p < 0.05$). In a follow-up test by topic, this effect was not present in the water contamination condition, but it was even more pronounced in the flooded roads condition such that the instrumental-only messages produced much lower safety efficacy ($M = 3.90$, $SD = 0.81$) than the choice-forward messages ($M = 4.26$, $SD = 0.59$; see Fig. 4).

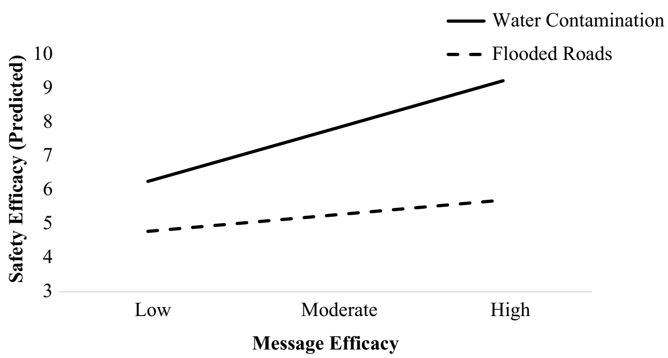

Fig. 3. Empathetic messages suppress safety efficacy more for flooded roads than for water contamination.

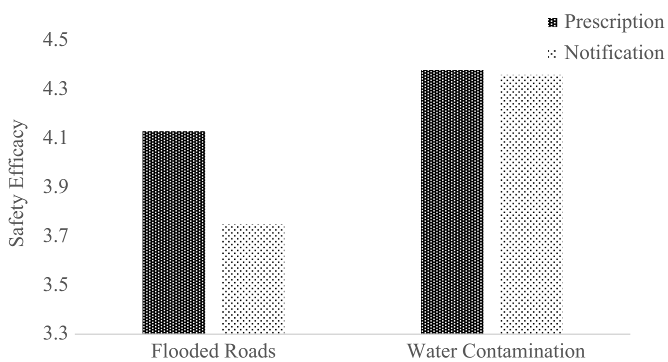

Fig. 4. Prescription impacted safety efficacy more strongly in flooded roads condition than in water contamination condition.

In summary, the effects observed were stronger in the flooded road (FR) conditions than the water contamination (WC) conditions (see Fig. 5). This finding pointed to the importance of message replications in experimental message research: The models that combined variation across message replications were more generalizable to the broader class of messages under study (Jackson 1992). The differences in the replications indicated that factors not specifically conceptualized for this research that may have important implications for message design. To examine the substantive differences among the messages tested, Fig. 6 shows the relative performance of each combination of message strategy and treatment on the outcomes of message efficacy and safety efficacy. Statistically significant contrasts illustrated that the "worst" and "best" performing messages for both outcomes were almost identical.

Worst Message Designs

In the flooded roads condition, notification only and notification plus empathy produced relatively low message efficacy ($M = 3.50$ and 3.74, respectively), and notification plus empathy produced relatively low safety efficacy ($M = 3.92$).

Best Message Designs

In the water contamination condition, the results differed slightly by outcome. For message efficacy, the most effective messages were prescription only (WC) ($M = 4.44$), prescription plus choice (WC) ($M = 4.50$), and notification only (WC) ($M = 4.58$). For safety efficacy, the most effective messages were notification only (WC) ($M = 4.24$) and prescription plus choice (WC) ($M = 4.48$).

Discussion

One of Dr. Dennis Mileti's foundational ideas was the need to consider risk information characteristics, such as message content, and audience characteristics, such as past experience with the hazard, to

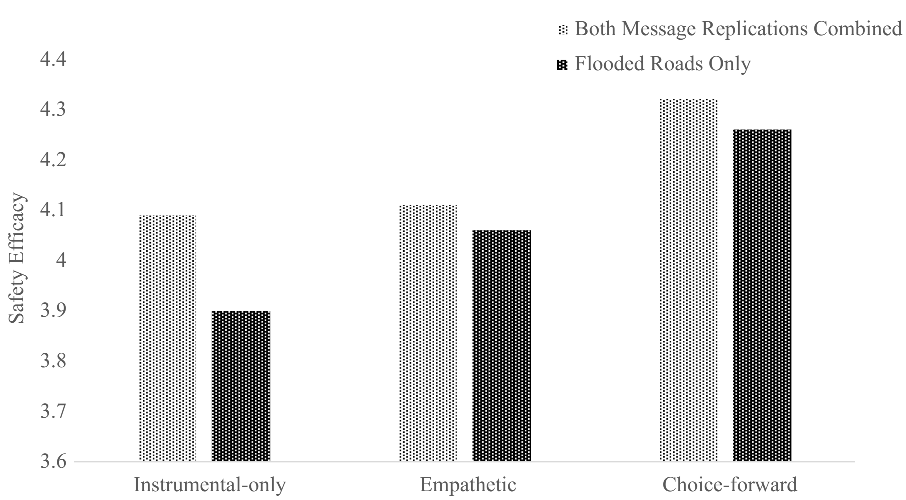

Fig. 5. Message strategy impacted safety efficacy more strongly in flooded roads condition than in both message replications combined.

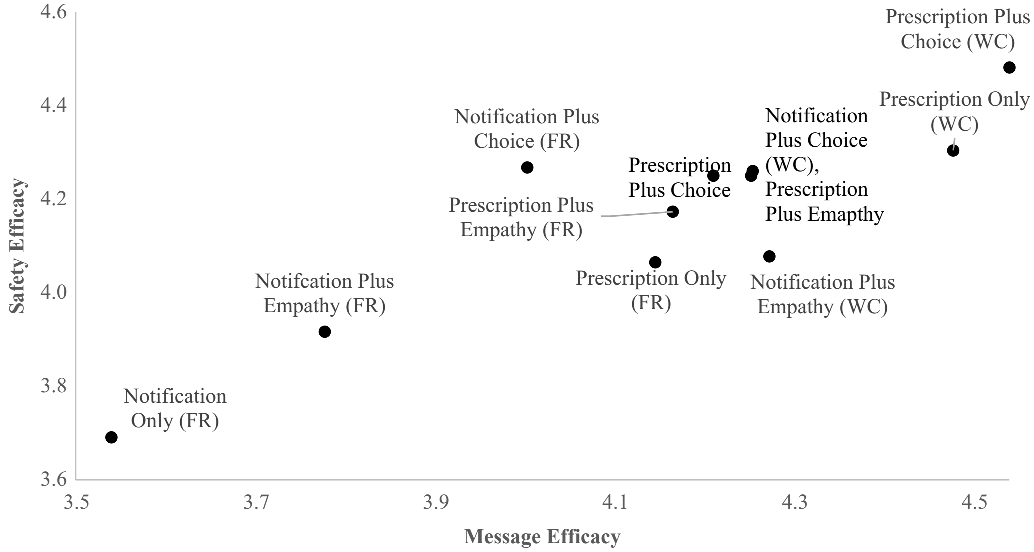

Fig. 6. Relative performance of message designs by topic.

understand individuals' perception of a risk (Mileti and Fitzpatrick 1991). Mileti and colleagues also promoted the idea that the outcome of a public hazard warning was best understood as binary, namely, whether the message recipient took immediate self-protective action or delayed action to seek additional information ("milling") (Mileti and Beck 1975; Mileti and Darlington 1997; Mileti and Fitzpatrick 1991; Mileti and O'Brien 1992; Sorensen and Mileti 1988). As mobile public warnings (MPWs) have developed, empirical research on MPWs has similarly framed warnings as effective to the extent that message recipients take, or report an intention to take, immediate self-protective action.

The present study builds on this research by studying responses to a broader category of mobile alerts and warnings that could be disseminated as free-form, rather than standardized or template-based, messages on private mobile alert technologies or social media platforms. We labeled this category of messages FMAWs; we also contrasted them with the narrower, better-studied subcategory of mobile public warnings. The study compared messages that gave a safety prescription with notifications that gave no prescription but were instead designed to prompt information-seeking. The study also examined empathetic and choice-forward message strategies, as strategies that would exemplify recommended practices in risk communication. We worked from the premise that recipients' interest in self-protective behavior (message efficacy) might not be the only outcome of interest; rather, for situations of more ambiguous location, severity, and timing, another key outcome would be recipients' confidence that they could figure out how to stay safe in their particular situation (safety efficacy).

This study makes three contributions to the theory and practice of mobile alerts and warnings in keeping with the important legacy of Dr. Dennis Mileti: First, it confirms the importance of prescription, especially in MPWs, as established in the work of Mileti and colleagues (Bean et al. 2015; Mileti and Peek 2000; Wood et al. 2018). At the same time, it demonstrates the value of safety efficacy as an outcome in the design of FMAWs. The interaction of message efficacy and message content toward safety efficacy further suggests that safety efficacy may influence the protective action search, assessment, and implementation phases of the protective action decision model (Lindell and Perry 2004; Sutton and Kuligowski 2019). It also provides insight into situations where milling may be productive and useful in response to emerging and ambiguous events. Second, the study indicated not just the value of these message strategies but also that how they functioned depended on message efficacy. Third, the study underscored, again, that the type of hazard has important implications for the study of these messages that may be overlooked when examining messaging contexts in isolation.

In Defense of Milling (When Severity, Location, and Timing Are Not Yet Known)

Embracing safety efficacy as a meaningful outcome takes the concept of milling back to Mileti and Sorenson's (1990) acknowledgment that, in not clearly imminent hazard situations, delaying action to seek additional information is a rational and reasonable response. Such a view also aligns with the iterative design of the protective action decision model, in which one might view a threat as credible, assess risks and options for actions, but decide to wait rather than act immediately; then, later, emerging information or cues may prompt a reexamination with a different decisional outcome. This reframing of milling would also help organizations cope with uncertainty about when to issue alerts or warnings (Sorenson and Mileti 1987; Mileti and Sorenson 1990). If the threshold for issuing a message is not an imminent, severe, precisely located threat, but rather stages of gradual notification and prescription, then there is less pressure on the organizations that originate alerts to establish and defend their dissemination decisions. Mileti's body of work reinforces the general idea that information reinforcement (e.g., number of times exposed to the warning) facilitates the decision to take self-protective action (Mileti and O'Brien 1992; Mileti 2018; Sorenson and Mileti 1988).

Building on this thinking, the role of the broader category of mobile alerts and warnings could be to empower message recipients with enough information to exercise significant choice. Research on significant choice in risk and crisis communication has tended to focus on long-term communication campaigns (Lyon 2007; Streifel et al. 2006; Ulmer and Sellnow 1997; Wickline and Sellnow 2013). This long-term focus reflects the empirical fact that often many useful and relevant self-protective actions exist, but single, terse messages can only highlight one to two at a time

(Sutton et al. 2015). The findings of the present study raise the possibility that significant choice can also be manifested in shorter, terse messages. If so, then the effect of interest would be safety efficacy rather than compliance with the particular safety directive that can be included in a CAP-compliant message.

The Benefits of Choice-Forward Messages for Free-Form Mobile Alerts and Warnings

The findings supported the idea that willingness to take self-protective action in response to a mobile alert or warning interacts with the message features to enhance or suppress the positive association between message efficacy and safety efficacy. In this study, when participants reported lower levels of message efficacy (i.e., reluctance to consider self-protective action), choice-forward messages enhanced the participants' confidence that they could figure out what to do to stay safe in the situation presented. In addition, when participants reported higher levels of message efficacy (i.e., willingness to take self-protective action), instrumental-only, empathetic, and choice-forward message strategies produced comparable levels of safety efficacy. For free-form mobile alerts and warnings, adding a statement that empowers recipients seems to subtly enhance traditional warning messages. It may only be feasible to include choice-forward messages on early-stage or incremental messages—and only on channels or platforms that do not use common alerting protocol. Even so, the message strategy presents advantages.

The least successful messages were those that notified the recipient of a hazard in the county in the form of a simple alert with a URL or that same alert with the addition of an empathetic message. Such messages produced relatively low levels of message efficacy *and* safety efficacy. The most successful messages gave specific safety instructions for the more-personalized risk of drinking-water contamination. Messages that included a choice-forward message were as effective as the prescription-only message in generating message efficacy but more effective in generating safety efficacy. In the present study, empowering choice, not communicating with empathy, influenced safety efficacy, but the value of empathy may depend on the originator of the alert. Future research should study additional outcomes that might be associated with the addition of choice-forward messages to mobile alerts and warnings, such as audience perceptions of the reputation or trustworthiness of the organization that serves as the alert originator.

Hazard Type May Contribute to the Personalization of Risk

An important focus of research on public warnings and mobile public warnings has been how to craft messages that encourage an audience to take the risk seriously (e.g., Kim et al. 2019). Effective approaches have addressed this challenge by personalizing messages (e.g., Sellnow et al. 2017a). Previous research has also established that the hazard type itself may carry a certain degree of risk personalization (e.g., Mileti and Darlington 1997). In this study, the higher levels of message efficacy for the drinking-water contamination replication suggested that participants may have taken the hazard presented by drinking-water contamination more seriously and were more willing to disrupt their routines to mitigate its associated risks. The differences may also reflect differences in risk personalization: Without knowing which roads are flooded and if there is any immediate need to travel on those roads, the flooded-roads messages may have offered less risk personalization. Across message conditions, the message that garnered the lowest message efficacy was, "Some roads are blocked by flooding. Before traveling, visit *yourtown.gov/road conditions* to see flood maps." In contrast, needing to use tap water at home may have inherently activated more risk personalization.

This research design did not allow participants to consult the link provided, and future research could assess these issues by doing so. For example, maps can enhance warnings (Liu et al. 2017); however, the lack of personalization in message text may deter recipients from consulting maps or other additional information in practice. Audiences may respond more to messages that replace "some roads" with more specific guidance about location and "blocked by flooding" with a more vivid depiction of the risk to human life (Bean et al. 2015; Mileti 2018).

Hazard type no doubt also interacts with participants' personal and place-specific experiences (e.g., "earthquake culture" in the Bay Area, Mileti and Darlington 1997). Although the experimental design controlled for participant differences by focusing on results above and beyond them, generalizing these insights should no doubt consider hazard type. The present study did not consider the relevant experiences of individuals or their geographical regions with particular types of hazards, which makes it more difficult to generalize the findings. The findings do point to the need for future research that would investigate how recipients' perceptions of different types of hazards and history with them may interact with direction type and message strategies. Mileti's scholarship provides guidance here as well, establishing that reactions to hazards vary due to individuals' personal experiences with them (Mileti and O'Brien 1992), the regional importance of particular hazards (Mileti and Darlington 1997), the salience of recent hazardous events, and the exemplification effect of particular stories, words, and images (see also, exemplification theory, Zillmann 2006). The results of the present study indicate that risk personalization embodied in the hazard itself may be key, especially given the strong evidence for the importance of risk personalization in the literature (Wood et al. 2018).

Ideas for Applications

These findings could also be usefully applied in practice. The findings suggest that FMAWs could be effective for cultivating safety literacy. In our study, notification-only messages performed poorly, particularly for the less-personalized risk of flooded roads in the county. In contrast, prescription-only and prescription-plus-choice messages performed well. When a hazard is not, or not yet, imminent, severe, and precisely geolocated, perhaps notifications could be reframed as just-in-time pre-event education. Scholars and practitioners have advocated for pre-event education to overcome a lack of understanding about which safety precautions could be useful and how to conduct them properly (Bean et al. 2021). Such information can be prepared in advance, and free-form messages from platforms like Twitter could help audiences find them when the salience of the information is strong, but there is no immediate need to act. They offer the possibility of directing the message recipient to additional information, such as a "frequently asked questions"-style compilation of relevant self-protective actions that they might consider and how to perform them. The "how" may be as important as the "what" because health and safety information often fails to match the "health literacy" of audiences (Wickline and Sellnow 2013).

Future research should explore how safety instruction templates that are predesigned for CAP- or WEA-message generating tools (e.g., Doermann et al. 2021) might still be used for not-yet-imminent hazard situations to prompt preparedness and pre-event self-education. A video on the CAL FIRE "Prepare for Wildfire" website provides a good example. The video states, "When wildfire strikes, you do not have to wait for wildfire authorities to advise you to leave. If you feel unsafe, evacuate immediately. It's time to go immediately upon the request of emergency officials" (CAL FIRE 2022). This statement exemplifies a choice-forward message that could be disseminated in areas adjacent to a current evacuation zone, where residents are likely seeing smoke and starting to wonder what to do. Such a message could also help prompt those ready and willing to evacuate to get on the road, thus reducing traffic congestion for others later, should officials mandate evacuation (Stephens et al. 2015).

FMAWs may also function as a prompt to reach out to personal contacts. Prior discussions of milling have focused on self-protective action for individual actors. Milling, however, may be as much about collective decision-making with partners, family members, or coworkers, as it is about figuring out one's individual course of action. When severity, location, and timing of a hazard are less certain, it may be advantageous to cue people to start discussing possible protective actions with their relevant personal contacts—not "how will I stay safe," but "how will *you* stay safe," or "how will *we* stay safe" (e.g., "informal warnings," as in Mileti and Sorenson 1990, or becoming aware that others are preparing, as in Mileti and Darlington 1997). Mobile alerts and warnings, in such situations, provide a message that is easy to forward to a personal contact to start this conversation. This phenomenon could be called "mobile milling"; it also has potential advantages for preparedness. A memorable line from Dr. Mileti's 2018 FEMA prep talk was, "Mobile technology warnings are fast, [but] mamas are faster" (Mileti 2018). If family members are able to forward messages easily, they can initiate or expedite their loved one's process of protective action decision-making. Future research should examine individuals' willingness to forward alerts or warnings to personal contacts, which may depend on the inclusion of specific message elements like those that empower significant choice. Such research could also consider idle alerts or alerts that seek information from the public such as Amber Alerts, which depend on maximum dissemination to get timely information (Bean and Hasinoff 2022).

Limitations

This study has four key limitations that should frame the reading of the results. First, this study focused on behavioral intentions, rather than actual behavior, as an outcome variable. As Bean et al. (2015) noted, field data about what people actually do in response to mobile messages is important for mobile alert and warning research. Second, the research did not measure intentions to seek information (cf., Choi and Noh 2021; Liu et al. 2017). If there might be such a thing as productive milling, then the measure of information behaviors would best reveal it. Third, the operationalization of notifications in the water contamination condition informed the message recipient about a boil water advisory, which may have reduced the distinctiveness between notification and prescription. In its very name, a boil water advisory advises people to boil their water. That said, the notification messages did not provide any explicit safety instructions, so individuals unfamiliar with how to comply with a boil water advisory would still experience this message as a pure notification.

Fourth, like most experiments, these findings are limited in the extent to which they may generalize outside the laboratory, as aforementioned. The representative panel sample and the development of experimental stimuli based on existing alerts and warnings mitigates but does not remove this limitation. In particular, the overrepresentation of participants who identified as female and participants with college education should be noted. Participants who identified as female reported higher levels of message efficacy than those who identified as male, and participants whose highest level of education ranged from "some college" to a graduate or professional degree reported higher levels of message efficacy than participants with no postsecondary education. The random assignment of participants to conditions controlled for subject effects in the comparisons among conditions; in practice, however, these demographic factors are important because of the difficulty of tailoring mobile alerts and warnings (Sutton and Kuligowski 2019). Setting aside the idea of tailoring mobile warnings for the recipient's gender or education, the results suggest that choice-forward messages may offer a general strategy to counterbalance factors that might be associated with reluctance to accept warning messages as valid or relevant. At the same time, advances in FMAWs may allow for greater tailoring in the future.

Conclusion

The present study started from the assumption that the message design guidance that scholars have developed for mobile public warnings could be extended with modification to the broader context of public and private organizations using mobile alert technologies. The study evaluated audience reactions to messages designed to illuminate the differing assumptions underpinning mobile public warnings and free-form mobile alerts and warnings. Overall, messages that emphasized choice, i.e., a proxy in this study for the ethic of significant choice, were associated with higher levels of confidence in participants' ability to make a good decision about how to stay safe. Safety efficacy may be an even more important outcome than message efficacy for pre-event conditions, locations near but outside of the precise geolocation of WEA recipients, or situations for which the severity of the risk is unclear or may vary widely within a region due to individual factors.

In practical terms, this study grappled with two challenges that arise out of the study of mobile public warnings and transcend to the broader context of mobile alerts and warnings: (1) milling is human nature; it is predictable and, to some extent, inevitable (Mileti 2018; Wood et al. 2018); and (2) mobile alerts and warnings can only be as specific as the accuracy of forecasts or estimates based on what is known at a particular moment in time and as the technological sophistication of segmenting message recipients allows. For the thousands of organizations working with less-severe risks, less-sophisticated forecasts, and less ability to segment, a message that deviates from the common alerting protocol may be the only realistic option. Beyond the public safety sector, an increasing number of organizations use mobile alert technologies to send time-sensitive messages to employees, parents and guardians, customers, subscribers, or other stakeholders. The best practices for such messages will likely differ from those associated with mobile public warning messages, but they should be designed in a way that leverages the growing body of knowledge that Dr. Dennis Mileti's work initiated, inspired, and continues to guide.

Appendix. Description and Sample of Notional Mobile Messages Used in Study

Each participant viewed only one stimulus message by random assignment. Stimulus messages were modeled after free-form protective action instructions found on the National Weather Service and the Centers for Disease Control websites. No scenario was

Screen Shot of Sample Notional Mobile Message, as Presented to Participants

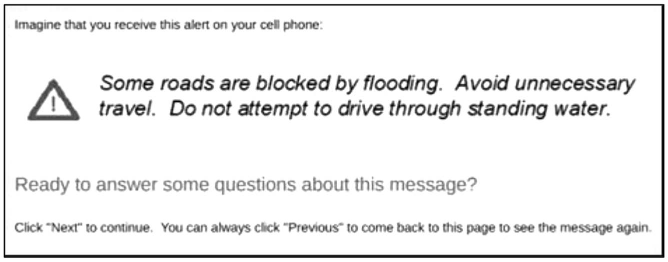

Fig. 7. Screen shot of sample notional mobile message, as presented to participants.

presented, only an image of the message with the instruction, "Imagine that you receive this alert on your cell phone" (see Fig. 7).

Data Availability Statement

All data, models, and code that support the findings of this study are available from the corresponding author upon reasonable request.

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