Systemic Vulnerabilities Created an Informal Warning System for U.S. Hispanic and Latinx Immigrants in the 2021 Quad-State Tornado Outbreak

Joseph E. Trujillo-Falcón[1], América R. Gaviria Pabón[2], Justin Reedy[3], and Kimberly E. Klockow-McClain[4]

[1] Graduate Research Assistant, Cooperative Institute for Severe and High-Impact Weather Research and Operations and NOAA National Severe Storms Laboratory, and Ph.D. Student, Dept. of Communication, Univ. of Oklahoma, Norman, OK 73019 (corresponding author). Email: joseph.trujillo@noaa.gov

[2] Graduate Research Assistant, Institute for Public Policy Research and Analysis, and Ph.D. Student, Dept. of Geography and Environmental Sustainability, Univ. of Oklahoma, Norman, OK 73019. Email: america.gaviria@ou.edu

[3] Associate Professor, Dept. of Communication, and Research Associate, Institute for Public Policy Research and Analysis, Univ. of Oklahoma, Norman, OK 73019. Email: jreedy@ou.edu

[4] Research Scientist, NOAA National Severe Storms Laboratory, 120 David L Boren Blvd, Norman, OK 73072. Email: kim.klockow@noaa.gov

ABSTRACT

On December 10-11, 2021, a tornado outbreak in Arkansas, Kentucky, Missouri, and Tennessee became the deadliest December tornado event in U.S. history. Due to a lack of multilingual programming in these areas, post-disaster coverage omitted the perspectives of many vulnerable groups that were impacted by these tornadoes. A week-long field study was conducted in Arkansas and Kentucky to understand how Hispanic and Latinx immigrants responded to the historic tornado event. Connecting with local organizations, we interviewed 25

immigrants, community leaders, and government officials. Social vulnerabilities, such as language proficiency, immigration status, and varying cultures of disaster preparedness, are examined and discussed as potential blockades to inclusive disaster planning and response. Themes are contextualized into Mileti and Sorensen's warning response model. Findings indicate that U.S. Hispanic and Latinx immigrants developed informal warning systems and relied mainly on unofficial sources that had no expertise in severe weather forecasting and communication, such as community leaders and family members. We conclude with practical recommendations and elevate the importance of multilingual Wireless Emergency Alerts, visual and auditory information in Spanish for illiterate communities, and the importance of educational campaigns that focus on fundamental hazard understanding and implications.

PRACTICAL APPLICATIONS

During the December 10-11, 2021 tornado outbreak, immigrant populations in Kentucky, Arkansas, and Tennessee were disproportionately affected by disaster due to unequal access to disaster warnings and information, cultural barriers to understanding, and their immigration status. Immigrants created an informal warning system, where they mainly relied on unofficial sources for life-saving information.

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 nocturnal EF-4 tornadoes, now nicknamed the "quad-state tornado." The National Centers for Environmental Information (2022) estimated $4 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). 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 resources before, during, and after the outbreak. Reported by Sandoval (2021), a tragic incident at a local candle factory exposed inequities within immigrant populations after they were allegedly forced to work through a tornado. Additionally, with the lack of Spanish-language programming, many were not aware of the incoming threat overall. 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 overall foreign-born population has increased by 21% in Arkansas, 34% in Kentucky, 18% in Missouri, and 27% in Tennessee in the last decade. Unless cultural and language disparities in hazard communication are addressed, underserved communities 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 2021 quad-state tornado outbreak, researchers from the NOAA National Severe Storms Laboratory interviewed practitioners and members of the public 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 tornado hazards 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 quad-state tornado outbreak are described in detail. Third, stories from Hispanic and Latinx immigrant communities are shared. We find that the following barriers inhibited immigrant populations from taking action in the Kentucky tornado: 1) language barriers, 2) varying cultures of disaster preparedness, 3) undocumented immigration status, and 4) inaccessible messages and resources. These vulnerabilities led to a development of an informal warning system that, to this day, has not been documented in academic literature for severe weather hazards.

MILETI AND SORENSEN'S WARNING 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, 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 must 5) take protective action. Using this theoretical framework, it is important to understand the prejudices that our current

emergency system imposes on underserved communities, especially since emergency systems are monolinguistic and rooted in systemic injustice for marginalized groups (Onís et al. 2021). For the purpose of this manuscript, we explore inequities under the lens of Hispanic and Latinx immigrants in the United States.

Following Mileti and Sorensen (1990)'s model, 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, after finding that the NWS and Federal Emergency Management Agency (FEMA) use different translations for tornado watch and warning, Trujillo-Falcón et al. (2022) revealed significant language inequities: while 79% of English speakers correctly identified the definition of a tornado warning, only 60% of Spanish speakers were able to identify the description correctly. Until the disaster enterprise can come together and provide consistent translations of scientific and risk terminology, bilingual communities will not have the proper resources to understand the phenomenon they are supposed to be taking protective action against.

When it comes to **believing**, or trusting the accuracy of information (Mileti and Peek 2000), underserved groups do not have many credible sources at their disposal. For immigrants or family members that have connections with immigrants, the history of family separation and deportation by U.S. government agencies has caused distrust of government organizations among

the most underserved in disaster contexts (Fussell et al. 2018). For example, Méndez et al. (2020) describe instances where local officials did not provide personal protective equipment for immigrant farm workers that were forced to work during a record-breaking wildfire. Continued mistreatment of immigrant populations can lead them to rely less on credible experts for safety and recovery information (Maldonado et al. 2015). In an emergency system that overlooks underserved groups, it can be tougher to find information they can thoroughly trust.

Personalizing risk, or the process of recognizing that one is susceptible to danger (Wood et al. 2017), 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). In order to mend these divides, disaster research and practices need to acknowledge instances of disaster linguicism and improve the emergency communication system, so it is multicultural, multilingual, and multifaceted for all affected populations in the U.S.

Combining the three challenges in understanding, believing, and personalizing risk information, underserved groups must find innovative ways to **mill**, or gather information informally, to ultimately **take protective action** (Lindell and Perry 2012; Wood et al. 2017). 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 programming and weather applications, some immigrant communities are at a disproportionate disadvantage for receiving reliable information from multiple sources.

Reviewing and problematizing Mileti and Sorensen's (1990) warning response model, it is evident that underserved populations may not follow all the given steps that the framework offers. By not incorporating cultural and linguistic perspectives into life-saving information, current risk communication recommendations only benefit a fraction of the served community. In addition, by not exploring historical and systemic inequities, like family separation and immigration, previous studies have left the most vulnerable populations in the shadows (Fussell et al. 2018). Our study conceptualizes Mileti and Sorensen's (1990) model and expands it to consider multicultural and multilingual communities by posing the following question:

*RQ: How did Hispanic and Latinx immigrants **understand**, **believe**, **personalize**, and **mill** risk and information during the 2021 quad-state 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. 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, west 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. The EF-4 tornado crossed into southeastern portions of Missouri and eventually dissipated in western Tennessee. After a short 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. Overall, the supercell thunderstorm persisted for over 250 miles (Fig. 2).

Tornadoes produced from this supercell thunderstorm have been referred to as the "quad-state tornadoes," alluding to the infamous tri-state tornado– the longest-tracked tornado in U.S. history at over 219 miles (Johns et al. 2013). Aside from the “quad-state tornadoes,” multiple lines of storms also produced strong and long-lived tornadoes. One in particular affected more central parts of Kentucky and Tennessee. The storms finished course near the border of Ohio overnight and eventually dissipated due to decreasing 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 moved directly through town. 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. 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 quad-state tornado outbreaks 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 tornado outbreak to learn about vulnerabilities and inequities experienced during this disaster. The team deployed from February 27th – March 5th, 2022 and interviewed government officials, NWS forecasters, emergency managers, and members of the public. For the purpose of this manuscript, we will focus specifically on responses from the immigrant and Hispanic/Latinx community.

Interview questions focused on five broad themes 1) weather awareness in the participants' native country, 2) weather awareness in the U.S., 3) warning reception, understanding, and response during the quad-state tornado outbreak, 4) trust in government and media, and 5) immigration status limitations (see Appendices S1 and S2). The interview guide was first developed in English so that risk communication experts could review the material but was later translated to Spanish by the first and second authors. To guarantee dialect-neutrality, the survey 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. To address sensitive issues, such as documentation status in the U.S., all participants' identities are anonymized throughout this study and are given pseudonyms. Prior to interviews, the 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 immigrant workers, residents, and community leaders (Table 1). We conducted semi-structured interviews in English and Spanish, depending

on the language preference of the interviewee. 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 immigrants and non-English speakers that would provide valuable insights into how a warning system may function for multicultural and multilingual people living in the U.S.

To reach these underserved populations, our team connected with community partners prior to conducting the field study. Trusted leaders in each city personally reached out to members of the community who were directly or indirectly affected by the tornado outbreak and asked whether they would be interested in participating in an interview. 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. In Bowling Green, our main point of contact involved the International Communities Liaison of the City of Bowling Green. Interviews were conducted in community centers, faith institutions, schools, and homes of immigrants (if invited) (Fig. 3).

Research Ethics

Though there is no universal code of conduct when conducting social science disaster research (Gaillard and Peek 2019), our team ensured we respected the local voices of these communities and approached them with a clear purpose: to elevate perspectives of the underserved to enhance risk communication strategies in the future. We took the time and effort to connect with trusted partners to better understand the culture and background of the people with whom we were about to speak. After our interviews were finalized, we devoted time to give back to the community and assisted them with recovery efforts. Additionally, 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, 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 spoke 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, we used a qualitative thematic analysis following the six-step strategy of Braun and Clarke (2006): 1) become familiar with the data, 2) generate initial codes, 3) search for themes, 4) review themes, 5) define themes, and 6) write-up. Our team used NVivo 12, a qualitative data analysis computer software package. First, we became familiar with the data by transcribing audio files and revising them for clarity. In total, we transcribed over 248 pages worth of conversation. After an initial skim of the data, we took memos and notes in the NVivo software to continue the familiarization process. Second, codes were created on how Hispanic and Latinx immigrants 1) understood, 2) believed, 3) personalized, and 4) milled tornado information. Third, searching for themes involved finding examples for each initial code. Fourth, notes were taken about the codes and were further reviewed. Fifth, themes were defined after the review was finalized. Finally, an analysis was conducted by the implementation of examples. Examples were then taken into account with the original research question in mind and some quotes 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 outbreak spoke a diverse set of languages and experienced trouble **understanding** life-saving information that was provided only in English. During the tornado outbreak, victims did not have any multilingual programming or meteorologist to guide them through the disaster. Information availability, then, 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, well, there was notice when [the tornado] almost happened. There was more 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."*
>
> *– 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 Wireless Emergency Alerts (WEAs; i.e., automated warnings) on their phones in English. Since they could not understand the message, they admitted to ignoring them. A fourth notification, which likely came from a mobile application they had at the time, translated the warning into Spanish, causing them to go to the first floor and seek protective action:

> *"10 minutes before the tornado, we received the last warning notification in Spanish since the previous ones were all in English. [If I did not receive the notification in 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*

Unfortunately, some immigrants did not have the same luck and were left with no information before, during, and after the tornado outbreak. A participant in Arkansas admitted she tried keeping up with the information in English since it was all they had. However, much of the communication was flooded with scientific and meteorological terminology, causing her 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."

– Carmen, Mexican Immigrant 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 Immigrant in Bowling Green

Beyond spoken language, it is important to highlight that, though it does not represent a majority of the population, some immigrants expressed that their inability to read inhibited 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 outweighs 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 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:

> *"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 immigrant 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 Immigrant in Jonesboro*

In addition to weather unfamiliarity, some immigrants emphasized that their home countries do not have formalized emergency systems or 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, they more easily adapted to the U.S. warning system, including knowing what information sources they can trust and having the ability to 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, an immigrant (and 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 and I realized that I really was not prepared for what was going to happen."

– Carmen, Mexican Immigrant 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 the 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. The notifications from community leaders, along with WEA alerts, initiated a milling process during the tornado outbreak. As soon as participants heard a notification they *understood*, they immediately went looking for other (often *informal*) resources:

> *"We started receiving alerts from our phones and our priest, so I ask 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.'"*

– Elisa, Mexican Immigrant 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:

> *"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 Immigrant in Bowling Green*

DISCUSSION

Theoretical Contributions: The Informal Warning System

As defined by Cutter et al. (2003), social vulnerability represents the characteristics a community has that makes them susceptible to the damaging impacts or effects of a hazard (see also Fitzpatrick and Spialek 2020; Fothergill 2004). 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 vulnerability 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 where no multilingual programming is available, residents were left trying to decipher key messages during the tornado outbreak in a "foreign" (to them) language. Meteorological jargon in English inhibited communities from comprehending any potential threats and their estimated time of arrival. Participants admitted that, if they did not understand the message, it would increase the chances of ignoring the message altogether. 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 not having reliable television networks in their language prevented them from staying updated during the most critical moments of the outbreak. 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 in Spanish (Abukhalaf and von Meding 2021; Trujillo-Falcón et al. 2021).

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 the majority of Latin America countries not having climates that support tornado hazards, many immigrants could not contextualize and personalize weather information. On the other hand, immigrants who have lived in the U.S. for decades were more keen in understanding the intricacies of the 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 widely can vary widely simply from being in the U.S. even a couple of years longer.

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 cultural and language barriers, they were only limited to *informal* sources. To be clear, the majority of these informal sources were not experts in meteorology or disaster preparedness. As a matter of fact, most of them were also not familiar with tornado hazards and emergency systems in the U.S. 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 broke 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).

Contrary to the model proposed by Mileti and Sorensen (1990), immigrants did *not* rely on a formal warning system to seek shelter nor take action during a disaster. Instead, they counted on social networks, mobile phones, word of mouth, and translated messages from community leaders. Future research needs to consider the role of informal warning systems in populations that are historically marginalized and how much of an influence these informal systems hold for other underserved communities, such as African Americans and other indigenous groups. Emergency preparedness practitioners and scholars should acknowledge

these vulnerabilities faced by marginalized populations and consider revisiting our core frameworks in an effort to ensure that *all* communities are safe from disaster.

Practical Recommendations

In addition to theoretical insights, our study provides practical solutions that can be implemented in areas across the U.S. that do not have readily available, multilingual resources. Our research supports the 1) incorporation of WEA messages in Spanish, 2) implementation of multilingual coverage in broadcast markets, and 3) educational material focused on fundamental weather hazards in the U.S. While creating the ideal situation will involve a funded and established multilingual emergency system, the following recommendations can serve as "low-hanging fruit" for many risk communicators and practitioners interested in reaching the most vulnerable groups in their area(s) before, during, and after disaster.

First, our research supports the expansion of WEA into other languages, as it was a principal information source for immigrants during the tornado outbreak. Even for those that were not well-versed in U.S. hazards and emergency systems, the immigrant populations interviewed in our study agreed that WEAs can provide information gaps for those who do not know where to find credible information, and if translated to other languages, could serve as a life-saving tool. WEA was recently updated to support Spanish-language messages nationwide (FCC 2021). We recommend that federal agencies support initiatives that incorporate these services into areas across the U.S., especially those areas that do not have multilingual television markets that can provide critical, life-saving information (such as Arkansas and Kentucky).

Second, while it is important to implement multilingual textual information, like WEAs, immigrants expressed interest in receiving visual and auditory information for members of their community that cannot read. In areas where there are only English-language news outlets,

broadcasters can incorporate multilingual information in their social media platforms or even as part of their news coverage. Some stations have begun experimenting with potential avenues and have found great success. For example, KBTX, a television station in College Station, TX, does not have bilingual meteorologists on staff; however, during potential significant severe weather outbreaks, meteorologists create a weather briefing and forward it to a bilingual speaker in their newsroom, who then translates it and shares it on social media (https://fb.watch/f2Ze0GLv2u/). Since most immigrants relied on informal sources, this small addition could also create an avenue for more immigrants to receive credible information from scientists and risk communicators.

Finally, to address disaster subcultures and the varieties of emergency preparedness cultures among immigrants, we recommend the creation of educational materials that overview 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. Leaders within the NWS have begun to translate educational materials into Spanish and have even made premade captions in both languages so that it is easily accessible for someone willing to share it on social media. 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 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 will introduce the Centro Hispano with the NWS Memphis WFO for future collaborations, including possible educational and outreach campaigns in Spanish. Additionally, we have worked together with Chief Meteorologist Ryan Vaughn of KAIT8 News to help bring automated watch and warning information in Spanish during significant events. In Bowling Green, we connected the International Communities Liaison with bilingual staff from the NWS Louisville WFO. Plans are underway 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. Rather, we hope this study can provide a framework for understanding some of the factors that need to be considered when communicating crucial weather hazard information to diverse communities.

CONCLUSION

While Hispanic and Latinx immigrants felt unprepared for what came in December 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 have to 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.

ACKNOWLEDGEMENTS

This article is dedicated to the resilient, courageous immigrants in the U.S. that fight for a better tomorrow. Special gratitude goes to the Centro Hispano, the Mayfield Independent School District, and the City of Bowling Green for their kind collaboration and contribution. We also want to express our appreciation to Cassandra Shivers-Williams and Gretchen Montgomery for insightful review and to Jonathan Thornton for his contributions to Figure 1. Funding was provided by NOAA/Office of Oceanic and Atmospheric Research under NOAA-University of Oklahoma Cooperative Agreement #NA21OAR4320204, U.S. Department of Commerce.

SUPPLEMENTAL MATERIALS

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

REFERENCES

Abukhalaf, A. H. I., and J. von Meding. 2021. "Psycholinguistics and emergency communication: A qualitative descriptive study." *Int. J. Disaster Risk Reduct. 55*(2): 102061. https://doi.org/10.1016/j.ijdrr.2021.102061.

Aguirre, B. E. 1988. "Feedback from the field: The lack of warnings before the Saragosa tornado." *Int. J. Mass Emergen. Disasters* 6(1): 65-74. http://www.ijmed.org/articles/133/download/.

Anderson, W. A. 1965. *Some observations on a disaster subculture: The organizational response of Cincinnati, Ohio, to the 1964 flood*. Columbus, OH: Disaster Research Center.

Braun, V., and V. Clarke. 2006. "Using thematic analysis in psychology." *Qual. Res. Psychol.* 3(2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

Bullington, J. 2021. "A tornado killed 9 people at the Mayfield candle factory. Here are their names." *Courier Journal,* December 15, 2021.

Cutter, S. L., B. J. Boruff, and W. L. Shirley. 2003. "Social vulnerability to environmental hazards." *Soc. Sci. Q.* 84(2): 242-261. https://doi.org/10.1111/1540-6237.8402002.

FCC (Federal Communications Commission). 2022. "Multilingual alerting for the Emergency Alert System and Wireless Emergency Alerts." Accessed August 15, 2022. https://www.fcc.gov/MultilingualAlerting_EAS-WEA.

Fitzpatrick, K. M., and M. L. Spialek. 2020. *Hurricane Harvey's aftermath: Place, race, and inequality in disaster recovery.* New York: NYU Press.

Fothergill, A. 2004. *Heads above water: Gender, class, and family in the Grand Forks flood*. Albany, NY: SUNY Press.

Fussell, E., L. Delp, K. Riley, S. Chávez, S., and A. Valenzuela Jr. 2018. Implications of social

and legal status on immigrants' health in disaster zones. *Am. J. Public Health* 108(12): 1617-1620. https://doi.org/10.2105/AJPH.2018.304554.

Gaillard, J. C., and L. Peek. 2019. "Disaster-zone research needs a code of conduct." *Nature* 575: 440-442. https://doi.org/10.1038/d41586-019-03534-z.

Johns, R. H., D. W. Burgess, C. A. Doswell III, M. S. Gilmore, J. A. Hart, and S. F. Piltz. 2013. "The 1925 Tri-State tornado damage path and associated storm system." *Electronic J. Severe Storms Meteor.* 8(2): 1-33. https://ejssm.org/archives/2013/vol-8-2-2013/.

Krocak, M., J. Ripberger, A. Bitterman, C. Silva, H. Jenkins-Smith, J. E. Trujillo-Falcón, and A. Gaviria Pabón. 2022. "The 2021 Severe Weather and Society Spanish Survey." Harvard Dataverse. Accessed August 1, 2022. https://doi.org/10.7910/DVN/IZNQVA.

Lindell, M. K., and R. W. Perry. 2012. "The protective action decision model: Theoretical modifications and additional evidence." *Risk Anal.* 32(4): 616-632. https://doi.org/10.1111/j.1539-6924.2011.01647.x.

Méndez, M., G. Flores-Haro, and L. Zucker. 2020. "The (in)visible victims of disaster: Understanding the vulnerability of undocumented Latino/a and indigenous immigrants." *Geoforum* 116: 50–62. https://doi.org/10.1016/j.geoforum.2020.07.007.

Mileti, D. S., and J. H. Sorensen. 1990. *Communication of emergency public warnings*. ORNL-6609. Oak Ridge, TN: Oak Ridge National Laboratory.

Mileti, D. S., and L. Peek. 2000. "The social psychology of public response to warnings of a nuclear power plant accident." *J. Hazard. Mater.* 75(2): 181–194. https://doi.org/10.1016/S0304-3894(00)00179-5.

National Centers for Environmental Information. 2022. "U.S. billion-dollar weather and climate disasters." NOAA. Accessed April 1, 2022. https://doi.org/10.25921/stkw-7w73.

NWS. 2021a. “NWS Storm Damage Summaries: Dec 10-11, 2021 Tornado Outbreak.” Accessed April 1, 2022. https://www.weather.gov/crh/dec112021

NWS. 2021b. “Dec 10, 2021 1630 UTC Day 1 Convective Outlook.”Accessed April 1, 2022. https://www.spc.noaa.gov/products/outlook/archive/2021/day1otlk_20211210_1630.html.

Onís, C. M. de, E. Cubelos, M. del Rocio Ortiz Chavarria. 2021. “‘No había humanidad’: Critiquing English monolingualism and other entwined systems of white supremacy in local emergency management responses.” *Soc. Justice* 47(1/2): 135-170. http://www.socialjusticejournal.org/wp-content/uploads/2021/05/159_06_de-Onis.pdf.

Robinson, S.E., J. M. Pudlo, and W. Wehde. 2019. “The new ecology of tornado warning information: A natural experiment assessing threat intensity and citizen-to-citizen information sharing.” *Public Admin. Rev.* 79(6): 905–16. https://doi.org/10.1111/puar.13030

Sandoval, E. 2021. “Tornado news: Death toll rises as states assess damage.” *The New York Times,* December 12, 2021.

Sandoval, E., and R. Fausset. 2021. “In a small Kentucky town, the candle factory was a lifeline for its workers.” *The New York Times*, December 16, 2021.

Seeger, M. W., and T. L. Sellnow. 2016. *Narratives of crisis: Telling stories of ruin and renewal*. Stanford University Press.

Siemaszko, C. 2022. “Kentucky candle factory destroyed by deadly tornado is closing.” *NBC News*. January 18, 2022.

Tompkins, A. 2021. Meet the local news meteorologist whose forecast saved lives in Kentucky. *Poynter*. December 14, 2021.

Tracy, S. J. 2019. *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact (2nd ed.)*. Wiley-Blackwell.

Trujillo-Falcón, J.E., O. Bermúdez, K. Negrón-Hernández., J. Lipski, E. Leitman, and K. Berry. 2021. "Hazardous weather communication en español: Challenges, current resources, and future practices." *Bull. Amer. Meteorol. Soc.,* 102(4): 765-773. https://doi.org/10.1175/BAMS-D-20-0249.1.

Uekusa, S. 2019. "Disaster linguicism: Linguistic minorities in disasters." *Lang. Soc.* 48(3): 353-375. https://doi.org/10.1017/S0047404519000150.

U.S. Census Bureau. 2010a. "P2: Hispanic Or Latino, And Not Hispanic Or Latino By Race." 2010 Decennial Census. Accessed May 15, 2022. https://data.census.gov/cedsci/.

U.S. Census Bureau. 2010b. "DP02: Selected social characteristics in the U.S." 2010 Decennial Census. Accessed May 15, 2022. https://data.census.gov/cedsci/.

U.S. Census Bureau. 2020a. "P2: Hispanic Or Latino, And Not Hispanic Or Latino By Race." 2020 Decennial Census. Accessed May 15, 2022. https://data.census.gov/cedsci/.

U.S. Census Bureau. 2020b. "DP02: Selected social characteristics in the U.S." 2020 Decennial Census. Accessed May 15, 2022. https://data.census.gov/cedsci/.

Wenger, D. E., and J. M. Weller. 1973. *Disaster subcultures: The cultural residues of community disasters*. Newark, DE: Disaster Research Center, The University of Delaware.

Wood, M. M., D. S. Mileti, H. Bean, B. F. Liu, J. Sutton, and S. Madden. 2018. "Milling and public warnings." *Environ. Behav.* 50(5): 535–566. https://doi.org/10.1177/0013916517709561

TABLES

Table 1. Demographics of Participants Interviewed

Gender	Proportion of Sample ($N = 25$)
Male ($n = 10$)	40%
Female ($n = 15$)	60%
Ethnicity	
Hispanic or Latino ($n = 22$)	88%
Not Hispanic or Latino ($n = 3$)	12%
Location	
Jonesboro, Arkansas ($n = 7$)	28%
Mayfield, Kentucky ($n = 16$)	64%
Bowling Green, Kentucky ($n = 2$)	8%
Community Role	
Government Officials ($n = 1$)	4%
Community and Nonprofit Officials ($n = 8$)	32%
Immigrant Workers and Residents ($n = 16$)	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).

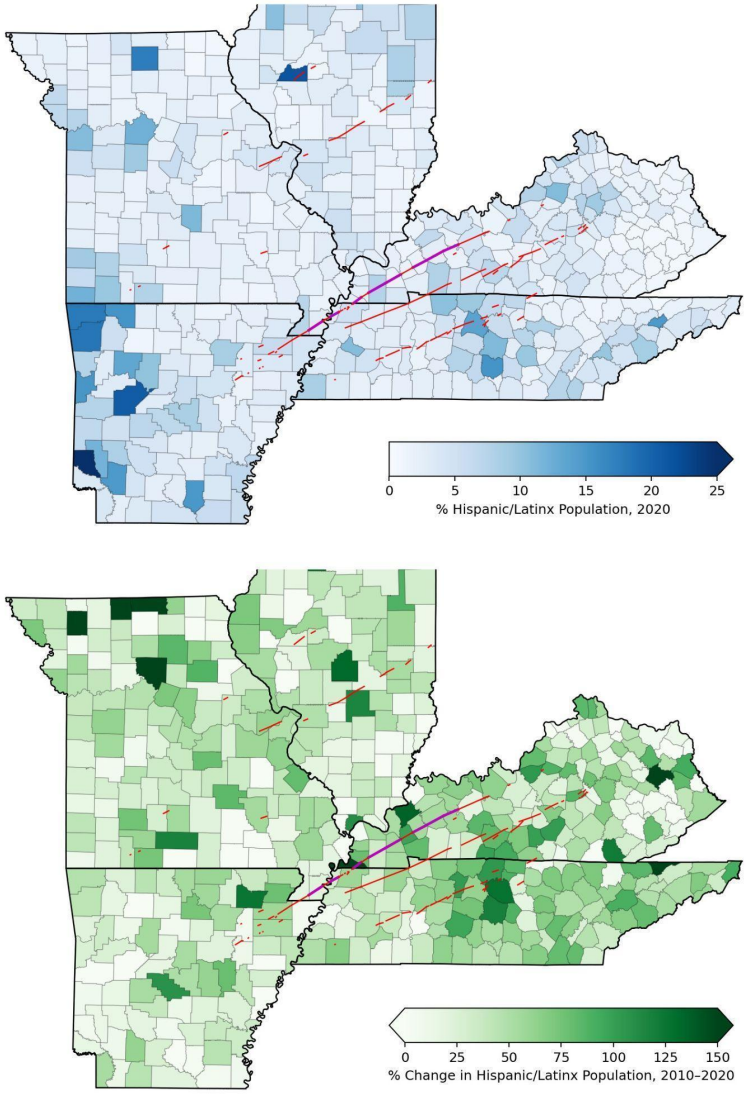

Fig. 2. The "Quad-State Tornado" and its warnings issued by the NWS (Image by TheAustinMan is licensed under CC BY-SA4.0).

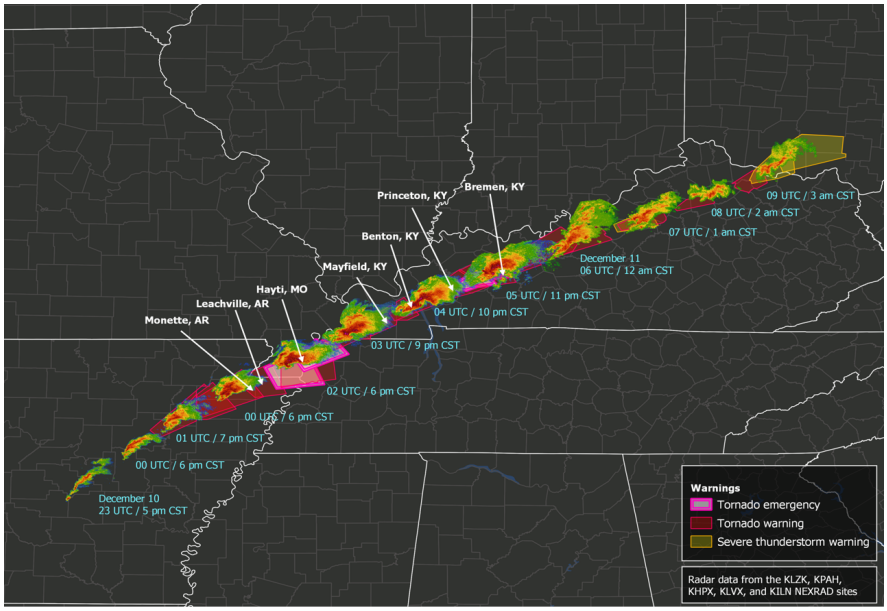

Fig. 3. Researchers conducting interviews in affected communities in Arkansas and Kentucky (Images by authors).