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Systemic Vulnerabilities in Hispanic and Latinx Immigrant Communities Led to the Reliance on an Informal Warning System in the December 10–11, 2021

Tornado Outbreak

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ABSTRACT

On December 10-11, 2021, the deadliest December tornado outbreak on record produced a family of EF4 tornadoes that severely impacted communities in Arkansas, Kentucky, Missouri, and Tennessee. Although the National Weather Service anticipated the outbreak three days earlier, not all communities received life-saving information before, during, or after the disaster. To examine systemic vulnerabilities experienced by Hispanic and Latinx immigrant populations, our team conducted a week-long field study in areas directly impacted by significant tornadoes. Connecting with local organizations, we interviewed 25 immigrants and community leaders in Arkansas and Kentucky. Social and systemic vulnerabilities, such as English proficiency, immigration status, and varying cultures of disaster preparedness, are examined as potential blockades to inclusive disaster response. Themes are contextualized into Mileti and Sorensen's warning response model. Findings indicate that U.S. Hispanic and Latinx immigrants relied mainly on unofficial sources that had no expertise in severe weather forecasting and communication, prolonging their time to effectively respond to tornadoes and take proper protective actions. We conclude with practical recommendations for developing a multilingual emergency alert system that integrates community leaders and underserved groups.

PRACTICAL APPLICATIONS

During the December 10-11, 2021 tornado outbreak, Hispanic and Latinx immigrant populations were disproportionately affected by disaster due to unequal access to warning information, linguistic barriers to understanding, and their immigration status. Hispanic and Latinx immigrants relied upon an informal warning system, where they mainly depended on unofficial sources for life-saving information. With limited access to official sources that communicated in their native language, immigrants took longer to process warning information

overall. We conclude with the proposal of a multilingual alert system that prioritizes the needs of the most vulnerable.

INTRODUCTION

From December 10–11th, 2021, a rare tornado outbreak impacted areas across the Mississippi Valley and southeastern U.S. Over the course of the event, the National Weather Service (NWS) issued 149 tornado warnings and received over 400 severe storm reports (NWS 2021a). The most significant damage occurred in Arkansas, Tennessee, Missouri, and Kentucky after one storm produced two EF4 tornadoes, now nicknamed the “quad-state tornado.” The National Centers for Environmental Information (2022) estimated \$4.3 billion in damages and deemed the event as the deadliest December tornado outbreak recorded in the U.S. Overall, reports account for at least 90 fatalities and 672 injuries.

Three days prior to the onset of severe weather, the NWS began forecasting a possible outbreak of severe weather and enhanced its forecast wording the day before to include the potential of long-lived, nocturnal tornadoes (NWS 2021b). While tornadoes can happen at any time of the day, nighttime (or nocturnal) tornadoes are more than twice as likely to be deadly due to reduced awareness and response among the public (Ashley et al. 2008; Krocak et al. 2021). As a result, frontline communications began covering the event days in advance to prepare the public for a possible tornado outbreak. Broadcast meteorologists and emergency alert systems were credited for saving many lives that night, as their non-stop coverage provided timely updates and safety recommendations for members of the public (Tompkins 2021).

Despite abundant coverage of severe weather, *all* residents did not have access to life-saving information before, during, and after the outbreak (Burriss 2022). Due to a lack of bilingual broadcast meteorologists in the area, local news stations communicated warnings only

in English. Wireless Emergency Alerts (WEAs), however, provided bilingual speakers with baseline warning information from official sources. Resembling a text message with a unique ringtone and vibration, WEAs are short emergency messages from authorized entities that are broadcasted to mobile devices in a given threat area to warn people of imminent hazards (FEMA n.d.). Over the course of the December 10–11th, 2021 tornado outbreak, the NWS translated 157 of 161 English-language WEA messages into Spanish through an automated system (Table 1; NWS n.d.). Despite the technology, major language barriers prevented Spanish-speaking communities from receiving additional information about the incoming threat and where it was headed. Beyond language barriers, underserved populations faced significant, systemic inequities when taking protective action. For example, a local candle factory in Kentucky allegedly forced their immigrant workers to keep operating through the December tornado, resulting in several casualties (Sandoval 2021).

While catastrophic, it is important to acknowledge that these tragedies are becoming more common as multilingual and multicultural communities expand. In the last decade, Hispanic and Latinx communities have grown considerably in the southeastern United States, with some counties nearly tripling their Hispanic and Latinx population in the last ten years (Fig. 1; U.S. Census Bureau 2010a, 2010b, 2020a, 2020b). Overall, the foreign-born population has increased by 21% in Arkansas, 34% in Kentucky, 18% in Missouri, and 27% in Tennessee in the last decade. Unless language disparities in hazard communication are addressed, underserved groups will continue to be disproportionately affected by disasters (Trujillo-Falcón et al. 2021).

To better understand inequities in disaster communication and response for Hispanic and Latinx immigrant populations in the December 10–11, 2021 tornado outbreak, researchers from the National Oceanic and Atmospheric Administration’s (NOAA) National Severe Storms

Laboratory interviewed community leaders and Hispanic and Latinx immigrant populations that were directly affected by the disaster. In a week-long field study, our research team visited various affected cities in Arkansas and Kentucky to learn how populations received, understood, and responded to tornadoes using Mileti and Sorensen's (1990) warning response model. First, we review the theoretical foundations of this work and establish our research questions. Second, the qualitative interview process with U.S. immigrants in the December 10–11, 2021 tornado outbreak are described in detail. Third, stories from Hispanic and Latinx immigrant communities are shared. We identify barriers that inhibited immigrant populations from taking protective action during the tornado. These vulnerabilities led immigrant communities to increasingly rely on informal warning systems that eventually prolonged the overall decision-making process.

LITERATURE REVIEW

Social Vulnerabilities and Systemic Inequities in Hispanic and Latinx Communities

Prior to a disaster, several characteristics and circumstances of a community may make their populations susceptible to the damaging effects of a hazard. Also known as vulnerabilities, the term explains why disasters are not inherently “natural,” but instead a failure of our society to address physical, social, economic, and/or environmental precursors to catastrophe (Wisner et al. 2004). Social vulnerabilities, or pre-existing factors that contribute to a community's ability to prevent human suffering and financial loss in the event of disaster (Cutter et al. 2000), help explain how underserved groups are disproportionately affected by calamity. From socioeconomic status (Hilfinger Messias et al. 2012) to language access (Ahlborn and Franc 2012) to social capital (Fitzpatrick and Spialek 2020), social vulnerabilities in Hispanic and Latinx communities can result in less preparedness, response, and recovery actions in disaster contexts (Bethel et al. 2013; Trujillo-Pagán 2007).

Despite established research on social vulnerabilities, emergency systems across the U.S. have struggled to incorporate equitable approaches for the populations they serve. On a broad scale, emergency management systems prioritize monolingualism and root themselves in systemic injustice, leaving the most marginalized behind (Onís et al. 2021). Within Hispanic and Latinx communities, the most vulnerable populations include undocumented immigrants. Due to their residency status, undocumented immigrants are not considered “worthy disaster victims” by society, preventing them from receiving critical life-saving information and resources (Burke et al. 2012; Gilman and Steglich 2018; Horton 2012; Méndez et al. 2020). In the cases where immigrant populations are acknowledged, very few recognize the diversity of these groups and often consider them to be monolithic in how they respond to disasters (Flaherty 2011; Gaviria Pabón 2022). Due to these systemic inequities, Hispanic and Latinx immigrants distrust governmental organizations before, during, and after disasters (Fussell et al. 2018). Considering that FEMA is under the U.S. Department of Homeland Security (who also houses the U.S. Border Patrol), history of family separation and deportation undermines rapport within governmental organizations. Until all social vulnerabilities and inequities are addressed and properly incorporated into our emergency systems, Hispanic and Latinx populations will continue to be disproportionately affected by disasters (Tripathi et al. 2023).

Mileti And Sorensen’s Warning Response Model In Underserved Populations

Warnings, or functional systems of messages informing audiences of imminent danger, have the potential to save lives and property (Seeger and Sellnow 2016). When individuals first receive a warning from a trusted source, whether formal or informal, they perform an ongoing and evolving process of interpretation that may motivate them to take protective action (Mileti and Sorensen 1990; Lindell and Perry 2012). Individuals begin to 1) understand, 2) believe, and

3) personalize the risk at hand by 4) milling, or obtaining and verifying information. Effective warning messages can convince individuals that they are no longer safe and encourage actionable 5) decision-making. Considering this theoretical framework, it is necessary to understand the prejudices our current emergency system imposes on underserved communities, especially since emergency systems do not cater to the most marginalized (Elcessor 2022).

Following Mileti and Sorensen (1990)'s framework, if an individual cannot **understand**, or comprehend, the incoming threat, they are not able to properly undergo the interpretation process necessary to take protective action. Aguirre (1988) was among the first to note this in the literature, as he linked language inequities in Spanish to disproportionate casualties of Hispanic and Latinx communities in the infamous 1987 Saragosa, Texas tornado. While bilingual risk communication efforts have increased in the last couple of decades, Trujillo-Falcón et al. (2021) emphasized that inconsistencies in translations exist in the present day due to the lack of established reference material and translation protocol within government agencies. For example, Trujillo-Falcón et al. (2022) found that the NWS and FEMA translated tornado watches and warnings in two different ways, causing risk communicators to deliver inconsistent messages to the public. For a baseline assessment of how bilingual communities understand these terms, the authors asked a national, representative sample of U.S. English and Spanish speakers to correctly identify the definitions of a tornado watch and warning. Only 60% of Spanish speakers were able to identify the tornado warning description correctly, compared to 79% of English speakers. In this scenario, using jargon, or terminology specific to a field, inhibited an effective translation (and eventual response) in Spanish.

When it comes to **believing**, or trusting the accuracy of information (Mileti and Peek 2000), underserved groups can consult with formal or informal sources. Considering that many

immigrants are distrustful of government and other “official” agencies, local organizations have taken a prominent role in the dissemination of disaster information and resources to marginalized groups (Maldonado et al. 2015; Tierney 2015). Through active trust building and service, community-based and non-governmental organizations have continuously responded to unmet needs by immigrant populations (Bolin and Stanford 1998; Sledge and Herschel 2019). While many of these organizations have earned their trust with the community, some of them are not trained to provide actionable recommendations in disaster contexts, contributing to continued inequities in response and recovery.

Personalizing risk, or the process of recognizing that one is susceptible to danger (Wood et al. 2018), can be difficult when one is not accustomed to the emergency system used in the area one is located in and/or is not familiar with the impending hazard. Depending on an individual’s culture of appropriate disaster response, or disaster subculture (Anderson 1965; Wenger and Weller 1973), they may have different levels of risk awareness. For example, an immigrant who grew up experiencing earthquakes in Perú may not have the generational knowledge nor be familiar with the emergency infrastructure of a tornado-prone state like Kentucky. In addition to culture, an individual cannot recognize they are at risk if they do not have a word in their language to describe the imminent threat. These linguistic discrepancies, coined disaster linguicism (Uekusa 2019), are linked to greater vulnerability among underrepresented communities (Abukhalaf and von Meding 2021).

Combining the three challenges in understanding, believing, and personalizing risk information, underserved groups must find innovative ways to **mill**, or gather information formally or informally, to ultimately **decide** on what protective action to take (Lindell and Perry 2012; Wood et al. 2018). Not being accustomed to severe weather because of their disaster

subcultures, some immigrants may not know where or to whom to turn for life-saving information for disasters and may rely on members of their community that may not have the required expertise to provide appropriate recommendations during disaster contexts. For example, Onís et al. (2021) described how Spanish-speaking communities in Puerto Rico mainly relied on one another to process information regarding hazardous water advisories, resulting in mixed messaging and confusion among the community. Using a nationwide survey, Krocak et al. (2021) found that U.S. Spanish speakers use their social networks (85.19%) just as much as the internet (85.82%), television (87.49%), and cell phone applications (89.21%) for weather information. Without reliable access to bilingual television programming and weather applications, some immigrant communities are at a disproportionate disadvantage for receiving reliable information from multiple sources.

Reviewing Mileti and Sorensen’s (1990) warning response model, immigrants of Hispanic and Latinx descent face multiple obstacles before taking proper protective action in disasters. By not exploring historical and systemic inequities, like family separation, previous studies have left the most vulnerable populations in the shadows (Fussell et al. 2018). Our study conceptualizes Mileti and Sorensen’s (1990) model in the Hispanic and Latinx immigrant community to explore how these “hidden” communities respond to imminent weather threats:

*RQ: How did Hispanic and Latinx immigrants **understand, believe, personalize, mill,** and **decide** in response to risk and information during the December 10–11th, 2021 tornado outbreak?*

THE DECEMBER 10-11, 2021 TORNADO OUTBREAK

Meteorological Synopsis

December 10th began as an abnormally warm day, as weather conditions felt more like a day in May rather than December for areas in the southeastern United States. With unseasonable temperatures and humidity, all the ingredients were favorable for strong tornadoes and severe weather (NWS 2021a). A tornado watch was issued at around 3:00pm Central Time across eastern Arkansas, western Tennessee, northwestern Mississippi, southeastern Missouri, and southern portions of Illinois and Indiana. At 5:51pm Central Time, the NWS office in Little Rock, Arkansas issued the first tornado warning for their eastern counties. In only fifteen minutes, an EF-0 tornado developed and quickly strengthened into an EF-4 tornado with winds of 170 mph, which could lead to the destruction of many homes and vehicles. The EF-4 tornado crossed into southeastern portions of Missouri and eventually dissipated in western Tennessee. After a small break, the supercell thunderstorm produced three short-lived, weak tornadoes before re-intensifying and producing the single most violent tornado of the entire outbreak. A nocturnal, EF-4 tornado developed in western Kentucky with winds over 190 mph. Due to the significant damage the tornado could produce, the NWS made a rare decision and issued a tornado emergency – an upgraded version of a tornado warning– for areas in western Kentucky (e.g., Table 1). Overall, the supercell thunderstorm persisted for over 250 miles (Fig. 2).

Affecting four states overall, the two EF-4 tornadoes produced by this supercell thunderstorm were nicknamed the "quad-state tornado," alluding to the infamous tri-state tornado– the longest-tracked tornado in U.S. history at over 219 miles (Johns et al. 2013). While the quad-state tornado did not break the tri-state tornado's record, the storm still caused catastrophic damage. Aside from the "quad-state tornado," multiple lines of storms also produced strong and long-lived tornadoes. The storms finished course near the border of Ohio overnight and eventually dissipated due to decreasing atmospheric instability (Fig. 2).

A First Glimpse of Destruction and Vulnerability

In the early morning hours of December 11th, 2021, the world began to see the first glimpses of catastrophe through pictures and aerial shots. One municipality garnered national attention: Mayfield, Kentucky, a working-class town of 10,000 people, suffered extensive damage as the EF-4 tornado moved directly through their neighborhood. Tragically, the tornado destroyed a local candle factory while employees were working, causing 9 fatalities (Bullington 2021). According to workers who survived the calamity, supervisors at the candle factory expected all employees to report for the overnight shift, even after a tornado warning was issued for the area (Sandoval and Fausset 2021). By the time they received a second, more urgent alert that a tornado was approaching the area, workers were allegedly threatened with termination if they left their workplace (Sandoval and Fausset 2021). The parent company, Mayfield Consumer Products, denied all allegations, but lawsuits have been filed against the employer. Approximately half of the original employees of Mayfield Consumer Products were transferred to a nearby location, while the other half were terminated (Siemaszko 2022). The Mayfield candle factory tragedy opened a nationwide conversation about workers' rights before, during, and after disasters.

A relatively unseen aspect of the Mayfield candle factory disaster relates to the immigrant population in the area. Sandoval and Fausset (2021) noted that more undocumented immigrants are moving to tornado-prone areas, like Mayfield, to find employment. With no established protections in the workplace, undocumented immigrants are subjected to higher vulnerability, as being fired from their job can result in severe complications to their residency status and state of living (Fussell et al. 2018). It is of utmost importance to better understand how

immigrants responded to the December 10–11, 2021 tornado outbreak so that effective strategies can be considered in future disaster planning for underserved groups.

METHOD

Research Design

Supported by the NOAA National Severe Storms Laboratory, a research team of social scientists conducted a field study in 1) Jonesboro, Arkansas, 2) Mayfield, Kentucky, and 3) Bowling Green, Kentucky after the December 10 – 11th, 2021 tornado outbreak to learn about vulnerabilities and inequities experienced during this disaster. The research team split into three groups from February 27th – March 5th, 2022 to understand how different practitioners and publics responded to the tornado outbreak (see Klockow-McClain et al. 2023). The first team interviewed emergency practitioners and local government officials, such as NWS forecasters and mayors. The second team spoke to members of the English-speaking public affected by the calamity. The third team focused their efforts on investigating how Hispanic and Latinx immigrants and their community leaders responded to the disaster. Since vulnerabilities were rich in detail among immigrant populations, this manuscript focuses on analysis from the third team of researchers.

Interview questions focused on five broad themes based on literature on bilingual risk and crisis communication that support the warning response model: 1) weather awareness in the participants' native country (Carter-Pokras et al. 2007; Gaviria Pabón 2022) , 2) weather awareness in the U.S. (Trujillo-Falcón et al. 2021), 3) warning reception and understanding during the tornado outbreak (Bitterman et al. 2023; Trujillo-Falcón et al. 2022), 4) trust in government and media (Méndez et al. 2020), and 5) immigration status limitations (Wilson et al. 2012) (see Appendices S1 and S2). The interview guide was first developed in English so that all

authors could review the material but was later translated to Spanish by the first and second authors, who are proficient in both languages and actively practice the culture of the participants of study. To guarantee dialect-neutrality, the questionnaire was forwarded to members of the weather enterprise that represented various Spanish-speaking countries for review. The feedback provided by these professionals resulted in minor edits to the interview guide wording. Prior to interviews, questions in English and Spanish were approved by the University of Oklahoma Institutional Review Board (OU IRB # 10548).

Participants and Data Collection

Our study involved a case study of 25 Hispanic and Latinx immigrants and community leaders (Table 2). For the purpose of our study, community leaders are individuals who guide, direct, and organize people in order to make their community a better place. Examples of community leaders include members of non-profit, religious, and community organizations that immigrant populations often count on for their personal well-being. The first and second authors conducted semi-structured interviews in English and Spanish, depending on the language preference of the interviewee. For most of the cases, both the first and second author actively participated in the interview so that it seemed more like a conversation. Interviews ranged from 20-45 minutes and were audio recorded after verbal consent. All responses were transcribed first in Spanish and then later translated to English by the first and second authors. To address sensitive issues, such as documentation status in the U.S., all participants' identities were anonymized throughout this study and are given random pseudonyms in the manuscript.

Participants were recruited through a critical instance sampling strategy, where we selected a small number of important cases that are likely to yield the most information and have the greatest impact on the development of knowledge (Tracy 2019). When contextualizing the

tornado outbreak, we focused on recruiting Hispanic and Latinx immigrants that would provide valuable insights into how a warning system may function for multicultural and multilingual people living in the U.S.

Research Ethics

Though there is no universal code of conduct when conducting social science disaster research (Gaillard and Peek 2019), the research team made great efforts to respect the local voices of communities interviewed and approached them with a clear purpose: to elevate perspectives of the underserved to enhance risk communication strategies in the future. Two months prior to conducting interviews, our team reached out to community leaders in Kentucky and Arkansas, such as teachers, pastors, and other non-profit organizations via email and telephone. We took into consideration that our research team is affiliated with a university and a federal agency and actively addressed any questions or concerns. Recognizing that we would be working with undocumented immigrants, we also stressed that we would keep their responses anonymous and would delete any identifying information during the transcription process.

After we gained their trust, the community leaders endorsed our research team and invited the local community who were directly or indirectly affected by the tornado outbreak to participate in our interviews. In most instances, the community leader would hand the research team a schedule of the participants that signed up, along with their contact information and where the interview would be held. In Jonesboro, we collaborated with the Centro Hispano, a community-based nonprofit organization serving the Arkansas Latinx community. In Mayfield, we connected with the Migrant Coordinator of the Mayfield Independent School District, along with two priests that led bilingual congregations. In Bowling Green, our main point of contact involved the International Communities Liaison of the City of Bowling Green. Individual

interviews were conducted privately in centers, faith institutions, schools, and homes of immigrants (if invited) (Fig. 3).

Before interviews began, our research team read an oral consent to participants, which stated that the interviews would be recorded, were completely voluntary, and their anonymity would be protected. Following the conclusion of our interviews, we gave back to undocumented communities. Since most undocumented immigrants are disqualified from recovery funds, we connected them with local charities that did not require proof of citizenship for assistance by helping translate the interaction between both groups. We continued to reach out to community champions after the study was completed and built partnerships with their local NWS Weather Forecast Office (WFO). Finally, we shared the final manuscript with all the community members to ensure that we were painted an accurate depiction of their community and experiences.

It is important to highlight that the two research team members who primarily conducted interviews and built partnerships were of Hispanic and Latinx origin and are fluent in both English and Spanish. One of these members was also formerly an undocumented immigrant and understood the perspectives of the community they were interviewing. This made a huge difference, as there were several instances where participants opened up more about their personal experiences once they realized the researchers truly represented them.

Thematic Analysis

To analyze the collected data, the first author used a qualitative, reflexive thematic analysis following the six-step strategy of Braun and Clarke (2006): 1) become familiar with the data, 2) code, or create succinct labels of data extracts, 3) generate initial themes, or patterns of meaning, 4) develop and review themes, 5) refine, define, and name themes, and 6) write up. The lead author used NVivo 12, a qualitative data analysis computer software package. First, with the

help of the second author, the lead author became familiar with the data by transcribing audio files and revising them for clarity. In total, both authors transcribed over 248 pages worth of conversation. Conducting the rest of the analysis, the first author took memos and notes using NVivo software to gain a thorough understanding of the data, including the parts he did not transcribe initially. Second, a deductive, latent approach to coding was based on Miletic and Sorensen's (1990) warning response model, exploring how Hispanic and Latinx immigrants 1) understood, 2) believed, 3) personalized, and 4) engaged in milling behavior, and 5) made decisions. Third, the first author created initial themes by examining and collating codes. Fourth, the lead author reviewed the themes to make sure it reflected the dataset properly. Fifth, themes were defined after the review was finalized. Finally, a write up weaved the analytic narrative with the dataset. Examples were then considered with the research question in mind and all quotes in Spanish were translated to English so that it is consumable by the readership.

FINDINGS

Language Barriers Prevented Access to Life-Saving Information

Immigrants who were affected by the 2021 quad-state tornado out-break spoke a diverse set of languages and experienced trouble **understanding** life-saving information that was provided only in English. In a monolingual environment, the lack of a bilingual communicator created barriers to understanding. Information availability throughout the event solely depended on whether immigrants had someone in their social network who spoke English and was able to translate that information for them:

"I think that there was some warning for [the tornado]. There was information [available to me]; I just did not have access to it [because I did not understand what they were saying]. I stayed updated through my wife [who speaks English]."

– Ernesto, Guatemalan Immigrant in Mayfield

For immigrants who did not have English speakers in their social networks, their survival solely depended on comprehending a message. For the case of one family in Mayfield, they received three WEAs on their phones in English. Initially only seeing the English version, the participant expressed confusion, ignored the notification, and missed the Spanish-language WEA that was also sent to their mobile device. A fourth WEA, showcased in Table 1, was received in Spanish by the user, causing them to go to the first floor and seek shelter:

"10 minutes before the tornado, we received the last warning notification in Spanish since the previous ones were all in English. [If it was not translated into Spanish], I would have stayed upstairs. I was not looking at [an information source] that told me it was going to get ugly [so I was not taking protective action]."

– Rosa, Guatemalan Immigrant in Mayfield

While WEA alerts can provide a general scope of the environmental hazard and its threat, they do not provide the user with additional information they might need to take protective action. After realizing a tornado was approaching their area, Isabel tried keeping up with the information through English radio since it was all they had available to them. However, much of the communication was flooded with scientific and meteorological terminology, causing Isabel to feel resigned during the tornado warning:

"I do understand English when I listen to [the radio], but there are certain terms that I do not understand because they are meteorological terms. It's all weird. So, like well, I guess this means [the tornado] is dangerous? I have to guess whether they're telling me to evacuate or not."

– Isabel, Venezuelan Immigrant in Jonesboro

While Spanish was the most popular spoken language other than English, participants in Mayfield and Bowling Green described these areas having sizable populations who spoke other languages. For example, the Guatemalan community in Mayfield emphasized that most of their families prefer to speak a Mayan language revered in their community known as K'iche'. For context, K'iche is practiced by nearly one million Guatemalans and is the country's second most widely spoken language. As a result of this linguistic diversity, community leaders in Mayfield explained that many immigrants from Guatemala first learn Spanish before English to get accustomed to their community. Therefore, when considering weather warnings, the warning message would: 1) have to be translated to Spanish, then 2) translated to indigenous languages, such as K'iche', to reach certain family members:

"Apparently there are many dialects in the language. From what I understand, some speak Mam, some speak K'iche' and some speak something else that I don't remember what they call it... Spanish is the second language of the majority [of Guatemalan immigrants]. We even have students that speak Spanish, K'iche', Mam, and English."

– Emma, Mexican Community Leader in Mayfield

In Bowling Green, the community leader had to provide post-disaster information in several languages, noting that victims of the tornado outbreak spoke *ten* different languages:

"Spanish, Swahili, Bosnian, Korean, Karenni, Zomi. And there was, yeah, I think those were the top languages. We included Pashto and Dari because there were some Afghans and there were some Somalis. Also, Somali was another language that was affected and just Burmese in general. Hmm. So about nine or 10 different languages."

– Jennifer, Venezuelan Community Leader in Bowling Green

Beyond spoken language, some immigrants expressed that their inability to read hindered them from understanding the warnings. Participants emphasized that warnings need to not only be given in textual format, but also be provided orally and visually (e.g., television, radio, etc.):

“[It is] not so much that I'm not interested [in warnings], I just don't understand it. For example, in my case, I don't know English, but I don't know how to read either. But if I had heard in Spanish that it was a tornado warning and to take shelter, it would have been different.”

– Elisa, Mexican Immigrant in Mayfield

Immigration Status Limited Disaster Preparedness, Action, and Recovery

For most non-U.S. citizens, immigration status played a huge role in how they evaluated information and **believed** certain sources. The fear of depending on government officials outweighed ever trusting them, even in dire situations like disasters. Rather than seeking help from government officials, immigrant families indicated they had several plans and personal funds they would rather use. Even when it was recommended to so, immigrants were not willing to visit public shelters due to the fear that they would be asked for documentation and only used resources when officials emphasized that their identities would not be compromised:

“Yeah, because sometimes [shelters] ask you for your Social Security number and there's so many people... there's like police around that if they hear you... you're so scared of ICE and 'La Migra' being called on you.”

– Patricia, Mexican Immigrant in Jonesboro

In Mayfield, where many were directly injured by the tornado, immigrants expressed hesitance in even seeking fundamental medical care. Immigrants emphasized that a lack of health

insurance and fear of deportation hindered disaster recovery efforts in the area, including the willingness to visit a hospital when they were critically injured:

“And [my husband] did not go to the hospital because he started thinking about what we had been through and then he said, ‘What if I go to the hospital? What if I get to immigration and they catch me, they deport me? Then [our family] here, with this situation that we have just gone through because of the tornado, with all the [medical] debts we would have, it is better not to do it.’”

– Rosa, Guatemalan Immigrant in Mayfield

In the aftermath of the disaster, most immigrants did not apply for recovery assistance due to their documentation status. While FEMA provided financial aid to disaster victims, funds were only distributed to American citizens. Through community leaders, many immigrants learned they could be eligible for assistance if one of their children were U.S. citizens. After his FEMA application was denied, a Guatemalan immigrant that lost everything in the tornado was encouraged to appeal his case by community leaders since his children are U.S. citizens. He later admitted to not following through because he did not want to risk possible consequences. All of these examples underscore how “credible” sources are not trusted in this community.

“I did not decide to [appeal my FEMA financial assistance case] because I had fears of my documentation status. If I had citizenship in this country, I would fight for my rights, but since I do not, [I have to acknowledge that] FEMA is a government agency. I could maybe win the case, but I do not want to suffer the possible repercussions.”

– Sebastián, Guatemalan Immigrant in Mayfield

Varying Cultures of Disaster Preparedness Affected Disaster Response

For many immigrants, moving to the U.S. involves a complete lifestyle change, including the climate they live in. Participants expressed varying degrees of weather awareness from their home countries, resulting in differences in how they **personalized** risk. For example, a Venezuelan community leader who has lived in the U.S. for only a couple of years admitted that she is not familiar with the hazards that they experience in Arkansas. The last significant disaster she experienced happened more than 20 years ago:

“[In Venezuela] we only have two seasons in the year: one of rain and one of drought. [The seasons] can have heavy rains and things like that, but tornadoes, hurricanes... we don't see that there. In December 1999, [we experienced the] the worst [flood] in Venezuela in the State of Vargas, which took almost the entire city.”

– Mariela, Venezuelan Community Leader in Jonesboro

In addition to weather unfamiliarity, some immigrants emphasized that their home countries do not have formalized emergency systems nor have the culture of keeping up with the weather altogether. For an immigrant that spent the first half of their life in Mexico, he notes significant differences between weather consumption in their home country versus the U.S.:

“Since we lived next to the mountains, there was no electricity, we just used oil lamps and candles. There was no way to listen to the news [or keep up] with the weather. But here [in the U.S.] you know what is going to happen tomorrow with the weather.”

– Saúl, Mexican Immigrant in Mayfield

Other immigrants told a completely different story. Coming from countries that have developed emergency systems, they were completely aware of the hazards at hand. For them, adapting to the U.S. warning system was easier, since they knew which information sources to trust and some could even interpret information in both English and Spanish. Participants

expressed that their time in the U.S. also provided valuable experience in preparing for disasters. For example, a community leader from Yucatán, Mexico expressed familiarity with weather hazards and emergency systems, as she often prepared for hurricanes year-round. However, even then, she acknowledged that tornadoes are a completely different hazard and admitted to being caught off guard during the outbreak:

“I think that the experience of two hurricanes has taught me to be prepared, because with the two hurricanes that we experienced... Gilberto, which was the biggest, we had no water for two weeks. When Isidoro hit, we had no water for almost 10 days and no water and electricity. So, I know that when the weather is bad it is time to act. In fact, in my house, there is an area where we keep water, food and batteries, things to be prepared. I think that experience has helped me to be prepared for what I thought was going to help me for the tornado. Until the tornado hit, I realized that I really was not prepared for what was going to happen.”

– Emma, Mexican Community Leader in Mayfield

Informal Perspectives Were Valued Due to Inaccessibility

Since most immigrants did not have access to reliable sources due to language, cultural, and documentation inequities, they had to rely on *informal* sources when **milling** for information. We define *informal* sources as people or organizations that are not experts in disaster preparedness and response. They can be community members, leaders, or organizations that do not have the required expertise to provide actionable recommendations during disaster. In Arkansas, the Centro Hispano, a community center dedicated to serving the local Latinx community for over 25 years, became an important source immigrants relied on during the

tornado outbreak. While the Centro Hispano does not specialize in emergencies, the center has earned trust within the community through previous actions:

“Oh, this is THE center for our community. This is like the one that you go to for anything that you need if you're having trouble with whatever you have. This is our safe place. [When it comes to tornadoes,] I do remember that they were contacting us because a lot of them have our phone numbers...”

– Patricia, Mexican Immigrant in Jonesboro

While Kentuckians did not have a centralized center like the Centro Hispano, immigrants expressed trust for their local school district, community organizations, and surrounding churches. Several sources initiated a milling process for immigrants during the tornado outbreak. In many cases, a WEA message (in English or Spanish) or a message from a local leader (often in their native language) sparked curiosity among the community to act. Since all other "official" sources were only available in English, immigrants were forced to consult with one another to make sense of the warning information. A priest in Mayfield described the milling process from their perspective. After the community received a WEA message, they immediately went to him for information, causing the priest to develop a community group text message for future events:

“[After the WEA was released], they would call me and say, ‘ey, pastor, will there be a storm?’ [As a result, I have created] a WhatsApp group text message with all the members of my church, and in there, we send warnings, recommendations on what to do [during severe weather] and anything else as much as we can.”

– Mateo, Puerto Rican Community Leader in Mayfield

In addition to providing updates on the tornado that night, *informal* sources also made the final call when it came to sheltering and other protective action. Many immigrants expressed that if it was not for their own children, they would not have sought shelter during the outbreak:

“[My daughter] received an alert [while] looking at her cell phone, and she said to her mother, ‘the tornado is going to happen, what should we do?’ [My wife] said ‘it’s not going to happen; I think it’s just [strong winds]’ ... [My daughter] was the one that urged them to seek shelter.”

– Arturo, Mexican Immigrant in Mayfield

In Bowling Green, a community liaison in local government became an important source for disaster information. Helping refugees move into Kentucky, she elaborated that her job role has evolved as more disasters are impacting diverse communities in her jurisdiction. In addition to her original responsibilities, she has created Facebook pages for community partnership for immigrants and refugees. During the tornado, she ultimately became the leading spokesperson for immigrant groups, leading them to aid they qualified for. While she admitted that she did not often originally provide warning information on Facebook, it is now a top priority after experiencing the outbreak.

“Typically, as part of my job, I try to do cultural orientation with newly arrived refugees and immigrants. I have developed a very, very basic presentation on natural disasters. But that’s not really the focus of my job within municipal government. I don’t have any formal training... On that Sunday night, I went on Facebook Live... I got the mayor on the phone... And so, in the midst of the rumble and everything and all the debris, we went on Facebook Live... I started interpreting his message in Spanish, basically without a script, without knowing what he was going to say to reassure the community.”

– Jennifer, Venezuelan Community Leader in Bowling Green

Delayed and Faulty Decision Making: A Result of Systemic Inequities and Vulnerabilities

When considering the various disaster subcultures and systemic inequities that inhibited Hispanic and Latinx communities from taking proper action, **decisions** made by our participants varied largely on their previous experience and social networks. One unifying theme among all immigrant groups, however, related to the *time* it took for protective action to occur. With a limited number of “official” sources (e.g., Spanish WEA), Hispanic and Latinx immigrants spent time verifying information from multiple, informal sources instead of taking protective action. Even the slightest delay in receiving consumable warning information resulted in significant consequences. Elisa, for example, was notified of an incoming tornado through her priest and began milling for safety recommendations. If it were not for her son pointing out exactly what to do, Elisa’s family would have faced a different fate on December 10th, 2021:

“We started receiving alerts from our phones and our priest, so I asked my son, ‘what is going on?’ He said, ‘Let me look for more information.’ He was checking the news, obviously in English, and said ‘Mom, a tornado is coming, we have to [find sturdy shelter].’ He started showing me different sources, ‘look at this, look at that’... When we went down to the basement to seek shelter, the windows began to rumble and eventually blew out. The [strong] wind whipped my son’s bed as if it were a blanket... God was merciful enough not to knock our house down.”

– Elisa, Mexican Immigrant in Mayfield

According to Mileti and Sorensen’s (1990) warning response model, informal sources are a valuable way to receive life-saving information. However, without the presence of formal sources that provide appropriate advice throughout the event, well-intentioned recommendations

can cause faulty decision making. During the tornado, Antonio mentioned that his entire family depended on his sister-in-law for updates as weather conditions evolved. While actively looking out for her family, the sister-in-law determined that the tornado would not impact the Mayfield area and suggested that their family make a 20-minute drive to a shelter in Mayfield. Ultimately, the tornado touched down at their final destination. The family members arrived at the shelter just in time, but minutes separated them from enduring a heartbreaking situation:

“I have a sister-in-law, she gets the notifications and it tells her when [and where] the tornado is going to pass. She thought it was going to pass through Graves County, that's where it's going to pass, it wasn't going to affect Mayfield. And [my brothers] went to Mayfield and I stayed at Wingo [KY] because she told me nothing was going to happen there. In the end, nothing happened at Wingo but [a tornado occurred in] Mayfield.”

– Arturo, Guatemalan Immigrant in Mayfield

DISCUSSION

Theoretical Contributions: The Informal Warning System

Due to language disparity, varying disaster subcultures, inaccessible resources, and immigration status, Hispanic and Latinx immigrants in the 2021 quad-state tornado outbreak experienced significant social and systemic vulnerabilities that led to inequity at every stage of the disaster process. When contextualizing these vulnerabilities into Mileti and Sorensen’s (1990) warning response model, we can better understand how Hispanic and Latinx immigrants 1) **understood**, 2) **believed**, and 3) **personalized** warning information during the tornado outbreak that eventually helped them 4) **mill** and 5) **decide** on what precautions to take.

First, language barriers inhibited communities from **understanding** information. Living in a region with limited multilingual communication sources, residents were left trying to

decipher key messages during the tornado outbreak in a “foreign” (to them) language. Moreover, participants admitted their chances of ignoring messages increased dramatically if they did not understand them. Even if a warning was received in Spanish (e.g., WEAs), communities still did not have access to crucial updates about the evolving storm system that further exemplified inequities during the response process. Community leaders that relayed information also expressed confusion, as various languages and dialects made relaying a unified message difficult. Especially in indigenous immigrant communities, reading comprehension was also a barrier to receiving important information, and they expressed the importance of accessible media that incorporates visual and oral components of disaster communication. These findings support previous research that language inequities serve as barriers to receiving life-saving information (Aguirre 1988) and that complicated jargon in English provides increased difficulties to delivering clear, effective messages when translated across other languages such as Spanish (Abukhalaf and von Meding 2021; Trujillo-Falcón et al. 2022).

Second, immigration status of participants and their family members hindered the ability to **believe** accurate information. The fear and skepticism of government officials limited immigrants at every step of the preparedness, response, and recovery process. Rather than trusting credible sources, many immigrants resorted to receiving their information from community partners, as they felt these leaders better understood their situation and needs. It is important to note that this trust was *earned* through previous efforts. For example, community organizations such as El Centro Hispano were also present during the height of the pandemic and throughout many important life events for these populations. Extending Méndez et al. (2020)’s findings for immigrant disparity in wildfire contexts, our study also supports the incorporation of community partners in the dissemination of life-saving information.

Third, disaster subcultures both benefitted and held back Hispanic and Latinx immigrants from **personalizing** risk altogether. Depending on where they were born and how they were raised, different immigrants inherited different cultures of disaster response, or disaster subcultures (Anderson 1965; Wenger and Weller 1973). Immigrants that recently arrived to the U.S. heavily depended on generational knowledge that their origin countries provided them when it came to disasters. With most Latin American countries not having climates that support tornado hazards, many immigrants could not contextualize and personalize weather information. Immigrants who have lived in the U.S. for decades, however, more successfully navigated the complex U.S. warning system. This finding provides clear evidence of why immigrants should not all be lumped into one category or given a one-size-fits-all solution; differences in emergency response can vary widely simply from being in the U.S. even a couple of years longer (Carter-Pokras et al. 2007; Gaviria Pabón 2022).

Fourth, Hispanic and Latinx immigrants **milled** through various information sources but did not have access to credible information. All immigrants expressed their hunger for information before, during, and after the tornado; however, due to language barriers, they depended more on *informal* sources. Most of these informal sources lacked meteorological or disaster preparedness experience and some of them expressed unfamiliarity with the warning system in the United States overall. If it was not for a knowledge broker that either 1) understood English and/or 2) knew how to read, a lot of immigrants would not have taken the actions they did to protect themselves. Some of these knowledge brokers were children that defied Hispanic and Latinx cultural norms and made decisions on behalf of the entire family, a phenomenon in line with previous research on Latinx immigrant communities navigating English-language

systems in the U.S. (Katz 2014). In addition, this knowledge-brokering process has recently been noted in weather hazard communication among the general population (Robinson et al. 2019).

Mileti and Sorensen's (1990) warning response model suggests that if individuals do not resonate with a message, they will not respond as intended nor make proper **decisions**. Due to multiple social vulnerabilities, the "official" tornado warnings in our case study were not sufficient to protect people. Following Ellcessor's (2022) work, our study found that warnings did not have the intended protective effects when it came from public authority figures; instead, community champions presented and translated information to prompt their members to act. As a result, warning messages from informal sources were much more effective than messages from formal sources. A key tenet of the Mileti and Sorensen's (1990) warning response model is that message writers create empowering information to *limit* the amount of time message receivers spend milling. Our research demonstrated the consequences of a monolingual emergency system, as a scarcity of information in languages other than English made individuals' milling processes much more pronounced, thereby putting people at risk by delaying their ability to respond (Bean et al. 2016). Overall, our research explains why the capacity of current warning systems *must* be expanded to include multilingual messaging and engage the most vulnerable in disaster contexts (Tripathi et al. 2023; Fitzpatrick and Spialek 2020).

Practical Recommendations

In addition to theoretical insights, our study provides practical solutions that should be considered in our current, monolingual emergency system. First, emergency frameworks need to expand their services into other languages other than English. Our study was able to verify the importance of such multilingual information. During the December 10-11, 2021 tornado outbreak, WEA messages were provided in English and Spanish due to recent efforts by the

NWS to automate weather WEAs translations between the two languages (NWS n.d.). Despite not having access to other communication mediums, such as television, immigrants in our study acknowledged that Spanish-language WEAs provided information gaps for those who do not know where to find credible information, which eventually created a milling process. WEA messages, however, are limited in what they can accomplish, as character counts may inhibit important context setting (Kuligowski et al. 2023). Conflicting translations from English to Spanish among government agencies can also cause messages to get lost in translation (Abukhalaf and von Meding 2021). With no official English to Spanish dictionary for weather terminology, jargon can enhance translation challenges (Trujillo-Falcón et al. 2022). Supplemental information, such as visual and auditory information, is critical for those that cannot read or have access to technology. Policymakers and researchers should develop policies that reduce jargon in warnings, standardize warning translations, and explore messaging strategies that more effectively meet the needs of underserved populations.

Second, taking deliberate and intentional steps toward an equitable, multilingual framework also requires reimagining *who* we collaborate with to ensure success. Our study underscored an important, yet often overlooked collaborator: community leaders. Going forward, federal agencies should recognize the importance of community expertise and incorporate it into the broader emergency system. That way, services to underserved populations can be culturally sensitive, timely, and relevant (Tripathi et al. 2023). Community leaders are the most knowledgeable of their populations, and they should be considered as critical partners when developing solutions going forward. We recommend that they are invited to severe weather briefings, local partner meetings with emergency practitioners, and are incorporated in research

settings. Compensation should be considered for community leaders, as local expertise can be valuable in identifying systemic barriers and solutions to effective risk communication.

Finally, to address disaster subcultures and the varieties of emergency preparedness cultures among immigrants, we recommend the creation of educational materials that emphasize fundamental weather hazards and alerts. It is vital that practitioners prioritize educational campaigns that go back to the basics of what weather phenomena are and the true implications of disasters instead of assuming their populations already know. Further, we recommend these materials vary regionally depending on the types of weather phenomena typically experienced. Resources such as pamphlets or refrigerator magnets can provide communities with the fundamental knowledge they need to be weather resilient. On television, broadcasters can provide multilingual information and educational graphics in their social media platforms or even as part of their news coverage. In stations with no bilingual meteorologist, broadcasters can create a weather briefing and forward it to a Spanish speaker in their newsroom, who then translates it and shares it on social media (e.g., <https://fb.watch/f2Ze0GLv2u/>). While it may seem like an uphill battle to develop multilingual information, government agencies have free and readily available tools to break the language barrier. To make it easy for someone willing to share it on social media or on television, NWS leaders have begun translating educational materials into Spanish and making premade captions in both languages. These resources can be found at <https://www.weather.gov/wrn/spanish>.

Practitioners and risk communicators in Kentucky and Arkansas have already started efforts to implement some of these recommendations into their operations. Realizing the importance of multilingual communication, the NWS Paducah WFO contacted our team to explore ways they can expand their reach and impact. In 2022, the NWS Paducah WFO debuted

a Spanish-language webpage that provides educational material for all hazards that affect their area, in hopes that it will reduce language and cultural barriers for the public they serve (<https://www.weather.gov/pah/SpanishWeatherSafety>). In Arkansas, our team introduced the Centro Hispano with the NWS Little Rock WFO for future collaborations, including possible educational and outreach campaigns in Spanish. In Bowling Green, we connected the International Communities Liaison with bilingual staff from the NWS Louisville WFO. Local community leaders plan to develop multilingual and multicultural pamphlets, as they will try to meet the needs of their community that speaks more than 40 languages.

LIMITATIONS AND FUTURE RESEARCH

Qualitative research methods can provide in-depth insights on how individuals perceive and give meaning to concepts, experiences, and interests (Tracy 2019). Qualitative perspectives are useful in uncovering ideas that may not have been considered previously, but the data are not meant to be generalizable and quantified. Though we hope our findings give important insights into some Hispanic and Latinx immigrants' experiences with weather hazard communication, we also recognize that these findings may not be generalizable to other Latinx immigrant communities and other immigrant groups in the U.S. We hope this study can expand our understanding of some of the factors that need to be considered when communicating crucial weather hazard information to diverse communities.

Future research can take several directions as a result of our study. While participants in this study recognized the importance of Spanish-language WEA messages in imminent disasters, little is known whether the current format of bilingual WEA messages are effective on a national scale. Nationwide surveys of U.S. Spanish speaking communities should evaluate the efficacy of WEA messages and explore whether some message characteristics need to be fine-tuned when

translating to other languages. While this study explored milling processes in areas with no multilingual television programming, it is also worth exploring how people seek information, formally or informally, in areas with Spanish-language networks. Lastly, future research should include other immigrant communities and analyze whether their milling processes differ from the ones of our participants.

CONCLUSION

While Hispanic and Latinx immigrants felt unprepared for what came on December 10–11, 2021, the community ultimately came together. Despite the setbacks and obstacles presented from a system that does not work for them, immigrant populations found innovative solutions in near-impossible situations. Moving to the U.S. is no easy feat; familiarizing oneself with the potential hazards and risks makes it even harder. For U.S. Hispanic and Latinx immigrants, not only do they have to gain generational knowledge of disasters that may affect them, but they also must know where to find it. The weather, water, and climate enterprise must rise to the challenge and serve these communities, starting with creating communications they can receive, understand, and use. After all, the NWS mission statement vows to protect *all* life and property.

DATA AVAILABILITY STATEMENT

All de-identified transcripts from the field that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPLEMENTAL MATERIALS

Appendixes S1 and S2 are available online in the ASCE Library (www.ascelibrary.org).

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TABLES

Table 1. Examples of WEA messages in English and Spanish disseminated by the NWS as the “quad-state tornado” passed through Graves County, KY on December 10th, 2021.

	English	Spanish
90-character WEA	NWS: TORNADO EMERGENCY til 10:15 PM CST. Tornado spotted in this area. Take shelter now!	SNM:EMERGENCIA DE TORNADO hasta las 10:15 PM CST. Tornado fue detectado. Refugiarse ahora
360-character WEA	National Weather Service: TORNADO EMERGENCY until 10:15 PM CST. Tornado spotted in this area. This is a life-threatening situation. Take shelter now in a basement or an interior room on the lowest floor of a sturdy building. If you are outdoors, in a mobile home, or in a vehicle move to the closest substantial shelter and protect yourself from flying debris.	SNM: EMERGENCIA DE TORNADO hasta las 10:15 PM CST. Un tornado ha sido detectado en esta area. Su vida esta en peligro. Busque refugio en un sotano o en el interior de un cuarto del nivel mas bajo de un edificio seguro. Si esta al aire libre, en una casa movil, o en un vehiculo, debe ir al edificio seguro mas cercano y protegerse de proyectiles.

Note. All WEAs are issued in its 90-character format. Since 2019, alerting authorities can also disseminate 360-character WEAs. If both formats are relayed, the mobile carrier will only send the 360-character WEAs to compatible mobile devices that have at least a 4G LTE network. *All* users receive WEA messages in English. Alerting agencies can also send a Spanish-language WEA to users that 1) set their phone’s language to Spanish and 2) have at least a 4G LTE network. Recently, the NWS coded their weather-hazard WEAs to translate instantly into Spanish. More information can be found in FEMA (n.d.) and NWS (n.d.).

Table 2. Demographics of Participants Interviewed

Gender	Proportion of Sample (<i>N</i> = 25)
Male (<i>n</i> = 10)	40%
Female (<i>n</i> = 15)	60%
Ethnicity	
Hispanic or Latino (<i>n</i> = 22)	88%
Not Hispanic or Latino (<i>n</i> = 3)	12%
Location	
Jonesboro, Arkansas (<i>n</i> = 7)	28%
Mayfield, Kentucky (<i>n</i> = 16)	64%
Bowling Green, Kentucky (<i>n</i> = 2)	8%
Community Role	
Community Leaders (<i>n</i> = 9)	36%
Hispanic and Latinx Immigrants (<i>n</i> = 16)	64%

FIGURES

Fig. 1. The Hispanic and Latinx population (top) and its growth over the last decade (bottom) with tornado tracks from December 10-11, 2021. Population data was gathered from the U.S. Census Bureau (2010a, 2010b, 2020a, 2020b).

Fig. 2. The “Quad-State Tornado” and its warnings issued by the NWS (Image by TheAustinMan is licensed under [CC BY-SA4.0](https://creativecommons.org/licenses/by-sa/4.0/)).

Fig. 3. Researchers conducting interviews in affected communities in Arkansas and Kentucky (Images by authors).