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Obstacles to timely emergency messaging for acute incidents

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ABSTRACT

Emergency alerts, warnings, and notifications (AWN) help protect the public by communicating information about impending hazards to encourage protective actions. Three key subsystems compose AWN systems: (1) detection; (2) management; and (3) response. While much research regarding the detection and response subsystems exists, few studies focus on the management subsystem. This subsystem involves emergency managers (EM) receiving and analyzing information about a hazard, deciding whether the hazard poses enough risk to warrant an emergency message, and where appropriate, transmitting that message across available AWN systems. To help improve understanding of this decision-making process, the researcher conducted interviews with EMs responsible for AWN decision-making and issuance, and leveraged participant responses to inform this work. This study details the threat interpretation, organization, technology, and infrastructure limitations that can directly delay or prevent AWN issuance. This work also outlines the adverse impacts on the public, EMs, and emergency services that can follow an AWN, as EMs must weigh these consequences when deciding to issue an emergency message. By outlining these obstacles, this study aims to help inform EMs of the challenges they may face during the critical moments of an incident, so they may better prepare to issue timely emergency messages to protect their communities. The findings gleaned from this research can also help technologists and social scientists better understand the influences their fields have on the EM, so that they may improve upon existing AWN systems and risk communication strategies.

Key words: emergency, alert, warning, notification, timely, early, barriers, obstacles, challenges

INTRODUCTION

Emergencies often provide little warning and unfold rapidly. These natural, technological, and human-caused incidents can quickly threaten lives and property if not identified, and their threats promptly communicated. While researchers understand much about the process of hazard identification and the public's response to emergency messaging, few studies examine the processes officials undergo and obstacles they face when interpreting and validating threat information and issuing an emergency alert, warning, or notification (AWN) to the public. As this responsibility often falls on the emergency manager (EM), this study's findings derive primarily from interviews with 15 EMs, each responsible for emergency messaging. During these interviews, EMs offered their expertise and insights into the obstacles they face during this critically important process. Their testimonies identify threat interpretation, organization, infrastructure, and technology-related factors that can hamper AWN issuance; Table 1 outlines these factors.

The adverse impacts AWNs can have on the public, EMs, and emergency services directly influence EMs' AWN decision-making processes. Therefore, the researcher also solicited EMs' insights into these impacts; Table 2 outlines these impacts.

While these obstacles remain formidable challenges for EMs, many can be mitigated. Still, no matter how much EMs prepare, those responsible for public messaging will face similar challenges over the course of their careers. EMs should work to understand these factors and impacts so they may better prepare to issue timely emergency messages in the future.

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Table 1. Factors that delay or prevent AWN issuance as described by interviewees

Threat interpretation	Technology
- Threat validation - Fluid incident boundaries - Variable risk tolerances - High likelihood of containment - Not informed of hazard	- User-application interface challenges - Inability to geotarget - Crafting messages within character limits - Software malfunction - Access controls preventing log in - Crafting multilingual messages
Organization	**Infrastructure**
- Insufficient training - EM unavailability - Lack of decision-making discretion - Undefined chain of command - Chain of command approvals - Infrequent system use - Nighttime/weekend challenges - No prescripted message templates - Task saturation - Multiperson review message process - Editing prescripted message templates - Organization not having alerting authority - Undefined thresholds - Conflicting orders - Insufficient technical competency - Waking up	- Network outage - Power outage - No capability to issue AWN remotely - Infrastructure damage - Network crash from increased public traffic - Network crash from issuance - Smartphone screen size limitations - Inadequate network coverage to disseminate - Inadequate network coverage to issue

Table 2. Adverse impacts to the public, EMs, and emergency services, that can follow an AWN issuance as described by interviewees

Public	EMs and Emergency Services
- People outside area at risk receiving AWN - Alert fatigue - Public disabling future AWNs - Uncontrolled rumor spreading - Shadow evacuation - Gunfire risk to spontaneous volunteers - People directed towards hazard - Recipients misunderstanding AWN - Increased violence	- Career or reputation implications - Public frustration - Increased calls to emergency communications centers (ECC) - AWN interference with law enforcement - Legal implications for no multilingual AWN - Spontaneous volunteers - Loss of public trust - Psychological harm from public criticism - Death threats

AWN SYSTEMS

Emergency AWN systems protect lives and property by identifying information about impending threats, communicating that information to those who need it, and encouraging the timely taking of protective actions.[1] AWNs constitute one of four primary functions of the Emergency Communications Ecosystem,[*] the others being (1) incident coordination and response; (2) reporting and requests for assistance; and (3) public interaction.[2] According to Mileti

[*]The concept of the Emergency Communications Ecosystem refers to entities with different communications functions, including decision makers, responders, supporting organizations, and citizens, relying on one another to exchange information prior to, during, and after incidents.

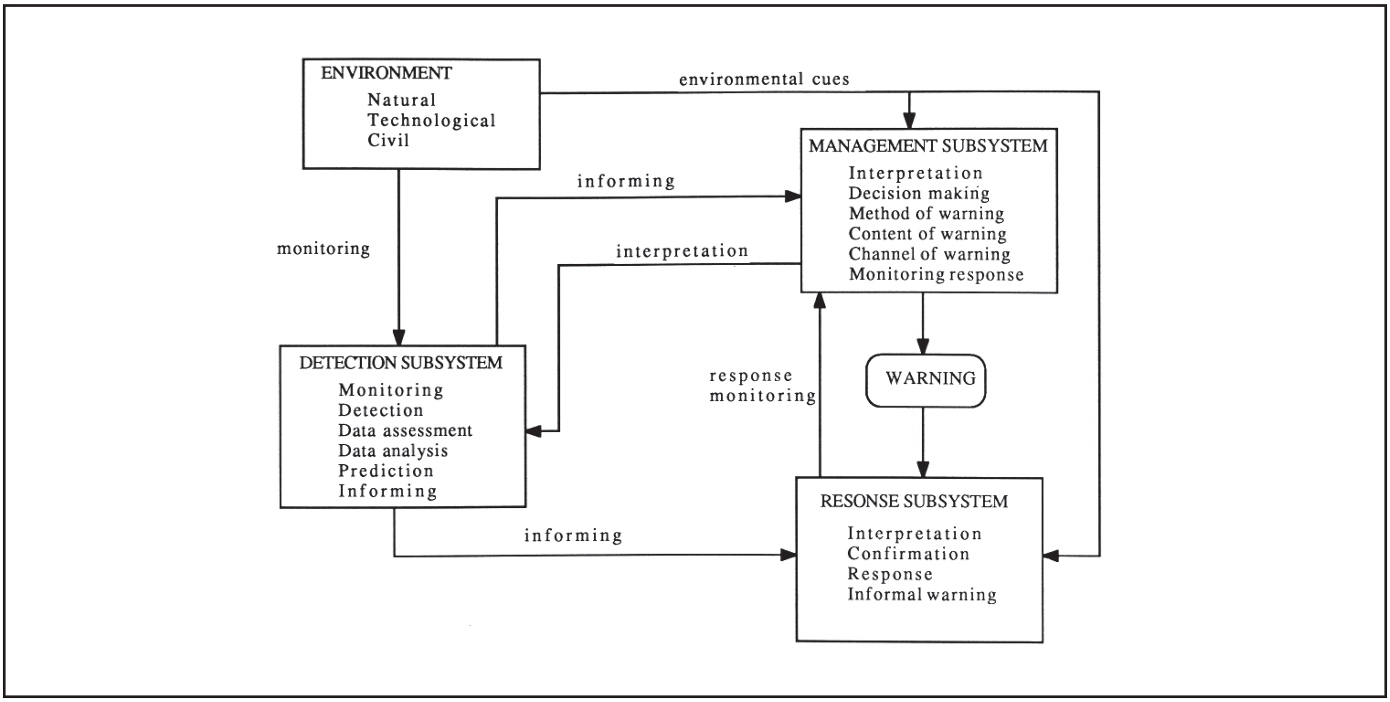

Figure 1. General components of an integrated warning system.[1p2-4†]

and Sorensen,[1] three essential components (hereafter referred to as "subsystems"), constitute an AWN system (see Figure 1). These three subsystems are as follows:

1. *Detection Subsystem*: The detection subsystem monitors natural, technological, and civil environments that can induce an emergency. This subsystem subsequently collects, collates, assesses, and analyzes information about these environments, and then predicts the possible occurrence of an emergency. Officials then communicate this prediction to the management subsystem. This communication typically originates from: (1) scientists who inform emergency management officials about impending natural and technological emergencies; and (2) military, law enforcement, or intelligence organizations that inform civilian EMs of civil emergencies. The entity detecting a hazard may also issue an AWN automatically and bypass the management subsystem, eg, the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) automatically issuing critical weather AWNs through the Federal Emergency Management Agency's (FEMA) Integrated Public Alert and Warning System (IPAWS).

2. *Management Subsystem*: The management subsystem, widely comprised of local EMs, receives information from the detection subsystem. The EMs use specified or ad hoc criteria to interpret this data to determine potential losses, eg, loss of life and property, and then decide if the associated risk warrants a public AWN issuance. EMs issue official public AWNs following an affirmative decision. EMs then monitor

†Figure 1 shows a model proposed by Mileti and Sorensen[1]—two researchers who have laid the foundation for the disaster research community's understanding of AWN systems—that recognizes the multiple warning subsystems, as well as the formal and informal linkages between them.

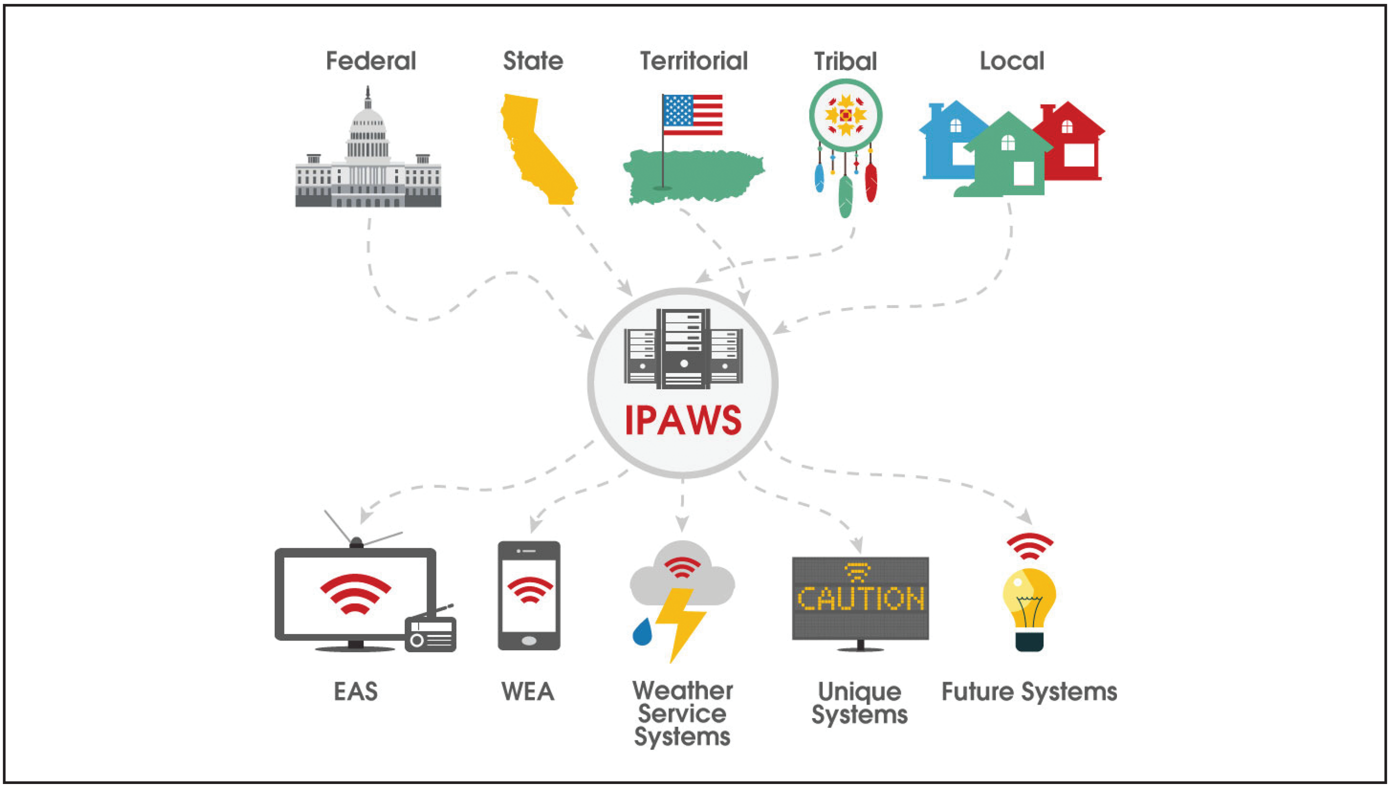

Figure 2. Alerting authorities and IPAWS[41] (also see FEMA's *IPAWS Architecture*).

responses to determine if refinement or change to subsequent AWNs is necessary to further minimize the public's exposure to risk.

3. *Response Subsystem*: The response subsystem encompasses the public's interpretation and response to AWNs they receive from the management subsystem—confirming messages and altering their actions based on their perception of events and social realities. The public also generates unofficial AWNs and passes this information to others, eg, neighbors, family members, and friends communicating with one another about a threat and the potential risk it poses.

Federal, state, local, tribal, and territorial EMs access FEMA's IPAWS to disseminate AWNs to their communities. The IPAWS platform is a conglomeration of AWN systems, including the Emergency Alert System (EAS), Wireless Emergency Alert (WEA) system, and NOAA NWS system (see Figure 2). These systems transmit messages across cellular, television, radio, and other devices. In extreme cases, the President of the United States may use IPAWS to issue an AWN to the entire nation.[3]

Along with IPAWS, organizations use proprietary systems like reverse 911 (cellular and landline) and siren systems to issue AWNs. Additionally, organizations leverage social media, television, websites, and route notifications, eg, knocking on doors, to inform the public. Incident severity generally dictates which combination of these systems EMs use to alert the public.[4] Nongovernment organizations like schools and privately owned companies also issue AWNs to their respective communities through proprietary systems.[5]

EXISTING RESEARCH

Two of the most notable works that describe the AWN-related challenges EMs face are Sorensen

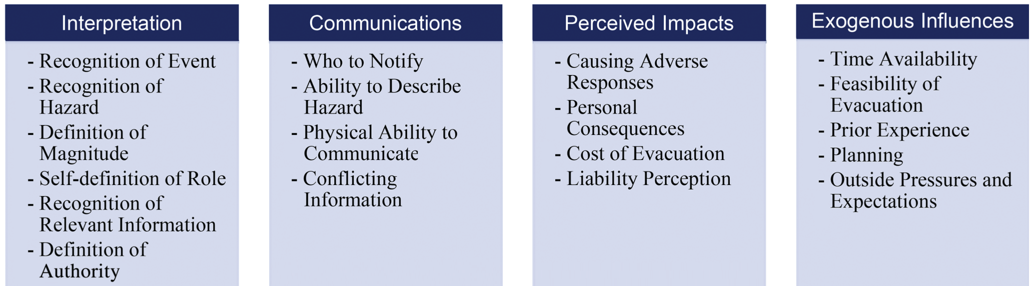

Figure 3. Uncertainty types in organizational decision-making in warning systems.[6]

and Mileti's article *Decision-Making Uncertainties in Emergency Warning System Organizations* (1987)[6] and their later publication, *Communication of Emergency Public Warnings: A Social Science Perspective and State-of-the-Art Assessment* (1990),[1] which draws upon data from their original study.

Sorensen and Mileti's original study examines 39 historical AWN-related case studies to identify the primary decision-making uncertainties organizations face that either impede or hasten AWN issuance. Their research surveys both slow-onset and acute emergencies across all three AWN subsystems. Within these case studies, the researchers identified approximately 200 uncertainties confronting organizations responsible for AWNs. They then organized these uncertainties into four categories, along with the particular types of uncertainties that comprise each (see Figure 3).

Academic databases[‡] contain few other publications that focus on the management subsystem or identify the challenges EMs face as they decide to and ultimately issue AWNs. Some articles describe AWN decision-making and issuance challenges for particular types of messages like those necessitating a mandatory evacuation.[7] Other works explore public messaging challenges for specific types of incidents like tornados[8,9] and hazardous chemical releases.[10] Additionally, a recent 2020 report by the Government Accountability Office (GAO) outlines seven AWN-related case studies, which detail some of the challenges EMs face when issuing emergency messages across IPAWS. These various studies either utilized focus groups, surveys or after-action reports (AAR) to obtain their data;[§] only Rogers[10] and GAO[11] conducted interviews with EMs.

Other studies examine the detection subsystem for specific hazards.[12-14] Several works also survey aspects of the response subsystem, including the public's perception of risk information,[15] response to AWNs,[16] and social media's roll in emergency communications.[17-19] Emergency management-specific risk and crisis communications resources[20-22] are also widely available.

Numerous publications detail best practice guidance for creating effective AWN structures and provide recommendations on how to mitigate a range of AWN-related challenges.[1,4,5,23] Other works describe the current body of knowledge in a more holistic manner.[24,25]

While these works provide valuable insight into the various AWN subsystems, few focus specifically on the challenges individual EMs face when deciding for and issuing AWNs during acute-emergency incidents, or how modern technological advancements now shape their choices. Mileti and Sorensen highlight these knowledge gaps in their later 1990 study, explaining that "the decision to warn the public is one

[‡]Searches within Google Scholar, Academic Search Premier, ProQuest, and Homeland Security Affairs databases identified the existing research related to this study. Searches utilized combinations of search terms including emergency, disaster, alert, warning, timely, early, barriers, obstacles, challenges, difficulties, issues, uncertainties, and issuance.

[§]Focus groups generally occur in an open forum which can impede dialogue regarding potentially controversial decisions. Surveys can also obstruct open dialogue by constraining responses to a particular set of answers. Finally, AARs often detail organization-level challenges or the consequences of specific choices and make recommendations accordingly. Rarely, do these reports examine the hurdles individual decision-makers encounter.

of the least understood aspects of warning systems."[1p2-8] Additionally, in reference to Sorensen and Mileti's 1987 study,[6] Lu states that "[i]n the twenty years after Mileti and Sorensen's landmark work in disaster research, this topic has not been explored further by disaster and crisis research communities."[26p30]

PURPOSE

In recent years, untimely and insufficient AWNs have highlighted major gaps in the nation's emergency messaging systems. For example, the Tubbs Fire, which occurred in October 2017 in California's Sonoma and Napa Counties, destroyed 5,643 structures and killed 22 people.[27] The November 2018 Camp Fire in Butte County was even more devastating, burning approximately 18,804 structures and leaving 84 people dead.[28] Reporters have tied the devastation of these incidents, in part, to insufficient AWNs; although officials issued AWNs across proprietary subscriber-based systems,[||] they did not issue a WEA.[29,30] Additionally, on January 13, 2018, Hawaii's EM officials mistakenly issued a false AWN to the islands that informed residents of an incoming ballistic missile. Unfortunately, a variety of organizational and technological factors significantly delayed the revocation of this false message, which left island residents in fear for their lives for 38 minutes following the initial message transmission.[31]

These incidents exposed a critical need to identify the obstacles EMs face that can either delay or prevent AWN issuances for acute-emergency incidents.[¶] This research draws upon interviews with EMs responsible for AWN decision making and issuance to explore the challenges they face, from the time they become aware of a potential threat, to the moment they issue an AWN across available communications networks or decide otherwise. In effect, this study highlights the uncertainties and challenges EMs encounter when deciding to issue AWNs. This work also explores the adverse impacts that can follow an AWN issuance, as these factors contribute to an EM's decision and ability to issue an AWN.

By presenting this information, this work aims to increase understanding of these obstacles among EMs to help them target mitigation strategies and better prepare to issue timely emergency messages. Additionally, technologists, eg, those specializing in human-machine interaction, computer networking, and wireless communications, and social scientists have had few opportunities to interact with the emergency management community to consider current gaps in AWN systems.[24] Therefore, this research also aims to provide a reference for these specialists to enhance their understanding of the influences their fields of study have on EMs.

METHODOLOGY

As EMs typically take the lead in providing AWNs to the public,[1] open dialogue with these professionals is necessary to understand the challenges officials face during the decision-making and message issuance process. The researcher identified 15 EMs within the United States to interview through a convenience sampling approach. The researcher solicited these professionals' participation primarily through personal relationships, but also through posted requests for participation on four separate online emergency management forums. These written requests for participation provided a brief overview of the research objectives and asked those interested in contributing to contact the researcher directly for more information. The researcher then provided participants with information about the research project, methods, and their rights as interviewees. Study participants also provided written confirmation of their informed consent. The interviewees were asked to consider their answer to the following question prior to the discussions: "What are the primary challenges EMs encounter that can either delay or prevent the issuance of [AWNs] for acute, emergency incidents?"

The researcher limited participation in the study to EMs either actively responsible for AWN decision-making and issuance or those having held

[||] Subscriber-based systems are generally less effective at reaching members of a population compared to WEAs, which can reach anyone with a compatible cellular device. For example, GAO[11] found that opt-in rates on these systems only account for between 9 and 17 percent of populations in four different jurisdictions.

[¶] While EMs issue AWNs for slow-onset incidents, eg, hurricanes, disease epidemics, and heat waves, this research only examines obstacles to AWN issuances for short to no-notice, acute incidents, eg, active shooters, wildfires, earthquakes, and tsunamis.

these responsibilities within the last ten years.** Interviewees had around 100 years combined experience issuing thousands of AWNs at various levels of government, ie, municipal [8], county [6], state [2], and federal [2], and across various sectors, ie, higher education [2], nonprofit [1], meteorology [1], and healthcare industries [1].††

The researcher conducted interviews prompted by the questions outlined in Appendix A, which derive from the root causes of the uncertainties shown in Figure 3 (as they apply to the management subsystem). All interviews took place via phone between February 13, 2019 and March 17, 2019. The researcher typed notes to document key findings from each conversation and subsequently hand-coded these notes to generate the data visualizations in later sections. Interviews were not recorded to allow for open dialog. Interview questions focused on process rather than personal experience. Additionally, interview results were recorded in a manner that does not reveal the identity of the interviewees or their associated organizations and jurisdictions. To limit bias, the researcher did not prompt any of the interviewees for specific answers, outside of asking them the questions outlined in Appendix A and obtaining clarification when necessary. In one instance, three EMs participated in an interview together; data reflect this variation by quantifying respondents' answers by interview, not interviewee. This paper also underwent a thorough peer review process following research composition. Ten professionals—three technical editors, three emergency managers with AWN expertise, three emergency management scholars, and one emergency communications technologist—reviewed and revised this article in full.

The "Threat Interpretation" through "Infrastructure" sections describe the uncertainties and challenges EMs face within the management subsystem, ie, those tied to threat interpretation, organization, technology, and infrastructure, which can either delay AWN issuance or result in nonissuance. The subsequent "Adverse Public Impacts" and "Adverse EM and Emergency Services Impacts" sections describe the potential adverse impacts on the public, EMs, and emergency services that can follow an AWN, as EMs must weigh these consequences when deciding to issue an emergency message. These findings draw from the decision-making uncertainties listed in Figure 3, along with additional findings from other academic studies, AARs, and news reports related to AWN issuance obstacles. This content combines with information gleaned from interviewees to provide the reader with a holistic view of the factors that influence EM decision-making for acute emergency incidents; uncited statements originate from anecdotal evidence deriving from interviewee comments. Still, the data below group differently than the data in Figure 3 to account for this study's specific focus on acute incidents and the management subsystem, as well as modern technological advancements.

Additionally, while certain factors may also hasten AWN issuance, this study does not outline these influences. Instead, the following sections focus only on the many obstacles that can delay AWN issuances. This work also draws few conclusions outside of newly identified recommendations.

THREAT INTERPRETATION

The risk an incident poses is not always known as EMs must sometimes make decisions based on little to no information. Alternatively, EMs may become oversaturated with information, which similarly inhibits decision-making. Therefore, "[t]he question of whether to warn or not is best cast not as whether the public needs to be told about risk or not, but instead as at what point should [EMs] recommend through public warnings that people act as if impact will occur and… engage in protective actions." The answer to this question is rarely straightforward.[1p3-6] This lack of clarity results from a complex set of factors including: (1) false, unverifiable, irrelevant, conflicting, incomplete, or secondhand reports; (2) fluid incident boundaries; (3) unclear hazard severity; and (4) overly technical or missing incident data that does not provide enough actionable information.

**The researcher limited interview participation to ensure the study's relevancy with two modern technological advancements; the public's use of social media and the adoption of smartphones. One of the earliest known uses of Twitter during an emergency was in 2007,[32] while social media use has risen from 5 percent of American adults in 2005 to 69 percent in 2018.[33] Apple's first release of the iPhone occurred in 2007[34] and while 33 percent of American adults owned smartphones in 2011, this percentage rose to 77 percent in 2018.[35]

††Some interviewees had held AWN responsibilities at multiple levels of government or within various sectors.

When making an issuance determination, EMs must balance these factors and their personal experience/understanding of the incident with the potential consequences of not issuing an AWN. Figure 4 shows how often interviewees cited these factors as delaying or preventing AWN issuances. In all interviews, EMs mentioned the time needed to validate a threat as a contributing factor.

More and more machine- and human-generated data from a growing number of Internet of Things devices and sensors increasingly bombard EMs. Oversaturation of information can generate internal "alert fatigue,"[36] which may cause a critical situation to go unrecognized. For example, if an EM receives numerous low-severity messages across their smartphone, smart watch, computer, and other devices, they may be unable to process all of this content. As such, an EM might overlook a hazard that poses a significant threat and therefore be unable to warn the public. Conversely, AWNs can be obstructed if an EM is not notified of a hazard.

Even once EMs become aware that a particular situation may pose a threat, they may then need to quickly sort through sizable amounts of irrelevant or conflicting information, or otherwise search for more information to understand the threat's actual validity and confirm the need to issue an AWN.[1,6] That is, EMs undergo a process of milling (in two interviews, EMs cited their own milling process as a specific cause for AWN delays) familiar to the public's response to information about a hazard.[16] In these instances, EMs work to make sense of a reported incident's circumstances in an effort to define its associated risks and potential results. For example, to verify a hazardous materials incident report from a 911 caller, a local fire department may first need to respond to the scene of an emergency, identify the agent, and confirm a threat to the surrounding community.

An EM may also face difficulty interpreting hazard information, eg, weather and geological, without prior technical training, or when information does not provide enough actionable situational awareness to make an issuance determination. These challenges can lead to: (1) misinterpretations of data; (2) uncertainties about the location of a hazard's impact; (3) miscalculations regarding the amount of time until a hazard's impact; and (4) uncertainty about the information to include in a message—all factors that can influence the consequent timing and issuance of AWNs.[1]

Differing perspectives can also influence an EM's ability to recognize the indicators of a hazard and the potential threats an incident may pose.[6] That is, an EM may have experience with a particular hazard, which can result in a belief that the incident will materialize in a fashion similar to their previous observations. This view can bias an EM's understanding of a threat's true validity and result in their delayed response to a threat.[1,6] For example, incident commanders (IC) on the scene of an incident

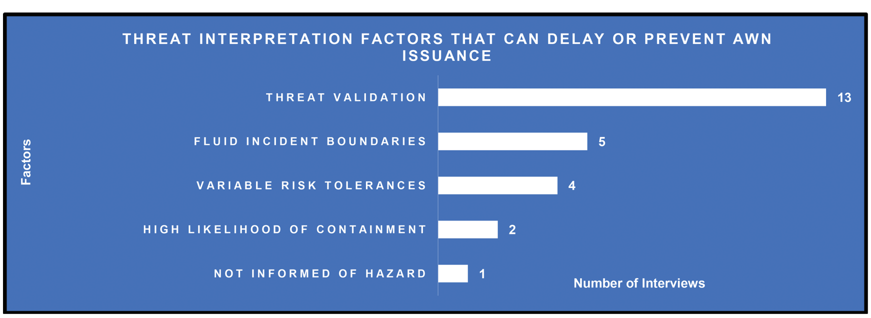

Figure 4. The frequency that interviewees cited the factors above as either delaying or preventing AWN issuance (actual or theoretical). The 13 interviews each received a maximum value of one (per factor), even if interviewees mentioned the factor multiple times. In the case where three interviewees participated in a single interview, this interview also received a value of either zero or one, despite the additional participants.

may delay an AWN issuance if they believe they can contain a situation.

Similarly, League et al.[8p169] found that EMs had different approaches when deciding to issue tornado warnings, as detailed in the following passage:

> "Only 60 percent of respondents indicated they always warn the public after the NWS first issues a tornado warning. During a focus group one EM was specifically asked to detail his warning decision after the NWS first issues a warning. He replied:
>
> 'No, I do not send out warnings automatically just because I'm included in the warning area. Some jurisdictions have that as a policy, we do not. I consider warning areas, but I also want to make sure there's an imminent threat because we found that if you put out too many warnings, people become complacent, and also if you put out a warning too early, then they don't react in the way that we want them to.'
>
> EMs were also asked if they will warn their jurisdiction if the NWS has not yet issued a tornado warning. Sixty-seven percent of survey respondents said they would warn their jurisdiction before the NWS issues an official warning. During a focus group session, an EM said he would because, 'If I can see something, if I've got eyes on something…we will always err on the side of caution.' Therefore, issuing warnings is not an automatic decision. Many EMs will exercise their own judgment in the warning process and will not just wait for an official warning issued from the NWS."

However, natural hazard incident detection and threat verification systems have advanced since their study, allowing for automated and near-automated issuance and dissemination of AWNs across IPAWS.[37-39] These innovations have sped emergency messaging by shifting responsibility to interpret some hazard-specific information and issue related AWNs off the EM. While these systems may detect hazards that pose a clear and present danger to particular regions, other incidents can be more fluid, and their areas of impact less defined. For example, in the case of a hazardous materials or wildfire incident, an EM may not know the exact boundaries of the hazard or how these boundaries will change over time. In such circumstances, EMs may face difficulty deciding which areas to warn or protective actions to recommend. For instance, an EM might advise a population to evacuate in a particular direction (away from the hazard), but winds could quickly change and push the hazard into evacuation paths or unwarned areas.

EM opinions vary on the amount of certainty required to issue an AWN—some EMs agree that AWNs should be issued even in uncertain circumstances, while others feel that hazard reports need some level of certainty and validation, eg, eyes on scene, multiple reports, or information from a trusted source, before issuing an AWN. These criteria become particularly essential when issuing wide-reaching AWNs that can affect large amounts of people, eg, a county-wide WEA. Still, some EMs feel that erring on the side of caution by issuing a forward-leaning AWN is necessary to protect the public and maintain their trust, especially if the AWN does not cause harm. In such cases, EMs will use wording like "reported" and state "more information will be provided as it becomes available" to ensure an AWN's appropriateness with their level of certainty.[1] These forward-leaning AWNs become particularly crucial in situations where damages may occur by the time a trusted source can verify an incident's status. For instance, Blair and Schweit[40] found that 69.8 percent of active shooter incidents end in 5 minutes or less, a statistic explaining their additional finding that 66.9 percent of incidents end before police can arrive on the scene of the emergency and engage the shooter. These situations generally end so rapidly because the shooter either flees, commits suicide, or someone at the scene incapacitates them. Such incidents—where a matter of minutes can mean the difference between life and death—highlight the importance of erring on the side of caution to ensure the public's safety when dealing with conflicting or uncertain information about a threat (a recommendation of CalOES[41]).

ORGANIZATION

Organizational processes can produce a range of challenges for EMs when issuing AWNs. Although plans, policies, and procedures can help speed emergency messaging through the identification of personnel roles and communication processes, AWN issuances are obstructed when these structures are inflexible, require too many steps, or are simply not in place at the time of an incident. Specifically, AWN issuance delays occur when decision-makers above those with day-to-day decision-making authority must first vet and approve a message. Officials may also face difficulty navigating AWN systems when they use these technologies irregularly. So even when organizations have ample staff available, only a select few may be comfortable using their AWN system. Delays can occur when these few individuals are off-site and must issue an emergency message remotely. Figure 5 shows the frequency that interviewees cited such factors as delaying or preventing AWN issuances. Interviewees most often pointed to insufficient training, unavailability of EMs, and officials lacking decision-making latitude as organizational factors that hamper AWN issuances.

When plans, policies, and procedures are not in place within an organization, personnel may be unaware of their roles within the communications chain or may not know the correct person to contact about a threat that necessitates an AWN.[6] Conversely, rigid plans that do not allow for flexibility can also obstruct AWN issuance.[6] For example, when EMs require expert advice to reach a decision, issuance slows. This delay most likely occurs because of the time needed to identify an expert and solicit their input.[10] AWN-related information

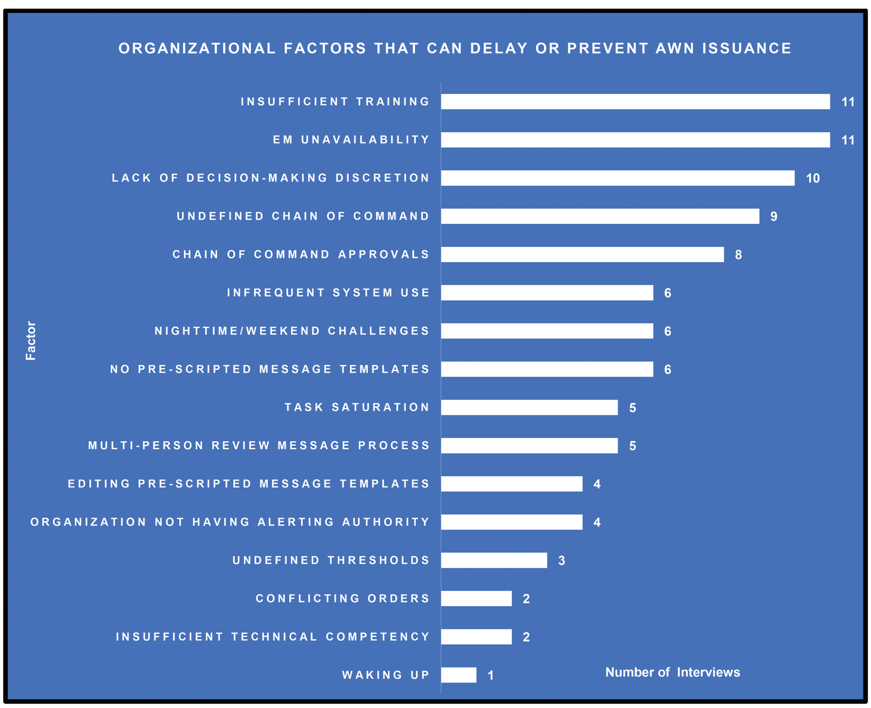

Figure 5. The frequency that interviewees cited the factors above as either delaying or preventing AWN issuance (actual or theoretical). The 13 interviews each received a maximum value of one (per factor), even if interviewees mentioned the factor multiple times. In the case where three interviewees participated in a single interview, this interview also received a value of either zero or one, despite the additional participants.

may also not reach its intended audience when personnel are unaware of their authority, eg, more than one person attempting to lead resulting in conflicting orders or nobody ultimately taking responsibility.[6]

Emergency messaging can also falter if an EM does not have authority to issue an AWN.[42] The decision to issue an AWN should occur by way of those who hold regular day-to-day emergency management decision-making authority.[1] Still, strategic level staff, those within the public relations branch of an organization, or elected officials may wish to review an AWN's content before an EM issues the message. However, these personnel may not have the same level of situational awareness as the day-to-day decision maker, which can limit their ability to gauge the severity of an incident correctly. In such cases—where more parties must review or approve an AWN—issuance can slow due to the time needed for information to pass between officials, for each to evaluate the information, and for all decision-makers to reach a consensus.[1,10,42] These issues can become more prevalent within larger bureaucratic organizations, where AWNs require more approvals. Additionally, hazards may cross jurisdictional boundaries. In these cases, EMs may need to coordinate with other jurisdictions to ensure message consistency (ideally, after an initial AWN issuance in the case of an imminent threat).

EMs may also spend time requesting a message be issued on their behalf if they are not an approved IPAWS alerting authority or may be unable to issue an AWN altogether. For example, GAO[11p9-10] found that two-thirds of the nation's 3,000 counties do not have access to IPAWS (see Figure 6):

> "Although access to IPAWS at the state level enables alerts to be sent, for example, to jurisdictions that may have lost their

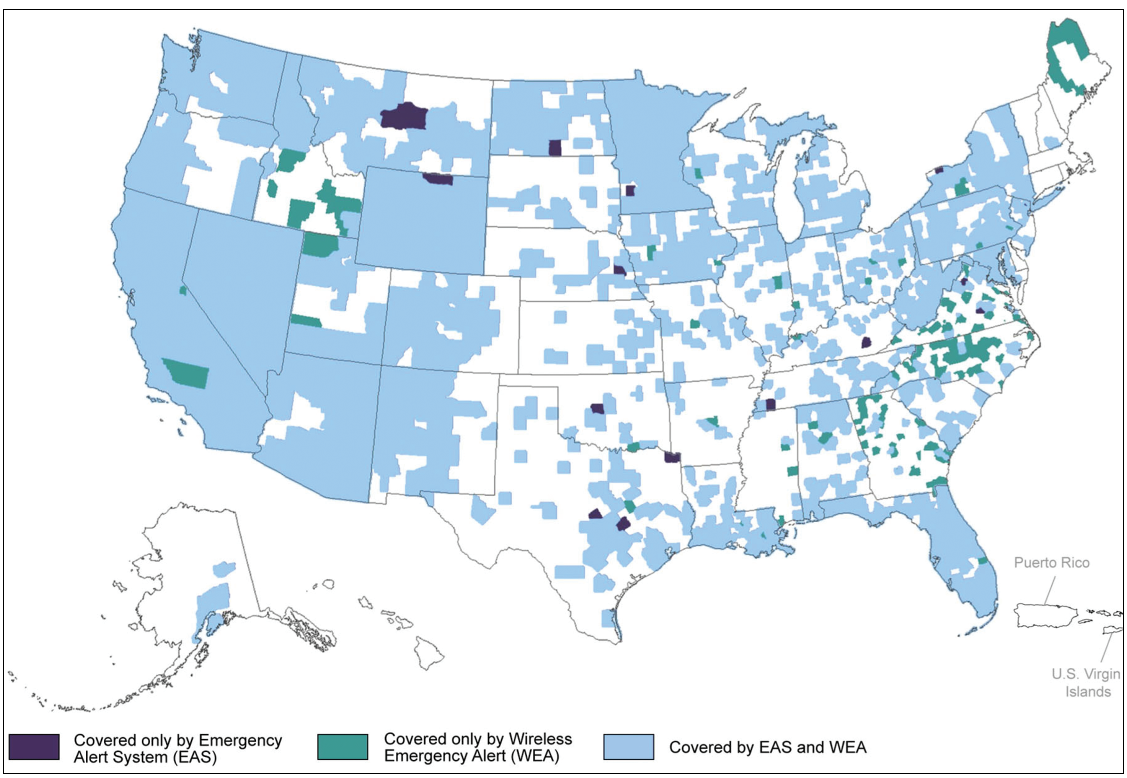

Figure 6. An analysis of FEMA data showing areas covered by local and tribal, ie, excluding federal, state, and territorial, alerting authorities that can send WEAs and use EAS, as of September 2019.[11]

> capability during an emergency, gaps in access to IPAWS for local officials could limit the timeliness of alerts as emergencies occur. For example, officials from an alerting authority told us that with the exception of alerts issued by NWS, all emergencies start locally. If a locality does not have access to issue an alert through IPAWS, information must be communicated from the locality to an authorized state official to issue the alert, which could result in delays in getting critical information to the public.
>
> Reasons for this gap at the local level could be related to a variety of factors. For example, some counties may still be in the process of applying for access. Other counties may not be able to gain access to IPAWS due to state or local laws, or a state's EAS communications plan may specify that only certain types of agencies can issue alerts. For example, state EAS communications plans may authorize the governor of the state, an emergency management office, state law enforcement agency, or a nongovernmental organization as the authorized agencies for sending alerts. In addition, an academic who specializes in rural emergency management told us that unfunded staff positions in emergency management are commonplace in rural areas and the areas may lack funding to apply for IPAWS access."

While FEMA has taken strides towards increasing local adoption of IPAWS, work remains, with 430 IPAWS applications pending as of September 2019. Factors contributing to this backlog include unsigned memorandums of agreement, pending state-level approvals, and limited staffing for application review.[11]

Smaller jurisdictions may also only staff a few employees authorized to issue AWNs. In some cases, others may function primarily through volunteer support, just staffing a part-time EM authorized to issue AWNs. In these circumstances, EMs may become over-tasked with other emergency management responsibilities, which can hamper their ability to issue an AWN. Still, to ensure accuracy, the Federal Communications Commission[25] recommends that more than one person validate a message's content before issuing wide-reaching AWNs, eg, a county-wide WEA, for high-impact incidents that affect a large number of people. Although EMs should not overlook the importance of this step, the extra time spent to achieve this redundancy can delay the issuance of an AWN message.

AWN issuances also falter when an organization does not have clear triggers/thresholds/threat levels defined, prescripted message templates developed,[23] step-by-step system navigation instructions outlined, and training programs in place. These structures help ensure AWNs remain a priority, as EMs can quickly become over-tasked with other responsibilities when coordinating incident response activities. Without these structures in place, EMs may spend additional time deliberating whether hazards warrant AWNs, crafting messages in their entirety, or navigating unfamiliar AWN systems. Message issuance may also falter if personnel have not undergone proper training,[11] or continue to serve in their roles without the necessary amount of technical competency following training and remediation efforts.

Some organizations may also limit access to AWN systems to decrease the potential for misuse and human error, especially in systems that can reach a significant portion of the population, eg, IPAWS. While these mitigation strategies may prevent false or inaccurate messaging, they can also delay the AWN process when trained and approved individuals are unavailable. Still, this same strategy of limiting user access to select officials who regularly operate the system can also help organizations issue AWNs, as proficiency in disaster-related tasks (like the use of AWN systems) decreases when duties are not routinely performed.[6] Consequently, challenges persist in larger organizations, where dispatchers are trained to issue AWNs but do not perform this task regularly. For example, when an incident necessitates an AWN issuance, but EMs are not on site, ie, during nights or weekends, dispatchers may contact EMs to request: (1) permission to issue a message; or (2) that the EMs issue the AWN themselves. This occurs even when dispatchers are trained and approved to issue AWNs, as these officials sometimes defer to EMs who have more experience weighing the need for an AWN, choosing appropriate dissemination pathways, and operating their organizations' AWN system. EMs may also have greater authority (official or unofficial) to make such decisions, as they often have responsibility for these tasks and perform them regularly during daytime hours. According to GAO,[11] IPAWS system use and proficiency challenges persist among approved state, local, and territorial alerting authorities, with less than 20 percent having issued a WEA message as of September 2020.

When EMs are not onsite, they may have fewer resources at their disposal for validating a threat. For example, EMs at their organizations' facility may have staff available to assist them with tasks like calling the IC on scene as well as obtaining access to video feeds from cameras positioned across their jurisdiction, ie, EMs on-site at their organizations' facility can more-quickly validate an AWNs necessity. Furthermore, if EMs are sleeping, their device may fail to wake them, and if and when they do awaken, the act of orienting themselves to the situation at hand takes time. These challenges are generally less prominent in jurisdictions with ECCs staffed around the clock with an EM authorized, trained, and comfortable with AWN processes.

These obstacles can be amplified during situations when an EM must issue an AWN to a large number of people. Such wide-reaching AWNs can require more approvals, which increases the amount of time before message issuance. Table 3 outlines the nighttime/weekend AWN issuance process (as detailed by an EM interviewee) for a severe emergency occurring within a city, where the respective county holds IPAWS alerting authority, ie, the city does not hold IPAWS alerting authority. These processes can vary from jurisdiction to jurisdiction, and their steps depend on which level of government holds IPAWS alerting authority.

Factors that can impact an organization's ability to manage low probability disasters

- Regular performance of disaster-related roles
- Flexibility in operations, mobilization, and response
- Ability to deal with change and uncertainty
- Ability to sacrifice autonomy in the interest of an effective response
- Definition of emergency work through the specification of roles, authorities, domains, tasks, and priorities
- Availability of resources and supplies
- Dependency between key organizations and regular communications
- Intra-organizational cohesion of members
- Provision of information through adequate channels on the probability and legitimacy of an incident[6]

TECHNOLOGY

Software vendors work hard to provide EMs with reliable tools, but like many technologies, AWN systems are fallible. These imperfections present when EMs interact with AWN software while training or during an actual incident. These difficulties may limit their confidence in their AWN system, as well as their ability to send an AWN quickly. Challenges amplify when EMs must communicate with non-native speakers or those with access and functional needs. AWN technologies have limitations and often do not generate messages in the range of accessible formats needed to reach all parts of an EM's community. While these challenges are not easily overcome due to technology limitations, understanding the variety of complications

Table 3. The nighttime/weekend AWN issuance process as detailed by an EM for a city where the county holds IPAWS alerting authority
1. IC recognizes threat in the field while managing an incident
2. IC calls dispatch via radio or cell phone to request AWN issuance to areas at risk[§§] specifying the direction residents should evacuate and any other essential incident details
3. Dispatcher receives call from IC and records AWN and evacuation request
4. Dispatcher asks dispatch supervisor to review AWN issuance request information
5. Dispatch supervisor aids dispatcher in compiling information and composing an AWN message
6. Although the dispatch supervisor may have permission to issue an AWN via reverse 911 (landline and subscriber-based cellular) to the entire city, they will likely call the off-site city EM to explain the situation and request the EM issue the AWN, as the dispatch supervisor normally does not perform this task—the EM agrees that the incident necessitates a reverse 911 AWN, as well as a WEA
7. Dispatch supervisor sends the composed AWN message to the city EM
8. City EM inputs message into AWN system on tablet, checks for errors, and issues AWN through reverse 911 to those within the areas at risk (or the entire city depending on the severity of the threat), while in parallel, the dispatch supervisor contacts the city's public information officer (PIO) to inform them of the situation
9. City EM immediately posts the AWN message to their organization's Twitter feed, as this takes little time
10. City EM calls county dispatch to request an alert through IPAWS
11. County dispatcher records incident information and requested AWN wording
12. County dispatcher transfers city EM and incident information to on-call county EM (on-site at the county's ECC)
13. City EM speaks with on-call county EM and relays additional incident information
14. On-call county EM inputs message into AWN system, checks for errors, and issues a county-level AWN through IPAWS
15. City EM updates their organization's other social media accounts and website with AWN information and additional incident information, and coordinates with other necessary partners

EMs experience can help EMs and technologists alike improve upon system design, and prepare for the unexpected obstacles that often present when humans and machines interact. Figure 7 shows how often interviewees cited technology factors as either delaying or preventing AWN issuances; EMs most often pointed to user-application interface challenges.

Software vendors design test portals for EMs to practice issuing AWNs, ie, portals that prevent EMs from risking an AWN issuance while undergoing training. Although a vendor may allow alerting authorities to redesign their live AWN system's platform—including changing the step-by-step process for issuing an AWN—they may not provide the same processes within the test portal. Thus, some trainees must learn the correct AWN issuance steps within a live AWN system, being careful not to issue an AWN. As a result, training on these systems may rarely occur due to the risk a trainee may mistakenly send out a false AWN. This limitation leads to decreased system use proficiency, fewer trained personnel, and risks a false message issuance.

System access controls and navigation can also hamper timely AWN issuance, especially in jurisdictions that do not frequently use their AWN systems. In such cases, passwords and system use

[§§]Communities are broken into zones, which speeds the identification of areas requiring evacuation, eg, the IC can request the evacuation of distinct areas, instead of requesting evacuations based on the at-risk community's relation to various streets or landmarks.

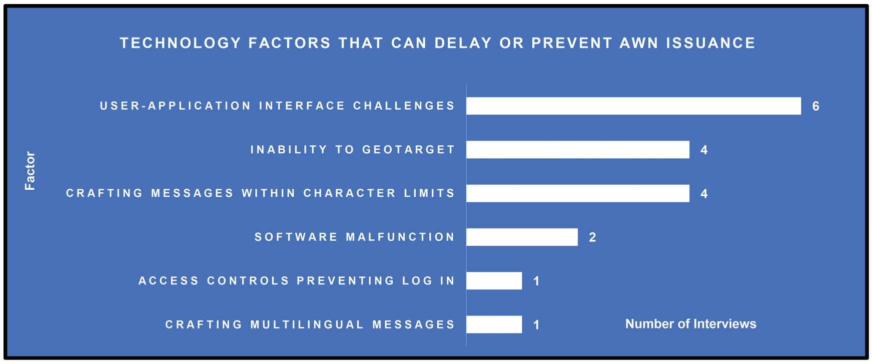

Figure 7. The frequency that interviewees cited the factors above as either delaying or preventing AWN issuance (actual or theoretical). The 13 interviews each received a maximum value of one (per factor), even if interviewees mentioned the factor multiple times. In the case where three interviewees participated in a single interview, this interview also received a value of either zero or one, despite the additional participants.

requirements are easily forgotten, which can force an EM to use a more familiar but otherwise less appropriate AWN system, eg, only posting to social media or issuing an AWN over a subscriber-based system when an incident's severity necessitates a WEA. Similarly, IPAWS requires EMs input specific codes for each type of message, and delays can occur if EMs do not have these codes' associated messages pre-identified before an incident.[25] An EM may also spend time coordinating with other officials to issue an AWN in the case where they cannot access or operate their AWN system. For example, an EM may request a different authorized individual issue the message because they are unable, which can delay messaging and may muddle message content depending on how information passes between personnel, eg, a text message sent with exact wording versus information transmitted via telephone. GAO[11] also found that alerting authorities may turn to their software providers as experienced AWN system users, because they either have limited staff or cannot send an alert because of a technical reason.

Additionally, EMs noted the following software challenges when using certain AWN systems:

1. AWN application interfaces may not be intuitive for users, which can present unforeseen obstacles. For example, AWN application displays can vary between computers and mobile devices—a factor that can hamper AWN issuance if an EM is more familiar with one interface but must navigate another. In other cases, AWN software may only function on a desktop computer and not on a mobile device, which can cause delays if an EM is unaware of this limitation.

2. Depending on the programing language and user design of an AWN application, a window may not be resizable without causing buttons necessary for AWN issuance to disappear. This restriction can render applications inoperable if other windows must always remain open on a screen. For example, dispatchers may need to keep certain windows on their screen open at all times to perform their job duties. In such cases, they may be unable to resize or minimize these windows to accommodate the window of an AWN application that only displays the correct buttons when sized appropriately.

3. Some software applications may display fields that are uninterpretable without prior user training—a challenge that may persist following training/instruction.

4. Some AWN systems may not allow EMs to geo-target emergency messages to specific locations, creating system use apprehension among EMs due to the possibility their AWN may reach too many people outside the area at risk (a challenge similarly identified by GAO[11]).

5. An EM may need to enter the AWN message into a field, save the message, and then navigate to a separate window to issue the AWN instead of these steps occurring fluidly.

6. An application may create an overlay window for EMs to input the AWN message, which they could easily exit out of by pressing the wrong key or clicking outside of the window, thereby deleting the message and requiring them to reformulate the AWN.

7. Stored message templates may not be searchable by keyword, a limitation that can force EMs to instead scroll through an extensive list until they find the correct one.

8. AWN software may not allow EMs to preview or confirm their message before issuance, ie, when an EM hits the send button, the AWN sends without the EM first viewing a safeguard message like: "This message will transmit to the entire county, are you sure you want to send this message?". Similarly, EMs may not receive confirmation of their message's dissemination following issuance (a challenge similarly identified by GAO[11]). Without these safeguards and steps in place, EMs note considerable apprehension when issuing AWNs due to the increased potential of mistakenly or incorrectly releasing a message.

9. Some AWN systems aggregate multiple platforms, eg, Facebook, Twitter, subscriber-based systems, eg, text, email, and text-voice, and IPAWS systems, into one. These systems of systems allow EMs to issue the same message across all platforms without needing to individually access platforms, input message content, and issue messages. In certain circumstances, a platform's programming can change, eg, a social media platform changing their application programing interface (API), causing the platform to no longer interoperate with the AWN system. When this occurs, EMs may receive a "bounce-back" message notifying them of a failed message delivery across a particular platform if the AWN system has not been updated to integrate the new API. In such circumstances, the EM would need to subsequently log on to the faulty platform and input the information manually.

Provision of multilingual AWNs can also challenge EMs. AWN issuance delays can occur if EMs attempt to prioritize the sending of these messages in parallel with the transmission of an initial English AWN. Still, some state laws require that EMs send multilingual AWNs in the other primary languages of their respective community members. According to one EM, however, only one AWN software vendor provides the capability to issue AWNs in multiple languages. Still, this software has a limited translation ability and concerns exist that messages might include errors. EMs have similar apprehensions regarding the abilities of Google Translate. To confidently send a message in multiple languages, EMs would either need to maintain fluency in the languages they wish to send a message or pre-identify a translator to assist in message composition and/or validation. Such a process is impractical during a rapid-onset emergency, where timely message issuance must occur to protect lives and property. Even if EMs wanted to issue a message in multiple languages, character limits prevent doing so across the WEA system. Such an approach would still be impractical, however, as message recipients would receive an "instruction manual style" list of AWNs in multiple languages.

Recipients would likely experience difficulty reading through such a message while under threat. To ensure timely emergency messaging, CalOES[41] recommends that initial AWNs not be delayed while alternate versions are prepared and that translations or other AWN variants be treated as updates. Some WEA capabilities have improved, however, with devices now capable of receiving a Spanish-language version of a WEA following an English WEA issuance.[43]

Character limits can also cause EMs difficulty when attempting to craft a simple English message that includes all the information necessary to ensure an AWN's effectiveness. According to one EM, the time to compile a message under 90-characters that also contains the correct content, eg, source, threat, location, guidance/time, and expiration time,[23] takes an average of 6 minutes. According to GAO,[11] EMs have needed to issue multiple AWNs to communicate information about the same incident due to the previous 90-character limit constraint of WEA messages; this limit has since increased to 360 characters to allow for greater message detail.[43]

While accounting for access and functional needs populations remains an essential aspect of emergency management, EMs did not point to accessibility as a factor that delays or prevents AWN issuance across existing systems. Outside of pre-planning efforts, like those described in the "Best practices for harder to reach audiences" subsection below, in many cases, ensuring accessibility of AWN messages falls to the end-user who must program their device to inform them of message receipt and describe the message in an accessible format, eg, having their smartphone flash a light at the moment of message receipt and read text messages aloud.[44]

Best practices for harder to reach audiences

One solution for ensuring broader message dissemination is to partner with community groups with access to distribution lists and channels, who can translate and disseminate messages in accessible formats. These groups can serve as trusted messengers, which can also increase recipients' receptiveness to recommended protective actions. Communicating AWNs to travelers poses similar challenges, as these individuals may not have access to the same devices or message distribution channels as residents. To communicate risk information to these individuals, an EM might work with lodging facilities in the community. Such facilities can inform their guests about how they might access safety information during an emergency, ie, providing information at check-in or in rooms. Hospitality services normally record guests' contact information and can pass AWN messaging to their patrons if needed. With this said, such services must balance their guests' experiences with EMs' needs to communicate risk information. EMs may also pay to customize their AWN system so messages include a link to a website with the same message translated into multiple languages. In such a scenario, an EM would input incident specific details, eg, location, into prescripted message templates. Still, this can be a costly endeavor for smaller organizations with limited budgets.

INFRASTRUCTURE

EMs must have functioning communications equipment to issue an AWN and can have difficulty transmitting AWNs if outages occur due to a hazard's impact on infrastructure, high volumes of network traffic, or lacking system interoperability.[6] Both power outages and infrastructure damage can cause a network to crash, which can result in either EMs being unable to connect to their local network to issue an AWN or may prevent AWN dissemination across the intended recipients' networks. In other cases, while a network may be functioning, EMs may need to travel to a facility to gain access to it, which can further delay AWN issuance. Bandwidth may also be taxed by an AWN issuance or from the public traffic that follows an emergency message, eg, many individuals calling their relatives to check to see if they are safe. Figure 8 shows how often interviewees cited infrastructure factors as either delaying or preventing AWN issuance. EMs most frequently pointed to network and power outages as contributing factors. While these infrastructure limitations are often costly to mitigate, EMs can work to identify the most critical nodes within their AWN systems to implement measures with the highest cost-benefit ratio.

A loss in power or network connectivity at an EM's facility could prevent AWN issuance,[11] especially if

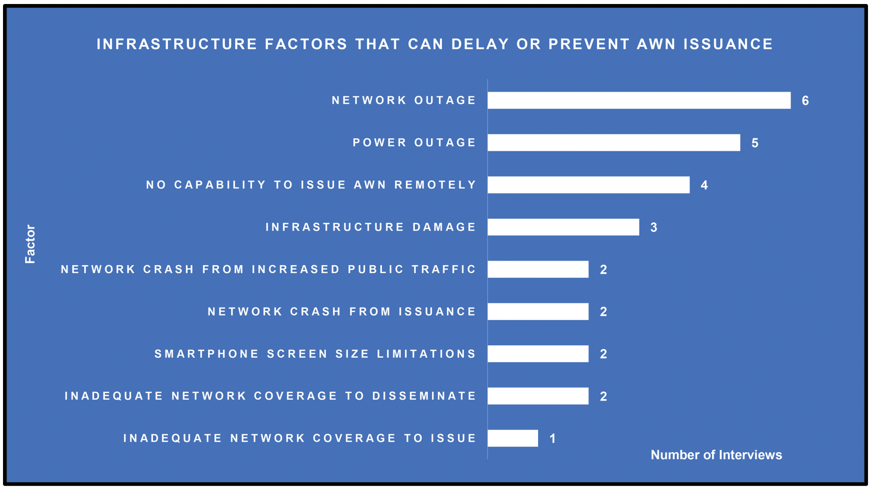

Figure 8. The frequency that interviewees cited the factors above as either delaying or preventing AWN issuance (actual or theoretical). The 13 interviews each received a maximum value of one (per factor), even if interviewees mentioned the factor multiple times. In the case where three interviewees participated in a single interview, this interview also received a value of either zero or one, despite the additional participants.

the EM does not have backup power, redundant network connectivity, or partnerships with other organizations capable of issuing an AWN. If the infrastructure to issue or disseminate an AWN does not exist, eg, nonexistent network connectivity in rural areas, at the time of a hazard's detection, EMs may not be able to connect to a network to issue a message, or their transmission may not reach their intended recipients.

EMs may encounter additional challenges if not on-site at their organization's facility. For example, some AWN systems are not cloud-based and require an EM to be physically present at the facility to issue a message. In cases where no trained officials are on-site, an EM in the field may need to travel back to the facility to access their organization's network. Issuing an AWN from a smartphone can also prove difficult due to the size of the device's screen, and the resultant extra time needed to input and review message text. EMs noted that each of these obstacles can cause significant issuance delays.

Additionally, if EMs do not first assess a communications network's capacity before issuing an AWN, their transmission may cause the local network to crash, eg, phone switches can only handle a certain amount of calls per minute without crashing. In other cases, the public may flood an ECC with calls following an AWN issuance for a variety of reasons, see the "Adverse EM and Emergency Services Impacts" section. For instance, an AWN software provider may allow EMs to choose whether their organization's phone number or the software vendor's generic toll-free number populates as the caller identification upon message receipt. In the case that the organization's phone number populates, recipients may place many calls to the organization issuing the AWN, which can flood phone lines and cause networks to crash. Such outages can prevent EMs from issuing additional AWNs.

Case study: Camp Fire outage

In some circumstances, communications infrastructure itself can face impacts from a hazard and become nonfunctional. The Camp Fire in Paradise, California, for example, caused 66 cell tower outages. Cell towers need electricity to operate but, in some cases, no requirement exists that these towers need to have backup electrical power. Cell service also relies on fragile glass fiber-optic networks to route calls from base stations to switching stations, and then to customers. Utility companies usually construct these systems in a line, so when one tower goes down, calls can no longer route across them. In the eastern Paradise neighborhoods, around 56 percent of the 4,272 emergency alert calls failed, potentially, because the network could not find adequate signal strength or bandwidth to transmit the call data because of cell tower failure. Rural areas may be particularly susceptible to these outages, as emergency officials may not know which towers are down or which carriers have lost service.[45] Also, certain utility plans involve shutting down parts of the electrical grid in high-risk areas to prevent wildfires. While these measures may mitigate the potential for wildfires, they may also pose obstacles for EMs, as these officials need electricity to issue AWNs across reverse 911 systems (landline and cellular).[46]

ADVERSE PUBLIC IMPACTS

While the benefits of issuing AWNs often far outweigh the consequences of not, AWNs can still cause a variety of adverse public impacts. For example, the public may face increased risk when responding to an emergency message, like spontaneous volunteers placing themselves in the crossfire of an active shooter incident, or the public increasing their exposure to a hazard when attempting to evacuate. Rumors may also spread rapidly following an AWN. Additionally, economic sectors can face revenue losses due to decreased demand or productivity. Beliefs also exist that an AWN can cause panicked, disorderly, or irrational reactions, which can result in damages to people or property—while this may occur in rare circumstances, these views are widely unfounded based on a review of previous incidents. The public may also become fatigued when over-alerted, which can reduce their future receptiveness to AWNs. Figure 9 shows how often interviewees noted these adverse impacts as following an AWN issuance.

In certain circumstances, issuing an AWN could result in increased violence or harm to the public. In the case of a school shooting, for example, members of the surrounding community may respond to the scene to help following an AWN dissemination, such as children's parents flocking to the facility to save their children or armed citizens responding to the incident to aid law enforcement. In such cases, parents could become caught in crossfire or armed citizens may be mistaken as suspects. Only EMs who had worked in small communities, as well as higher education, pointed to such spontaneous volunteers responding to the scene of an incident and putting themselves at risk of gunfire. Citizen-to-citizen communications, eg, through social media, texts, and calls, or citizens listening to responders' unencrypted radio traffic can amplify these public responses, as well as the spread of information, accurate or otherwise.

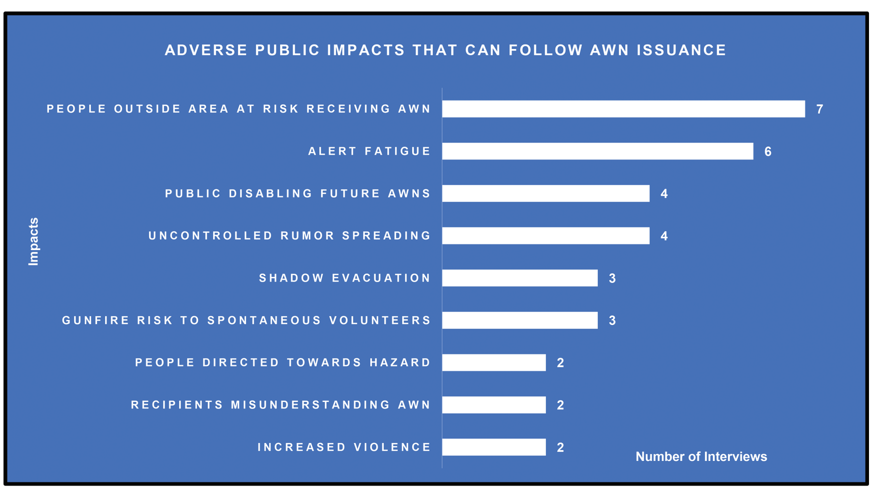

Figure 9. The frequency that interviewees described the AWN impacts above (actual or theoretical). The 13 interviews each received a maximum value of one (per factor), even if interviewees mentioned the factor multiple times. In the case where three interviewees participated in a single interview, this interview also received a value of either zero or one, despite the additional participants.

EMs may also delay issuing an AWN because they feel that providing the public with too much lead time before a hazard's impact could diminish people's sense of urgency or lead them to take risks. For example, individuals might decide to return to their homes instead of sheltering in place because they believe they have time before a hazard's impact, while in reality, this action might place them in the path of a hazard.[8] In cases, issuing an AWN might also increase risk for some as they attempt to evacuate, due to a hazard's severity, geographic constrictions, or unsafe evacuation routes.[6] EMs have also hesitated to use broad-reaching AWN systems out of concern that notifying too many people may cause a shadow evacuation—where those not in danger or within an area under a declared threat also evacuate, flooding the roadways, and causing traffic congestion that can prevent the egress of those truly at risk.[7,47,48] Congested roads can also slow public safety's response to the incident of concern or other separate emergency incidents. Additionally, Rogers[10] found that EMs delay AWN issuances by an hour or more, on average, for incidents occurring in the evening, ie, after 19:00, versus those occurring in the early morning, ie, before 07:00. He equated this variation to EMs' tendencies to delay evacuations until daylight hours when roads are easier for residents to navigate and public safety officials can manage their egress.

Revenue losses and missed wages, as well as impacts to productive economic sectors, can all occur following an AWN issuance that leads to an evacuation.[6] EMs may also believe that damages to people and property could result from panicked, irrational, or disorderly reactions to emergency messages. Although this may occur in rare circumstances—where the social climate predisposes communities to such behavior and the disaster acts as a trigger[49] or where death appears imminent[50]—these beliefs are widely unfounded based on a review of previous incidents.[1,6] Additionally, in one instance, a man went into cardiac arrest following the receipt of an emergency message that had been issued in error. The man was revived by cardiopulmonary resuscitation and underwent surgery. He and his girlfriend later sued the agency responsible for issuing the message for physical and emotional damages.[51] In two instances, interviewees mentioned causing panic as a reason an EM might hesitate to issue an AWN, but each noted this adverse impact as a general falsehood and not a valid reason to delay or prevent an AWN issuance.

EMs may also hesitate to issue an AWN to prevent causing the "cry-wolf syndrome" among recipients—in other words, people no longer believing an AWN following repeated false alarms, where the hazard fails to impact.[1,6] While false alarms do not tend to cause the public to view officials or their messages as dishonest in the case of unnecessary calls for evacuation, the public may question the accuracy of future orders.[52] EMs may also hesitate to issue AWNs to avoid causing "alert fatigue" among message recipients—where the public overlooks messages due to message oversaturation—thereby lessening the likelihood they will undertake protective actions.[‡‡] Additionally, EMs note that the simple act of issuing AWNs can cause recipients to unsubscribe from AWN services or block future messaging on their devices.

Concerns also exist among EMs that the public will not interpret a message as intended, and consequently react to the news inappropriately. As a result, EMs may spend additional time to ensure their message content takes into account how the message displays across various platforms. For example, an EM may want to construct an AWN message for Twitter differently than a message on Facebook to best convey the information and increase AWN receptiveness. Additionally, although continuous monitoring of social media can help EMs understand how the public receives, interprets, and responds to their AWN, EMs may not always receive immediate feedback. This limitation can present when AWN systems do not provide EMs with receipt confirmations or a way for recipients to provide feedback, thereby slowing an EMs ability to correct unclear or inaccurate messaging.

ADVERSE EM AND EMERGENCY SERVICES IMPACTS

EMs can also face several personal and professional adverse impacts following an AWN issuance.

‡‡Researchers have identified "alert fatigue" in clinicians, ie, from too many medical equipment alerts,[36] and the similar public behavior, ie, the "false alarm effect," in response to the receipt of numerous tornado warnings.[53]

If an AWN proves unnecessary, EMs may face career or reputation implications, as well as public criticism, and even death threats in the case of a false alarm. These negative implications can leave a psychological toll on EMs and may result in hesitation when issuing future AWNs. Still, many EMs agree that these barriers should not prevent an AWN in the case of a confirmed and imminent threat to public safety.

An AWN issuance may also impact emergency services. ECCs may become flooded with calls, which can impede other emergency communications. EMs also described delaying an AWN to first ensure the emergency message would not interfere with law enforcement operations. General emergency management expenses may also be incurred from evacuations, provision of resources, and overtime pay for emergency services personnel. Figure 10 shows how often interviewees cited these adverse impacts.

EMs may feel pressured by persons, another level of government, or a different government agency not to issue an AWN. In such circumstances, EMs may face criticism or career implications if they decide otherwise and their AWN subsequently causes public outcry or political consequences for their superiors.[6] An EM may also be apprehensive about issuing an AWN due to the possibility of embarrassment or loss of reputation.[1,6,7] Still, of the 13 interviews, in seven, interviewees volunteered (without prompting) that they would not delay an AWN for any reason in the case of an acute, emergency incident that posed a confirmed imminent threat to public safety.

AWN issuance can also be a highly personal decision, for which EMs often must take sole ownership. EMs can face excessive amounts of public disapproval following an AWN issuance, especially through social media platforms where some can dissociate with the person on the receiving end of their criticisms.[54] Even if the senders of these comments direct their frustration toward the organization responsible for the AWN, the criticisms may feel like personal attacks to the individual EM. Such condemnations can take a psychological toll on the EM and lead to future paralysis when they must decide for and issue future AWNs. In four interviews, EMs cited the false AWN issuance for an incoming ballistic missile sent to the Hawaiian Islands on January 13, 2018—an incident that provoked death threats against emergency management agency personnel[55]—as contributing to AWN issuance apprehensions. Furthermore, EMs responsible for AWN decision-making often receive some amount of negative feedback following an AWN issuance, whether or not the message is warranted (due to, in part, AWNs reaching some of the wrong people and inconveniencing others). As such, four EMs described a moment of

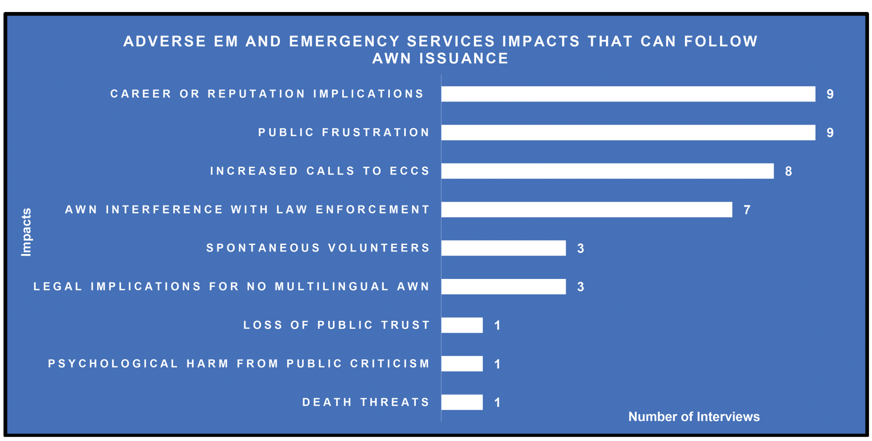

Figure 10. The frequency that interviewees described the AWN impacts above (actual or theoretical). The 13 interviews each received a maximum value of one (per factor), even if interviewees mentioned the factor multiple times. In the case where three interviewees participated in a single interview, this interview also received a value of either zero or one, despite the additional participants.

general hesitation that can delay AWN issuance when they are deciding to press the button that issues their message when targeting a large number of people within their community. Such apprehension may stem from the understanding that wide-reaching messages may trigger a number of adverse reactions or impacts even when appropriately deliberated.

ECCs may also become flooded with calls following an AWN issuance. These calls can include: (1) requests for more information about an AWN in the case of an unclear or high-impact message;[56] (2) complaints about an AWN, eg, if the AWN occurs at night and does not apply to many people;[57] (3) circumstantial reports if the AWN requests residents call 911;[58] and (4) requests to be unsubscribed from an organization's AWN list. In such instances, networks may become clogged and ECCs unable to keep up with the influx of calls. In other cases, if an EM does not include the source of the message within their AWN, recipients may believe that the message originated from a different EM and may call that EM's associated ECC in response. Additionally, in the case of a riot, an AWN issuance has the potential to rile crowds and increase violent behavior against police officers. EMs may sometimes delay issuing an AWN to first coordinate with law enforcement because of these potential adverse impacts.

Localities must also generally provide resources to aid their communities in the case of an AWN that results in an evacuation,[7] which can incur significant costs. Such expenditures can spur from the provision of public transportation, eg, transportation for egress and suspension of tolls, sheltering, eg, food, water, and other supplies, and overtime pay for emergency personnel.[1,6,7]

AWN system costs

Although IPAWS does not charge EMs to use their AWN portal, organizations must still procure access to system-compatible software to issue AWNs across this FEMA platform,[59] which can vary in cost depending on the specific needs of an organization. For example, although software vendors provide message templates as an option for EMs, this capability can cost an additional fee. Service costs can also be expensive. For example, a software vendor might charge $10,000 for an EM to issue a 1-minute reverse 911 message to a community of 50,000. In some cases, however, EMs may need to issue more messages or reach more people than their organization's budget initially allocated. Some smaller organizations may face difficulty justifying such subscriptions,[11] application add-ons, and system customizations, particularly when they rarely use these services.

LIMITATIONS

The researcher conducted this study in a short-time period due to the time constraints associated with an academic degree conferral. Although relatively representative of the emergency management community, a larger interviewee sample size could provide further insights. Though more than 15 professionals had expressed interest in participating in the study, some were unable; contributing factors may have included the general time constraints associated with the profession of emergency management, as well as a possible hesitation to provide written informed consent or discuss AWN topics with an unknown researcher. Additionally, although not explicitly stated, some EMs may have been unable to participate due to active litigation associated with prior incidents, a challenge described by Rogers[10] when he worked to solicit EMs for his interviews.

Additionally, the researcher outlines data results in a single voice, with uncited statements derived from interviewee comments. While the researcher quantified these statements through bar charts, additional surveys of EMs could better define how the obstacles EMs noted impact emergency messaging timeliness. Also, few studies on this particular AWN topic exist, so many points outlined within this work are either original findings or supported through news articles or other web content, rather than peer-reviewed academic research. This study is also one-sided in a sense, focusing on obstacles that can either delay or prevent the issuance of AWNs rather than the factors that can speed issuance. Furthermore, additional interview questions pertinent to the line of inquiry, but unrealized by the researcher, could have better-guided interviewee responses toward alternative topics, which may have provided further insight into AWN issuance obstacles.

Due to time constraints, two interviewees provided written answers to questions unanswered during the interview, which may have skewed responses from their otherwise verbal answers. In the case where three EMs participated in one discussion together, the data reflect this interview with a value of one, like all other interviews, as this interview did not allow for distinguishable individual responses. The corresponding data for this interview may include more data points, ie, factors and impacts, than other interviews. Furthermore, in all cases, interviewee statements derive from both theoretical concerns as well as experience, and are not easily delineated without discussing specific incident details, which could impinge upon the confidentiality of interviewees.

Additionally, no officials from tribal or territorial government organizations participated, and many other diverse nongovernment organizations were similarly unrepresented. This study also focuses only on AWN obstacles within the United States. Additional perspectives from other alerting authorities from different levels of government, organizations, and geographies would likely provide greater insight. Finally, bias could have skewed the results of this paper, as the researcher characterizes himself as an emergency management professional aimed at highlighting the obstacles EMs face while deciding for and issuing AWNs, rather than their shortcomings.

FUTURE DIRECTIONS

Additional research could better quantify the obstacles outlined within this paper. A future study could examine how often these obstacles present within the AWN management subsystem during actual incidents, as well as the amount of time (in minutes/hours) each delays AWN issuance. By synthesizing these two data sets and weighting them appropriately, researchers could identify the most formidable obstacles to timely emergency messaging. These findings could in turn help EMs better target mitigation efforts to reduce AWN issuance delays.

Also, federal emergency communications officials may consider implementing the following measures to improve AWN processes:

1. *Create a new AWN Coordinator role within FEMA's National Qualification System (NQS)*: While FEMA has a process to certify jurisdictions as IPAWS alerting authorities, ie, Collaborative Operating Groups,[59] the agency could also work to develop a formal credentialing process as a part of the NQS to help ensure that individual EMs responsible for emergency messaging receive sufficient training before sending AWNs across IPAWS and other AWN platforms. Currently, FEMA has a PIO position outlined within the NQS.[60] While one of the primary capabilities of this position is "warning," the training requirements for the position exclude AWN-related training, like those of FEMA's IPAWS independent study courses. Even still, the PIO is not always the individual issuing emergency messages; this responsibility often falls to the EM designated as an AWN Coordinator. As such, establishing a separate position of AWN Coordinator within the NQS and outlining the requisite training requirements for this position would help define this role and ensure agencies dedicate sufficient attention to emergency messaging during an incident.

2. *Integrate AWN issuance processes into the National Incident Management System (NIMS)*: Integrating AWN issuance processes into the emergency operations center (EOC) component of NIMS could help standardize and speed emergency messaging. NIMS could recommend that EMs train ICs within their jurisdictions to both recognize the need for an AWN and request an AWN issuance through their EOC's/ECC's designated AWN Coordinator.

3. *Encourage municipal adoption of the WEA system*: As of December 19, 2019, IPAWS now provides EMs the capability of issuing geotargeted AWNs, ie, dissemi-

nating AWNs based on recipient location, across the WEA system with no more than a 0.1 mile overshot.[43] This new technology better equips EMs to issue an AWN at the municipal level, ie, officials can now send WEAs to a more defined area with less concern that others outside the area at risk will receive the AWN. Implementation of these more localized WEA capabilities helps limit the delays caused by information passing between officials from city to county as shown in Table 3. As such, the Department of Homeland Security (DHS) could help speed emergency messaging by encouraging the widespread adoption of the IPAWS WEA system across municipal governments.

4. *Create a National Emergency Messaging Framework*: The Cybersecurity and Infrastructure Security Agency's Emergency Communications Division, FEMA's IPAWS Program Management Office, and DHS Science and Technology Directorate's First Responder Group could partner to integrate existing DHS AWN guidance into a practitioner-validated National Emergency Messaging Framework, which could serve as the cornerstone for national AWN best practices.

5. *Consider additional AWN practices*: Federal officials could recommend EMs implement the following practices not yet included in federal AWN guidance:

a. Use AWN software more regularly, eg, within daily operations to provide information and updates to employees, rather than just for emergencies, to increase familiarity and speed message issuance to larger groups of people within an EM's jurisdiction during an emergency.

b. Include user-interface and design requirements in requests for proposals when selecting a software vendor to build an AWN system.

c. Staff a technical specialist familiar with AWN systems to resolve issues should they arise during an incident.

d. Provision AWNs in a plume model, issuing messages first at the hazard's epicenter and then moving outward to ensure those facing the highest level of risk can evacuate first when the concern of a shadow evacuation preventing egress exists.

CONCLUSION

Existing studies identify AWN issuance obstacles for particular types of emergency messages, hazards, and AWN systems, while others examine organizational AWN obstacles across all AWN subsystems for both slow-onset and acute emergencies. This research, however, appears to be the first study to identify the obstacles that individual EMs face when issuing AWNs for acute-emergency incidents, irrespective of hazard, organization/agency, and AWN system type. This research has highlighted a range of factors that can delay or prevent emergency messaging, ie, those tied to threat interpretation, organization, technology, and infrastructure, as well as the adverse impacts on the public, EMs, and emergency services, which can follow an AWN issuance. Indeed, creating a new AWN Coordinator role within the NQS, updating NIMS to account for this role, increasing municipal adoption of the WEA system, developing a National Emergency Messaging Framework, and providing additional AWN best-practice recommendations each have significant potential to improve emergency messaging. The first step, however, is for EMs to increase their understanding of the many obstacles to timely AWNs. Only then will EMs be able to implement the mitigation and preparedness measures necessary to speed emergency messaging.

"When in doubt, warn"

"The public would rather be safe than sorry. People tolerate false alarms if there is a valid scientific rationale for the warning and the 'miss.' For example, the public has been tolerant of hurricane warnings, for which there is an evacuation warning false alarm rate of 70 percent. People subject to this hazard are willing to evacuate needlessly 70 percent of the time to ensure that they will avoid staying when evacuation is needed. The bottom line is, when in doubt, warn. The consequences of being wrong are more severe if a disaster occurs when there has been no public warning than if a disaster does not occur after warning. In addition, even if an official warning is not issued, unofficial ones are likely to be made as information about the risk becomes available to the press and the public."[1p3-6]

"Emergency officials have sometimes delayed issuing public warnings in order to get more information and increase their confidence that they will issue a 'correct' warning. There is a belief that people will not respond if the lead time to act is too long, yet the ultimate danger of delay is issuing a warning when it is too late for people to take protective action. Ideally, a warning should be issued early and its content geared to the uncertainty and likelihood of the event. The warning then can be revised to reflect the changing circumstances. Early and open disclosure will prevent officials from being 'scooped' by unofficial sources such as the media or being accused of a cover-up. Failure to disclose information can undermine the credibility of those issuing information to the public through the emergency warning system.[1p3-7]"

DISCLAIMER OF LIABILITY

All official federal, state, local, tribal, and territorial public-safety agencies and associations may publicly promote this research to their partners and stakeholders without prior approval from the author or publisher. Readers may direct inquiries regarding this research to jab558@georgetown.edu. This study did not require Institutional Review Board approval. Jeremy Bernfeld conducted this study in his personal capacity prior to entering the civil service. The opinions expressed in this document are the author's own and do not reflect the views of the International Association of Emergency Managers, Georgetown University, Booz Allen Hamilton, the Department of Homeland Security, or the United States government. As a condition of the use of this document, the reader agrees that in no event shall this document's author, contributors, publisher, or directly and indirectly associated organizations, be liable for any damages, including but not limited to, direct, indirect, special or consequential damages, arising out of, resulting from, or in any way connected to this document or the use of information from this document for any purpose.

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Jeremy Bernfeld, MPS, CEM, Management and Program Analyst, National Preparedness Directorate, Federal Emergency Management Agency, Department of Homeland Security, Washington, DC.

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APPENDIX A: INTERVIEW QUESTIONS

The researcher asked the following questions after professional introductions, a review of the informed consent materials, and confirmation of interviewees' eligibility to participate in the study:

1. What are the primary challenges emergency managers (EM) face that can either delay or prevent the issuance of alerts* for rapid onset incidents?
2. What factors lead EMs to hesitate to issue an alert?
3. What are some organizational challenges that can delay or prevent the issuance of an alert?
4. What technology or infrastructure issues can delay or prevent the issuance of an alert?

*The researcher informed interviewees that the term "alert" applies to any message, ie, an alert, warning, or notification, issued for an acute-emergency incident.

5. What are some adverse impacts that can occur following an alert issuance?

6. What are some unjustifiable reasons an EM might not issue an alert?

7. What alerting challenges or opportunities could change in the future with advancements in technology, or otherwise?

APPENDIX B: ACRONYMS

Acronym	Meaning
AAR	After Action Report
API	Application Programing Interface
AWN	Alert, Warning, and Notification
DHS	Department of Homeland Security
EAS	Emergency Alert System
ECC	Emergency Communications Center
EM	Emergency Manager
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
GAO	Government Accountability Office
IC	Incident Commander
IPAWS	Integrated Public Alert and Warning System
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NQS	National Qualification System
NWS	National Weather Service
PIO	Public Information Officer
WEA	Wireless Emergency Alerts

APPENDIX C: DEFINITIONS

Term	Definition
Alert	Sent at the beginning of an incident or during an ongoing incident that poses a continuing or imminent threat to draw attention to a risk or hazard*
Dissemination	Message distribution across infrastructure and the subsequent receipt of the message by those at risk
Emergency Communications Center	Public safety answering point, ie, 911 call center, and/or watch center
Emergency Manager	Public safety official responsible for emergency message issuance decision-making, who may or may not be responsible for physically issuing a message, among other responsibilities
Emergency Messaging	The issuance and dissemination of emergency AWNs
Hazard	Natural or man-made source or cause of harm or difficulty**
Incident	Unplanned occurrence, caused by either human action or natural phenomena, that may cause harm and require action**
Issuance	Physical transmission of an emergency message
Locality	A county, city, or town (and equivalent jurisdictional levels)
Municipality	A city or town (and equivalent jurisdictional levels)
Notification	Sent during and after immediate threats to provide information about protective actions or an ongoing incident*
Risk	Potential for an unwanted outcome resulting from an incident or occurrence, as determined by its likelihood and the associated consequences**
Spontaneous Volunteers	People who receive word of an incident and respond to help but are not normally pre-approved first responders
Threat	Natural or man-made occurrence, individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment, and/or property**
Warning	Guidance distributed prior to an anticipated incident to help the public prepare*

*Department of Homeland Security Cyber Security and Infrastructure Security Agency (2019, April). Public safety communications: Ten keys to improving emergency alerts, warnings, and notifications. Available at *https://www.dhs.gov/publication/alerts-and-warnings*.[5]
**Department of Homeland Security (2010, September). DHS risk lexicon. Available at *https://www.dhs.gov/dhs-risk-lexicon*.[61]