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William R. Donner, Havidan Rodriguez, and Walter Diaz

Abstract

Recent research in three Southern states supplied data describing the role community structure and culture played in shaping public response to tornado risks. The following study identifies and describes how residents received, made sense of, and ultimately used information to make decisions about responding to warnings. In addition to a range of theoretical concerns, research was also intended to develop a set of safety policies derived from what the data reveals about the social psychology of risk perception, economic constraints to shelter, and the cultural aspects of response. Data analysis reveals a diverse set of social factors governing community response to tornado warnings, including social networks, language, issues in comprehension, siren ambiguities, false alarms, tornado tracking, local business behaviors, warning specificity, and cultural myths.

KEYWORDS: warnings, tornados, public response, social psychology

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INTRODUCTION

Despite advances in warning technologies, tornadic deaths and injuries still occur with troubling regularity. The 2011 tornado season was the 4th most deadly in U.S. history and also holds the distinction of causing the 2nd highest number of injuries (Storm Prediction Center 2012.) Revealed in these statistics is a need for more research on the social and psychological factors at play in the warning response process. Past research identifies those factors most commonly linked to warning response, but there are few studies that do so using a qualitative approach to data collection and analysis. The following study attempts to describe in detail the common processes associated with response to tornadic events in three Southern states during the 2007 storm season. What stands out in these processes is a fundamental connection to community culture and structure, revealing the profound social nature of warning response. Consequently, research and policy efforts should focus on behaviors rooted in the social and cultural realities of communities rather than on those of a more random or idiosyncratic nature. This study uses data from interviews within communities recently under tornado warnings to understand how individuals respond to and make use of warning information. Based on this understanding, the study also offers a set of policy guidelines to inform policymakers on issues of warning accessibility, decision making, and other matters.

LITERATURE REVIEW

Modern research into risk and disasters has moved beyond the idea that people naturally respond to threats. McLuckie remarks (1973: n.p.): “In developing a warning system, a number of personal and social influences affecting those being warned must be considered.” Empirical research has largely confirmed this assertion. Demographic characteristics, such as education (Balluz et. al. 2000), gender (Bateman and Edwards 2002), and income (Edwards 1993), may shape response to disaster threats. Similarly, one’s connection (or lack thereof) to social networks may also play a role in how individuals respond to warnings. An earlier study by Drabek and Stephenson (1971) shows that families that were together during a flood were more likely to respond to warnings. Moreover, family decisions to evacuate or seek shelter often shape individual decisions (Gladwin, Gladwin, and Peacock 2001). Apart from social characteristics, the literature also asserts a strong link between human psychology and risk. Studies routinely demonstrate the importance of warning specificity (Lindell and Perry 1987; Mileti and Beck 1975), consistency (Mileti and Fitzpatrick 1992), familiarity (Lindell and Perry 1987), and credibility (Peters, Covello, and McCallum 1997) to the process of responding to natural and technological hazards.

Finally, social networks have been found to have some influence on the reception of tornado information (Kirschenbaum 1992). Scholars have found that a strong connection to primary or secondary social networks increases the probability of message reception. Frequent interaction of family members (Lardry and Rogers 1982), strong community or network involvement (Rogers and Sorenson 1991), and regular association with a subculture or voluntary association (Perry, Lindell, and Greene 1981) led to higher rates of warning reception among individuals. Therefore, recent migrants may be at greatest risk due to disconnection from information networks. In many cases, factors ranging from language barriers to a distrust of authorities make the presence of informal organizations such as churches necessary for the transmission of warning information to at-risk groups. This may especially be true for immigrants isolated from the community at large, finding themselves unable to receive or understand warning information in the absence of alternative social networks.

Despite a large number of studies on the topic of warning response, few attempts have been made to unite these findings into a general model. Nevertheless, an exception to this has emerged in several studies, most notably in the work of Mileti and Sorenson (1990), as well as Lindell and Perry (1992). Through the examination and synthesis of the literature, they advance a number of formal statements on warning systems.

Mileti and Sorenson (1990) characterize warnings as complex systems with three sub-systems: 1) the detection subsystem, involving the monitoring, collection, and assessment of the environment; 2) the management subsystem, encompassing the interpretation, use, and coordination of data; and 3) the response subsystem, comprising the processes by which the public receives, understands, and responds to information. According to these researchers, the response sub-system, the system with which we are primarily concerned, is composed of six major processes: 1) hearing the warning, 2) understanding, 3) believing, 4) personalizing, 5) deciding and responding, and finally 6) confirming. In his book, *Disasters by Design*, Mileti (1999) adapts Lindell and Perry's (1992) response model to prior research by Mileti and Sorenson (1990), resulting in a model that includes how and whether safety resources are accessed. Past research, for instance, shows an individual's decision and ability to respond is strongly tied to the availability of resources (Duval and Mulilis 1999).

SAMPLE AND METHODOLOGY

Sampling Strategy

The data collection strategy for this study involved a synthesis of purposive and snowball sampling applied at several stages throughout the sampling process. In

qualitative research, Creswell (2007) notes that the purpose of the study must drive sample selection with the aim of obtaining different perspectives. Purposive sampling directs researchers to sample respondents whose interviews address empirically and theoretically important issues. One point of view in this study, for instance, was that of Hispanics or Latinos/as, the inclusion of whom was made possible by identifying areas in which they made up a significant part of the local population (identified through Census records). These purposive sampling techniques were driven by the literature and guided decisions in the early stages of the sampling process, but in-field selection of participants was governed by a convenience and snowball sampling approach. Consequently, sampling was a two-fold process. First, research sites were chosen on the basis of two conditions: the presence of tornados and the issuance of a warning. Absent either condition, areas were removed from the sample space. If a community experienced both a tornado and a warning, attempts were made to interview members of minority communities, women, the elderly, and the disabled (constituting the purposive element of the sampling strategy). Researchers visited these areas to acquire information on these groups. Once in these communities, a combination of snowball and purposive sampling was used to generate the sample.

Close attention was paid to the meteorological, geographic, and demographic characteristics of regions when selecting study locations. In the event that storms were likely in the continental United States, national and local news stations (CNN, MSNBC, The Weather Channel, etc.) were monitored for the likelihood, location, and intensity of tornadoes. If tornadoes did occur, this information was compared to Storm Prediction Center (SPC) Storm Report data, which are made available promptly after the majority of storms. Using these data, ArcView GIS was used to map where the tornadoes occurred, their potential path, and their intensities. Latitudes and longitudes of each event specified through SPC observations (based on local observations) were subsequently overlaid on corresponding shapefiles downloaded from the U.S. Census website. On these shapefiles we plotted (again using latitudes and longitudes) local communities with the purpose of selecting populations at varying distances from each specific tornado. This afforded researchers the opportunity to choose communities at varying levels of threat, allowing for greater variation in the experiences of interviewees in the dataset. For instance, those at a distance from event would be far less likely to experience direct environmental cues, which have been shown to influence response patterns among the public.

Data Collection Tool

The principal data collection tool in the study was an interview guide. In-depth interviews were designed around Mileti's synthesized model of warning response,

intending to capture core concepts such as warning credibility, comprehension of warnings, barriers to response, perceptions of tornado risk, perceptions of appropriate behavior, and so on. Thus, questions such as “how did you receive warning information” and “did you believe the warning was true” were used to explore these theoretical ideas.

Specifically, the data collection tool included open-ended questions addressing:

- How and under what conditions watches, warnings, and tornado information were received
- Whether and how weather information was understood
- Whether and how weather information was believed
- Whether and how weather information was confirmed
- How respondents formulated the ultimate need to take action and rationalizations for needing and using resources (e.g., shelters).

The open-ended structure of the guide allowed researchers to probe for additional information during the interview. Interviews took place in a variety of locations, including interviewee's homes, restaurants, and public buildings. The duration of the interviews ranged from approximately 15 minutes to 1 hour in length, and all interviews were recorded and later transcribed by trained research assistants. Results were initially coded using the seven stages previously mentioned and later coded more specifically. For instance, if an interviewee misunderstood a warning because they did not speak English, this was initially coded as "2" and later coded as "Spanish/Multiple Languages." All interviewees were informed of IRB-required information, including the study's goals, intended number of interviewees, and survey length. The resulting data set offered researchers insights into the depth and complexity of the warning response process. Also inferred from these data were numerous policy recommendations, with excerpts from the transcripts included where further illumination of the authors' remarks was needed. These recommendations are presented below (for a more theoretical presentation of the findings, see Donner 2007).

Discussion of Research Sites

Research was conducted from February until April 2006, during which time three separate tornado events in Louisiana, Missouri, and Tennessee were studied. Researchers interviewed warning recipients across New Orleans and the surrounding Jefferson parish in southern Louisiana; cities and towns in the areas surrounding Springfield, Missouri; and communities in the immediate region of

Dyersburg, Tennessee. These efforts resulted in the following sample sizes: New Orleans, LA (n=21), Springfield, MO (n=20), and Dyersburg, TN (n=14).

New Orleans. On February 14, 2006, several strong tornados struck the city, as well as its surrounding suburbs and towns, causing significant damage to an already devastated region. The majority of the destruction--as a result of two or three F1 tornadoes--occurred in Kenner and Metairie; the former is a western suburb of New Orleans, where significant damage had been done to the Louis Armstrong International Airport by Hurricane Katrina. New Orleans offered a unique site in which to conduct research, given the great cultural, social, and economic diversity in this area. Research sites included New Orleans and the more suburban communities of Kenner and Hahnville. Interviews took place on February 21-26th, 2006. Interestingly, it should be noted that, although several of those interviewed were still living in personal or FEMA trailers, few respondents made specific links between how they responded to the tornadoes and Hurricane Katrina. Indeed, Hurricane Katrina, despite striking New Orleans mere months prior to the study, was rarely mentioned during the interviews.

Missouri. From March 9 through March 12th, 2006, a major tornado outbreak occurred in the Central United States. During the outbreak, over 105 (one of which was confirmed as an F4) tornadoes were spawned from the supercell, causing extensive damage across the region. Specifically targeted for fieldwork was Verona, MO, a community with a sizable Hispanic population. Research sites included the communities of Fordland, Republic, Battlefield, Nixa, Marionville, and Verona in Missouri. Interviews were conducted during April 15-17th, 2006.

Tennessee. Research in Tennessee was conducted on tornadoes that struck the region on April 2, 2006, in Western Tennessee, where an F3 tornado was confirmed. The research sites included the cities of Millsfield, Newbern, and Caruthersville, MO, which lies near the border of Tennessee. Interviews took place during June 2-3rd, 2006.

Table 1: Demographics of Sampled Communities (2000 Census)

	ST	Population Total	% African- American	% Latin	Med Age	%HS Grad	%Fam Pov
Kenner	LA	72874*	25*	13.6	35.6*	81.1*	11
New Orleans	LA	437186*	67.5*	3.1*	35.2*	82.3*	21.8*
Hahnville	LA	2,792*	50.9*	1.1*	34.2*	75.5*	19.8*
Nixa	MO	12,124	0.5	1.3	31.9	88.5	8.1
Battlefield	MO	2,385	0.2	1.2	32	90.1	1.5
Republic	MO	8,438	0.2	1	33.3	82.2	5.8
Marionville	MO	2,113	0.1	0.6	38.5	75.6	19.5
Fordland	MO	684	0	1.6	34.3	79.4	4.8
Verona	MO	714	1.5	31	30.8	60.4	19.4
Millsfield	n/a						
Newbern	TN	2,988	12.3	12.5	33.9	80.4	9.2

* Estimate prior to Katrina. Possibly not accurate estimate of population at the time of study, especially in Kenner and New Orleans.

OBSERVED PATTERNS OF PUBLIC RESPONSE

Social Networks

In addition to receiving information from formal warnings (e.g., sirens), results from interviews suggest that interviewees received information through informal (i.e., family, friends, and co-workers) channels as well. If informal information represents a primary source of warning for some people, it would be useful, from a policy perspective, to consider what kinds of people informal information is *least likely* to reach. It follows naturally that groups outside social networks are expected to be less likely to receive warning information.

The data reveal much about the nature of informal information seeking during periods of warning. Such was the case in the study site of Verona, MO, where local churches channeled warning information to a sizable and growing Hispanic population. This observation is consistent with the literature, which suggests that Latinos, due to language and social barriers, often have limited access to formal community resources (Eisenman et al. 2009). Exploring the case of Verona somewhat further, a local Honduran priest often became, during periods of warning, something of an informal emergency manager for the community's sizable Hispanic population. This was because many Hispanics in the community could not understand warnings communicated in English and were unable to communicate with English-speaking members of the community. As a result, many sought information from the priest during severe storms. His

authority as a church figure made him an important source of warnings, weather information, and shelter assistance during the storms. Even when absent from the community, the priest still received numerous calls from local Hispanics about the possibility of severe weather in the area. What is more, social networks also played a key role in the sheltering phase; without basements or adequate shelters, many in the Verona Hispanic community used the priest's house as a shelter.

Care should be taken, however, to avoid assuming that such communities are helpless—indeed, far from it. Emergency managers must determine if what these groups have decided to do is effective and, if so, facilitate these preexisting informal response strategies instead of changing them. Attempting to transform successful—albeit admittedly unofficial—methods of adaptation in the community will at best accomplish nothing or, at worst, reverse those safety gains already achieved.

While strong social connections helped to protect Hispanics in Verona, the absence of social networks presents increasing problems for elderly and disabled populations, who may find themselves increasingly isolated from community networks. The following description of an elderly man in Missouri demonstrates how growing older may disrupt one's social networks and therefore leave an individual more vulnerable: *“DM: So did you talk about it all with your neighbors, beforehand, that you knew it [the tornado] was coming? A: No. We got, in this particular community right here, I believe that lady is gone, the next house, they're pretty much shut-ins, the next few houses are all empty, so in fact that lady down there died just a couple weeks ago... and the next two people, they're, like I said, we're the youngest folks here. And he's on oxygen and doesn't get out very much and this lady over here broke her hip, she's in the hospital, so really there wasn't, you know”* [QR-MO-9].

Spanish/Multiple Languages

Researchers have observed difficulty among minority groups in understanding warnings due to language barriers (Aguirre 1988). Responding to a warning implies that one has both received a warning and understood the nature of the risk communicated in the warning. Some warning recipients may only generally understand the warning and misinterpret the true level of risk, location of threat, or recommended courses of action. The following conversation with a Hispanic resident of Verona tells of the difficulties faced by a large population of non-English speaking Latinos during periods of warning in the small community:

BD: Okay. Okay. When they issue tornado warnings ... what percent of the Hispanics around here, do you think, speak English?

A: 20 %

BD: About 20%?

A: Yes.

BD: So when the National Weather Service or the local news issues tornado warnings, how do ...

A: The people don't understand.

BD: They don't understand?

A: They don't understand... [on the] television or the radio, say tornado watch or whatever- the people don't understand.

Understanding of Warnings and Watches

Some interviewees could not fully grasp the difference between watches and warnings; others understood only the general meanings of these very different forms of information. If the public is unable to differentiate between watches and warnings, this will have an impact on their response (or lack thereof) to warnings. Public education campaigns should focus on these differences, taking special care to differentiate between: a) the sequence of watches and warnings (watches come first); b) the level of risk warnings and watches are intended to convey; and c) the different meteorological conditions with which warnings and watches are associated. As one interviewee remarked, *“I am a nurse, but I don't really completely understand the difference that much between a watch and a warning, and one doesn't mean more to me than the other”* [QR-MO-2]. It remains possible that the technical definitions of the two terms are confusing to warning recipients. A potential alternative explanation is that the definitions of warnings and watches rarely enter the minds of residents at times when they are not in effect. Respondents told interviewers that severe weather was something that was rarely thought about on a regular basis—especially outside of storm season. Without a sense of immediacy and threat, there is little incentive to learn and remember the subtle—yet important—distinctions between the alerts. Interviews seem to further suggest public misunderstanding of the technical meanings of NWS warning terminology.

Siren Confusion and Misperceptions

One would assume that sirens offer a clear and unequivocal warning, and in many cases this is true. However, in other situations, clarity can be lost in the presence of multiple possible threats (e.g., tornadoes, chemical spills, hurricanes) for which a single-toned siren is tasked. For example, among the general population in one

community, whose single-toned sirens could signal the presence of a tornado, hurricane, or chemical leak, considerable confusion emerged even within households. A husband and wife debated the meanings of local sirens in one interview:

B (Wife): There's a different sound for chemicals, aren't there, [husband's name]? It's a different.

A (Husband): I don't know, it's just an emergency siren.

B: It's an emergency siren, you turn to the local T.V. and they's supposed to...

A: I don't know that there's a different sound, I don't think it does [QR-NO-19].

Interestingly, the single-tone, multiple-event system further encourages the well-documented tendency among warning recipients to confirm warnings (Mileti 1999), yet concerns arise that this may simply delay overall response time. According to the literature, individuals who feel threatened and receive warnings generally seek further validation regarding the credibility of the warning. The net result is delaying individual response, which, in the context of rapid-onset events such as tornadoes, could be fatal. Multiple-tone sirens add further layers of ambiguity to the response process and thus encourage the need for additional confirmation among communities, which in turn delays response.

If possible, single-tone, multiple-event sirens should be eliminated. Even jurisdictions unable to opt for more effective warning systems can take actions to improve the effectiveness of these siren systems by considering the causes of the public's confusion. (That many communities cannot do without single-tone multiple-event systems has not escaped the authors' perception.) We realize that much of this policy stems from the demands of multiple hazards in communities often too poor to install multiple systems. Alternatives can often be very expensive. In communities unable to escape the use of such systems, what might possibly counteract this confusion is the use of police or fire department personnel directly announcing the threat type to the communities at risk of being impacted by the hazard event. Of course, education, training, and raising the awareness of the general public is also essential. This would allow emergency managers to reach a broader population and present a clearer picture of the risk the community is facing. Some additional means of conveying what type of threat is present that would not require the community to confirm for prolonged or unnecessary periods of time could have a significant and positive impact on public safety.

False Alarms

Interviewees appeared concerned about false alarms. One Missouri resident remarks, "*We don't get a lot of false alarms around here...our sirens don't go off real often. If they went off all the time, that would be a bad thing*" [QR-MO-8]. When asked about the frequency of false alarms, another interviewee replied, "*Just about every day here, I mean here lately*" [QR-TN-10]. Why were interviewees so concerned with the false alarm rate? The public, emergency managers (EM), and the National Weather Service (NWS) appear to hold different definitions of what constitutes a false alarm. For the NWS, a warning might be false if a tornado fails to enter a geographic warning polygon. The public, on the other hand, holds a much more subjective definition of warnings: a watch, warning, or siren sounded without the clear presence of a tornado may be regarded as "false." For instance, one interviewee complained, "*The siren goes off so many times, we had sirens go off and a tornado nowhere near us, it was in Dyersburg*" [QR-TN-11]. Thus, from the interviewee's perspective, he experienced a "false alarm" although a tornado did indeed occur.

From the interviews, it would seem that the public uses value judgments, past experience, and discussion with others to assess the false alarm rate. Even when the mathematical probability of a tornado touchdown is high, if the public does not immediately experience the tornado, some within the community may define this as a false alarm. Emergency managers are thus faced with a problem: even if the data suggest the need for a warning, if no tornado appears, the community may label the siren a "false alarm," which may have implications for future response. Whether false alarms truly have a negative impact on behavior finds mixed support in the scientific literature, but findings from the current study suggest some influence on warning response. In the end, officials and policymakers must come to terms with a public whose perceptions of the false alarm rates may be vastly different from "official" or NWS definitions.

Thus, the question remains as to how false alarms influence community response. In some studies, there is support for the hypothesis that a high rate of false alarms leads to disbelief of warnings; other studies, however, challenge this view. (For an illustration of the debate, see Dow and Cutter 1998; Atwood and Major 1998; Breznitz 1984.) In the current study, false alarms did not lead to inaction; interviewees responded to warnings ultimately. False alarms, however, *prolonged* the time taken to respond. This point is precisely illustrated in the following statement made by an interviewee in Tennessee: "*You get warnings, you [get] used to 'em. And you just don't, you know, that's why I come outside and I watch for the... signs*" [QR-TN-11].

Tornado Tracking

It appears from many of the quotes that interviewees closely monitor the paths of storms via television. When news reports showed tornadoes dangerously close, interviewees would then either take action or seek additional information. Interviewees revealed that hearing of tornadoes touching down in nearby communities prompted protective action. One interviewee claims, *“When we saw the storm was, was going through this other community of Billings and I knew that the storm...would just... if it missed us by any, it wouldn’t miss us by much. We decided just to go ahead and go to the shelter, where it’s partially underground and we kind of just kind of felt more comfortable under there”* [QR-MO-5].

There are, however, a variety of social factors that can limit one’s ability to track storms effectively. Recent immigrants may gain the least benefit from tracking storms. For example, immigrants may be unfamiliar with the locations of towns or cities in new areas and may therefore be unable to determine the exact location of the tornado. New or recent residents may not experience similar feelings of risk upon hearing that the town of “Billings” or any other geographic benchmark will be impacted by a hazard event, as they are more than likely unfamiliar with their new and surrounding communities.

Specific or General Warnings?

Related to tracking storms, interviewees are in some cases barraged by information. Warnings are conveyed through the internet, television, and radio (and, in some cases, NOAA weather radio). However, the focus on multiple sources of information has not resulted in a commensurate concern over how warnings are worded. As far as content goes, in our conversations with interviewees one particular piece of information stood out as vital, especially with long-term residents. The found references to towns or landmarks in warning reports of key importance when deciding to respond (which, again, may help only long-term residents and be of little use to recent immigrants). One interviewee remarked on a lack of specificity he found in weather information: *“It was just [a] typical watch broad area map showing pretty much hundreds of counties, doesn’t really, a lot of times doesn’t really get effected, you know it doesn’t really get a rise out of anyone because I think it’s just so widespread most of the time”* [QR-MO-6].

The mention of specific towns or geographic locations seemed very important to some interviewees. This may have been for two reasons. First, local communities are more familiar and make threats seem more personalized. Envisioning a tornado destroying something familiar may be more distressing -

and therefore more likely to warrant response - than the destruction of something unfamiliar or remote. Second, nearby communities act as more concrete reference points on which to base a decision. One thing that we know from the literature is that more specific warnings are taken more seriously (Perry, Lindell, and Greene 1981). Based on this premise, we might view as suspect warnings that are too broad or only include measurements of distance (e.g., "the tornado is 10 miles to the east"). Hearing that a tornado is 10 miles away from a familiar community gives a far clearer *psychological* or *emotional* reference point. One interviewee summed up the problem of specificity nicely: "*The siren goes off so many times, we had sirens go off and a tornado nowhere near us, it was in Dyersburg but you know they spotted one in Dyersburg so the sirens go off here to warn us to take cover. Well, you know, I'm not gonna go lock myself and my husband up in a closet for an hour wondering if this thing's passed* [QR-TN-11].

Another problem one interviewee encountered was deciding which piece of information in a warning to respond to. Confronted with the possibility of hail or tornadoes, one interviewee tellingly remarks: "*Right, well that's what I thought. Matter of fact when I heard that there was hail, my mind said, 'oh hail instead of tornado.' Which makes it okay to run out and move your car cause I'll brave the hail, not an F-3 tornado 500 feet away.*" [QR-MO-8]. In some cases, warning recipients may be more concerned with protecting private property than personal safety.

Local Business Behaviors

For some time, sociologists of disaster have known that environmental cues prompt people to action (Hammer and Schmidlin 2002; Mileti and Fitzpatrick 1993; Tierney 1987). When asked why they decided to seek shelter, a common response from interviewees is, "I saw debris flying," or "felt pressure in the ears," or "I saw the tornado." Rarely considered, however, is how the "social environment" influences the decision to protect oneself. In many cases, seeing others evacuating or preparing to evacuate causes people to do the same. A sense of urgency and timeliness is transmitted in such situations.

Businesses are a part of this "social environment" and appear influential in the process of community risk perception. The operation of businesses during periods of severe weather seems to convey a *sense that everything is normal* and that no immediate risk presents itself. People are likely to patronize local businesses that remain open during warnings, as witnessed with a local Pizza Hut and a Casino in this study. In extreme cases, patrons may even protest the closure of businesses despite the severe weather. Most notably, Caruthersville is home to a floating casino docked on the Mississippi River. Interviewees on the boat and the bartender claimed that during the storm gamblers would not seek shelter.

Solutions to this problem, however, may be difficult to envision, due to issues of legality and potential loss of revenue as a result of temporary closure. Even if local emergency managers conceivably could force businesses to close, the economic impacts and the backlash from an angry community for doing so would still be problematic.

Cultural Myths

Educational efforts traditionally seek to explain the meaning of watches and warnings and to instruct the public on appropriate responses to tornadoes. Few attempts have been made, however, to alter the often-mistaken popular knowledge communities hold on the subject of tornado climatology (for a general discussion of disaster myths, see Fischer 2008). A path we might take towards improving public response would involve countering the cultural myths that cause people to either: a) disbelieve tornadoes will form (“tornadoes can’t form in the mountains”), or b) depersonalize risk (“there is a tornado but it cannot pass the river and specifically harm *us*”).

Upon analysis, a typology of tornado myths emerged - myths may be categorized as geographic, demographic, or related to perceived hazard frequency. Although one interviewee clearly knew a tornado was present, she nevertheless believed the region's mountains offered protection from severe weather [MO-MO-2]. Another interviewee reflects this concern: *“I had told a couple friends of mine that live in the country about it. I told ‘em I said, you know, ya’ll may get hit cuz ya’ll in a flat plain area”* [QR-NO-14]. Demographically, one interviewee held that *“I never heard of that [it could come through a city] you know being in urban areas.”* [QR-NO-13]. Hazard frequency myths, on the other hand, worked to deny the possibility of uncommon threats. For instance, in New Orleans one interviewee remarked, *“I didn’t even expect a tornado so I didn’t know what it was capable of. All I know is hurricanes. If they only say hurricane watch I knew I had to get out. I know about the hurricanes you know. But tornado I just I never”* [QR-NO-13].

Discussion and Policy

In this study, we have attempted to develop categories explaining behaviors and attitudes towards warnings. In summary, we found that social networks, language barriers, confusion about warning messages, false alarms, local business behaviors, and cultural myths played key roles in the reception, acknowledgement, and use of risk information. From this, we synthesize five policy suggestions that might help improve warning response and prevent fatalities and injuries.

Encourage and Facilitate Minority Community Leadership

With respect to non-English-speaking communities, of which Hispanics are the most sizable in the United States, two courses of action are necessary. First, emergency managers should develop an institutionalized means of engagement with minority community leadership. Second, along with English-language warnings, communities should strongly consider issuing Spanish-language warnings as well.

On the first point, in considering minority communities, especially recent immigrants, emergency managers and policymakers should ask themselves the following questions: Who is important in the minority community and who generally takes on an emergent leadership role in periods of crisis? How are the groups and their leadership organized? Do significant language barriers exist? What do these groups commonly do during a disaster? Coordination, communication, and training are only possible when emergency managers “tap into” these networks to truly understand how they function. Minority communities often lack the language skills and connections to conventional institutions necessary for organized response. Minority leadership helps compensate for these problems and should therefore be facilitated. Doing so might involve, for example, providing computers, communications equipment, and transportation to these leaders so that they might more effectively communicate safety information. Enabling these roles will be a crucial step in the development of effective warning policies.

On the second point, the case of Verona further calls for a greater dialogue on the necessity of Spanish-language warnings. To date, few—if any—jurisdictions offer Spanish-language warnings regardless of the number of Latinos living in the community. It was clear from interviews in Verona that the absence of Spanish-language warnings prevented effective sheltering and response among the Hispanic population. An additional Spanish-language warning describing the situation, what to do, and where to seek shelter would likely improve response among this community.

Educate to Target Cultural Myths and False Alarms

Targeted education campaigns are necessary to overcome problems created by cultural myths and false alarms. Changing these beliefs will be difficult because many of these myths appear tightly woven into the cultural fabric of communities. The public does not understand the meanings of false alarms as intended by forecasters, emergency managers, and scientists. The public often sees warnings as either “hit” or “miss,” whereas those responsible for issuing and creating warnings view success in terms of probabilities or objective mathematical

outcomes. If a warning is issued and no tornado appears, this will be considered a “false alarm” by many among the public even if the tornado had a very strong chance of striking the community. Informing the public about how warnings are developed may reduce perceptions of the false alarm rate, and perhaps the resulting doubt about the credibility of warnings faced by many communities.

On the other hand, tornado myths should be addressed in two ways. First, there are those tornado myths that are *general* – for instance, the myth that the safest spot is in the southwest corner of the house. These should be generally addressed in all public service announcements. However, local emergency management planning committees should also acknowledge *local* cultural myths that threaten the community. For instance, interviewees living near rivers often held the belief that they were somehow protected from tornadoes, as did those who lived in areas of high elevation where it was believed that tornadoes could not pass through mountains. Others doubted that tornadoes could enter urban areas for a host of reasons. Targeting these local myths through education may have a positive impact on public response.

Reconsider the Language of Watches and Warnings

Noted earlier, one interviewee was unable to distinguish watches from warnings. This is troubling given that the literature reports the need for clear and consistent messages if warnings are to elicit response. According to NWS operational definitions, “watches” imply the potential for the development of severe weather; “warnings,” on the other hand, signal the presence of tornadoes. To the public, however, the meaning of either term may be dramatically different. Nothing within the words “watch” or “warning” inherently imply, beyond a meteorological context, more or less danger. Thus, individuals may confuse warnings with watches and vice-versa or simply fail to grasp their significance. There may be two solutions to this problem. The most dramatic is to discontinue the use of the terms “watch” and “warning.” Doing so would then necessitate the creation of an alternative rubric through which to communicate different levels of threat. Alternatively, we may opt to preserve the language of watches and warnings with the intention of continuously educating the public as to their meanings and use. Education should most likely focus on helping communities understand a) the sequence of watches and warnings, b) the level of risk watches and warnings alternatively convey, and c) the type of meteorological conditions each alert implies.

If the public continues to ignore the distinction, we may encounter future difficulties in issuing warnings. The repeated issuing of tornado watches may artificially inflate the perceived false alarm rate among communities, especially among those either unable or unwilling to differentiate between watches and

warnings. Watches have a much higher false alarm rate given that they are based on initial meteorological data. Thus watches, which routinely “fail” to predict tornadoes, may therefore unintentionally be working to increase skepticism towards warning systems in general.

Advise Local Business

A sense of "normality" remained when businesses were open during periods of warning. Local emergency managers may call for the closure of public institutions, but the closure of private business remains a legal grey area. One solution might be for emergency managers to petition local businesses to close during periods of warning or siren soundings. The effect would be two-fold. First, members of the community would have fewer reasons for exiting their homes during periods of warning. Second, closure would create a heightened sense of urgency among local communities and would serve to further reinforce the notion of danger.

The problem with this policy course would be potential economic impacts. In communities where tornadoes are rare, the occasional closing of businesses would have little impact on the economy. Yet communities that experience a higher number of tornadoes may feel deeper and broader economic impacts under policies of forced closure. Therefore, communication and coordination with local businesses is necessary to find balance between public safety and the economic needs of communities.

Unambiguous Siren Tones

One specific problem noted in New Orleans was that sirens alerted to multiple events (e.g., tornadoes and chemical spills). Solutions to the problem vary with the nature of the threats communities faced coupled with the availability of resources. Ideally, sirens should be used only for tornados. In cases where communities face multiple threats, different tones for different events, in conjunction with a sustained public education program, may present solutions to this problem.

Conclusion

Given the variety of causes and potential solutions, emergency managers should explore why these factors emerge and to what extent they are affecting the members of their community. We explored several reasons in this study, ranging from immigration to the functioning of businesses to language barriers. Perhaps some means of surveying can be developed whereby local residents could express

their needs and concerns about the problems they routinely confront during periods of warning. This would allow local emergency managers to identify more precisely the specific needs of their constituent groups. There is no simple “one-size-fits-all” solution to the matter; each community is unique. We must therefore develop diverse solutions that recognize that no two communities are alike and furthermore that there is a great diversity of need present within communities due to variation in socioeconomic status, culture, and race, as well as the psychological and social-psychological patterns that appear during periods of crisis. Coming to view severe weather as both an environmental *and* social problem will allow us to take steps towards addressing a host of response issues.

Academically, future research should explore several issues related to community and warning response. One area we feel demands further investigation is the role of local businesses and institutions in shaping warning response. Another area of research should focus on how local leaders of minority communities emerge and how they manage risk information within these communities. Finally, how the public perceives false alarms vis-à-vis the NWS also would yield additional theoretical and policy insights.

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