

# For Whom the Siren Sounds: Public Perceptions of Outdoor Warning Sirens in Northeast Alabama

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## ABSTRACT

In tornado-prone Alabama, outdoor emergency sirens are used as a major component of the Emergency Alert and Notification System. However there have been no studies to date of the effectiveness of these sirens in Calhoun County. In April 2011 a major tornado swept through this area of northeast Alabama, leaving in its wake over 300 fatalities and massive destruction. This preliminary study examines public perceptions and reactions to the sirens for notification of tornadoes. Faculty and students of a mid-sized university in Calhoun County, Alabama were surveyed before and after the devastating 2011 tornado. Although the respondents find the sirens helpful, they have difficulty understanding the tones and spoken messages emitted by the sirens. Concerns about tornadoes did increase slightly after the 2011 tornado. Those who did experience an increase in concern were likely to change their behavior in preparations and response to tornadoes.

## Keywords

Emergency sirens, tornadoes, emergency alert radios (EARs)

## INTRODUCTION

In the state of Alabama in the U.S., outdoor sirens are administered by the Alabama Emergency Management Agency (EMA) and are used to warn residents of weather emergencies (such as tornadoes), environmental hazard emergencies (e.g. chemical incidents), and other civil emergencies. As preliminary research into public perceptions of warning systems, particularly for weather related events, the focus of this paper is on the use of outdoor emergency sirens to alert the public about weather related threats, especially tornadoes. Because the types of warnings issued by sirens differ from locale to locale, one must tailor studies of sirens to particular geographic locations. This study was conducted in the Calhoun County region of Northeast Alabama, a sparsely settled area which has an area of 608.46 square miles and a population, in 2010, of 118,572. Two surveys, one before and one after the devastating tornadoes of 2011, examine opinions about sirens and other widely-used sources of warning in the Calhoun County area.

Outdoor sirens are only part of a comprehensive alert system in Alabama. There are 108 sirens located in Calhoun County alone, but the EMA has, to date, only studied sound propagation and not effectiveness or perceptions of them (Stone, 2010). To warn residents in their homes and cars, National Oceanic and Atmospheric Administration (NOAA) Emergency Alert Radios (EARs) along with local television and radio are used. EARs display text and voice information, sound alerts, and are capable of receiving more than 80 different kinds of alerts. Through a \$3.25 million grant from FEMA (Federal Emergency Management Agency), EARs have been freely available to residents of a number of Alabama counties, including Calhoun, and are also available for purchase in major retail stores.

Outdoor sirens have advantages: devices do not need to be purchased, on-hand and turned on to receive alerts; they are location-specific; different tones can be used for different alerts allowing a single siren, for example, to alert the public of a chemical spill, tornado, flood, or other emergency. But, as this research will show, the public needs to be educated as to what various alerts mean, and how to respond to them. We investigate:

1. To what extent do residents in this area rely on sirens vs. or with other sources of warnings?
2. What problems are there with sirens as warning systems?

3. Did perceptions of problems with sirens or use of other sources of information change after the recent (2011) major tornado event?

The use of outdoor sirens is not without opponents or controversy. The public can become desensitized towards them; they are ineffective in alerting the hearing impaired (which may include the elderly); they are designed to be heard in outdoor settings rather than indoors, where many people are likely to be; topography and wind direction can affect how audible the tone emitted is; and the tones are not standardized across areas of use (Laidlaw, 2010). Sirens that emit verbal warnings and instructions are available and in use in Calhoun County, but it is not clear that such messages are discernable. Sirens are expensive (between \$10,000 and \$50,000 each) (Spann, 2006; Laidlaw, 2010) so some communities (e.g. Little Rock, AK) have eliminated them

One opponent of sirens, James Spann, a meteorologist in Northeast Alabama, has expressed concern that sirens may actually be harmful because they can promote a “siren mentality” in which individuals become overly dependent upon sirens to warn them of danger (Spann, 2006). In an email correspondence, Spann expressed concern that sirens are “horribly inefficient” because they cannot be heard well in buildings and when people rely on them, they often fail to obtain NOAA weather radios to alert them indoors (Spann, 2010).

Universities and some local television stations provide services that send warnings to phones, mobile phones and other devices. According to Candace Stone of the Calhoun County EMA, the EMA is working with the National Weather Service to develop such a program (Stone, 2010). But, a limitation to these other systems is that they are not location-aware. The systems provide alerts based on a fixed location registered with the service, no matter where the recipient is actually located at the time of the alert. Eventually, through FCC mandates, cell phones will need to be locatable within 50 feet which will enable technology solutions to the problem of alerting mobile devices based upon actual rather than registered location.

Efforts are underway to use new technologies for location-aware mobile device notification. The 2006 Warning, Alert, and Response Network Act mandated the development of a national location aware alert system to push emergency notifications to wireless devices. This system, PLAN (Personalized Location Alerting Network), will allow government officials to send alerts to PLAN-enabled cell phones that are currently within a targeted geographic area. Participation is voluntary for wireless carriers. PLAN alerts will be of three types: Presidential alerts, alerts involving imminent threats to safety or life (e.g. tornadoes), and Amber alerts (issued when a child is missing). Notifications will be delivered by popping up on the device with a unique signal and vibration (FCC). A pilot launch is being undertaken in New York City for customers of AT&T, Sprint, T-Mobile, and Verizon who have PLAN-enabled devices. However, PLAN will not be of use for alerts to those who do not have a PLAN-enabled device with them, turned on, with notifications enabled at the time of an event.

Siren warnings have the advantage that people in the area do not have to have a device on-hand and turned on to receive the alert. A location specific warning such as a siren can mitigate confusion that results from broadcasts of multiple warnings (covering multiple locations) or a lack of attention to media warnings. The choice of alert systems is critical to safeguard the public. In a study of responses to a large tornado in Arkansas in 1997, researchers found that television bulletins and sirens were the most common means by which the public was warned of tornadoes in the area, (Balluz et al., 1997). Inadequate warning is a primary cause of tornado-related injuries and death (Balluz et al., 1997) and so this investigation is important as understanding the effectiveness of using outdoor sirens can lead to measures that can save lives.

In April of 2011, a tornado hit Alabama and Mississippi, resulting in massive destruction and loss of over 300 lives. Alabama ranks first among the states for the percentage of tornadoes that result in at least F-2 damage and/or cause fatalities (Legates and Biddle, 1999). In 2011, Alabama led the nation as the state experiencing the most tornadoes

## METHODOLOGY

In November 2010 (Survey 1), one of the authors of this paper, as part of a Master’s degree project under the supervision of another author, developed an online survey to investigate perceptions and effectiveness of warning sirens in Calhoun County and surrounding areas. The survey link was emailed to the faculty of the Mathematical, Computing, and Information Sciences (MCIS) department of Jacksonville State University (JSU) in Calhoun County, with a request to complete the survey and ask their students to voluntarily respond. Of the 289 respondents, 119 specified Calhoun County as their residence, with the remaining respondents residing in surrounding counties. In addition, the student researcher conducted email interviews with the Communications Manager for the Calhoun County EMA and a renowned local meteorologist.

In 2011 changes occurred, prompting the development of a new survey (Survey 2). In addition to the devastating tornado of April 2011, Calhoun County (subsequent to that tornado) ceased sounding sirens for severe thunderstorm alerts. The student researcher, now on the JSU faculty, and the other co-authors of this paper developed a new survey which investigated perceptions and reactions to siren alerts and if and how attitudes and behaviors towards the alerts changed since the April 2011 events. Survey 1 consisted mostly of Likert scales. To increase the ability to do analysis, the Survey 2 was comprised mostly of semantic differential scale items. The link to Survey 2 was emailed in September 2011 to the faculty of JSU's MCIS department.

## SUMMARY OF RESULTS OF SURVEY 1

Survey 1 examined two primary issues: perceived effectiveness of the sirens and receptiveness to alternative technologies. Questions included ones that asked where the respondents were the last time the sirens sounded, how much time on average they spend outdoors, and how clearly they can hear and understand the spoken messages emitted by the sirens. Overall, 76% reported that they were indoors when the sirens last sounded, with an additional 6.8% reporting they were in a vehicle. The percentage of Calhoun County residents who were indoors was even greater (81.4%).

When asked how well they understood the siren's spoken instructions, results suggest that respondents are able to understand them. Only 17.1% of Calhoun County residents and 20.1% of all respondents indicated they cannot understand the instructions at all. However, the respondents generally did not know the difference between tones emitted for different events. Respondents from Calhoun County were somewhat more knowledgeable (44.5% reported a degree of confidence) than respondents from other counties (21.0%).

Using 7-point semantic differential scales ("never" to "always") the respondents were asked what they do when they hear the siren. They reported frequently ( $\mu > 4$ ) checking the radio or tv ( $\mu = 5.77$ ) and checking a website or computer application ( $\mu = 4.65$ ). Less frequently they would go to a safe place ( $\mu = 3.66$ ) or ignore it ( $\mu = 2.37$ ). Spoken instructions emitted by the sirens are intended to guide the public in their response to an emergency and so must be clearly understood. Using Kruskal-Wallis tests (the data were not normally distributed), results suggest that the clarity of instructions did not significantly affect ignoring the siren ( $X^2 = 4.77$ ,  $p = .190$ ), checking the tv or radio ( $X^2 = 3.49$ ,  $p = .322$ ), checking a website or computer application ( $X^2 = 1.96$ ,  $p = .582$ ) or checking a mobile device app or text/voice message ( $X^2 = 5.92$ ). However, how frequently the respondents went to a safe place upon hearing the siren, did differ by how clearly the siren's instructions were understood ( $X^2 = 10.91$ ,  $p = .012$ ). Although Kruskal-Wallis tests do not indicate where differences lie, an examination of the means of "getting to a safe place" by clarity of sirens, suggests that the respondents are more likely to go to a safe place if they clearly understand the instructions (Table 1). As getting to a safe place is imperative in the event of a tornado, results suggest that the quality of spoken instructions emitted by the sirens should be improved.

Perception of clarity of siren	N	Mean of Going to a Safe Place	Standard Deviation
No problem understanding	43	4.42	1.679
Usually can understand	63	3.52	1.740
Occasionally can understand	78	3.51	1.618
Can't understand at all	48	3.38	1.875

**Table 1. Means of Going to a Safe Place by Clarity of Siren**

Despite the fact that respondents spend little time outdoors, 84.4% of Calhoun County residents (81.5% overall) find the sirens helpful in alerting them to emergencies or severe weather conditions. Additionally, 40.9% of Calhoun County residents reported that sirens are how they expect to be first alerted, compared to only 18.8% of respondents from other counties. This disproportionately high reliance on sirens by people who spend most of their time indoors suggests that Spann's "siren mentality" might have some basis in Calhoun County.

Rather than relying on a single warning system, multiple systems may be more effective. Therefore, the survey addressed alternative/ complementary methods. Only 17% reported believing that EARs would be the most useful primary method, although 61.3% reported possessing one in their home. Telephone, email, or text notifications were considered by 40% of Calhoun County residents (45.3% of residents of other counties) to be the most useful media for alerts. Most respondents (89% of Calhoun County residents; 95.9% from other counties) reported owning a mobile phone. However, it should be noted that all the respondents had university affiliation. The percentage of the general population that owns mobile phones may be lower, in which case accessibility may still be an issue. But, as the use of cell phones is increasing in the U.S. mobile technology alerts as part of an overall warning system may be effective once the problem of location-awareness is solved.

## SUMMARY OF SURVEY 2 RESULTS

In September 2011, a link to the revised survey was disseminated to the JSU community. The main goal of this survey was to ascertain if the responses to the sirens, and preparation of the public, had changed after the April 2011 tornado. Thus, we focused on Research Question 3. A total of 251 usable responses were collected. As with the first survey, the majority of respondents (69%) live in Calhoun County. In Survey 2, semantic differential items (with ratings of 1 to 7) were used whenever possible. Because the data were not normally distributed, nonparametric statistical tests were used. Table 2 shows the means, standard deviations and skewness of the variables of interest.

Question	N	Mean	Standard Deviation	Skewness
How much time do you spend outdoors on an average day? (1=little to no time; 7=most of my time)	251	3.64	1.49	.188
How well would you say that you know the difference between the siren tones for severe weather, a hazardous materials accident, a chemical incident at the Anniston Army Depot, and a test of the system? (1=I don't know the different tones; 7=I can identify all of the tones)	249	2.07	1.58	1.537
How clear do you usually find the spoken instructions of broadcast information over the emergency sirens to be? (1=not clear at all; 4=somewhat clear; 7=very clear)	249	2.98	1.84	.556
When you hear the emergency siren do you ignore it? (1=never; 4=sometimes; 7=always)	238	2.91	1.85	.470
When you hear the emergency siren do you go to a safe place? (1=never; 4=sometimes; 7=always)	237	3.90	1.69	.010
When you hear the emergency siren do you check the TV or radio? (1=never; 4=sometimes; 7=always)	245	5.41	1.79	-1.04
When you hear the emergency siren do you check a website or computer application? (1=never; 4=sometimes; 7=always)	245	4.84	1.89	-.567
When you hear the emergency siren do you check a mobile device app or text/voice message?	243	3.85	2.29	-.027
How helpful are the emergency alert sirens to you in making you aware of severe weather? (1=not helpful at all; 4=somewhat helpful; 7=very helpful)	251	4.76	1.82	-.404
How close did the tornado (of April 2011) come to your home or location? (1=in the path; 4=within a few miles; 7=safely distant)	244	4.61	1.71	-.035
How concerned are you now about the threat of tornadoes compared to before April 2011? (1=much less; 4=equally; 7=much more)	249	4.70	1.47	-.079

**Table 2. Descriptive Statistics for Variables of Interest, Survey 2 (2011)**

As found by Survey 1, respondents tend to spend most of their time indoors and check the tv or radio and/or computer when they hear the siren. On average, the respondents do not understand the siren's tones ( $\mu=2.07$ ) or spoken instructions ( $\mu=2.98$ ) and so go to another source to determine what is happening and what they should do. However, the respondents do find the sirens helpful in making them aware of severe weather ( $\mu=4.76$ ).

Fortunately, only 6 respondents reported being directly in the path of the April 2011 tornado. On average, the respondents were a few miles from the path ( $\mu=4.61$ ). A majority, (57.2%) have not changed their behavior since that event, but a substantial number have (42.8%). Most who changed behavior (76.9%) find they listen more carefully to the sirens now, and a substantial number (43.3%) have prepared a safe place in their home and/or have downloaded a phone app for weather updates (40.4%). Perhaps because most were not directly in the tornado's path, the respondents are only slightly more concerned about tornadoes than previously ( $\mu=4.7$ ).

Table 3 shows the correlations (Spearman's rho) of clarity of the siren's spoken message with actions taken.

	Ignore the siren	Go to a safe place	Check TV	Check the computer	Check text messages	Time spent outdoors	Find sirens helpful
Clarity of siren spoken message	$r = -.278$ $p < .001$	$r = .305$ $p < .001$	$r = .211$ $p < .001$	$r = .108$ $p = .094$	$r = .195$ $p = .002$	$r = .176$ $p = .005$	$r = .393$ $p < .001$

**Table 3. Correlations with Clarity of Siren's Spoken Message, Survey 2 (2011)**

All correlations, except between clarity of message and checking the computer, are significant. The more clearly understood the siren's message, the less likely the respondents are to ignore it and the more likely they are to take action such as going to a safe place and checking other media for additional information. There is also a significant, albeit small, correlation between time spent outdoors and clarity of the siren's spoken message, suggesting that efforts be made to improve the clarity of the audible instructions.

Surprising is that there is no correlation between proximity to the April 27, 2011 tornado and change in concern about the tornado threat ( $r=.009$ ,  $p=.889$ ). We had expected that those most affected by the tornado would have increased concern. However, this result may be because most of our respondents were not directly affected, or possibly because all residents know that they are in the path of tornado danger.

## CONCLUSION AND FUTURE RESEARCH

Both surveys indicate that although members of the community find it difficult to understand the siren's tones, they find the sirens helpful. Respondents to Survey 2 found it more difficult to understand the spoken messages. Multiple media are used for information and to help in decision-making in the event of a weather emergency. After the 2011 tornado a substantial number of respondents did take action to improve their ability to gather information and respond. Those who changed their behavior were more likely to have heightened concern about tornadoes. The implications are that in order for outdoor sirens to be effective, efforts should be made to educate the public about the meanings of the different tones and modify the sirens to improve the clarity of spoken messages emitted. A comprehensive community emergency plan must be cognizant of the fact that citizens use multiple channels for information and ensure there is coordination and awareness of the availability of information over many channels.

The generalizability of these findings is hindered by the fact that the surveys were only distributed to the JSU community which may not be representative of the general Calhoun County population. Additionally, as the two surveys were different in design (Likert scales in Survey 1, semantic differential items in Survey 2), we cannot statistically compare differences between the results.

Both studies suggest that sirens alone are not sufficient to warn of extreme events. Both Stone (2010) and Spann (2010) recommend that the public install NOAA EARs in their homes and offices, and take advantage of other services available for alerts such as SMS message and email notifications. However, since the overwhelming majority of respondents do consider the sirens helpful and they have location-awareness as an advantage, we make no recommendations at this time as to the future of sirens.

Moving forward, we will conduct surveys of larger populations from a wider geographic area that are more representative of the general public. We will conduct interviews with victims of a large scale tornado to ascertain how they used information available from a range of systems, and problems they experienced. We have contacted the Calhoun County EMA and will be in discussion with them to incorporate into future studies questions they would like answered to make their plans and actions more effective. Outdoor sirens are used for a variety of potential threats. We will broaden our focus to examine more uses of emergency sirens in more regions of the country and study other warning systems, such as the PLAN system, which have the potential to solve some of the problems of mobile device alerts.

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