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A Decade of Wireless Emergency Alerts: A Longitudinal Assessment of Message Content and Completeness

Short Title: Wireless Emergency Alert Content & Completeness

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Abstract

Wireless Emergency Alerts (WEAs) provide a direct way for public safety officials to reach at-risk publics via text-based messages on their mobile devices. Although WEAs were introduced over a decade ago and can be either 90 or 360 characters in length, we currently do not know what these messages have contained. To address this gap, we quantify the contents of the last decade of WEA messages using the principles of effective warning message design. Specifically, we use quantitative content analysis to conduct a longitudinal assessment of 6,080 WEAs sent by Alerting Authorities (AAs) from 2012 to 2022. We code these messages according to the concepts in the Warning Response Model (WRM; Mileti & Sorensen, 1990), which establishes that WEAs need to include information about the hazard, location, source, guidance, and time. Our results indicate that source and timing information are included at a much lower rate than location, hazard, and guidance information. Furthermore, only 8.5% of these messages are complete—or include all five pieces of WRM content. Complete WEA messages can minimize protective action delay while maximizing message understanding, belief, and personalization. We also find that 360-character WEAs are more likely to be complete than 90-character WEAs. Thus, those responsible for crafting WEAs should continue to take full advantage of the increased number of characters to write complete messages that warn populations at risk, rather than simply alert them to the existence of a hazard.

Keywords. Wireless emergency alerts, warning communication, risk communication

A Decade of Wireless Emergency Alerts: A Longitudinal Assessment of Message Content and Completeness

Disasters create information voids, whereby those affected want to know immediately what has happened and what they should do to protect themselves (Coombs, 2007). However, after action reports consistently say that providing information during disasters is one of the biggest obstacles in response. For example, the terrorist attacks on September 11th, 2001 illustrated a lack of coordinated and interoperable communication systems (National Research Council, 2003) and Hurricane Katrina demonstrated a lack of capacity to communicate directly to those at risk (United States Congress, 2006). In response to these large-scale disasters that revealed the United States' inability to quickly inform and warn those in danger, President George W. Bush signed Executive Order 13407 on June 26th, 2006, which mandated that the United States "have an effective, reliable, integrated, flexible, and comprehensive system to alert and warn the American people in situations of war, terrorist attack, natural disaster, or other hazards to public safety and well-being" (see Section 1). What resulted from this Executive Order was the 2006 Warning, Alert, and Response Network (WARN) Act that created the Integrated Public Alert and Warning System (IPAWS). IPAWS unites the United States' multiple warning systems, including the WEA system introduced in 2012 (National Academies of Sciences, 2018). Since its introduction, over 78,000 WEA messages have been sent across the United States (Federal Communications Commission [FCC], 2023).

WEAs are a key way for public safety officials to quickly provide lifesaving information to the public (Bean, 2019). WEAs allow Alerting Authorities (AAs), such as law enforcement and emergency managers, at the federal, state, tribal, and local level to send text-based messages to at risk individuals via their mobile devices for imminent threats, AMBER alerts/missing persons, presidential alerts, and, as of 2019, public safety messages (FEMA IPAWS, 2021). Most wireless device operating systems in the United States are WEA-compatible and none require users to "opt in" to receive messages. Rather, WEA users may opt out of receiving (i.e., turn off) all WEA message types except for presidential alerts.

Initially, WEA messages were limited to 90-characters and could only be delivered in English. Updates were made in 2019 that allowed AAs to send WEAs up to 360 characters in length (i.e., a fourfold increase in character count), written in Spanish, and including a URL/hyperlink (FCC, 2019). With these improvements, WEA messages had the potential to become more complete, specific, and understood, which can lead to positive behavioral outcomes that save more lives (Mileti & Sorensen, 1990; Trujillo-Falcón et al., 2022). Also in 2019, WEA improved its "geo-targeting" capabilities. Taking advantage of a technology known as Device Based Geo-Fencing (DBGF), this improvement allows alert originators to send WEAs to capable devices within a very precise geographic area (FEMA IPAWS, 2022). With DBGF, an alert would then be sent only to capable devices within and no more than 1/10th of a mile outside of the given geographic area, thus allowing for enhanced precision and targeted alerts (FCC, 2023). As of 2022, it is estimated that approximately 60% of mobile devices in the United States support improved geo-targeting (FCC, 2023).

These advancements to the WEA system throughout the last decade primarily focus on technological improvements (e.g., infrastructure, software) that enhance the delivery of WEA messages (Kumar et al., 2018; McGregor et al., 2014; Stoddard et al., 2014). Although important, the emphasis on technological capabilities suggests that WEA is merely a channel to send information; however, the information itself is also important to consider. Thus, WEAs can be classified as both a channel *and* a message—and it is the message that motivates the public toward protective action (Mileti & Sorensen, 1990).

Indeed, decades of research on alerts and warnings demonstrates how WEA message content and style helps people make protective action decisions (see Sutton & Kuligowski, 2019). This body of theoretical and empirical research has produced recommendations for how WEA messages should be constructed (see National Academies of Sciences, 2018). However, researchers have yet to classify WEA message contents for all hazards or assess their potential to motivate at risk public(s) to protect themselves.

Thus, the purpose of this study is to provide a longitudinal assessment of the first decade of WEA messages to determine what types of messages have been sent, by who, and what they contain. Specifically, we provide a comprehensive evaluation of WEAs sent between 2012 to 2022, excluding those sent by the National Weather Service, for missing persons, AMBER Alerts, or messages in Spanish. Using research on effective warning message content, we quantify the frequency of WEA contents and how they differ between 90- and 360-character messages. This assessment allows us to determine where messaging problems exist and offer communication recommendations to AAs, thus improving the effectiveness of WEA message writing in the future. We begin with an overview of effective warning message content and its associated research, which provides the basis of our evaluation.

Literature Review

WEA Message Content

WEAs that contain (a) hazard, (b) location, (c) time, (d) source, and (e) guidance information increase message receivers' understanding, belief, and personalization, which improves their protective action decision making (Mileti & Sorensen, 1990; Sutton &

Kuligowski, 2019). Furthermore, WEAs that include these five types of content are considered "complete" (Bean et al., 2022). Complete messages reduce the likelihood of milling—or the process of searching for additional information, confirming warning information, and/or observing others (Turner & Killian, 1957; Wood et al., 2018). During imminent threats, milling results in protective action delay by reducing the time one has to protect themselves.

The importance of these five contents was first identified by Mileti and Sorensen (1990) and, more recently, was referred to as the "Warning Response Model" (WRM: Kuligowski et al., 2023). The WRM is a popular framework used to design and test WEAs and other terse messages for a variety of hazards, including earthquake (Sutton et al., 2023), tornado (Sutton et al., 2021), tsunami (Liu et al., 2017; Sutton, Vos., et al., 2018), radiological release (Bean et al., 2014; Liu et al., 2017; Wood et al., 2015), active shooter (Kim et al., 2019; Liu et al., 2017; Wood et al., 2015), explosion (Kim et al., 2019), and improvised nuclear device detonation (Bean et al., 2016; Wood et al., 2018).

Although less attention has been devoted to using the WRM to evaluate actual WEAs that have been sent to the public, recent research has begun to address this gap. For example, Bean et al. (2022) examined the frequency of WRM contents in 213 WEAs about COVID-19 and Kuligowski et al. (2023) applied the WRM to 1,284 WEAs sent for wildfire events. Together, both Bean et al. (2022) and Kuligowski et al. (2023) help us understand what hazard specific WEAs have contained. What we need, however, is to determine the extent to which WEAs for *all* hazards have utilized the empirically based recommendations included in the WRM. Next, we discuss each of the five key content types identified in the WRM in greater detail and their importance in WEA messages.

Hazard

First, warning messages should include the name of the hazard—or the event that poses a threat to people (Mileti & Sorensen, 1990). Confusion, uncertainty, and anxiety can occur when a hazard is not named (Mileti & Peek, 2000), which can increase the likelihood of milling (Lindell & Perry, 2012). In addition to naming the hazard, a warning should also describe the hazard—or "provide enough detail for all members of the public to understand the physical characteristics of the hazard agent from which they are to protect themselves" (Mileti & Peek, 2000, p. 185). Describing the hazard helps people better understand (a) the situation that is occurring, (b) why it is a threat to them, and (c) why certain protective actions need to be taken (Mileti & Peek, 2000). Therefore, in our assessment of WEAs sent from 2012-2022, we ask:

RQ1: How frequently is the (a) hazard named and (b) described?

WEAs can also be issued for various types of hazards and events, including imminent threats, public safety, missing persons, and presidential alerts. This means there is a wide range of hazards that can be communicated via WEA, and there is no policy that directs or limits their use by AAs. However, researchers and practitioners alike have raised concerns that WEAs for non-imminent or life-threatening events could make the public perceive WEAs as irrelevant and intrusive (Holpuch, 2023). This may lead people to take future messages less seriously, ignore them (Kim et al., 2019; Sorensen & Sorensen, 2007), or turn WEA off altogether. Given the breadth of potential hazards that can be communicated via WEA, including the recent addition of public safety messages and new emergent threats like COVID-19, we ask:

RQ2: For which hazards are WEAs most frequently sent?

Location

Next, warning messages need to indicate the location(s) at risk. Location information specifies who is and who is not at risk for experiencing a hazard's consequences, as well as who needs to take protective action (Wood et al., 2018). Location information most commonly includes descriptions of a geographical or physical area of a threat and its boundaries (Mileti & Peek, 2000; Wood et al., 2018), as well as the location of potential impact and populations that may be affected. In some cases, location information will include the direction a hazard is moving or the location of evacuation shelters outside the path of the threat (Doermann et al., 2021).

How a location is described, and its specificity, can increase message understanding and personalization of the threat. Specific location information helps people locate themselves in proximity to the hazard and increases their confidence that the threat is relevant. Conversely, non-specific locations (e.g., "in this area") can lead message recipients to feel they are not at risk for experiencing hazard consequences (Bean et al., 2016). Thus, specific location information should be used whenever possible (Bean et al., 2015), which can include:

- Use names of cities/towns/counties (Doermann et al., 2021)
- Major landmarks (Cao et al., 2016; Doermann et al., 2021; Sutton, Woods, & Vos, 2018)
- Major road/intersection road names (Cao et al., 2016)
- Evacuation zones (if applicable; Kuligowski et al., 2023)

Therefore, in our assessment of WEAs sent from 2012-2022, we ask:

RQ3: How frequently is (a) location information present and (b) how is it described?

Time

WEA messages also need to include information related to time. Timing information should be clearly stated to account for technological problems, such as message latency and/or delivery delay. And although timing information like “now” helps convey urgency, this type of timing information can be problematic if messages are not received immediately.

Timing information in WEAs primarily manifests in three ways. First, timing information can indicate the time of the hazard and its impacts, which provides an estimate of when a hazard is expected to arrive in a particular area and the duration of the event (Mileti & Peek, 2000; Sorensen, 2004). Second, timing information can refer to the time in which protective actions should be initiated and for how long (Mileti & Sorensen, 1990). Third, timing information can include the time at which the message expires (Mileti, 2018). Therefore, in our analysis of WEAs sent from 2012-2022, we ask:

RQ4: How frequently is (a) timing information present and (b) what types of timing information are included?

Source

WEAs should name the message source—or the individual or organization sending the message (Mileti & Sorensen, 1990). A clearly recognizable source is necessary for message receivers to understand that the warning is official, urgent, and actionable. In other words, message receivers must know who the message is coming from to believe it (Mileti & Peek, 2000). WEAs that do not include a message source or include a source that is not easily recognized due to unfamiliarity and/or the use of an acronym will lead to decreased message credibility and believability (Bean et al., 2016). This results in message recipients confirming where the message is coming from, which delays protective action decision making (Sutton & Kuligowski, 2019).

Furthermore, how receivers perceive the source of a message has implications for their behavioral responses (Lindell & Perry, 2012). Sources perceived as credible, knowledgeable, and "official" can help message receivers believe the legitimacy of the threat (Bean et al., 2016), the urgency of the situation (Stephens et al., 2013), and increase the likelihood that they will protect themselves (Wogalter et al., 1999). Indeed, sources perceived as highly credible can lead to protective action decision making even when an individual is uncertain about the situation or when warning message content is insufficient (e.g., telling people to evacuate but not why; Lindell & Perry, 2012). Therefore, in our assessment of WEAs sent from 2012-2022, we ask:

RQ5: How frequently is the name of the message source included?

Guidance

Protective action guidance tells warning recipients what action(s) they should perform to keep themselves safe in response to a threat (Mileti & Peek, 2000; Mileti & Sorensen, 1990). Without guidance information, warnings serve as an informational alert that only notifies people about the existence of a threat, absent instruction about what to do. Indeed, providing actionable guidance information is often more critical than communicating the risk (Wood et al., 2012). And in the warning phase of an imminent threat (i.e., the period when immediate action is warranted), people indicate they want guidance information the most (Krocak et al., 2023). In some cases, guidance directs people to additional information, which has the potential to reduce the time spent searching for content about the threat (Sutton et al., 2023; Sutton, Woods, & Vos, 2018). Therefore, in in our assessment of WEAs sent from 2012-2022, we ask:

RQ6: How frequently is guidance information included?

Overall, these five types of warning content help the public make protective action decisions (Sutton & Kuligowski, 2019). However, the style of the message—or how the content is presented and structured—also has implications for behavioral response (Mileti & Peek, 2000). Warning message style considerations include the clarity, certainty, and consistency of message content. But perhaps the most important stylistic component is the extent to which a message is complete, which we define as the inclusion of hazard name, source, location, time, and guidance within a single warning message. Next, we discuss the importance of a complete WEA message.

WEA Message Completeness

Complete warning messages increase the likelihood that message recipients will protect themselves within an appropriate timeframe, while simultaneously decreasing their likelihood of milling (Doermann et al., 2021). However, recent assessments of WEA messages for both wildfire (Kuligowski et al., 2023) and COVID-19 (Bean et al., 2022) found that incomplete messages are common. For example, in Bean et al.'s (2022) evaluation of 213 COVID-19 WEAs sent between March and April of 2020, they found that less than 3% of these messages contained all five recommended WRM contents. Given the importance of complete messages to help the public make protective action decisions quickly, when looking at WEAs sent from 2012-2022, we ask:

RQ7: How many WEAs are complete—or include hazard name, source, location, guidance, and time?

Kuligowski et al. (2023) also argue that including a URL or hyperlink in a WEA can increase message completeness by allowing message recipients to obtain additional information and confirm the information included in the message more easily. Yet, people typically want all pertinent information in a single message, without having to look at other sources (Wood et al., 2018). Furthermore, people are often reluctant to click on hyperlinks that have unspecified domain names (e.g., bit.ly) due to concerns that they be taken to a webpage that is malicious (Sutton, Woods, & Vos, 2018). However, URLs that direct to .gov or other domains are often perceived to be more trusted, leading to a possible willingness to click when users need more information (Sutton, Woods, & Vos, 2018). Thus, to better understand message completeness via the inclusion of a URL/hyperlink, we look to the WEAs sent from 2012-2022 and ask:

RQ8: How frequently is (a) a URL/hyperlink included and (b) what types of websites do they link to?

Overall, empirical research on effective warning messages demonstrates the importance of including all five WRM contents to motivate action. These contents should be included regardless of message length (Sutton & Kuligowski, 2019), meaning that 90-character WEA messages should also be complete to reduce milling and protective action delay.

In practice, however, 90-character messages often lack specificity about the hazard and its impacts, the location at risk (e.g., stating “in this area” instead of an exact location), and the specific actions that should be taken (Bean et al., 2014). Thus, 90-character WEAs often lead to milling as people attempt to clarify what is happening, where, to whom, when, and what they should do to protect themselves (Wood et al., 2018). The expansion of WEA from 90-characters to 360-characters enables message writers to design messages that are not only complete in terms of the contents, but also provide increased specificity. This is especially important for those who are unfamiliar with the hazard and do not know what actions are necessary to protect themselves (Fischer et al., 2023; Sutton et al., 2021).

Yet AAs often do not take full advantage of the additional information that can be included in a 360-character WEA. For example, Kuligowski et al. (2023) examined wildfire WEAs and the differences between 90- and 360-character messages, quantifying their completeness and identifying strategies AAs use to make messages more specific. They found that even with the increased number of characters available, approximately 32% of AA’s replicate the text of a 90-character message in the place of a more complete 360-character message, suggesting that there is a great deal of room for improvement. Therefore, to better understand the differences in message completeness between 90- and 360-character WEAs sent between 2012-2022, we ask:

RQ9: Are there differences between 90- and 360-character messages and the frequency of (a) hazard, (b) location, (c) source, (d) guidance, and (e) timing information?

RQ10: Are there differences between 90- and 360-character messages and their completeness?

Method

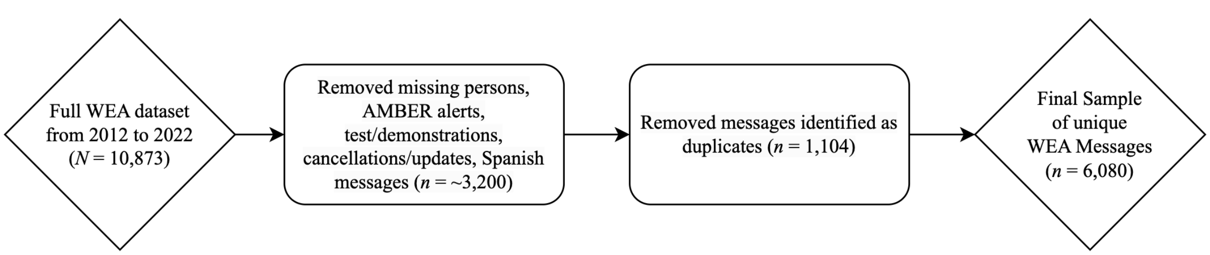
Using quantitative content analysis, we examined WEA messages sent from 2012 to 2022. We coded these messages following the WRM to determine the frequency of (a) hazard, (b) location, (c) time, (d) source, and (e) guidance information. We also look at the frequency of hazard description information, the extent to which they include a URL or hyperlink, the types of location and timing information present, and their level of completeness. In addition, we performed chi-square tests to determine if 90- and 360-character messages significantly differ in their inclusion of WRM contents and completeness. To create a comparable sample for chi-square analyses, we selected WEAs sent between 2019 and 2022. The start of this timeframe coincides with the introduction of 360-character WEAs (i.e., 90-character messages that did not have a 360-character counterpart were excluded from comparison analyses). This resulted in a more balanced number of 90- and 360-character WEAs, totaling 4,777 messages available for our chi-square analyses.

Sample

We received the corpus of WEAs sent from June 2012 to April 2022, excluding messages sent from the National Weather Service (*N* = 10,873). This is a non-public dataset that we received directly from FEMA IPAWS. Meta-data elements include technical elements necessary for message sending, as well as other identifying information such as message ID, alerting authority name and type, date of sending, and alert type. We manually removed messages about missing persons, AMBER alerts, test/demonstrations, cancellations/updates (i.e., messages that do not necessitate protective action upon message receipt) and messages sent in Spanish (*n* = ~3,200). We also removed what were identified as duplicate messages (*n* = 1,104)—that is, messages where the 90-character messages and 360-character messages contained the same contents. The identification of duplicate messages stemmed from AAs generating a 90-character message and replicating it in both the 90-character and 360-character message text fields in their respective alert origination software. In these cases, they were counted as a 90-character message. Thus, our final sample was composed of 6,080 unique WEA messages. Of these, 69.2% (*n* = 4,207) were 90-character messages and 30.8% (*n* = 1,873) were 360-character messages.

Figure 1

WEA Sample Description



Data Analysis and Coding Scheme

The 6,080 WEA messages were first coded by a single coder using the coding scheme in Table 1, building on a similar coding structure to Kuligowski et al. (2023). Each message was coded for the presence (= 1) or absence (= 0) of each category. When coding for the presence of guidance in each WEA, the total number of discrete actions that were recommended by the message were also counted. Then, a second coder was trained and coded 300 messages independently (Lombard et al., 2010). These messages were randomly selected from the total set of WEAs and reflected the sample proportions of 90- and 360-characters (roughly 70% of 90-character and 30% of 360-character messages). Intercoder reliability was calculated using ReCal OIR (Freelon, 2013) and was deemed reliable (α > .80) for each content category (Krippendorff, 2011; see Table 1).

Table 1

Warning Response Model Content Definitions, Reliability, and Example Messages

Variable	Definition	Krippendorff's Alpha		Example WEAs
		90-char.	360-char.	
Hazard	The name of the impending hazard, threat, or event that has precipitated the message	.85	.85	Wabaunsee County residents west of Pretty Creek and Pavillion Road to the north should evacuate due to large out of control **fire**.
Hazard Description	Information describing the hazard	.88	.81	National Weather Service: Snow squall warning until 6:45 PM. Slow Down! **Rapid changes in visibility and road conditions are expected with this dangerous snow squall. Be alert for sudden whiteout conditions.**

Source	Name of the organization providing the information in the message	.90	.98	This is a message from **the Gallatin County Sheriff**. At 3:30 this morning two men were shot and killed in Three Forks near 6th Ave East and Ash St. The suspect has not been located. Residents are encouraged to lock their doors and report anything suspicious to 911.
Guidance	Information about how people should protect themselves or the actions they should/could perform	.97	.93	Emergency message from the City of Sugar Land: there are live powerlines in several backyards on Pickett and Gettysburg due to a previous fire from power lines. **Please avoid your backyard at this time**. Centerpoint has been notified.
Time	When message receivers should expect hazard impacts, when they should take action, when the message expires, or how long they have to take action	.99	.89	Fire has jumped 395. Rancho Haven and Flanigan Flats areas need to evacuate **now**. Evacuation point is Hug High School for people and small animals. Large animals can evacuate to RSLEC. Evacuate to the south. Check media for updates.
Location	Landmark; town/city/county; road/intersection/ highway; zone or Zonehaven info	1.00	.95	**Klamath County, north of the town of Beatty**. Level 3 (GO NOW) Evacuation **starting at the forest boundary 6.5 miles north of 140 extending east of Ivory Pine Rd 4 miles**. This is due to IMMINENT DANGER due to wildfire.

Note. Bolded text is used to emphasize contents that warrant inclusion for a particular category.

Frequencies were calculated for each category and chi-square tests were performed to determine the differences between 90- and 360-character messages.

For time and location, we identified and coded additional subcategories (see Tables 5 and 6). If a message was found to contain timing or location information, it was further analyzed to identify the subcategory in which that information fit best. For instance, if a message was found to contain timing information, it then was assessed further to identify if that information referred to time of impact, time to take action, or expiration time. The same principle holds true for the location subcategories.

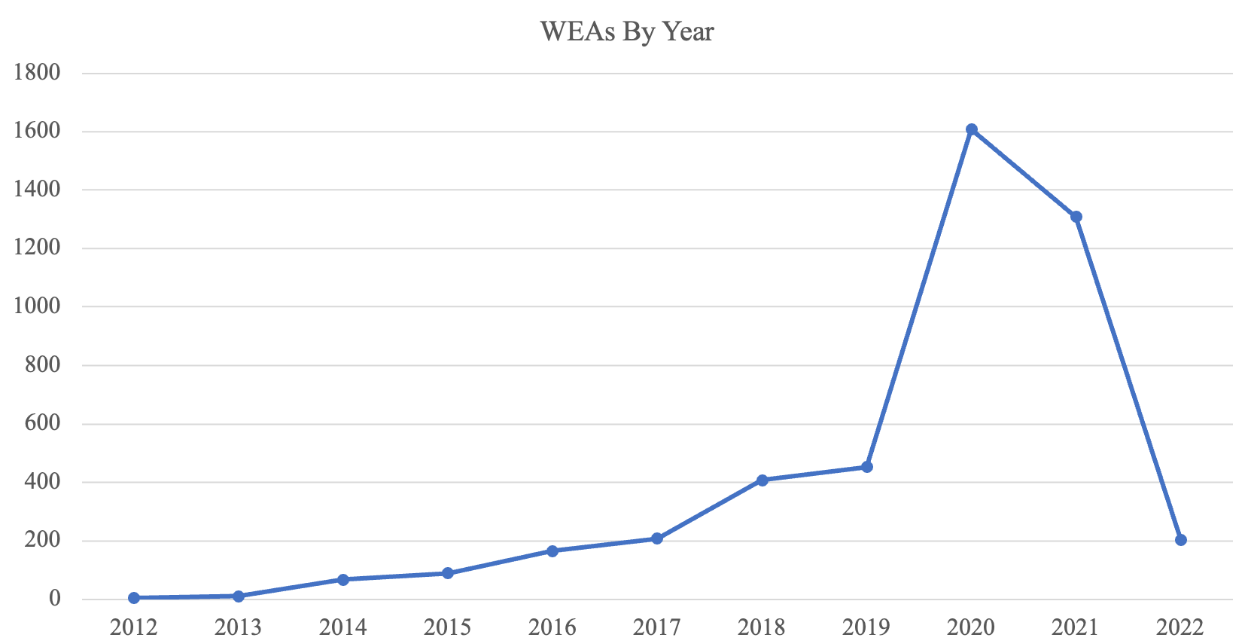
Furthermore, we organized hazard names into overarching hazard categories (see Sutton et al., 2023). To determine the most appropriate category for each message, we assessed the hazard name mentioned in the message. For example, if the hazard named in a message was a "hostage situation," this would be placed into the law enforcement category. Each message was analyzed individually for categorization. In the cases where the reason for message sending was obscure or was not able to be determined, they were placed into the other/unknown category.

Results

We begin by providing a short description of our overall data set. First, in Figure 2, we show the number of 90-character WEAs sent from 2012 to April 2022. Here, we see a sharp increase in the number of WEAs sent from 2019 to 2020.

Figure 2

WEA Events by Year



Note. Data collection ended in April 2022, so this figure does not reflect the complete sum of WEAs sent in 2022.

The largest number of WEAs were sent from AAs located in California (27.1%; *n* = 1,645), followed by Texas (8.3%; *n* = 515), and Washington (5.4%; *n* = 329). The AAs in the remaining states each sent fewer than 300 WEA messages in total. Of the AAs sending WEAs during this timeframe, we found that nearly three-quarters of WEAs were sent by county-level AAs (71.5%, *n* = 4,349). Additional results are summarized in Table 2.

Table 2

Alerting Authority Type

Alerting Authority Type	# of WEAs (*N* = 6,080)	%
County	4,349	71.5
State	931	15.3
City	500	8.2
Other	208	3.4
City and County	90	1.5
Town	2	< 0.01

Note. “Other” includes airports, tribal nations, US army garrisons, etc.

Next, we discuss the frequency of each WRM content category and if this information differs between 90- and 360-character messages (see Table 3).

Message Content

We begin with a review of message content frequencies for each WRM category. We also calculate the differences of these frequencies between 90- and 360-character messages. Results are summarized in Table 3.

Table 3

Frequency of Message Content Categories and Chi-Square Values

Content Category	**χ^2 (df)**	**90-char. WEAs (*N* = 4,207) *n* (%)**	**360-char. WEAs (*N* = 1,873) *n* (%)**	**Total WEAs (*N* = 6,080) *n* (%)**
Hazard	67.33 (1)***	2,958 (70.3%)	1,510 (80.6%)	4,468 (73.5%)
Hazard Description	197.82 (1)***	702 (16.7%)	627 (33.5%)	1,329 (21.9%)
Location	103.17 (1)***	3,417 (81.2%)	1,714 (91.5%)	5,131 (84.4%)
Time	176.38 (1)***	1,379 (32.8%)	1,002 (53.5%)	2,381 (39.2%)
Source	288.76 (1)***	1,119 (26.6%)	976 (52.1%)	2,095 (34.5%)
Guidance	384.33 (1)***	2,692 (64.0%)	1,649 (88.0%)	4,341 (71.4%)

Note. ****p* < .001

Hazard, Hazard Description, and Hazard Type

Overall, 73.5% (*n* = 4,468) of WEAs named a hazard. There was a significant difference between 90- and 360-character messages (χ^2 (1) = 67.33, $p < .001$, phi = .119), whereby 360-character messages were more likely to include a named hazard. Specifically, 80.6% of 360-character messages (*n* = 1,510) and 70.3% of 90-character WEAs (*n* = 2,958) named a hazard in the WEA message.

Next, 21.9% (*n* = 1,329) of WEAs included a description of the hazard, which we coded as a subcategory of naming the hazard (i.e., not a component of a complete message). There was a significant difference between 90- and 360-character messages (χ^2 (1) = 197.822, $p < .001$, phi = .203), whereby 360-character messages were more likely to include hazard description information. Specifically, 33.5% of 360-character WEAs (n = 627) and 16.7% of 90-character WEAs (n = 702) included a hazard description.

Finally, we also examine the overarching type of hazards the WEAs were sent for following the hazard categories in Sutton et al. (2023; see Table 4). Here, we find that 32.0% (n = 1,944) of WEAs were sent for wildfire, followed by public safety (17.6%, n = 1,069) and law enforcement (15.9%, n = 967) hazards. Furthermore, we find that AAs are sending WEAs for atmospheric hazards (12.1%, n = 733). The NWS is responsible for sending WEAs for nine hazards (i.e., dust storms, extreme wind, flash flooding, hurricanes/typhoons, severe thunderstorms, snow squall, storm surge, tornadoes, and tsunamis; NWS, n.d.a); however, AAs are also sending WEAs for atmospheric hazards in addition to and/or in place of what the NWS is responsible for.

Table 4

Frequency of Hazard Categories

Hazard Category	**# of WEAs (N = 6,080)**	**%**
Wildfire (fire, wildfire, brush fire)	1,944	32.0
Public Safety (911 outage, boil water, traffic event)	1,069	17.6
Law Enforcement (curfew, criminal suspect, police activity)	967	15.9
Public Health (COVID-19, flu, air quality)	865	14.2
Atmospheric (flooding, thunderstorm, tornado)	733	12.1
Technological (gas leak, non-wildfire type fire[a], dam failure)	257	4.2
Other/Unknown (mental health, generator safety, debris clean-up)	192	3.2
Geophysical (debris flow, earthquake, avalanche)	53	0.9

Note. The top three examples of specific hazards within each category are provided in parentheses.

[a]Non-wildfire type fire refers to any kind of fire events that are not wildfires. Examples include vehicle fire, industrial fire, house fire, building fire, etc.

Location

Overall, 84.4% (n = 5,131) of WEAs included location information. There was a significant difference between 90- and 360-character messages (χ^2 (1) = 103.17, $p < .001$, phi = .147), whereby 360-character messages were more likely to include specific location information. Specifically, 91.5% of 360-character WEAs (n = 1,713) and 81.2% of 90-character WEAs (n = 3,417) included location information.

Furthermore, specific types of location information as identified by Doermann et al. (2021) were also coded (see Table 5): using a town, city, county, or other geographical boundary (61.9%, n = 3,766); naming a road, highway, or street (33.1%, n = 2,014); using local landmarks (29.2%, n = 1,776); and identifying at-risk evacuation zones or ZoneHaven zones (1.8%, n = 110). However, 15.5% of WEAs either did not mention location or used ambiguous or non-descriptive language to communicate location (e.g., "in your area"; n = 944).

Table 5

Location Subcategories

Location Category	**90-char. WEAs (*N* = 4,207) *n* (%)**	**360-char. WEAs (*N* = 1,873) *n* (%)**	**Total WEAs (*N* = 6,080) *n* (%)**
Town, city, county, or other geographical boundary	2,354 (56.0%)	1,412 (75.4%)	3,766 (61.9%)
Road, highway, or street	1,241 (29.5%)	773 (41.3%)	2,014 (33.1%)
Local landmark	1,152 (27.4%)	624 (33.3%)	1,776 (29.2%)

"In your area," ambiguous or no location information	783 (18.6%)	161 (8.6%)	944 (15.5%)
Evacuation or ZoneHaven zones	66 (1.6%)	44 (2.3%)	110 (1.8%)

Time

Overall, 39.2% (n = 2,381) of WEAs specified some timing aspect. There was a significant difference between 90- and 360-character messages (χ^2 (1) = 176.38, p < .001, phi = .192), whereby 360-character messages were more likely to include timing information. Specifically, 53.5% of 360-character messages (n = 1,002) and 32.8% of 90-character WEAs (n = 1,379) included timing information.

We also coded for the three types of timing information as indicated by Doermann et al. (2021): time to hazard impact, time to take action, and time at which the warning expires. Results are summarized in Table 6.

Table 6

Timing Subcategories

Time Category	**90-char. WEAs (*N* = 4,207) *n* (%)**	**360-char. WEAs (*N* = 1,873) *n* (%)**	**Total WEAs (*N* = 6,080) *n* (%)**
Time until hazard impact	724 (17.2%)	575 (30.7%)	1,299 (21.4%)
Time to take action	466 (11.2%)	359 (19.2%)	825 (13.6%)
Message expiration time	611 (14.5%)	385 (20.6%)	996 (16.4%)

Source

Overall, 34.5% (n = 2,095) of WEAs included a source. There was a significant difference between 90- and 360-character messages (χ^2 (1) = 288.76, $p < .001$, phi = .246), whereby 360-character messages were more likely to include a source. Specifically, 52.1% of 360-character messages (n = 976) and 26.6% of 90-character WEAs (n = 1,119) included a source. Additionally, 49.8% of source names were abbreviated across the 90- and 360-character messages.

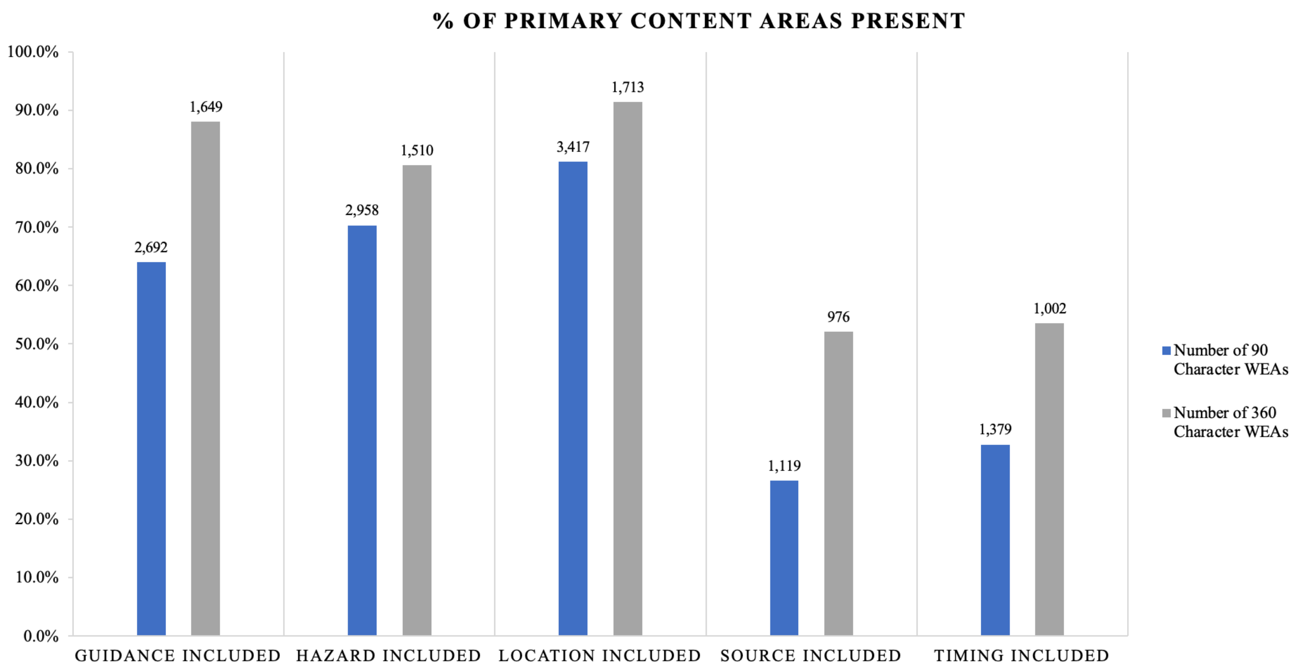
Guidance

Overall, 71.4% (n = 4,341) of WEAs included guidance information. There was a significant difference between 90- and 360-character messages (χ^2 (1) = 384.33, $p < .001$, phi = .284), whereby 360-character messages were more likely to include guidance. Specifically, 88.0% of 360-character messages (n = 1,649) and 64.0% of 90-character WEAs (n = 2,692) included guidance information.

Overall, our results demonstrate significant differences between WRM content types and 90- and 360-character messages (see Figure 3). Next, we discuss how these message types differ in their overall level of completeness.

Figure 3

Percentages of WRM Content Types for 90- and 360-Character Messages



Message Style

Message Completeness

Of the 6,080 messages, only 8.5% (n = 518) included all five of the components of the WRM—or hazard name, location, source, time, and guidance information. There was a significant difference between 90- and 360-character messages (χ^2 (1) = 431.53, p < .001, phi = .301), whereby 360-character messages were more likely to include all five WRM contents. Specifically, 21.9% of 360-character messages (n = 1,329) and 2.9% of 90-character WEAs (n = 122) included all five contents (see Table 7).

Table 7

Frequency of Message Style Categories and Chi-Square Values

Content Category	χ^2 (df)	90-char. WEAs (*N* = 4,207) *n* (%)	360-char. WEAs (*N* = 1,873) *n* (%)	Total WEAs (*N* = 6,080) *n* (%)
Message Completeness[a]	431.53 (1)***	122 (2.9%)	1,329 (21.1%)	518 (8.5%)
URL	83.42 (1)***	625 (21.5%)	625 (33.4%)	1,453 (24.1%)

[a]Defined as including hazard name, location, source, time, and guidance information.

***$p < .001$

URLs/Hyperlinks

Overall, 24.1% (n = 1,463) of WEAs included a URL or hyperlink. There was a significant difference between 90- and 360-character messages (χ^2 (1) = 83.42, $p < .001$, phi = .132), whereby 360-character messages were more likely to include a URL. Specifically, 33.4% of 360-character messages (n = 626) and 21.5% of 90-character WEAs (n = 625) included a URL or hyperlink. The primary types of URLs are summarized in Table 8.

Table 8

Types of URL/Hyperlinks

URL/Hyperlink Type	WEAs (*N* = 6,080)	%
.gov	459	7.02
.org	395	6.04
.com	348	5.32
bit.ly	132	2.02
.net	64	0.98
.co	27	0.41
.us	25	0.35

.health	23	0.14
.cc	7	0.11

Discussion

In this study, we conduct a longitudinal assessment of the first decade of WEA messages sent by AAs across the United States. We evaluate these messages based on the presence of WRM message contents and the differences between 90- and 360-character messages. By uncovering the types and frequency of these contents, we now have a better understanding of how WEA has been used and where gaps exist. We begin with an overview of the most frequent types of WRM contents before discussing these differences, including message completeness, between 90- and 360-character messages.

WEA Message Content

The most frequent WRM content type included was location, with approximately 84% of messages including some type of location information. When a location was mentioned, it was most commonly in reference to a large area, such as the name of a town/city/county, found in approximately 62% of all messages. Although less frequent, more specific types of location information were included, including road/highway/streets (approximately 33%) and local landmark(s) (approximately 29%). These more specific types of location information allow people to determine where they are in relation to the hazard, which is especially important for those who are unfamiliar with the area (Sutton & Woods, 2016). Conversely, when location information is non-specific or absent, people may feel anxious and seek more information to reduce their anxiety, resulting in protective action delay (Sutton & Woods, 2016).

Second, 73.5% of WEAs included the hazard name. When the hazard was named, the most common hazard referenced was wildfire (or approximately 32% of the messages; see Kuligowski et al., 2023, for a complete assessment of these messages). Many WEAs were also sent for hazards that could be classified as public safety in nature, rather than imminent threats. For example, events like 911 outages or boil water advisories were found in approximately 18% of all messages. Although these public safety hazards do not represent an imminent threat (i.e., the danger is not immediate or life threatening), awareness and/or action may still be necessary (FEMA IPAWS, 2021). Finally, law enforcement incidents were the third most common type of hazard, found in approximately 16% of the messages. However, many law enforcement messages function as "idle alerts"—or "messages that ask recipients to increase their alertness or to observe their surroundings" (Bean & Hasinoff, 2022, p. 360). For example, a message found in our dataset states "New Berlin PD advising to Be On the Lookout for missing subject near Menard Dr/Marquette." This message informs recipients about a threat they should be aware of without instructing them to take protective action—in fact, if there is enough of a threat to the public to warrant taking protective action is unclear. Recent questions have emerged about the appropriateness and function of using WEA for idle alerts (Bean & Hasinoff, 2022), particularly if they are sent when receivers are not at risk of being harmed. Although FEMA IPAWS does not place any restrictions on what an AA can use WEA for, sending WEAs for a broad set of events suggests that it has become a channel to broadcast all sorts of notifications, rather than a channel to communicate imminent, high impact hazards. The danger of this evolution is the possibility that message receivers will tune out or turn off WEA messaging capabilities, affecting their ability to be notified of future threats.

Additionally, only 21.9% of all messages included a description of hazard, which details specific characteristics of the hazard itself (e.g., windspeed, amount of rainfall). We coded this as an additional type of information about the hazard, but it was not considered as a component of a complete message. Additional information about the hazard can also include hazard impacts—or the consequences of a hazard on the individual (e.g., life threatening) and/or their environment (e.g., homes will be destroyed; see Mileti, 2018). Impact statements also help illustrate why certain protective action(s) are necessary. Describing the hazard and its impacts can help message receivers perceive the severity of the situation and personalize their risk (Morss et al., 2018), which helps predict protective action intentions (Potter et al., 2018).

Third, approximately 72% of all messages included some type of guidance. Thus, most messages told the message recipient what to do to protect themselves from the hazard to mitigate its impact(s) (Seeger et al., 2018; Wood et al., 2012), which may include looking for more information (Sutton, Woods, & Vos, 2018). When guidance is included and focuses on protective actions, one's self-efficacy increases (Sutton et al., 2021). Self-efficacy is the degree to which one feels confident in their ability to perform a behavior and is a powerful predictor of risk reduction behaviors (Milne et al., 2000; Witte & Allen, 2000). However, when guidance information is absent or ambiguous, people are left to fill in the gaps on what they think they should do, as "it cannot be assumed that the public will know what would constitute an appropriate protective action" (Mileti & Peek, 2000, p. 186); therefore, they may perform actions contrary to what is recommended.

Fourth, timing information was only included in approximately 39% of WEAs. Time until hazard impact was the most frequent expression of time, used in 21.4% of all messages. Message expiration, found in 16.4% of messages, was the second most frequent expression of time; however, message expiration information can be confusing to message recipients without an indication of when the message was sent (Bean et al., 2014). Additionally, message expiration may not be realistic to include in WEAs for hazards with uncertain end times. When timing about the expiration of an event is unknown, time may be expressed as a statement of uncertainty, such as “until further notice.” Finally, although the time at which someone must act was less frequent compared to the other types of timing information, time to complete protective actions(s) is considered a part of adequate guidance (Bean et al., 2014). However, these statements tended to be less specific by using words like “now” or “immediately.” This type of timing information can convey the urgency of the situation and the time in which the action should be initiated (Bean et al., 2015; Sutton & Kuligowski, 2019), but lacks an overall degree of specificity.

Finally, source was the least frequent type of WRM content included, found in only 34.5% of messages. Messages without a source can lead to protective action delay by increasing the likelihood of confirming where the message is coming from (Bean et al., 2016). Furthermore, we find that approximately 50% of source information was abbreviated or used acronyms. As Sutton and Kuligowski (2019) note, acronyms and abbreviations should be avoided; however, this is challenging when message writers must restrict their messages to 90 characters. Next, we discuss the differences between 90- and 360-character messages and the implications for warning message design overall.

Message Completeness and 90- and 360-Character Messages

Our results demonstrate that only 8.5% of WEAs sent in the past decade can be considered complete—or have all five components of the WRM. By providing the necessary types of information one needs to act, complete warnings can reduce information insufficiency

(Gutteling et al., 2018)—or what someone feels they need to know before addressing a risk (Seeger et al., 2018). By reducing information insufficiency and meeting the informational needs of message recipients, complete messages can decrease information seeking and protective action delay (Doermann et al., 2021).

Yet, the brevity and limitations of 90-character WEAs all but ensure that these messages will be incomplete, which can negatively impact message recipients' ability to understand, personalize, and protect themselves (Bean et al., 2014; Wood et al., 2018). Indeed, we find that fewer than 3% of the 90-character WEAs were complete. Thus, we argue that 90-character WEAs are *alerts*—or messages intended to gain one's attention, whereas 360-character WEAs are *warnings*—or messages that provide guidance and motivate protective action decision making (Sutton & Wood, 2022). Specifically, 90-character WEAs act as a "bell ringer" (Bean, 2019) that calls attention to the fact that something has happened or is happening. In contrast, by expanding the amount of information that can be included, 360-character WEAs are warnings that include instructional content and help individuals to take appropriate protective action (Kuligowski & Dootson, 2018).

Overall, the distinction between 90-character alerts and 360-character warnings is important when considering the role WEAs can play in motivating people to act quickly during imminent threats. Because information seeking increases in times of uncertainty (Aguirre & Tierney, 2001), providing content that clearly informs and guides individuals about the hazard and protective actions can lead individuals to quickly understand, believe, personalize, and decide to act while reducing the time spent milling (Mileti & Sorensen, 1990; Wood et al., 2018).

Furthermore, WEAs for *all* hazards should be complete warnings. This means that public safety (i.e., non-imminent) WEA messages should also include all five types of WRM content.

For example, location in a COVID message might be where vaccination clinics exist or cities where "stay at home" orders are in effect. Timing for 911 outages may include when 911 services went down and/or when they are expected to return. Although how content is described will vary, it is important that each type of information *is* included in some capacity. Indeed, upon receipt of any warning message, people ask themselves similar questions: (a) is this a threat to me, and (b) do I need to take protective action (Lindell & Perry, 2012; Sutton & Kuligowski, 2019). Complete messages answer these questions and aid decision making.

We recognize that AAs are required to alert using 90-character WEAs per FEMA policy, as not all mobile devices in the United States can receive 360-character messages (FEMA, 2023). Still, these devices constitute a small minority of all mobile devices in the United States (Cellular Telecommunications and Internet Association, 2023). Despite the need to continue to create 90-character WEAs, AAs should also take advantage of the opportunity to reduce protective action delay by utilizing the full 360-characters of a WEA to *warn* populations at risk.

Summary

Although most WEAs sent from 2012-2022 included hazard, guidance, and location information, they are also incomplete (i.e., did not include all five types of WRM contents). Most often, time and source information were absent, which can negatively impact message believability and increase the likelihood of additional information seeking. Thus, we find that the last decade of WEA messages have acted as *alerts* meant to gain attention, rather than complete *warnings* that can lead to protective action decision making.

Limitations and Future Research

This study focuses on determining the frequency of WRM contents in WEAs sent from 2012 to 2022, as well as the difference between 90- and 360-character messages. However, this study has several limitations that can be addressed through future research.

First, this study does not provide evidence that the WEA messages we examined were received, understood, believed, personalized, or acted upon, which are the key outcomes measured in the WRM. Although we establish if an individual message is complete based upon the factors identified in the WRM, we do not know that a message prompted protective action decision making. Furthermore, it is unlikely that a single WEA will be the only alert or warning issued during an imminent threat. In a vast multi-media ecology, people may receive multiple messages from multiple sources as they make protective action decisions. Future research may consider testing the messages we examined with the public via survey and/or experimental methods, coupled with social or environmental cues (Lindell & Perry, 2012).

Second, we excluded certain types of WEA messages. For example, we do not analyze messages about missing persons or AMBER alerts because they do not require any protective action response upon message receipt. However, these are a common type of message sent through FEMA IPAWS, with approximately 1,457 AMBER alerts sent between 2012 and 2021 (National Center for Missing and Exploited Children, 2022). Future research should determine how these types of messages are typically written and if models like the WRM can help categorize their contents. But perhaps most importantly, researchers can investigate the practical implications of using a single channel to notify people of such a broad range of hazards and events, ranging from actionable to idle, and ask questions such as:

- Does the unmoderated use of WEA affect public perceptions of over-alerting or message fatigue?

- Does the broad range of hazards that can be included lead to disengagement with the channel?
- In the future, how will this affect alerting capabilities?

We also did not analyze messages from the National Weather Service, who sends the greatest number of WEA messages in the United States with over 60,000 WEAs sent from 2012 (National Weather Service, n.d.b). This means that when the public receives a WEA message on their mobile device, it most likely comes from the NWS for one of nine meteorological hazards (National Weather Service, n.d.a). NWS messages were excluded because the agency automatically sends WEAs using a standardized template; thus, there is little to no variation in these messages. Researchers who wish to categorize these messages using the WRM could do so easily, as well as assess their effect on behavioral response.

Finally, we did not analyze non-English messages. The importance of sending WEAs in languages other than English continues to be recognized (see Communications Security, Reliability, and Interoperability Council VIII, 2023); thus, the contents of these messages must be examined using similar methods and techniques. Furthermore, how non-English speaking populations perceive and use the channel itself should also be examined (Trujillo-Falcón et al., 2023).

We recognize that designing a complete message that motivates behavioral response requires training and education for AAs. The nature of emergency management organizations suggests that personnel changes and resource limitations make it challenging to keep people up to date on warning message writing exercises. Although AAs are encouraged and/or instructed to develop messaging templates during periods of preparedness (FEMA IPAWS, 2022b), they often have limited access to resources to complete this task. Therefore, AAs need access to a

"Lexicon" of warning message contents that is complete, accurate, and designed with the end-user in mind (see Sutton et al., 2023). Future research can evaluate how AAs make use of those contents for message design and test their effectiveness with message receivers.

Conclusion

This study demonstrates how WEAs have historically been written and identifies where messaging gaps exist. To accomplish this, we used quantitative content analysis methods to code 6,080 WEAs sent from 2012 to 2022 and determined how frequently they contain hazard, location, guidance, source, and timing information, as well as differences between 90- and 360-character messages.

Ultimately, we identify significant shortcomings in WEA messages sent in the past decade. First, it was uncommon for WEAs to include timing information and the name of the message source. Furthermore, only 8.5% of all WEAs were complete—or contained all five components of effective warning content. Fewer than 3% of all 90-character WEAs were complete; thus, 90-character WEAs have historically been used to alert people to an impending or on-going threat. In contrast, 360-character WEAs can act as warnings capable of providing useful instructional content. Those responsible for writing WEA messages should take full advantage of the 360-character limit and include all warning message design elements.

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