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MAS ALLÁ DE LAS PALABRAS: LANGUAGE, CULTURE, AND MEANING IN SPANISH TROPICAL WEATHER MESSAGES

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By AMERICA ROSARIO GAVIRIA PABÓN

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MAS ALLÁ DE LAS PALABRAS: LANGUAGE, CULTURE, AND MEANING IN SPANISH TROPICAL WEATHER MESSAGES

A DISSERTATION APPROVED FOR THE

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL SUSTAINABILITY

BY THE COMMITTEE CONSISTING OF

Dr. Mark Shafer, Chair

Dr. Renee McPherson

Dr. Jacqueline M. Vadjunec

Dr. Joseph T. Ripberger

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Abstract

The Spanish-speaking population in the United States continues to grow, and Spanish is currently the second most spoken language in the country. Despite this demographic shift, most weather risk information provided by the National Weather Service (NWS) is primarily produced in English. To improve accessibility, recent efforts have explored the use of artificial intelligence to translate weather information into Spanish. However, it is important to evaluate whether these translations effectively communicate risk and support appropriate warning responses among Spanish speakers. In addition, is important to recognize that Spanish speakers come from different cultural backgrounds, disaster subcultures, and lived experiences that shape their risk perceptions and warning responses to tropical weather information

This dissertation focuses on the communication of tropical weather messages and examines how Spanish-speaking communities interpret and respond to translated alerts. Using a mixed-methods approach, the study combines quantitative survey data with qualitative interviews. The first part of the research uses a survey experiment to examine how Spanish speakers evaluate the quality of AI-generated translations of tropical weather alerts and how these perceptions influence warning responses (understanding, belief, perrsonalization, self-efficacy and response-efficacy).

Through interviews, the second part of the dissertation explores how lived experiences, cultural backgrounds, and disaster subcultures shape how Spanish speakers perceive tropical hazards and respond to warnings. These interviews also help identify gaps in the information currently provided to Spanish-speaking communities and highlight barriers that may affect access to or understanding of weather risk information.

Together, these complementary studies provide a more comprehensive understanding of how translation quality, lived experiences, and cultural context influence warning interpretation and response. The findings aim to provide recommendations to improve the accessibility, clarity, and effectiveness of tropical weather communication for Spanish-speaking communities in the United States.

Chapter 1: Introduction

Challenges in Risk Communication

Diverse Populations

The United States experiences a wide range of weather phenomena due to its vast geography and diverse climate zones. From region to region, the types of hazards people face vary significantly. For instance, residents in the southern U.S. are more accustomed to severe thunderstorms and tornadoes, while those in coastal areas like Florida and Houston are frequently exposed to hurricanes. Meanwhile, individuals living in the Northeast are more likely to encounter winter storms and nor'easters. Given this variability, it is crucial to communicate weather hazards risks clearly and effectively across all regions, especially as these threats continue increasing and demand immediate action. The National Weather Service (NWS) is tasked with the federal responsibility of providing weather, water, and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy (NWS website 2025). Therefore, the NWS must consider the different populations that are likely to receive and make use of these messages when issuing this information.

As the United States becomes increasingly diverse, communicating weather risk information to culturally and linguistically varied populations such as Spanish-speaking communities requires an understanding of how these groups interpret, perceive, and respond to weather warnings (Trujillo-Falcón et al. 2021, 2022, 2024; Gaviria-Pabón et al. 2025). Cultural background, language, and lived experience all shape how people react to risk (Gaviria-Pabón 2022; Morss et al. 2020; Trujillo-Falcón et al. 2024). While English remains the primary

language used in official weather communication, this creates a significant gap in protection for individuals who are not fluent in English.

According to the U.S. Census Bureau, between 1980 and 2019, the number of individuals in the United States who spoke a language other than English at home grew significantly from 23.1 million to 67.8 million (Dietrich & Hernandez 2022). Among these, Spanish stands out as the most widely spoken non-English language, primarily due to the Hispanic population being the largest minority group in the country. In fact, Spanish is spoken in 62% of non-English-speaking households, a figure that is roughly 12 times higher than those speaking the next most common languages: Chinese, Tagalog, Vietnamese, and Arabic (Dietrich & Hernandez, 2022). The U.S. Census Bureau stated in 2024 that "the Hispanic population is expanding at a substantially faster rate than the non-Hispanic population" (U.S. Census Bureau 2024). The growth of the Hispanic/Latino population further amplifies the urgency to ensure that weather warnings are both accessible and understandable to Spanish speakers. Barriers such as limited English proficiency, literacy challenges, unfamiliar terminology, and inadequate access to bilingual resources continue to hinder the effectiveness of risk communication within these communities (Mast & Ruiz 2023; Trujillo-Falcón et al. 2022, 2024; Aguirre 1988).

Research consistently shows that risk perception is not uniform; it is shaped by community specific concerns, histories, and values (Sutton et al. 2021; Morss et al. 2020; Mileti & Sorensen 1990; Burns & Slovic 2012). For Spanish-speaking populations, the lack of linguistically and culturally relevant information can hinder comprehension and delay protective decision-making (Aguirre 1988). Trujillo-Falcón et al. (2022, 2024) emphasize that barriers related to language proficiency and limited access to bilingual resources are among the most significant obstacles to effective risk communication Delivering weather warnings in both

Spanish and English broadens accessibility and helps build trust, ensuring that critical messages reach individuals no matter what language they speak.

Bridging Language Gaps in Weather Risk Communication

Effective communication of weather risk information is essential so that Spanish-speaking communities can take protective actions. The accuracy of translations, particularly when conveying immediate threats, plays a critical role in ensuring that Spanish-speaking communities receive, comprehend, and act upon crucial information.

Accuracy, readability, acceptability, and satisfaction are critical factors in evaluating the quality of translated messages (Koby et al. 2014; Castillo 2015; Castilho and O'Brien 2017). When combined, these factors determine whether a translation not only informs but also resonates, a critical distinction for weather communication. According to McDonald (2022), a high-quality translation must accurately convey the original meaning, be easily understood by the intended audience, and align with their cultural norms and expectations. Castilho and O'Brien (2017) emphasize that acceptability reflects whether a translation meets the social and cultural standards of the target audience, which is especially important when communicating life-saving information. They also highlight satisfaction as an important evaluation criterion, as it captures how users perceive the overall quality and usability of a translation beyond technical accuracy (Castilho and O'Brien 2017). Additionally, Koby et al. (2014) argue that readability and clarity are essential for ensuring that warnings are properly understood and acted upon.

Efforts to improve communication with Spanish-speaking communities have grown in recent years. Trujillo-Falcón et al. (2021) described several initiatives aimed at addressing this gap, including the NWS Spanish Outreach Team (SOT), the NWS Multimedia Assistance in Spanish

(MAS) team, the American Meteorological Society (AMS) Committee for Hispanic and Latinx, and a Spanish-language hurricane information website developed by The Extreme Events Institute's International Hurricane Research Center at Florida International University in partnership with the National Hurricane Center (NHC). Despite these advancements, challenges persist in providing translations that are both linguistically accurate and culturally meaningful.

For example, Trujillo-Falcón et al. (2022) documented inconsistencies in the translation of weather watches and warnings into Spanish, particularly noting that NWS translations of "tornado watch" and "tornado warning" conveyed a low sense of urgency. Bitterman et al. (2023) reported similar findings when analyzing SPC risk category translations in Spanish. Conflicting or unclear messages from different sources across the weather enterprise can lead to confusion, which may delay or prevent protective action. These issues underscore the complexity of translating not just words but meaning especially in high-stakes contexts like severe weather alerts.

Recognizing these challenges, and to increase access to weather risk information for multilingual communities in 2021, the NHC launched the NWS Artificial Intelligence (AI) Translation Program in partnership with academic and private-sector collaborators (Trujillo-Falcón et al. 2025). The program uses a human-in-the-loop framework in which bilingual forecasters review, correct, and retrain AI-generated translations to improve translation quality and operational consistency. In 2024 the NHC released its Spanish-language text products. This included a broader range of advisories and updates for both the Atlantic and eastern Pacific basins, such as Public Advisories, Tropical Cyclone Discussions, and Key Messages (National Hurricane Center 2024). These products will now use AI-generated translation techniques tested in 2023 and will replace previous translations provided by offices such as the NWS San Juan Forecast Office (U.S. Department of Commerce, National Oceanic and Atmospheric Administration 2023). While

this expansion represents a step forward in increasing language accessibility, it also raises important questions about translation quality, especially when speed and scale are prioritized through automation.

Emerging Technologies in Translation: The Role of AI

During imminent threats such as tornadoes, hurricanes, or flash floods where immediate action is required, unclear or poorly translated messages can lead to delays in protective decision-making or even complete inaction (Aguirre 1988; Trujillo-Falcón et al. 2024). The urgency of accurate and culturally appropriate communication becomes paramount in these situations. The importance of translating in weather risk communication goes beyond issuing warnings. Translations play a crucial role in ensuring that Spanish-speaking populations can prepare adequately for hazards, respond effectively when threats occur, and recover more confidently after disasters. Ensuring accuracy, clarity, and cultural relevance in these translations is not just a matter of language, it's a matter of safety, trust, and equity.

Study Overview

As tropical weather hazards become more frequent and communities in the United States become more multilingual, effective weather risk communication is a matter of public safety. Many Spanish-speaking communities especially in coastal areas such as Tampa, Florida depend on translated weather alerts to make decisions that protect their lives and families. While there have been important efforts to improve the translation of weather information, it is still unclear whether these improvements actually shape how Spanish speakers understand warnings and take action. This dissertation addresses that gap by examining whether improvements in translation quality influence Spanish speakers' warning response.

Spanish-speaking communities are not a single, uniform group. Spanish speakers in the United States come from different countries and regions and bring diverse cultural backgrounds, migration histories, and past experiences with hazards. These differences shape how individuals understand risk, interpret weather messages, and decide how to respond during hazardous events. As a result, even when translations improve in accuracy or clarity, people may still interpret and act on those messages in different ways. This diversity helps explain why translation quality alone may not fully capture warning response and motivates the second and third papers in this dissertation, which focus on lived experience, disaster subcultures, and the information Spanish speakers feel is missing from current weather risk communication.

The first paper focuses on how Spanish speakers evaluate the quality of AI-generated versus human-translated tropical weather alerts and whether higher-quality translations are associated with stronger warning response. The second paper shifts attention to lived experience, using phenomenology and the concept of disaster subcultures to examine how Spanish speakers make sense of weather messages based on their past experiences, cultural context, and everyday realities. The third paper explores what information Spanish speakers feel is missing, unclear, or insufficient in current weather risk communication and how these gaps affect their confidence and decision-making during hazardous events.

This research is grounded primarily in the Warning Response Model (Mileti and Sorensen 1990), which explains how people receive, understand, believe, personalize, and act on warning information. The Protective Action Decision Model (PADM) supports this framework by clarifying how message characteristics, social cues, and individual perceptions shape decision-making. Phenomenology and the concept of disaster subcultures further strengthen this approach by centering lived experience and place-based knowledge, highlighting how cultural background,

prior hazard experience, and social context influence how Spanish-speaking communities interpret and respond to translated weather messages. Together, these perspectives provide a strong foundation for examining not only whether translations improve, but whether those improvements meaningfully shape protective action among Spanish speakers.

This dissertation uses a mixed-methods approach that includes a nationwide survey and semi-structured interviews with Spanish-speaking individuals living in hurricane-prone regions. The interviews provide insight into how people's experiences shape the way they understand and make decisions based on weather risk information, how trust in those messages is built or weakened, and how cultural and linguistic factors shape response.

Overall, this dissertation contributes to both research and practice by centering the perspectives of Spanish-speaking communities. By focusing not only on whether translations have improved, but on whether those improvements actually influence warning response, this work offers guidance for creating clearer, more effective, and more culturally responsive weather communication that better supports protective decision-making

Frameworks for Understanding Risk and Response among Spanish-speaking communities

The Role of Social Factors to understand Spanish-speaking Communities Vulnerabilities

The foundational work of Blaikie, Wisner, Cannon, and Davis in their book *At Risk* (2004) reframes disasters as socially constructed phenomena shaped by political, economic, and social processes. They argue that disasters are closely linked to everyday vulnerabilities influenced by factors such as class, gender, ethnicity, immigration status, and disability (Blaikie et al. 2004, pp. 6-10). As Verchick (2012) points out, natural disasters disproportionately impact disadvantaged groups; those with the least social and economic power. Simon (2014) adds that

wealthier communities are better equipped to mitigate their vulnerability, which reinforces existing inequalities over time. Vulnerability is not uniform; it is deeply influenced by systemic social inequalities and differential access to resources.

According to the *Pressure and Release (PAR) Model* introduced in *At Risk*, disasters arise from the interaction of root causes, dynamic pressures, and unsafe conditions (Blaikie et al. 2004, pp. 53-56). Root causes include historical and structural inequalities such as colonialism, economic exploitation, and systemic racism that create vulnerabilities by limiting access to resources, power, and knowledge. These underlying conditions contribute to dynamic pressure factors like inadequate preparedness, limited education, insufficient infrastructure, and lack of access to bilingual resources that can exacerbate risk and hinder protective action. When these pressures manifest as unsafe conditions such as poorly built housing or inadequate translation of weather warnings, the potential for disaster is heightened.

The *Access Model* complements the PAR Model by emphasizing how access to resources directly influences a person's ability to prepare for, respond to, and recover from disasters (Blaikie et al. 2004). Vulnerability is not simply about exposure to hazards but is also shaped by inequitable access to resources and opportunities. This is particularly relevant for Spanish-speaking communities in the U.S., who often face barriers related to language, socioeconomic status, immigration status, and unfamiliarity with specific terminology, concepts, and recommended protective actions (Maldonado et al. 2016; Mendez et al 2020). Trujillo-Falcón et al. (2022, 2024) and Gaviria-Pabón (2022) note that the absence of clear and culturally relevant communication can prevent individuals from taking timely and effective action during weather emergencies. Furthermore, Mast and Ruiz (2023) report that 39% of Spanish speakers in the U.S. speak English "less than very well," suggesting a significant portion of the population may not

fully understand weather alerts if only presented in English. Communication barriers such as these ones and lack of knowledge about community resources can prevent immigrant communities such as Spanish-speakers from taking protective measures (Yong et al. 2017).

The interconnectedness of language barriers, social vulnerability, and unequal access to resources underscores the importance of addressing these structural inequalities in risk communication. The *At Risk* framework, through the PAR Model and Access Model, highlights how root causes, dynamic pressures, and inadequate access to resources contribute to heightened vulnerability. This understanding is crucial for developing effective communication strategies that bridge language and cultural gaps, ensuring that Spanish-speaking communities can better prepare for, respond to, and recover from weather-related hazards. These frameworks help illustrate that vulnerability is not merely a product of exposure to hazards but rather a consequence of broader socio-political and economic systems that disproportionately affect marginalized groups.

Cultural Worldviews and Disaster Subcultures

Culture plays an important role in how people understand risk and decide how to act. Culture can be broadly understood as a shared set of beliefs, values, attitudes, and behaviors that are passed down through generations and shape how people interpret the world around them (Matsumoto et al. 1996; Lederach 1995). These shared cultural elements influence how individuals think about uncertainty, responsibility, and control, especially in the context of environmental hazards and risk.

Language is a central part of culture and shapes how people communicate, interpret meaning, and understand risk. Language both reflects culture and is shaped by it, carrying historical experiences, values, and ways of thinking (Jiang 2000). Because of this close relationship, culture and language cannot be fully understood without one another (Wardhaugh 2002; Elmes 2013). Differences in language use and meaning can influence how warning messages are interpreted and whether they feel clear, credible, or relevant.

Cultural differences in risk perception are often explained through the Cultural Theory of Risk. Douglas and Wildavsky (1982) argue that cultural worldviews can be understood along two dimensions: *group*, which reflects how strongly people identify with and feel obligations toward others, and *grid*, which reflects acceptance of rules, authority, and social structure. Together, these dimensions shape how people evaluate risks and decide how to respond. Research shows that individuals exposed to the same hazard may interpret its seriousness differently based on their cultural worldview (Douglas and Wildavsky 1982; Shi et al. 2015; Morss et al. 2020). The psychometric paradigm explains risk perception by showing that people evaluate hazards based on feelings of dread and how unknown or unfamiliar a risk seems rather than only on objective probabilities or statistics (Slovic 2000). This highlights that emotional and subjective judgments play a central role in how individuals understand and respond to risk. It further shows that risk perception is not purely rational but is shaped by emotions and lived experiences.

Cultural cognition research builds on these ideas by showing how deeply held values guide how people interpret scientific information and warning messages (Shi et al. 2015). One important distinction within this work is between individualistic and collectivist orientations. In many U.S. and Western European contexts, individualistic values emphasize autonomy, self-reliance, and personal responsibility. In contrast, East Asian and Latine cultures often place

greater emphasis on family relationships, collective well-being, and shared responsibility (Naiman et al. 2023). These orientations influence how people approach decision-making during hazards, including whose safety they prioritize and how quickly they act.

For example, in more collectivist contexts, decisions are often made in consultation with family members and shaped by a sense of obligation to protect others. Marin (1991) notes that many Hispanics feel a strong responsibility toward family, both emotionally and economically, which can influence how risks are evaluated and how protective actions are chosen. Cultural beliefs about control and fate also shape responses to risk. Fatalistic beliefs common in agricultural societies exposed to unpredictable weather may reduce planning when outcomes are seen as beyond individual control. At the same time, cultural expressions emphasizing prevention and responsibility suggest that planning and action can coexist with faith-based or externally oriented beliefs (Marin 1991). These examples highlight that cultural worldviews are not fixed and can include both fatalistic and action-oriented elements.

Within broader cultures, more localized patterns of meaning and behavior can emerge in response to recurring hazards. Anderson (1965) described *disaster subcultures* as shared beliefs, knowledge, and practices that develop in communities regularly exposed to disasters. These subcultures form through social learning and repeated experience, shaping how people prepare for, interpret, and respond to hazards (Warner and Engel 2014). Disaster subcultures are influenced by both cultural worldviews and place-based experience, meaning that communities exposed to different hazards may develop different expectations, levels of trust, and response patterns.

Research shows that disaster subcultures shape responses to hazards in many parts of the world, including Europe, the United States, and Asia (Wenger and Weller 1972; Engel et al. 2014; Hagen et al. 2021). For example, during the 2010 earthquake in Chile, residents relied on shared historical knowledge and past experience to respond effectively, while tourists without this cultural understanding were less prepared (Engel et al. 2022). In Galveston, Texas, some residents chose not to evacuate during Hurricane Ike due to skepticism toward officials and media, shaped by prior experiences with false alarms (Baer et al. 2019). These examples show how disaster subcultures influence trust in information sources and willingness to take protective action.

Disaster subcultures are especially relevant for immigrant communities. Many immigrants bring risk perceptions shaped by hazards in their countries of origin, which may differ from those they face in the United States (Fischhoff 1995; Burns and Slovic 2012). For example, someone from Guatemala may be more familiar with earthquakes than with tornadoes or winter storms. Without prior experience, perceived risk may be lower, making protective action less likely (Botzen and Van Der Bergh 2009; Klockow et al. 2014).

Hispanic and Latino communities in the United States often face heightened vulnerability to weather hazards due to the interaction of cultural factors, language barriers, and structural challenges (Maldonado et al. 2016; Méndez et al. 2020; Trujillo-Falcón et al. 2021). Immediate concerns such as housing, employment, and family responsibilities may take priority over preparedness for unfamiliar hazards (Donner and Rodríguez 2008). Without targeted and culturally informed communication, language differences can further increase vulnerability (Benavides and Arlikatti 2010).

At the same time, prior experience and cultural background can support protective action. Gaviria-Pabón (2022) found that Spanish-speaking individuals drew on cultural knowledge, beliefs, and past experiences when responding to a tornado outbreak. These findings show that risk communication cannot be separated from culture. As Trujillo-Falcón (2024) emphasizes, warning responses are shaped by both individual experience and shared cultural patterns. Disaster subcultures among Spanish-speaking communities continue to evolve as individuals adapt to new hazards in the U.S. context while drawing on experiences from their countries of origin. Understanding these cultural and experiential factors is essential for designing warning messages that are clear, relevant, and meaningful for Spanish-speaking audiences.

Together, cultural worldviews and disaster subcultures show that how people understand and respond to weather risk cannot be separated from their cultural backgrounds, lived experiences, and the places where they have learned to manage hazards. Cultural worldviews shape how risk information is interpreted, while disaster subcultures reflect the shared knowledge and practices that develop through repeated exposure to hazards. For Spanish-speaking communities in the United States, these influences are especially complex, as individuals draw on experiences from their countries of origin while adapting to new hazards, warning systems, and communication practices. This dissertation incorporates these perspectives to examine how translated weather messages are interpreted, trusted, and acted upon by Spanish speakers. By integrating cultural worldviews and disaster subcultures with warning response theory, the dissertation moves beyond translation accuracy alone and toward a more holistic understanding of how weather risk communication functions for diverse Spanish-speaking populations.

Phenomenology and Behavioral Geography

Phenomenology and Lived Experience

Phenomenology is a philosophical approach and research tradition focused on understanding how people experience and interpret the world around them. Originally developed by Edmund Husserl (1962) in the early twentieth century, phenomenology seeks to describe experiences as they are lived rather than explained through abstract theories alone (Tomasulo 1990; Qutoshi 2018). A central idea in Husserl's work is intentionality, which emphasizes that consciousness is always directed toward something and that experiences are inherently meaningful (Tomasulo 1990; Qutoshi 2018). To study these experiences, phenomenological research encourages the use of epoché, or bracketing, where researchers set aside their own assumptions to focus closely on how participants describe their lived realities (Qutoshi 2018).

Phenomenology was later expanded to emphasize interpretation and context. Martin Heidegger argued that experiences are always shaped by social relationships, culture, and the surrounding world, making phenomenology especially useful for understanding how meaning is formed within specific environments (Heidegger 1977 as cited in Tomasulo 1990). Because of this focus on lived meaning, phenomenology has become an important approach in the social sciences for exploring how individuals understand their own realities within broader social and cultural settings (Lester 1999; Cohen, Manion, and Morrison 2007). Phenomenology has also been used in media studies to examine how people actively interpret and engage with information rather than passively receiving it, emphasizing how meaning is shaped through personal experience and social context (Merleau-Ponty 1963 as cited in Tomasulo 1990; Creswell 2007; Spiegelberg 1969).

Place, Experience, and Behavioral Geography

Phenomenology has strongly influenced behavioral geography by shifting attention toward lived experiences of place and space. Geographer Anne Buttimer introduced the concept of the lifeworld to describe how people's everyday routines, social relationships, and emotional attachments shape how they experience and understand places (Buttimer 1976). Rather than separating individuals from their environments, this perspective emphasizes that people and places are deeply interconnected. Behavioral geography builds on this idea by examining how emotions, memories, and sensory experiences influence environmental perceptions. Buttimer's work on time–space rhythms shows how daily patterns of movement, work, and interaction create feelings of familiarity and belonging, shaping how people relate to their surroundings (Buttimer 1976).

Environmental perception research supports this view by showing that risk perceptions are shaped through repeated exposure and lived experience. Over time, hazards such as extreme weather events can shift from abstract possibilities to lived realities that become part of everyday decision-making (Pidgeon 2012; Leiserowitz et al. 2013; Morss et al. 2020). Place also plays an important role in shaping these perceptions. For example, residents of the Southern High Plains often view drought as a natural and recurring condition rather than as a sign of climate change, reflecting local knowledge shaped by long-term experience (Colston et al. 2018). From a phenomenological perspective, these place-based understandings show that environmental risks are interpreted through cultural identity, personal history, and emotional attachment to place rather than through objective assessments alone (Merleau-Ponty 1962; Colston et al. 2018).

Phenomenology, Emotion, and Risk Communication

Phenomenology is particularly useful for understanding how people respond to hazards because it captures how emotions shape interpretation and action. Emotions are not separate

from decision-making; they are part of how individuals make sense of risk in the moment. Emotion theorists have shown that emotions are linked to patterns of action, such as fear motivating avoidance or escape and concern motivating protective behavior (Arnold 1960; Plutchik 1962, 1980; Frijda 1986). (Roseman 1984; Roseman et al. 1994) further argued that emotions are tied to specific goals and motivations, such as fear motivating efforts to avoid danger or sadness motivating recovery after loss. These perspectives support the phenomenological view that lived emotional experiences shape how risks are understood and how protective actions become possible.

Research on disasters further demonstrates the value of this approach. Green (2018), in a phenomenological study of Haitian survivors of the 2010 earthquake, showed how emotions, cultural beliefs, and social relationships shaped both coping and recovery. Participants described long-term fear and exhaustion alongside resilience and collective support. Religious beliefs played an important role in how individuals made sense of survival and loss, reflecting what Green (2018) described as deterministic acceptance, where faith-based explanations coexist with active efforts to recover and rebuild. This example illustrates how phenomenology captures the connection between emotion, meaning-making, and action.

Broader social contexts also influence lived experiences of risk. Media and public discourse can amplify or reduce perceptions of danger, shaping how people interpret uncertainty and urgency (Kasperson and Kasperson 2012). Processes such as uncertainty transfer further show how doubt introduced through communication becomes part of individuals' lived experience of risk (Pidgeon 2012). From a phenomenological perspective, these influences form part of an individual's horizon of experience, shaping how information is understood, trusted, and acted upon.

Applying Phenomenology to Weather Risk Communication

In this dissertation, phenomenology provides a lens for understanding how Spanish-speaking communities experience, interpret, and respond to weather risk information. Drawing on the concept of the lifeworld, this approach highlights how language use, cultural background, prior hazard experience, and everyday social contexts shape trust and comprehension of weather warnings (Buttimer 1976). Rather than focusing only on translation accuracy, this perspective helps explain why certain messages feel clearer, more credible, or more meaningful to different individuals.

By incorporating demographic factors such as age, ethnicity, geographic location, and Hispanic origin, this research examines how language familiarity and cultural resonance influence whether translated warnings are perceived as relevant and actionable. Linguistic and cultural factors also shape self-efficacy and response efficacy, which are critical components of effective risk communication (Lindell and Perry 2012; Trujillo-Falcón et al. 2024). As phenomenology suggests, effective communication depends not only on what is said, but on how messages align with individuals' lived experiences, emotions, and cultural frameworks (Trujillo-Falcón 2024). Integrating phenomenology with behavioral geography allows this dissertation to examine weather risk communication as a lived, contextual process and provides a deeper understanding of how Spanish-speaking individuals interpret warnings, develop confidence in protective actions, and navigate risk in their everyday lives.

Warning Response Model

Effective weather risk communication depends not only on whether warnings are translated, but on whether the information in those warnings supports understanding and action.

While making weather alerts available in Spanish is essential, translation alone does not guarantee that messages will be interpreted correctly or acted upon. Research shows that when people struggle to understand warning information, they may delay or avoid taking protective action, increasing their risk during hazardous events (Aguirre 1988; Trujillo-Falcón et al. 2022).

The Warning Response Model (Mileti and Sorensen 1990) offers a useful framework for understanding how individuals process and respond to warning messages. According to this model, people move through several connected stages when responding to a warning: receiving the message, understanding its content, believing the risk, personalizing the threat, and deciding whether and how to act. For these stages to work together, warning messages must include clear and useful information about the hazard, recommended actions, location, timing, and message source. When key information is missing or unclear, the warning response process can break down.

At the early stages of the model, receiving and understanding a warning are shaped by how clear and accessible the message is. Research shows that simple language, appropriate message length, and clear explanations improve comprehension, especially during stressful situations (Klockow et al. 2014; Sutton et al. 2021). For Spanish-speaking communities, understanding can be further affected by unfamiliar terminology, limited experience with U.S. warning systems, or differences in how hazards are communicated in other countries (Gaviria Pabón 2022; Trujillo-Falcón et al. 2024). Understanding a warning is not just about reading the message, but about making sense of what it means in a specific context.

Belief in the warning is another important step in the response process. People are more likely to believe and trust a warning when it comes from a familiar and credible source and when

the information appears consistent and reliable (Mileti and Peek 2000; Cox and Wogalter 2006). Among Spanish speakers, trust may also be shaped by prior experiences with government agencies, media outlets, and warning systems, both in the United States and in their countries of origin (Gaviria Pabón 2022). If individuals doubt the accuracy or intent of a message, they may hesitate to act even if they understand the information being provided.

Personalizing risk occurs when individuals recognize that a warning applies to them and their situation. Research shows that people are more likely to take protective action when messages clearly explain who is at risk, where the threat is occurring, and why the hazard matters for their own safety (Wood et al. 2018; Sutton et al. 2021). For Spanish-speaking communities, disaster subcultures and past hazard experiences play a key role in this stage. Prior exposure to different types of hazards or warning systems can influence whether individuals see a threat as urgent or dismiss it as unlikely to affect them (Trujillo-Falcón 2024).

The final stage of the warning response process involves deciding whether to take protective action. This decision is influenced by how confident individuals feel in their ability to respond and whether they believe the recommended actions will be effective. Clear guidance about what actions to take and how to take them can increase confidence and reduce uncertainty, while vague or incomplete instructions may lead people to seek additional information or delay action (Janssen et al. 2006; Bandura 2010; Wood et al. 2018). For Spanish speakers, these decisions are shaped not only by message content, but also by cultural norms, household dynamics, and available resources.

This dissertation uses the Warning Response Model as an organizing framework to examine how Spanish speakers process and respond to translated weather warnings. Across three

papers, the dissertation explores whether improvements in translation quality influence warning response, how lived experience and disaster subcultures shape interpretation and decision-making, and what information Spanish speakers feel is missing from current weather risk communication. By combining this theoretical framework with insights from behavioral geography and phenomenology, the dissertation develops a Spanish-speaking framework for weather risk communication that recognizes both the structure of warning messages and the diverse ways Spanish speakers understand and act on risk.

Protective Action Decision Model (PADM)

The goal of risk communication is to support informed decision-making and encourage protective action during hazardous events. Early work by Mileti and Sorensen (1990) emphasized that effective warning messages should be clear, timely, accurate, and actionable, helping individuals understand their vulnerability and what steps to take to reduce risk. More recent research similarly highlights that warning messages should clearly explain what actions to take, how to take them, and how those actions improve safety (Sutton et al. 2021).

The Protective Action Decision Model (PADM) provides a complementary framework that helps explain how individuals move from receiving warning information to deciding whether and how to act (Lindell and Perry 2012). While the Warning Response Model focuses on the flow of information within warning messages, PADM emphasizes the broader decision-making context in which those messages are interpreted. According to PADM, responses to warnings are shaped not only by message content, but also by environmental cues, social influences, and individuals' prior experiences, beliefs, and resources.

This perspective is especially relevant for Spanish-speaking communities, whose responses to warnings may be influenced by cultural background, language proficiency, immigration experiences, and trust in information sources. PADM highlights how these factors can either support or constrain protective action, even when warning messages are well designed. The model also underscores the importance of self-efficacy and response efficacy, emphasizing that people are more likely to act when they feel confident in their ability to carry out recommended actions and believe those actions will be effective (Lindell and Perry 2012; Wood et al. 2018; Mileti and Sorensen 1990).

In this dissertation, PADM is used to support the Warning Response Model by providing additional insight into how personal, cultural, and contextual factors shape decision-making among Spanish speakers. Together, these frameworks help explain why improvements in warning message quality such as clearer translations or more detailed guidance may not always lead to uniform responses across diverse Spanish-speaking populations.

Research Framework

This dissertation uses an integrated framework to understand how Spanish-speaking communities perceive, interpret, and respond to weather risk information. Rather than relying on a single theory, the framework brings together phenomenology, cultural worldviews, disaster subcultures, the Warning Response Model, and the Protective Action Decision Model (PADM). Together, these perspectives help explain how social context, lived experience, and message characteristics shape warning response among Spanish speakers.

Phenomenology provides the foundation for this framework by centering lived experience. It focuses on how individuals make meaning of hazards through their everyday lives, language use, cultural background, emotions, and prior experiences (Buttimer 1976). This approach is especially important for understanding Spanish-speaking communities, whose interpretations of weather warnings are shaped by experiences from their countries of origin, exposure to different hazards, and interactions with U.S. warning systems. Phenomenology allows this research to move beyond whether messages are technically accurate and instead examine how warnings are actually experienced, understood, and trusted.

Cultural worldviews further shape how risk information is interpreted. Shared values related to responsibility, control, family, and authority influence how individuals evaluate threats and decide whether to act. These worldviews help explain why people exposed to the same warning may respond differently, even when they receive the same information. For many Spanish-speaking communities, collectivist orientations, family obligations, and beliefs about fate or prevention influence how risk is understood and how decisions are made during hazardous events. These cultural perspectives form an important backdrop for understanding warning response.

Disaster subcultures build on these cultural worldviews by emphasizing place-based experience. Communities that are repeatedly exposed to hazards develop shared expectations, knowledge, and practices for responding to risk (Anderson 1965). Disaster subcultures shape trust in warning sources, perceptions of urgency, and beliefs about appropriate protective actions. For Spanish-speaking communities in the United States, disaster subcultures are often shaped by a combination of experiences from countries of origin and new hazards encountered after

migration. This framework helps explain variation within Spanish-speaking populations and highlights why warning response is not uniform across individuals or places.

The Warning Response Model (Mileti and Sorensen 1990) serves as the primary organizing framework for this dissertation. The model explains warning response as a process that includes receiving a message, understanding its content, believing the risk, personalizing the threat, and deciding how to act. It emphasizes the importance of message characteristics such as hazard description, guidance, location, timing, and source in supporting protective decision-making. In this research, the Warning Response Model provides a structure for examining how translated weather messages move through these stages for Spanish-speaking audiences.

The Protective Action Decision Model (PADM) is used to support the Warning Response Model by offering additional insight into how social cues, environmental cues, and pre-existing beliefs influence decision-making (Lindell and Perry 2012). PADM highlights that responses to warnings are shaped not only by the message itself, but also by trust in information sources, social networks, and prior experiences. While PADM outlines decision-making processes, this dissertation uses phenomenology, cultural worldviews, and disaster subcultures to deepen understanding of *why* individuals interpret and act on warnings in particular ways.

While the frameworks above explain how warnings are interpreted and acted upon, broader structural conditions also shape vulnerability and response. The Pressure and Release (PAR) Model and the Access Model help explain why Spanish-speaking communities often face greater vulnerability to natural hazards. The PAR Model emphasizes that vulnerability is socially produced and shaped by economic, political, and institutional conditions rather than by hazards alone (Blaikie et al. 2004). For Spanish speakers in the United States, factors such as language

barriers, immigration status, limited access to resources, and structural inequality can increase exposure to risk and reduce the ability to prepare for, respond to, and recover from disasters (Aguirre 1988; Cutter et al. 2012; Verchick 2012). The Access Model complements this perspective by focusing on how access to information, resources, and support systems shapes disaster outcomes (Blaikie et al. 2004). In the context of weather risk communication, access to clear, timely, and culturally relevant information in Spanish is a critical resource. When this access is limited or inconsistent, Spanish-speaking communities may face additional barriers to understanding warnings and taking protective action (Trujillo-Falcón et al. 2022; 2024).

Together, these frameworks allow this dissertation to connect message content, lived experience, and social context. Phenomenology grounds the analysis in how Spanish-speaking individuals experience warning messages in real life. Cultural worldviews and disaster subcultures explain shared patterns in interpretation and response, while the Warning Response Model and PADM provide structure for analyzing how warnings lead or fail to lead to protective action. By integrating these perspectives, this research moves beyond translation quality alone and offers a more comprehensive understanding of how weather risk communication functions for diverse Spanish-speaking communities.

In the chapters that follow I will explore the following research questions:

1) *Are there differences in how Spanish speakers rate the translation quality of AI-generated and human-translated Key Messages graphics?*

2) Are there differences in Spanish speakers' warning responses based on whether they viewed AI-generated or human-translated Key Messages graphics?

3)How do Spanish-speaking individuals make sense of tropical weather alerts in their everyday lives, and how do language, culture, memory, and prior experiences with storms influence the

meanings, emotions, and actions associated with these messages?

4)To what extent do Spanish speakers perceive the weather warning information they receive as clear and easy to understand for making protective decisions?

5)What information do Spanish speakers feel is missing, unclear, or insufficient in current weather warning messages, and how might these gaps affect their confidence and decision making?

Together, these questions are designed not only to examine the specific experiences of Spanish-speaking communities, but also to generate insights that may be applicable to other multilingual and culturally diverse populations facing similar challenges in weather risk communication.

Dissertation Outline

This dissertation is organized into six chapters. Chapter 1 introduces the research problem, outlines the theoretical frameworks guiding the study, and explains the importance of understanding how Spanish-speaking communities interpret and respond to translated weather risk information. Chapter 2 describes the mixed-methods approach used in the dissertation, including survey design, data collection, and interview methods. Chapter 3 examines how Spanish speakers evaluate the quality of AI-generated and human-translated weather alerts and whether differences in translation quality influence warning response. Chapter 4 uses a phenomenological approach to explore how lived experience, cultural worldviews, and disaster subcultures shape Spanish speakers' understanding of and reactions to weather warnings. Chapter 5 focuses on what information Spanish speakers feel is missing, unclear, or insufficient in current weather risk communication and how these gaps affect confidence and protective decision-making. Chapter 6

concludes the dissertation by summarizing key findings, discussing implications for weather risk communication and translation practices, and identifying directions for future research.

References

Aguirre, B. E., 1988: Feedback from the field: The lack of warnings before the Saragosa tornado. *International Journal of Mass Emergencies and Disasters*, 6, 65–74.

Anderson, W., 1965: Some observations on a disaster subculture: The organizational response of Cincinnati, Ohio to the 1964 flood. Disaster Research Center Rep., University of Delaware.

Arnold, M. B., 1960: *Emotion and personality*. Columbia University Press, New York.

Baer, R. D., S. C. Weller, and C. Roberts, 2019: The role of regional cultural values in decisions about hurricane evacuation. *Human Organization*, 78, 133–146.

Bandura, A., 2010: Self-efficacy. In *The Corsini Encyclopedia of Psychology* (I. B. Weiner and W. E. Craighead, Eds.), Wiley, 1–3.

Benavides, A., and S. Arlikatti, 2010: The role of the Spanish-language media in disaster warning dissemination. *Journal of Spanish Language Media*, 3, 41–58.

Bitterman, A., and Coauthors, 2023: Assessing public interpretation of original and linguist-suggested SPC risk categories in Spanish. *Weather and Forecasting*, 38, 1095–1106.

Blaikie, P., T. Cannon, I. Davis, and B. Wisner, 2004: *At risk: Natural hazards, people's vulnerability and disasters*. Routledge.

Botzen, W. J. W., and J. C. J. M. van der Bergh, 2009: Managing natural disaster risks in a changing climate. *Environmental Hazards*, 8, 209–225.

Burns, W. J., and P. Slovic, 2012: Risk perception and behaviors. *Risk Analysis*, 32, 579–582.

Buttimer, A., 1976: Grasping the dynamism of lifeworld. *Annals of the Association of American Geographers*, 66, 277–292.

Castilho, S., and S. O'Brien, 2017: Acceptability of machine-translated content. *Linguist. Antverp. N. S.–Themes Transl. Stud.*, 16.

Castillo, L. M., 2015: Acquisition of translation competence and translation acceptability. *Translation & Interpreting*, 7, 72–85.

Cohen, L., L. Manion, and K. Morrison, 2007: *Research methods in education*. Routledge.

Colston, N., J. M. Vadjunec, and T. Fagin, 2018: Examining perceptions about drought and climate change. *Environmental Communication*, 12, 1–17.

Cox III, E. P., and M. S. Wogalter, 2006: Warning source. In *Handbook of Warnings* (M. S. Wogalter, Ed.), Lawrence Erlbaum Associates, 111–122.

Creswell, J. W., 2007: *Qualitative inquiry and research design*. Sage.

Cutter, S. L., B. J. Boruff, and W. L. Shirley, 2012: Social vulnerability to environmental hazards. In *Hazards Vulnerability and Environmental Justice*, Routledge, 143–160.

Dietrich, S., and E. Hernandez, 2022: *Language use in the United States: 2019*. American Community Survey Reports, No. ACS-50, U.S. Census Bureau, 12 pp.

Donner, W., and H. Rodriguez, 2008: Population composition, migration, and inequality: The influence of demographic changes on disaster risk and vulnerability. *Social Forces*, 87, 1089–1114, https://doi.org/10.1353/sof.0.0141.

Douglas, M., and A. Wildavsky, 1982: How can we know the risks we face? *Risk Analysis*, 2, 49–58.

Elmes, D., 2013: The relationship between language and culture. *GIST Education and Learning Research Journal*, 7, 11–18.

Engel, K., G. Frerks, L. Velotti, J. Warner, and B. Weijs, 2014: Flood disaster subcultures in the Netherlands: The parishes of Borgharen and Itteren. *Natural Hazards*, 73, 859–882, https://doi.org/10.1007/s11069-014-1116-5.

Engel, K., J. Warner, and G. Frerks, 2022: Disaster subculture in greater Concepción, Chile. *International Journal of Mass Emergencies & Disasters*, 40, 1–34.

Fischhoff, B., 1995: Risk perception and communication unplugged. *Risk Analysis*, 15, 137–145.

Frijda, N. H., 1986: *The emotions*. Cambridge University Press.

Gaviria Pabón, A. R., 2022: The role of disaster subcultures in Spanish-speaking Hispanic/Latino immigrants. M.S. thesis, University of Oklahoma.

Gaviria Pabón, A. R., M. J. Krocak, J. T. Ripberger, and J. E. Trujillo-Falcón, 2025: Linguistic challenges in severe weather communication. *Bull. Amer. Meteor. Soc.*, 106, E1940–E1954.

Green, C., 2018: Exploring cultural belief systems and coping behavior. Ph.D. dissertation.

Hagen, K., M. Petterson, D. Humphreys, and N. Clark, 2021: Why disaster subcultures matter. *Geosciences*, 11, 387.

Heidegger, M., 1977: *The question concerning technology*. Harper & Row.

Husserl, E., 1962: *Ideas: General introduction to pure phenomenology*. Collier Books.

Janssen, A. P., R. R. Tardif, S. R. Landry, and J. E. Warner, 2006: Pandemic influenza messages. *Journal of Public Health Management and Practice*, 12, 388–394.

Jiang, W., 2000: The relationship between culture and language. *ELT Journal*, 54, 328–334.

Kasperson, R. E., and J. X. Kasperson, 2012: *Social contours of risk*. Routledge.

Klockow, K., R. Peppler, and R. McPherson, 2014: Tornado folk science in Alabama and Mississippi. *GeoJournal*, 79, 791–804.

Koby, G. S., P. Fields, D. Hague, A. Lommel, and A. Melby, 2014: Defining translation quality. *Revista Tradumàtica*, 12, 413–420.

Lederach, J. P., 1995: *Preparing for peace*. Syracuse University Press.

Leiserowitz, A., E. Maibach, C. Roser-Renouf, G. Feinberg, and P. Howe, 2013: *Extreme weather and climate change in the American mind*. Yale Project on Climate Change Communication, New Haven, CT.

Lester, S., 1999: An introduction to phenomenological research. Stan Lester Developments.

Lindell, M. K., and R. W. Perry, 2012: Protective action decision model. *Risk Analysis*, 32, 616–632.

Maldonado, A., T. Collins, S. Grineski, and J. Chakraborty, 2016: Exposure to flood hazards in Miami and Houston: Are Hispanic immigrants at greater risk than other social groups? *Int. J. Environ. Res. Public Health*, **13**, 775, https://doi.org/10.3390/ijerph13080775.

Marin, B., 1991: Hispanic culture. *Focus*, 6, 1.

Mast, B. D., and T. Ruiz, 2023: Visualizing Spanish-speaking limited English proficiency populations. *Cityscape*, 25, 281–286.

Matsumoto, D., T. Kudoh, and S. Takeuchi, 1996: Individualism and collectivism. *Culture & Psychology*, 2, 77–107.

McDonald, S. V., 2022: Accuracy, readability, and acceptability in translation. *Appl. Transl.*, 16, 1–9.

Méndez, M., G. Flores-Haro, and L. Zucker, 2020: The (in)visible victims of disaster. *Geoforum*, 116, 50–62.

Merleau-Ponty, M., 1962: *Phenomenology of perception*. Routledge & Kegan Paul.

Merleau-Ponty, M., 1963: *The structure of behavior*. Beacon Press.

Mileti, D., and J. Sorensen, 1990: Communication of emergency public warnings. ORNL-6609 Report.

Mileti, D. S., and L. Peek, 2000: The social psychology of public response to warnings of a nuclear power plant accident. *Journal of Hazardous Materials*, **75**, 181–194.

Morss, R. E., H. Lazrus, A. Bostrom, and J. L. Demuth, 2020: Cultural worldviews and hurricane risk. *Journal of Risk Research*, 23, 1620–1649.

Naiman, S. M., R. C. Stedman, and J. P. Schuldt, 2023: Latine culture and the environment. *Journal of Environmental Psychology*, 85, 101902.

National Hurricane Center, 2024: *National Hurricane Center products and services update for the 2024 hurricane season*. NOAA.

National Weather Service, 2025: About the National Weather Service. NOAA. https://www.weather.gov/about

Pidgeon, N., 2012: Climate change risk perception and communication. *Risk Analysis*, 32, 951–956.

Plutchik, R., 1980: A general psychoevolutionary theory of emotion. In *Theories of Emotion*, R. Plutchik and H. Kellerman, Eds., Academic Press, 3–33.

Plutchik, R., 1962: *The emotions: Facts, theories, and a new model*. Random House.

Qutoshi, S. B., 2018: Phenomenology. *J. Educ. Educ. Dev.*, 5, 215–222.

Roseman, I. J., C. Wiest, and T. S. Swartz, 1994: Discrete emotions. *Journal of Personality and Social Psychology*, 67, 206–221.

Shi, J., V. H. Visschers, and M. Siegrist, 2015: Public perception of climate change: The importance of knowledge and cultural worldviews. *Risk Analysis*, 35, 2183–2201, https://doi.org/10.1111/risa.12406.

Simon, G. L., 2014: Vulnerability-in-production. *Ann. Assoc. Amer. Geogr.*, 104, 1199–1221.

Slovic, P., 2000: *The perception of risk*. Earthscan.

Spiegelberg, H., 1969: *The phenomenological movement*. Martinus Nijhoff.

Sutton, J., L. Fischer, and M. M. Wood, 2021: Tornado warning guidance and graphics. *Wea. Climate Soc.*

Tomasulo, F. P., 1990: Phenomenology and media theory. *Quarterly Review of Film and Video*, 12, 1–8.

Trujillo-Falcón, J. E., 2024: Examining warning response among Spanish speakers in the United States to enhance multilingual wireless emergency alerts. Ph.D. dissertation, University of Oklahoma

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. *Bulletin of the American Meteorological Society*, 102, E765–E773.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. T. Ripberger, A. Bitterman, J. B. Thornton, M. J. Krocak, S. R. Ernst, E. Cassiani Obeso, and J. Lipski, 2022: ¿Aviso o alerta? Developing effective, inclusive, and consistent watch and warning translations for U.S. Spanish speakers. *Bulletin of the American Meteorological Society*, 103, E1542–E1556, https://doi.org/10.1175/BAMS-D-22-0050.1.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. Reedy, and K. E. Klockow-McClain, 2024: Systemic vulnerabilities in Hispanic and Latinx immigrant communities. *Nat. Hazards Rev.*, 25, 04023059.

U.S. Census Bureau, 2024: New estimates highlight differences in growth between the U.S. Hispanic and non-Hispanic populations. *U.S. Census Bureau Press Release*, 27 June 2024, https://www.census.gov/newsroom/press-releases/2024/population-estimates-characteristics.html, accessed 4 Feb. 2026.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 2023: NOAA uses artificial intelligence to translate forecasts and warnings into Spanish and Chinese.

Verchick, R. R., 2012: Disaster justice: The geography of human capability. *Duke Environmental Law & Policy Forum*, 23, 23–48.

Wardhaugh, R., 2002: *An Introduction to Sociolinguistics*. 4th ed. Oxford, United Kingdom, Blackwell Publishers.

Warner, J., and K. Engel, 2014: Disaster culture matters. *Environment & Society*, 17, 1–8, https://doi.org/10.1590/1809-4422ASOCEx002V1742014.

Wenger, D., and J. Weller, 1972: Some observations on the concept of disaster subculture. Disaster Research Center Rep. 48, University of Delaware.

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

Yong, A. G., L. Lemyre, C. Pinsent, and D. Krewski, 2017: Risk perception and disaster preparedness in immigrants and Canadian-born adults: Analysis of a national survey on similarities and differences. *Risk Analysis*, **37**, 2321–2333, https://doi.org/10.1111/risa.12797.

Chapter 2: Methodology

Mixed Methods Approach

In research on risk communication and social behavior, both quantitative and qualitative methods offer distinct yet complementary insights. Quantitative approaches, often guided by a positivist paradigm, seek to identify generalizable patterns across populations using measurable variables. Qualitative approaches, such as phenomenology, prioritize context, lived experience, and meaning making. As Malina et al. (2011, p.2) argue, both positivist and phenomenological methodologies rely on indirect interpretation and involves direct access to objective "truths" or concepts. Instead, each constructs understanding by analyzing structured data: "qualitative method might construct a phenomenological platform in the form of interview data (similar to a quantitative researcher's statistical dataset), which is used to construct concepts or reflect on extant theory." In both cases, the rigor and transparency of the analytical process whether statistical or interpretive are critical to ensuring that findings are credible and useful.

Building on this philosophical grounding, this dissertation employs a mixed-methods approach to examine how Spanish-speaking communities perceive, interpret, and respond to tropical weather information. Framed by the Warning Response Model (WRM), The Protective Action Decision Model (PADM), disaster subcultures, and phenomenology, this study investigates how cultural, linguistic, and structural factors shape comprehension, trust, risk perceptions, and protective behavior among Spanish-speakers. The quantitative component analyzes survey data evaluating the accuracy, readability, acceptability, and satisfaction of AI- and human-generated translations of tropical weather alerts. The qualitative component uses semi-structured interviews to explore participants' lived experiences, cultural perspectives, and interpretive processes. Together, these methods offer a comprehensive understanding of the cognitive, social, and linguistic dynamics involved in weather risk communication.

Mixed methods research is particularly effective when grappling with complex, real-world issues that cannot be fully understood through one lens alone. Ivankova amd Wingo (2018, p.80) note that by "collecting, analyzing, and integrating both quantitative and qualitative data," researchers can produce conclusions that are "more credible or convincing." This integration enables exploration of both confirmatory and exploratory dimensions, while grounding abstract concepts in lived experience and context (Creswell et al. 2011; Morse & Niehaus, 2009). As Malina et al. (2011) further emphasize, the challenge is not between methods but ensuring that the concepts, whether numerical or narrative, validly represent the phenomenon under study.

Examples of effective mixed-methods applications can be seen in Eady et al. (2020), who combined qualitative interviews and survey research to understand how seniors experience and cope with heat waves, and Bica et al. (2019), who used both diffusion metrics and qualitative content analysis to investigate how hurricane risk images spread and were interpreted on Twitter. Gaviria-Pabón (2022) combined a survey and interviews to understand how disaster subcultures shape Spanish speakers' risk perceptions and decision making to severe weather hazards and information. These studies show how integrating methodologies can clarify the relationships between communication, perception, and behavior across both individual and systemic levels.

In this dissertation, the integration of statistical analyses and experiential insights helps address a critical gap in the literature how Spanish-speaking populations engage with translated weather messages, particularly in contexts shaped by linguistic diversity and cultural meaning making. By combining analytic and systemic approaches, this study not only enhances empirical understanding but also supports the development of equitable, culturally attuned risk communication strategies that improve comprehension, trust, and protective decision-making in vulnerable communities.

Quantitative Study

Addressing linguistic and communication barriers including language proficiency, literacy levels, and access to bilingual resources is essential to ensure that Spanish-speaking communities can fully understand and respond to weather warnings and watches (Trujillo-Falcón et al. 2022, 2024). Equally important is the need to recognize and account for the cultural and linguistic diversity within these communities when developing risk communication strategies (Gaviria-Pabón 2022; Trujillo-Falcón 2024). These strategies must be culturally and linguistically appropriate to improve community resilience to weather related hazards and ensure equitable access to critical information during these events.

The first part of this mixed-methods dissertation employs a quantitative approach to systematically examine how Spanish-speaking individuals perceive translated tropical weather information and if there are any differences in warning response (understanding, belief, personalization, self-efficacy and response-efficacy). This component focuses on evaluating whether messages translated either by artificial intelligence (AI) systems or by human forecasters are perceived as accurate, readable, acceptable, and are satisfied with the translation. We also examine if warning responses of participants change based on whether they saw the AI or human forecaster version of the message.

To better understand how cultural and linguistic diversity shapes risk communication outcomes, the quantitative study also analyzes how perceptions of translation quality differ across key demographic variables, including ethnicity, age, Hispanic origin, regional dialect, language proficiency, and geographic location. This allows for an exploration of how intersectional factors contribute to disparities in information processing and response, particularly in the context of severe weather communication.

The survey instrument was designed to capture both cognitive and affective responses to translated messages, as well as behavioral intentions related to self-efficacy and response efficacy. By anchoring the analysis in theoretical frameworks such as the Warning Response Model and the Protective Action Decision Model this study assesses how translated information influences risk perception, belief in message credibility, and motivation to act. Ultimately, this quantitative phase provides a foundational understanding of the patterns and relationships among translation quality and risk-related decision making. These insights will later be expanded upon and contextualized through the qualitative component of the study, ensuring that the research captures both statistical trends and the nuanced, lived experiences of Spanish-speaking communities.

Survey Design

This study draws on data from the Extended 2024 Tropical Cyclone Spanish (Extended TCS24) Survey, which was developed and administered through a collaborative effort between the Department of Climate, Meteorology, and Atmospheric Sciences at the University of Illinois Urbana-Champaign and the Institute for Public Policy Research and Analysis (IPPRA) at the University of Oklahoma. This nationwide survey aimed to enhance understanding of how Spanish-speaking individuals in the United States make decisions during tropical cyclone events. It extends a series of weather communication surveys conducted annually since 2022 (see Trujillo-Falcón et al. 2026) for more on the 2023 Extended Tornado Survey). The TCS24 was fielded between December 9, 2024, and January 13, 2025.

Participants completed the survey online. A total of 640 U.S. adults aged 18 and older who self-identified as speaking Spanish “well” or better were recruited through an internet panel designed to mirror the demographic composition of the U.S. Spanish-speaking population based

on Census estimates. This survey built on the Tropical Cyclone 2023 (TC23) survey, which provided a foundation for assessing how adult Spanish speakers interpret and respond to tropical cyclone warnings. The TCS24 instrument was tailored to explore how cultural backgrounds, both in the U.S. and countries of origin, influence responses to various types of tropical cyclone risks. In particular, this study focused on evaluating artificial intelligence (AI) generated Spanish translations produced by the National Weather Service, establishing a benchmark for translation quality to guide future improvements.

Data Collection

Verasight, a research and marketing company, provided the participant sample. Verasight maintains an online panel of U.S.-based users who agree to take part in surveys and recruits participants through various channels including web advertisements, social media, affiliate programs, and digital partnerships. Because respondents self-selected into the online panel, the sample may include individuals who are more comfortable with computers and digital technology than the general population, which should be considered when interpreting the results.

For the TCS24, Verasight employed a dynamic sampling approach to identify eligible respondents specifically, U.S. adults living in the contiguous United States. Initial invitations were sent to a subset of panelists reflecting the survey's target demographic characteristics. As responses came in, sampling adjustments were made to achieve balanced representation; more invitations were issued to underrepresented groups, and fewer to overrepresented ones. This approach helped achieve a sample that is broadly representative of Spanish-speaking adults in the U.S. Demographic comparisons with U.S. Census data are summarized in Table 1.

To protect participants' rights and privacy, all survey materials and protocols were

reviewed and approved by the University of Oklahoma Institutional Review Board (IRB #15113). While Verasight managed recruitment and sampling, the University of Oklahoma oversaw survey implementation and data management. The survey was designed for asynchronous, self-paced completion within time constraints that ensured high data quality. On average, respondents completed the survey in 23 minutes. Participation was voluntary, and all respondents who completed the survey received compensation in the form of points provided by Verasight.

	U.S Adult Population (%)	Participants (%)
Gender		
Female	50.1	74.8
Male	49.9	24.7
Age		
18-24	14.3	11.7
25-34	20.2	19.4
35-44	20.5	33.8
45-54	18.2	25.6
55-64	13.6	8.3
65 +	13.3	1.2
English-speaking		
Yes	90.2	91.5
No	9.8	8.5
Ethnicity		
Non-Hispanic	5.7	4.7
Mexican, Mexican Am., Chicano	53.5	21.9
Puerto Rican	7.4	10.6
Cuban	4.6	9.4
Other Hispanic, Latino Or Spanish Origin	28.8	53.4
NWS Region		
Eastern	21.1	40.0
Southern	36.3	26.2

Central	9.9	10.8
Western	32.6	23.0

Table 1: Demographic Distribution of Spanish-Speaking Adults in the Extended TC24 Sample.

Survey Experiment

The primary goal of this study was to explore Spanish-speaking participants' perceptions of translation quality in key tropical cyclone messaging from the National Hurricane Center (NHC), and to examine how those perceptions influenced risk perceptions, understanding, and decision-making across both AI and Human generated translations (NHC 2024). The analysis also considered variation by demographic characteristics, information sources preferences and trust, attitudes toward AI, and Spanish dialect differences.

To investigate these issues, an embedded experiment was included in the TCS24 survey. The experiment tested how the National Hurricane Center's (NHC) Spanish-language *Key Messages* graphic was perceived under two different translation source conditions. The *Key Messages* product was selected for this study because it is widely disseminated on social media, making it more accessible to the general public, including Spanish-speaking audiences, than many other NHC products. Its concise, visual format and broad reach make it a critical tool for evaluating how effectively translated risk communication is received and understood.

At the time the experiment was being developed, Hurricane Beryl was the first named hurricane of the 2024 Atlantic season, and the NHC had already issued *Key Messages* graphics for this storm. As such, the *Key Messages* graphic for Hurricane Beryl was used as the basis for the experiment. To simulate real-world conditions and preserve ecological validity, participants were shown versions of the graphic that closely mirrored the original NHC product.

As an illustration, one of the statements included in the third message of the graphic showed minor differences between translation sources. In the AI-translated version, the sentence read: “Considerable flash and urban flooding is expected today into tonight across portions of the middle and upper Texas Gulf Coast and eastern Texas. Minor to isolated major river flooding is also expected” (see Figure 1). In the human-translated version, the sentence read: “Considerable flash and urban flooding is expected today into tonight across portions of the middle and upper Texas Gulf Coast and eastern Texas. Minor flooding, or isolated major flooding, of rivers is also expected” (see Figure 2). While the overall meaning remains consistent, the phrasing differs slightly, particularly in how the severity and structure of river flooding is conveyed. This example illustrates the type of subtle variation in wording that participants were exposed to across conditions.

Participants were randomly assigned to one of two experimental conditions:

Condition 1 (Fig. 1): Participants viewed the official NHC graphic as published online, which included the standard disclaimer: “This message was originally written in English but was translated into Spanish using AI.” This AI-translated version reflects the current operational approach adopted by the NHC for Spanish-language dissemination.

Condition 2 (Fig. 2): Participants viewed a *Key Messages* graphic accompanied by the message: “This message was originally written in English but was translated into Spanish by forecasters at the National Hurricane Center.” This translation was completed by a bilingual meteorologist at the NWS San Juan office, which has historically been responsible for producing Spanish-language translations of tropical weather products prior to the use of AI systems.

Participants were randomly assigned to one of these two groups to ensure balanced exposure to each condition. After viewing the graphic, respondents answered a series of questions designed to evaluate their perceptions of the translation, including, accuracy, readability, acceptability, and overall satisfaction (see Table 2). These perception measures help assess how Spanish-speaking individuals engage with translated hurricane information in real time communication environments.

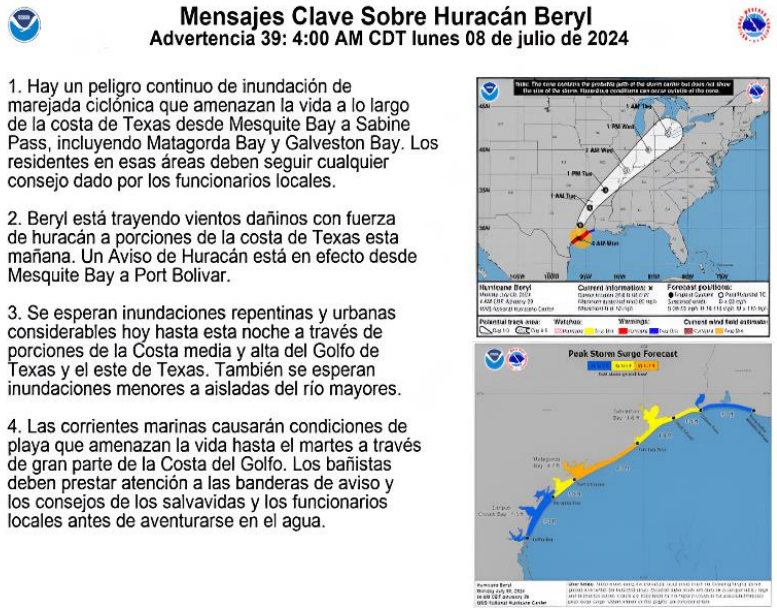


Figure 1: Key Messages graphic translated using AI. This version is the official NHC graphic published online and includes a message noting that the translation was produced using artificial intelligence.



Figure 2: Key Messages graphic translated by a human forecaster. The graphic includes a message stating that the original English text was translated into Spanish by forecasters at the National Hurricane Center.

Accuracy	**Readability**	**Acceptability**	**Satisfaction**
The translation accurately conveys the main message of the text. *La traducción transmite con precisión el mensaje principal del texto*.	The translated text is easy to read and understand. *El texto traducido es fácil de leer y comprender.*	The translation adheres to the linguistic norms and conventions of the Spanish language *La traducción se ajusta a las normas y convenciones lingüísticas de la lengua española.*	I am satisfied with the translation. *Estoy satisfecho con la traducción*
The information in the translation is clear and aligns with what you would expect from the text. *La información de la traducción es clara y se alinea a lo que se espera del texto.*	The message in the translated text is clear and straightforward. *El mensaje del texto traducido es claro y directo.*	The translation reads naturally and is appropriate. *La traducción se lee con naturalidad y es adecuada.*	The translation provides the information I need effectively. *La traducción proporciona la información que necesito de forma eficaz.*
The translation effectively communicates the key points and details. *La traducción comunica eficazmente los puntos clave y los detalles.*	The structure and language of the translation make it accessible and comprehensible. *La estructura y el lenguaje de la traducción la hacen accesible y comprensible*	I can understand and relate to the meaning and context of the translated text. *Puedo entender y relacionarme con el significado y el contexto del texto traducido.*	I would recommend this translation to others *Recomendaría esta traducción a otras personas*

Table 2: Items used to assess participants' perceptions of the translated Key Messages graphic, including accuracy, readability, acceptability, and satisfaction. Responses were recorded using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly

Statistical Analysis

To examine how Spanish-speaking participants evaluated and responded to translated weather messages, this study used a quantitative approach that combined multiple survey questions into composite measures. The survey focused on participants' reactions to translated "Key Messages" graphics from the National Hurricane Center (NHC).

Translation quality was measured using four composite measures: accuracy, readability, acceptability, and overall satisfaction. Each area included several survey questions (see Table 2), and responses were averaged to create composite scores. These scores represent participants' overall evaluations of the translated message rather than responses to individual questions.

The survey also measured warning response outcomes that reflect how participants understood and reacted to the information. These included understanding, belief, personalization, self-efficacy, and response efficacy (see Table 3). As with translation quality, composite scores were created by averaging responses across related survey items.

Understanding	How well do you understand the information that is being presented in this graphic? *¿Qué tan bien entiende la información que se presenta en este gráfico?*
Belief	Please indicate the level of trust that you have in the information presented through this graphic? *Por favor, indique el nivel de confianza que tiene en la información presentada a través de este gráfico.*
Personalization	After reading the message, do you feel you are in danger if you were on the Texas coast? *Después de leer este mensaje, ¿siente que está en peligro si estuviera en la costa de Texas?*
Self-Efficacy	Do you think you can take the protective measures that are recommended? *¿Cree que puede tomar las medidas de protección que se recomiendan?*
Response-Efficacy	How confident are you that the protective measures you take will keep you safe? *¿Cuán seguro está de que las medidas de protección que toma le mantendrán a salvo?*

Table 3: Items used to assess participants' warning response to the Key Messages graphic, including understanding, belief, personalization, self-efficacy, and response-efficacy. Responses were recorded using a 5-point Likert scale.

Descriptive statistics were used to summarize the composite measures, and group comparisons were conducted to examine differences between AI-generated and human-translated messages. Mean differences and confidence intervals were used to compare how participants evaluated translation quality and how they perceived their ability to respond to the message.

This approach allows for a clear comparison of how different translation methods influence message evaluation and warning response among Spanish-speaking participants. Detailed statistical findings are presented in Chapter 3.

Qualitative Study

This study's qualitative component is grounded in the concept of disaster subcultures and a phenomenological approach to understanding risk communication. Disaster subcultures emphasize that communities repeatedly exposed to hazards develop shared expectations, norms, memories, and interpretive frameworks that shape how warnings are understood and acted upon (Anderson 1965). These culturally and historically informed patterns influence not only how risk information is interpreted, but also what types of information are perceived as credible, relevant, and actionable (Gaviria-Pabón 2022; Trujillo-Falcón 2024). For Spanish-speaking communities, disaster subcultures are shaped by linguistic practices, migration histories, prior experiences with tropical cyclones, and place-based knowledge, all of which influence how weather alerts are evaluated.

Building on this perspective, phenomenology provides the methodological lens for examining how individuals experience and make sense of tropical weather risk communication in their everyday lives. Rather than seeking objective or universal interpretations of warning effectiveness, phenomenology centers lived experience and meaning making. As Malina et al. (2011) note, phenomenological inquiry does not produce immediate interpretation at the level of theory or factual claims but instead constructs understanding through reflective engagement with experience. In this study, qualitative interview data serve as an analytic platform comparable to a

quantitative dataset, enabling systematic interpretation of how participants perceive, interpret, and respond to translated weather alerts.

Together, disaster subcultures and phenomenology provide a complementary framework for examining how language, culture, and place shape Spanish speakers' interactions with tropical weather information. This combined approach is particularly well suited for risk communication research, where warning interpretation is influenced not only by message content, but also by collective memory, cultural familiarity, and prior hazard experience.

Study Site and Data Collection

Semi-structured interviews were conducted in Tampa, Florida, a region highly vulnerable to hurricanes and home to a large and diverse Spanish-speaking population. Tampa was selected as the study site due to its recent exposure to tropical cyclone impacts such as Hurricane Milton and Hurricane Helene and the opportunity it provided to engage participants with varied national origins, migration histories, and experiences with tropical hazards.

Interviews were conducted with Spanish-speaking adults and took place entirely in Spanish. A semi-structured interview format was used to balance consistency across interviews with flexibility to explore participants' experiences in depth. This format supported the phenomenological emphasis on lifeworlds by allowing participants to situate weather risk communication within their personal histories, community contexts, and lived experiences with storms.

Interview Design

The interview guide (see Table 4) was designed to explore how Spanish speakers experience and evaluate tropical weather alerts, with particular attention to language,

comprehension, cultural familiarity, and decision-making. Interviews began with background questions related to place of origin, length of residence in the United States, and prior experience with tropical storms or hurricanes. These questions provided essential context for understanding how participants' disaster histories and community experiences shaped their interpretation of warning information.

Subsequent questions focused on participants' experiences receiving tropical weather alerts in Spanish. Participants were asked whether the information felt clear, complete, and useful, how Spanish-language alerts compared with English-language alerts, and whether the messages supported decisions about protective actions. These discussions captured how disaster subcultures shape expectations about what warnings should include and how they should be communicated.

The interview guide also addressed language and comprehension by asking participants to identify aspects of alerts that felt clear or confusing, whether any information felt missing, and whether the wording reflected how Spanish is commonly spoken in their communities. These questions highlighted the role of tone, phrasing, and dialect in shaping both understanding and cultural resonance, reinforcing the idea that translation quality extends beyond literal accuracy to include familiarity and social meaning.

Finally, participants were asked to reflect on confidence and decision-making. These questions examined whether alerts helped participants feel confident about what actions to take, how messages influenced perceptions of urgency and personal relevance, and what changes could improve future communication. This line of inquiry connects phenomenological meaning-

making with protective action by examining how lived experience, cultural context, and language influence preparedness and response.

Introduction	**Lifeworld and Cultural Connection**	**Comprehension and Relatability**	**Geographic Relevance and Place-Based Meaning**	**Self-Efficacy and Taking Action**	**Cultural Familiarity and Community Connection**
Can you tell me a little bit about yourself? Where are you from originally, and where do you currently live? Have you ever experienced a tropical storm or hurricane before?	Can you describe a time when you received tropical weather information in Spanish? [Follow up: How did it make you feel or influence your actions?] When you have receive alerts in Spanish instead of English, what does that mean to you personally? Why does that difference matters or not to you?	When you read tropical weather alerts, what makes the message feel clear or helpful? Are there certain words, phrases, or examples that make a difference? In your opinion, what is missing from (or what would you like to see in) tropical weather alerts? What would make tropical weather alerts more relevant to you? Does the language used (dialect) in alerts feel like something people in your community would say? If not how could it be improved?	Do you feel that the alerts you get reflect your local area and the things that matter where you live? How could they do a better job of this? When you get weather alerts in Spanish, how does that shape how you think about protecting your family or neighbors?	When you get a tropical weather alert, how confident do you feel in knowing what to do? What kind of message or language would make you feel more prepared to act during a storm?	Are there any cultural references, phrases, or tones that would make tropical weather information feel more familiar or personal to your community? Does the way the alerts are written ever make you feel more (or less) included or connected? In your opinion, what (if anything) might make weather alerts more culturally aware? Is there anything I

					didn't ask that you think is important for people to understand about your experience with weather alerts?

Table 4: Interview Guide for Spanish speaking participants

Researcher's Positionality

When conducting research, a researcher's perspective and worldview are referred to as positionality. Positionality reflects the position a researcher adopts within a given study and describes the researcher's relationship to their research participants (Goundar 2025). What a researcher chooses to study, how the research is conducted, and how findings are interpreted are all shaped by this position. A researcher's positionality is influenced by a range of factors, including personal experiences, values, beliefs, and social identities, which in turn shape assumptions, interactions with participants, the questions posed, and the interpretation of results (Goundar 2025). For higher degree research in the social sciences, explicitly addressing researcher positionality is an important component of methodological transparency and rigor, as it enhances clarity and credibility by acknowledging the researcher's position as both an insider and outsider in relation to the study.

In this study, the researcher is a Spanish speaker who grew up in Puerto Rico and has personally experienced multiple hurricanes, including Hurricane María. These experiences informed the researcher's sensitivity to linguistic nuance, cultural references, and place-based meanings present in participants' narratives. At the same time, the researcher recognizes that shared language or cultural background does not imply shared experience or interpretation.

Participants' perspectives were shaped by diverse geographic contexts, migration histories, and disaster experiences.

To address this insider–outsider dynamic, the researcher engaged in an iterative analytic process that involved repeatedly reviewing interview transcripts and refining codes and themes to ensure that interpretations remained grounded in participants' accounts rather than assumptions based on the researcher's own experiences. By making positionality explicit, this study acknowledges how the researcher's background both informed and required careful reflexive attention during the analysis, strengthening the transparency and credibility of the qualitative findings.

Thematic Analysis

All interviews were transcribed and analyzed using thematic analysis. This approach is grounded in the assumption that reality is socially constructed and that meaning emerges through individuals' interpretations of their experiences within specific social, cultural, and contextual settings (Riger and Sigurvinsdottir 2016). From this perspective, there is no single fixed reality independent of people's interpretations; instead, multiple versions of reality may coexist, shaped by individuals' social positions, lived experiences, and interactions with others. Researchers working from critical and community-oriented perspectives further emphasize the role of power, dominance, and control in shaping how people understand and interpret phenomena (Schensul 2012).

Consistent with this epistemological orientation, an inductive coding approach was employed, allowing codes and themes to emerge directly from participants' narratives rather than being imposed by predefined theoretical categories. The analytic focus centered on how

participants made sense of their experiences with translated weather alerts, including recurring patterns related to disaster experience, message clarity, language and comprehension, cultural familiarity, place-based meaning, and decision-making. This emphasis on meaning-making aligns with the core goal of thematic analysis: to understand how people interpret their experiences and how those interpretations give rise to perceptions and behaviors (Riger and Sigurvinsdottir 2016).

Thematic analysis proceeds through a systematic process of identifying recurring ideas or themes within a textual data set, forming the core of many qualitative approaches (Riger and Sigurvinsdottir 2016). While content analysis also involves coding, it typically treats codes statistically by examining their frequency, whereas thematic analysis does not rely on statistical analysis. Unlike grounded theory, in which data collection and analysis occur simultaneously to guide further data collection, thematic analysis begins after all data have been collected. However, similar to grounded theory, thematic analysis seeks to develop interpretations and theoretical insights that are grounded in the data themselves (Riger and Sigurvinsdottir 2016).

In line with established guidance, themes were derived inductively from interview data and could be either explicit or implicit within participants' accounts (Braun & Clarke 2006; Pistrang & Barker 2013). Themes were identified both within individual interviews and across interviews and were required to capture elements that were salient to participants and meaningful in relation to the research questions. The process of identifying and developing themes was conducted consistently across the data set, with attention to how language, culture, prior hazard exposure, and disaster subcultures shaped participants' interpretations of weather risk and protective action.

The use of thematic analysis is particularly appropriate for this study given its emphasis on understanding subjective meaning in context. Qualitative methods have been shown to be especially valuable for capturing the richness, nuance, and contradictions present in lived experience, particularly in underresearched areas (Pistrang & Barker 2013). Thematic analysis allows for in-depth exploration without relying on preordained analytic categories that might constrain participants' responses or obscure culturally specific interpretations (Braun & Clarke 2006). This flexibility is a key strength of thematic analysis, as it can be applied across a range of theoretical frameworks and worldviews while remaining methodologically rigorous (Braun & Clarke, 2006; Riger and Sigurvinsdottir 2016).

Moreover, thematic analysis aligns with broader arguments in community and critical research emphasizing the importance of giving voice to individuals and communities that have been historically underrepresented in research (Banyard & Miller 1998; Pistrang & Barker 2013). By centering participants' own words and interpretations, this approach allows Spanish-speaking individuals to articulate their experiences with weather messages without being constrained by predetermined response categories. This is especially important in the context of disaster research, where responses to risk may vary across individuals, settings, and cultural contexts. Overall, the thematic analysis complements the quantitative findings by providing deeper insight into how language, culture, and lived disaster experience shape interpretations of risk and protective action.

Reliability and Validity

Reliability and validity in qualitative research are evaluated differently than in quantitative studies. This study followed Lincoln and Guba's (1985) criteria of trustworthiness, which include authenticity, credibility, transferability, dependability, and confirmability. These

criteria emphasize rigor in qualitative research and have been widely used to evaluate the quality of interpretive studies (Glesne 2011; Lincoln and Guba 1985; Riger and Sigurvinsdottir 2016). Authenticity refers to the fairness and depth with which participants' experiences are represented and whether the research promotes mutual understanding of the phenomenon under study. Credibility refers to the accurate representation of multiple realities, ensuring that participants' perspectives are reflected in the findings. Transferability concerns the applicability of findings to other contexts. Dependability refers to the consistency of findings within the data, and confirmability addresses the extent to which findings are grounded in the data rather than shaped by researcher bias (Glesne 2011; Lincoln and Guba 1985; Riger and Sigurvinsdottir 2016).

For authenticity, the researcher drew on prior academic training and professional experience in bilingual weather risk communication and engagement with Spanish-speaking communities in the United States. As a bilingual researcher with experience conducting interviews and surveys in both English and Spanish, the researcher approached the study with familiarity with linguistic and cultural factors that shape how weather information is interpreted. Interview questions were designed to be culturally and linguistically appropriate for Spanish-speaking participants and were informed by existing literature on weather risk communication and disaster experiences among Latino communities. To make sure the interview questions were cleared they were reviewed by a member of the dissertation committee, which is a geography professor with expertise in phenomenological research methods, and a professor from another academic institution specializing in bilingual weather risk communication. Their feedback helped refine the wording and structure of the questions to better align with the study's research objectives.

Credibility was supported by conducting interviews in Spanish, allowing participants to describe their experiences in their preferred language and reducing potential barriers related to translation or interpretation. While participant validation was initially considered, logistical constraints prevented formal member checking; however, participants were encouraged during interviews to clarify or expand upon their responses to ensure their perspectives were accurately represented.

Transferability concerns the extent to which findings may apply to other contexts. Although this study focuses on Spanish-speaking individuals' experiences with weather messages within a specific geographic and hazard context, some findings may be relevant to other settings where similar linguistic, cultural, and structural factors shape risk communication among multilingual and culturally diverse communities.

Dependability refers to the consistency of findings within the data and was supported through a systematic and transparent analytic process. Consistent with best practices in thematic analysis, themes were reviewed iteratively, and attention was given to identifying patterns that were stable across interviews. Because this dissertation was conducted as an independent, interpretive qualitative study grounded in phenomenology, formal intercoder reliability procedures were not used. Instead, coding was conducted in Dedoose using an iterative approach in which transcripts were revisited, and the codebook was refined as themes developed, helping maintain consistency and transparency in analytic decisions.

Confirmability addresses the extent to which findings are grounded in the data rather than shaped by researcher bias. To support confirmability, the analysis included attention to negative or deviant cases that challenged emerging themes, ensuring that interpretations reflected the full

range of participant experiences rather than only dominant narratives. Together, these strategies support the rigor, transparency, and trustworthiness of the qualitative analysis.

Implications

This study has broad implications for improving the effectiveness of translated weather risk communication, particularly for Spanish-speaking communities in the United States. By systematically assessing the accuracy, readability, and acceptability of translated weather information, the research will inform the development of more effective, accessible, and culturally responsive communication strategies. These insights will be valuable not only to the National Hurricane Center (NHC) but also to emergency managers, forecasters, and public agencies working to enhance multilingual outreach during extreme weather events.

Beyond technical translation quality, the study also explores public perceptions of translated messages and identifies the social, cultural, and linguistic factors that influence trust and engagement. Understanding these dynamics is critical to ensuring that translated content is not only linguistically correct but also contextually meaningful and culturally appropriate.

The findings will underscore that effective communication is not simply a matter of converting words from one language to another, but of conveying risk in a way that aligns with the target audience's lived experiences, values, and preferred modes of communication. Recognizing that Spanish-speaking communities are diverse, shaped by different regional dialects, migration histories, and cultural practices, this research highlights the need for translation strategies that go beyond a one-size-fits-all approach. By advancing a more nuanced understanding of how translated content is received and acted upon, this study supports the

creation of equitable and inclusive communication practices that enhance preparedness, build trust, and improve protective outcomes for linguistically and culturally diverse populations

References

Anderson, W., 1965: Some observations on a disaster subculture: The organizational response of Cincinnati, Ohio to the 1964 flood. Disaster Research Center Rep., University of Delaware.

Banyard, V. L., and K. E. Miller, 1998: The powerful potential of qualitative research for community psychology. *American Journal of Community Psychology*, 26, 485–505.

Bica, M., J. L. Demuth, J. E. Dykes, and L. Palen, 2019: Communicating hurricane risks: Multi-method examination of risk imagery diffusion. *Proc. 2019 CHI Conf. on Human Factors in Computing Systems*, ACM, 1–13.

Braun, V., and V. Clarke, 2006: Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77–101.

Creswell, J. W., and V. L. Plano Clark, 2011: *Designing and Conducting Mixed Methods Research*. 2nd ed. Thousand Oaks, CA, Sage.

Eady, A., B. Dreyer, B. Hey, M. Riemer, and A. Wilson, 2020: Reducing the risks of extreme heat for seniors: Communicating risks and building resilience. *Health Promotion and Chronic Disease Prevention in Canada*, 40, 215–222.

Gaviria, A. R., 2022: The role of disaster subcultures in Spanish-speaking Hispanic/Latino immigrants in the United States. M.S. thesis, University of Oklahoma, https://shareok.org/handle/11244/336948.

Glesne, C., 2011: *Becoming qualitative researchers: An introduction*, 4th ed. Pearson Education, Boston, MA.

Goundar, P. R., 2025: Researcher positionality: Ways to include it in a qualitative research design. *International Journal of Qualitative Methods*, 24, 16094069251321251.

Ivankova, N., and N. Wingo, 2018: Applying mixed methods in action research: Methodological potentials and advantages. *American Behavioral Scientist*, 62, 978–997.

Lincoln, Y. S., and E. G. Guba, 1985: *Naturalistic inquiry*. Sage.

Malina, M. A., H. S. Nørreklit, and F. H. Selto, 2011: Lessons learned: Advantages and disadvantages of mixed method research. *Qualitative Research in Accounting & Management*, 8, 59–71.

Morse, J. M., and L. Niehaus, 2009: *Mixed method design: Principles and procedures*. Left Coast Press.

Pistrang, N., and C. Barker, 2013: Varieties of qualitative research: A pragmatic approach to selecting methods. In *APA Handbook of Research Methods in Psychology*, Vol. 2 (H. Cooper, Ed.), American Psychological Association, 5–18.

Riger, S., and R. Sigurvinsdottir, 2016: Thematic analysis. In *Handbook of Methodological Approaches to Community-Based Research: Qualitative, Quantitative, and Mixed Methods*, L. A. Jason and D. S. Glenwick, Eds., Oxford University Press, 33–41.

Schensul, J. J., 2012: Methodology, methods, and tools in qualitative research. In *Qualitative Research: An Introduction to Methods and Designs* (S. D. Lapan, M. T. Quartarol, and F. J. Riemer, Eds.), Jossey-Bass, 69–107.

Trujillo-Falcón, E., J. Joseph, A. Gaviria Pabón, E. Muñoz Suárez, A. Wanless, M. Ruiz, A. L. Corrales, E. De Jesús-Otero, et al., 2026: ExTCS24. Harvard Dataverse. https://doi.org/10.7910/DVN/HQ5UHE.

Trujillo-Falcón, J. E., 2024: Examining warning response among Spanish speakers in the United States to enhance multilingual wireless emergency alerts. Ph.D. dissertation, University of Oklahoma.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. Reedy, and K. E. Klockow-McClain, 2024: 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. *Natural Hazards Review*, 25, 04023059.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. T. Ripberger, A. Bitterman, J. B. Thornton, M. J. Krocak, S. R. Ernst, E. Cassiani Obeso, and J. Lipski, 2022: ¿Aviso o alerta? Developing effective, inclusive, and consistent watch and warning translations for U.S. Spanish speakers. *Bulletin of the American Meteorological Society*, 103, E1542–E1556, https://doi.org/10.1175/BAMS-D-22-0050.1.

Chapter 3: De La Traducción a la Acción: Examining Spanish Speakers' Warning Response to Human and Machine Translations of National Weather Service Products

Introduction

The United States is home to a growingly diverse population that have a multitude of cultural backgrounds and spoken languages. Over the last few decades, linguistic diversity has increased across the country. According to the U.S. Census Bureau, the number of people speaking a language other than English at home rose from 23.1 million in 1980 to 67.8 million in 2019 (Dietrich and Hernandez 2022). Among these, Spanish is by far the most commonly spoken non-English language, largely due to the Hispanic population being the nation's largest minority group (Funk and Lopez 2022). Spanish is used in 62% of households that speak a language other than English, roughly 12 times more than the next most common languages: Chinese, Tagalog, Vietnamese, and Arabic (Dietrich and Hernandez 2022). As of 2024, the U.S. Census Bureau (2024) also confirmed that the Hispanic population is expanding at a substantially faster rate than the non-Hispanic population, signaling the increasing importance of effective communication strategies in multiple languages.

The National Weather Service (NWS) has been actively working to meet this need. Over the past decade, the agency has established volunteer translation teams to make forecasts and educational campaigns more accessible. Since 2013, the Spanish Outreach Team (SOT) has played a central role in translating preparedness materials and coordinating translations efforts across regional offices (Negrón-Hernández and Johnson 2018). Similarly, the Multimedia Assistance in Spanish (MAS) program and staff at the San Juan Weather Forecast Office (WFO) provide translation services for NWS products, ENSO discussions, and outreach campaigns

(Colón-Pagán 2021). While these initiatives represent major progress toward effective communication in non-English languages, inconsistencies in terminology and translation quality remain (Trujillo-Falcón et al. 2021; 2022). Additionally, the focus on translation only in Spanish hinders weather communicators from reaching other non-English speaking groups across the country.

To address some of these challenges, the NWS has recently turned to artificial intelligence as a way to improve both speed, accuracy, consistency, and scalability of weather translations. In 2021, the agency launched the NWS Artificial Intelligence (AI) Translation Program in partnership with academic and private-sector collaborators (Trujillo-Falcón et al. 2025). The program uses a human-in-the-loop framework in which bilingual forecasters review, correct, and retrain AI-generated translations to improve translation quality and operational consistency. Pilot studies at the San Juan WFO have shown promising results: the AI translation tool reaches up to 99% accuracy when translating tropical weather information and reduces translation time from nearly an hour to just a few minutes for certain products. The AI tool has also expanded to provide translations in Spanish, Chinese, and Vietnamese, among other non-English languages. Ongoing evaluations combine automated translation quality metrics (e.g., BLEU, COMET) with community feedback to ensure that human oversight remains central to quality control and public trust (Trujillo-Falcón et al. 2025).

Despite major advances in AI-assisted translation, important challenges remain. Trust in AI tools depends not only on translation quality but also on whether messages feel authentic and culturally relevant (Scharowski et al. 2022; Bostrom et al. 2024). As Castillo (2015) notes, linguistic acceptability is socially and culturally shaped, meaning effectiveness cannot be measured by algorithms alone. What remains unclear, and central to this study, is whether

improved translations conducted by AI actually strengthen warning responses among Spanish-speaking audiences. Ensuring the long-term success of the NWS AI Translation Program will require thorough evaluation of how its products perform with real users from across the country.

Through a nationwide survey of 640 Spanish speakers, this study examines how audiences across the United States understand and respond to both human- and AI-translated weather messages. Drawing from translation studies, we assess how participants evaluate the quality of these translations. We also apply the Warning Response Model (WRM) to explore whether translated messages prompt consideration of protective actions during severe weather. Our findings offer practical recommendations for improving the design, testing, and dissemination of multilingual weather communication, especially in AI contexts.

Literature Review

Challenges in translating information

Translation is more than just converting words from one language to another. It involves ensuring that messages make sense, read naturally, and carry the same intent as the original. Chen (2024), for example, argues that an effective translation must meet two conditions: the meaning of the original message must be conveyed faithfully, and the text must be grammatically and stylistically appropriate in the target language. Beyond these conditions, translation studies scholars point to four qualities that define quality: accuracy, readability, acceptability, and satisfaction (Koby et al. 2014; Castillo 2015; Castilho and O'Brien 2017). When combined, these factors determine whether a translation not only informs but also resonates, a critical distinction for weather communication.

Results from studies in weather risk communication shows that these standards are not always achieved. Trujillo-Falcón et al. (2022) found that inconsistent Spanish translations of "tornado watch" and "tornado warning" reduced intended urgency of the original terminology and caused confusion among users. Bitterman et al. (2023) reported similar findings when analyzing Storm Prediction Center (SPC) risk categories translations in Spanish. Both studies linked these inconsistencies to dialectal variation, referring to regional and cultural differences in Spanish that affect how certain words are perceived by speakers from distinct backgrounds. These studies help explain why Spanish speakers are more vulnerable in extreme weather contexts. As Gaviria-Pabón et al. 2025 found, Spanish speakers remain less likely than English speakers to receive, comprehend, and act on weather warnings, reinforcing the need to evaluate translations in the future.

Evaluating AI and its Translation Capabilities

As the NWS starts to rely more upon AI to translate weather information, new challenges emerge in ensuring that translations remain accurate, culturally appropriate, and easy to understand. Studies in cross-cultural and intercultural research have shown that the effectiveness of AI translations depends on how closely related the source and target languages are. Researchers call this genetic similarity (Kunst and Bierwiaczonek 2023). In other words, languages that come from the same linguistic family or share similar roots tend to produce more accurate machine translations, since the grammar and vocabulary aligns more naturally. However, when languages are less similar or related, machines often struggle more. Therefore, researchers recommend greater human involvement in the translation process (Kunst and Bierwiaczonek 2023).

Research has also highlighted gaps between the linguistic form of training data and its meaning, resulting in machine translation programs lacking the necessary level of natural language understanding to secure human users' trust (Chen 2024). Consequently, human intervention is considered an indispensable component of the machine translation process (Chen 2024). However, research has also demonstrated that AI-generated translations can achieve a quality approaching that of human translations (Kunst and Bierwiaczonek 2023).

Warning Response Model

To better understand how individuals interpret and respond to translated weather information, this study draws primarily on the Warning Response Model developed by Mileti and Sorensen (1990), which outlines a series of cognitive and social processes guiding protective action. Upon receiving a warning, individuals typically progress through several stages: they must first understand the message, then believe it is credible and relevant, personalize the risk, and finally make a decision to act (Mileti & Sorensen 1990). Each of these stages can be disrupted when communication is delivered in a language that does not align with the recipient's linguistic or cultural background.

Trujillo-Falcón et al. (2024) highlighted that inconsistent or jargon-heavy translations can hinder comprehension, preventing individuals from accurately interpreting the severity of the threat. If a person cannot understand a message, they are unlikely to believe it, personalize it, or take timely action. Belief also depends on trust in the source. For many Spanish speakers, particularly immigrants or those with limited English proficiency, formal agencies such as NWS or FEMA may be perceived as less trustworthy than community networks or informal sources (Maldonado et al. 2016; Sledge & Thomas 2019). While informal networks may provide trusted communication, they often lack the training or expertise to convey accurate or actionable

information (Onís et al. 2021). Cultural unfamiliarity with U.S. warning systems, lack of standardized terminology across dialects, or conflicting messages across platforms further complicate personalization and action (Abukhalaf & von Meding 2021; Uekusa 2019; Gaviria-Pabón 2022; Trujillo-Falcón et al. 2022; Trujillo-Falcón 2024).

The Protective Action Decision Model (PADM) by Lindell & Perry 2012 complements the Warning Response Model by emphasizing how cognitive appraisals such as perceived credibility, efficacy, and trust in the message shape protective action. Together, these frameworks highlight why translation quality matters: without accurate, clear, and culturally resonant translations, warning response processes can easily break down.

Research Study

Given these ongoing developments and persistent challenges, it is essential to incorporate the perspectives of end users themselves, more specifically those who rely on translated weather information to make time-sensitive protective decisions. While AI-generated translations are expanding, creating more accessibility and reducing translation times, their effectiveness cannot be only evaluated by technical accuracy. What matters most is how these translations are received, understood, and trusted by the communities they are intended to serve, and whether they ultimately support protective action.

This study directly addresses that need by evaluating Spanish speakers' perceptions of AI-generated versus human-translated versions of tropical weather Key Messages. Using a nationwide survey, participants were asked to rate each translation on four widely recognized indicators of translation quality: accuracy, readability, acceptability, and overall satisfaction. The survey also collected demographic information such as age, ethnicity, dialect, and prior storm

experience. However, these factors were not explored further in the analysis, as they did not emerge as statistically significant in shaping perceptions of translation quality or warning response.

Beyond quality perceptions, the study also draws from the Warning Response Model (Mileti & Sorensen 1990) and the Protective Action Decision Model (Lindell & Perry 2012) to examine how translation quality relates to stages of warning response. These include belief in the message, comprehension, personalization of risk, and confidence in taking protective action both self-efficacy and response efficacy.

By integrating user perspectives with behavioral models of decision-making, this research contributes to a more comprehensive understanding of how translation quality intersects with risk perceptions and protective action in multilingual hazard contexts. It moves the evaluation of translation beyond linguistic correctness to focus on its life saving potential in diverse communities.

To guide this analysis, the study is organized around two primary research questions: 1) *Are there differences in how Spanish speakers rate the translation quality of AI-generated and human-translated Key Messages graphics? 2) Are there differences in Spanish speakers' warning responses based on whether they viewed AI-generated or human-translated Key Messages graphics?*

Together, these questions are designed to examine whether Spanish speakers' evaluations of translation quality and their warning responses differ depending on whether they viewed AI-generated or human-translated messages.

Data & Methods

This study draws on data from the Extended 2024 Tropical Cyclone Spanish (Extended TCS24) Survey, which was developed and administered through a collaborative effort between the Department of Climate, Meteorology, and Atmospheric Sciences at the University of Illinois Urbana-Champaign and the Institute for Public Policy Research and Analysis (IPPRA) at the University of Oklahoma. This nationwide survey aimed to enhance understanding of how Spanish-speaking individuals in the United States make decisions during tropical cyclone events. It extends a series of weather communication surveys conducted annually since 2022 (see Muñoz Suárez et al. 2024 for more on the 2023 Extended Tornado Survey). The TCS24 was fielded between December 9, 2024, and January 13, 2025.

Participants completed the survey online. A total of 640 U.S. adults aged 18 and older who self-identified as speaking Spanish "well" or better were recruited through an internet panel designed to mirror the demographic composition of the U.S. Spanish-speaking population based on Census estimates. This survey built on the Tropical Cyclone 2023 (TC23) survey, which provided a foundation for assessing how adult Spanish speakers interpret and respond to tropical cyclone warnings. The TCS24 instrument was tailored to explore how cultural backgrounds, both in the U.S. and countries of origin, influence responses to various types of tropical cyclone risks. In particular, this study focused on evaluating artificial intelligence AI-generated Spanish translations produced by the National Weather Service, establishing a benchmark for translation quality to guide future improvements.

Data Collection

Verasight, a research and marketing company, provided the participant sample. Verasight maintains an online panel of U.S.-based users who agree to take part in surveys and recruits

participants through various channels including web advertisements, social media, affiliate programs, and digital partnerships.

For the TCS24, Verasight employed a dynamic sampling approach to identify eligible respondents specifically, U.S. adults living in the contiguous United States. Initial invitations were sent to a subset of panelists reflecting the survey's target demographic characteristics. As responses came in, sampling adjustments were made to achieve balanced representation; more invitations were issued to underrepresented groups, and fewer to overrepresented ones. This approach helped achieve a sample that is broadly representative of Spanish-speaking adults in the U.S. Demographic comparisons with U.S. Census data are summarized in Table 1.

To protect participants' rights and privacy, all survey materials and protocols were reviewed and approved by the University of Oklahoma Institutional Review Board (IRB #15113). While Verasight managed recruitment and sampling, the University of Oklahoma oversaw survey implementation and data management. The survey was designed for asynchronous, self-paced completion within time constraints that ensured high data quality. On average, respondents completed the survey in 23 minutes. Participation was voluntary, and all respondents who completed the survey received compensation in the form of points provided by Verasight.

Survey Design

The primary aim of this study was to explore Spanish-speaking participants' perceptions of translation quality in key tropical cyclone messaging from the National Hurricane Center (NHC), and to examine warning responses across both AI and Human generated translations.

To investigate these issues, an embedded experiment was included in the TCS24 survey.

The experiment tested how the NHC's Spanish-language *Key Messages* graphic was perceived under two different translation source conditions. The *Key Messages* product was selected for this study because it is widely disseminated on social media, making it more accessible to the general public including Spanish-speaking audiences than many other NHC products. Its concise, visual format and broad reach make it a critical tool for evaluating how effectively translated risk communication is received and understood.

At the time the experiment was being developed, Hurricane Beryl was the first named hurricane of the 2024 Atlantic season, and the NHC had already issued *Key Messages* graphics for this storm. As such, the *Key Messages* graphic for Hurricane Beryl was used as the basis for the experiment. To simulate real-world conditions and preserve ecological validity, participants were shown versions of the graphic that closely mirrored the original NHC product.

Participants were randomly assigned to one of two experimental conditions:

Condition 1 (Fig. 3): Participants viewed the official NHC graphic as published online, which included the standard disclaimer: "This message was originally written in English but was translated into Spanish using AI." This AI-translated version reflects the current operational approach adopted by the NHC for Spanish-language dissemination.

Condition 2 (Fig. 4): Participants viewed a *Key Messages* graphic accompanied by the message: "This message was originally written in English but was translated into Spanish by forecasters at the National Hurricane Center." This translation was completed by a bilingual meteorologist at the NWS San Juan office, which has historically been responsible for producing Spanish-language translations of tropical weather products prior to the use of AI systems.

Participants were randomly assigned to one of these two groups to ensure balanced exposure to each condition. After viewing the graphic, respondents answered a series of questions designed to evaluate their perceptions of the translation, including, accuracy, readability, acceptability, and overall satisfaction (see Table 5). These perception measures help assess not only how the source of the translation influences comprehension and trust, but also how Spanish-speaking individuals engage with translated hurricane information in real-time communication environments. In addition, after participants saw the message they were asked a series of questions regarding their warning responses to the message (see Table 6).

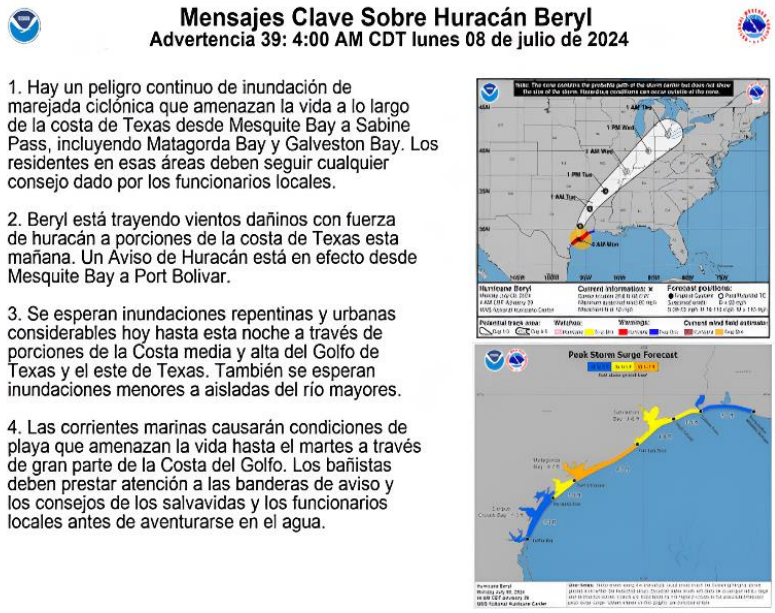


Figure 3: Key Messages graphic translated using AI. This version is the official NHC graphic published online and includes a message noting that the translation was produced using artificial intelligence.



Figure 4: Key Messages graphic translated by a human forecaster. The graphic includes a message stating that the original English text was translated into Spanish by forecasters at the National Hurricane Center. The translation used in this condition was completed by a forecaster at the National Weather Service in San Juan, Puerto Rico.

Accuracy	Readability	Acceptability	Satisfaction
The translation accurately conveys the main message of the text.	The translated text is easy to read and understand.	The translation adheres to the linguistic norms and conventions of the Spanish language	I am satisfied with the translation
The information in the translation is clear and aligns with what you would expect from the text.	The message in the translated text is clear and straightforward.	The translation reads naturally and is appropriate.	The translation provides the information I need effectively.
The translation effectively communicates the key points and details.	The structure and language of the translation make it accessible and comprehensible	I can understand and relate to the meaning and context of the translated text.	I would recommend this translation to others

Table 5: Items used to assess participants' perceptions of the translated Key Messages graphic, including accuracy, readability, acceptability, and satisfaction. Responses were recorded using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly

Understanding	How well do you understand the information that is being presented in this graphic?
Belief	Please indicate the level of trust that you have in the information presented through this graphic?
Personalization	After reading the message, do you feel you are in danger if you were on the Texas coast?
Self-Efficacy	Do you think you can take the protective measures that are recommended?
Response-Efficacy	How confident are you that the protective measures you take will keep you safe?

Table 6: Items used to assess participants' warning response to the Key Messages graphic, including understanding, belief, personalization, self-efficacy, and response-efficacy. Responses were recorded using a 5-point Likert scale.

Statistical Analysis

To examine how Spanish-speaking participants evaluated and responded to translated weather messages, this study employed statistical analyses that reduced multiple survey items into meaningful composite constructs. Translation quality was assessed using composite measures of accuracy, readability, acceptability, and satisfaction, each created by averaging responses across multiple survey items (see Table 5). Warning response was assessed using composite measures of understanding, belief, personalization, self-efficacy, and response efficacy (see Table 6). Composite scores were calculated using descriptive summary statistics, and mean differences between AI-generated and human-translated messages were examined using group-level comparisons with corresponding confidence intervals. Together, these analyses

captured how participants evaluated the quality of translated “Key Messages” graphics from the NHC and how they perceived and responded to the information presented in the message.

Results

Translation Quality

We wanted to understand whether there were any differences in how participants evaluated the translation quality of AI-generated versus human-translated messages. Overall, participants rated both types of translations similarly across all four translation quality dimensions: accuracy, readability, acceptability, and satisfaction.

For accuracy, human translations received a slightly higher mean rating (M = 3.78) than AI translations (M = 3.73); however, this difference was not statistically significant (estimate = −0.05, p = .45). Readability ratings were very similar for human (M = 3.82) and AI translations (M = 3.80), with no significant difference between groups (estimate = −0.02, p = .76). For acceptability, human translations were again rated slightly higher (M = 3.85) than AI translations (M = 3.81), but this difference was also not statistically significant (estimate = −0.04, p = .56). Satisfaction ratings were the same for both human and AI translations (M = 3.85), and no significant difference was observed (estimate = −0.01, p = .93).

Taken together, these results indicate that participants did not perceive meaningful differences in translation quality between AI-generated and human-translated messages. Across all dimensions, differences in mean ratings were small and statistically non-significant, suggesting that translation quality evaluations were not strongly influenced by whether the

translation was generated by AI or a human.

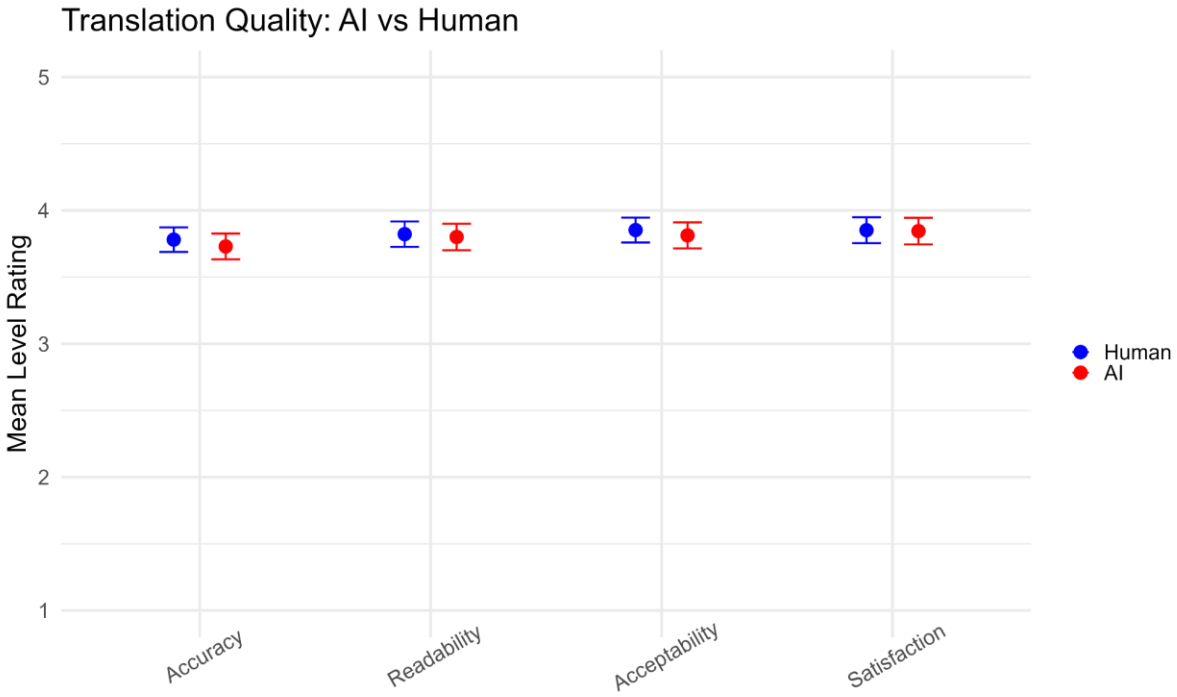


Figure 5: Mean ratings and 95% confidence intervals for accuracy, readability, acceptability, and satisfaction for AI-generated and human-translated messages.

Warning Response

We also examined whether there were differences in participants' warning responses to AI-generated versus human-translated messages. Warning response was measured across five dimensions: understanding, belief, personalization, self-efficacy, and response efficacy.

For understanding, participants reported higher mean levels when the message was generated by AI (M = 3.51) compared to a human translation (M = 3.31). This difference was statistically significant (estimate = −0.20, p = .013). For belief, mean ratings were similar for AI (M = 3.57) and human translations (M = 3.54), and no statistically significant difference was observed (estimate = −0.04, p = .62).

For personalization, AI-generated messages received slightly higher mean ratings (M = 3.87) than human-translated messages (M = 3.78), but this difference was not statistically significant (estimate = −0.09, p = .27). Self-efficacy ratings were also higher for AI-generated messages (M = 4.28) compared to human translations (M = 4.16); however, this difference was also not statistically significant (estimate = −0.12, p = .06). Finally, response efficacy ratings were similar for AI (M = 3.52) and human translations (M = 3.44), with no statistically significant difference between groups (estimate = −0.08, p = .26).

Overall, these results suggest that warning response outcomes were largely similar across AI-generated and human-translated messages. However, AI-generated messages were associated with significantly higher levels of understanding and showed small differences for personalization and self-efficacy, however the latter two were not statistically significant.

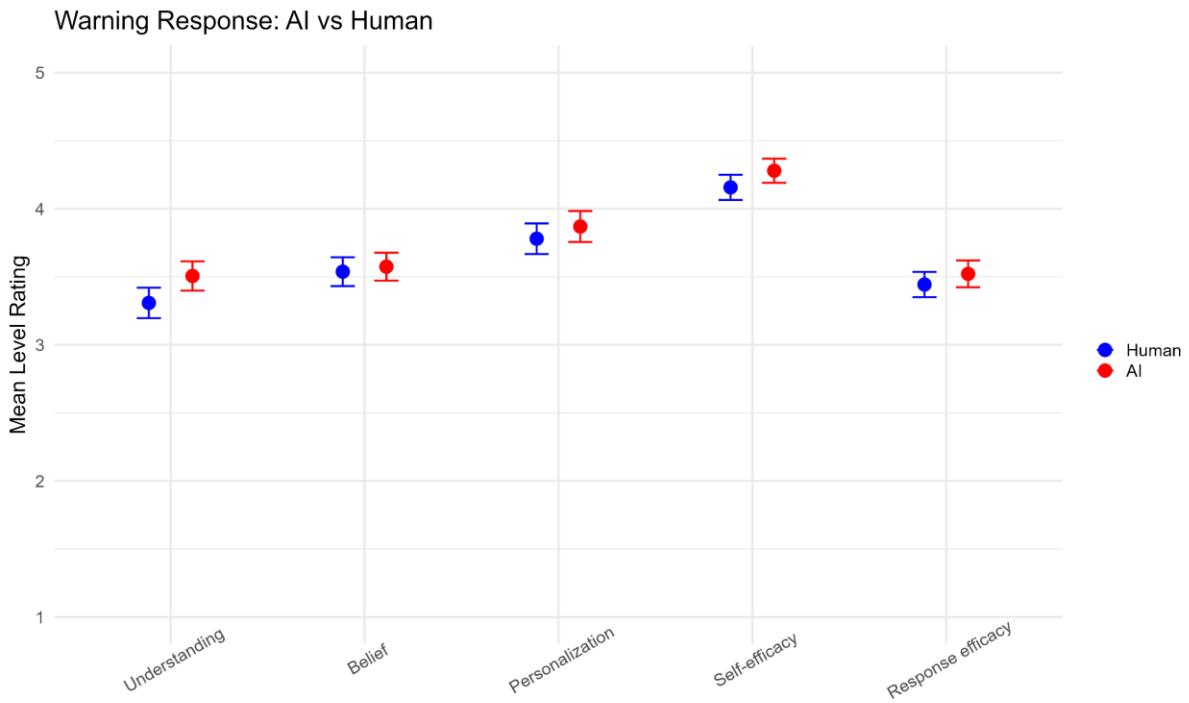


Figure 6: Mean ratings and 95% confidence intervals for understanding, belief, personalization, self-efficacy, and response efficacy for AI-generated and human-translated messages.

Discussion

The purpose of this study was to examine how Spanish speakers evaluate the translation quality of AI-generated versus human-translated messages in the context of tropical weather information. Specifically, the study assessed whether evaluations of translation quality differed between AI and human translations of the NHC Key Messages graphic. The study also examined whether Spanish speakers' warning responses varied depending on whether the message was translated by AI or by a human.

Our first research question asked if there were any differences on how Spanish speakers evaluated the quality of AI vs human generated translations. The results showed that, overall,

participants evaluated the messages in similar ways regardless of whether the message was generated by AI or translated by a human forecaster.

Our second research question examined whether there were differences in Spanish speakers' warning responses to AI-generated versus human-translated versions of the NHC Key Messages graphic. Overall, participants responded similarly to both types of messages across most warning response dimensions, regardless of translation source. However, perceived understanding of the message was rated slightly higher for AI-generated translations, and this difference was statistically significant.

These findings align with previous research suggesting that improving translation quality particularly by incorporating cultural factors and moving away from direct word-for-word translations toward meaning-based translations can help Spanish speakers make better decisions during hazardous weather events (Trujillo-Falcón et al. 2022; 2024; Trujillo-Falcón 2024; Gaviria-Pabón 2022; Bitterman et al. 2023). Prior studies have also demonstrated that AI-generated translations can achieve a level of quality approaching that of human translations (Kunst and Bierwiaczonek 2023). At the same time, research emphasizes that AI translation quality improves when a human is involved in the translation process (Chen 2024; Kunst and Bierwiaczonek 2023). The AI translation system used by the National Weather Service includes a human-in-the-loop component. Our results help confirm that when human oversight is present and when recommendations from previous research on Spanish-speaking communities are incorporated, warning messages regardless of source are more likely to be understood, believed, personalized, and to increase confidence in the recommended protective actions.

Conclusion

This study contributes to important and ongoing work in weather risk communication, specifically for Spanish-speaking communities. The findings demonstrate that improving the quality of translated weather messages whether produced by a human or by AI can meaningfully increase participants' warning responses. Translations were perceived as clear, accurate, and well written, across both translation sources and there were very small differences across their warning responses. These results highlight that translation quality itself, rather than the source of the translation, plays a central role in supporting effective protective decision making.

In a context where technologies continue to evolve and the use of AI in communication is becoming more widespread, maintaining consistency and high-quality standards throughout the translation process is critical. This is especially important for high-stakes communication such as tropical weather warnings, where misunderstandings or unclear messaging can have serious consequences. The results suggest that AI, when implemented thoughtfully and with attention to quality and oversight, can serve as a useful tool for expanding access to timely and understandable weather information.

Continued efforts to improve weather communication for Spanish-speaking communities remain essential, particularly as weather hazards become more frequent and severe and these communities often face heightened vulnerability due to linguistic, social, and structural barriers. While this study focused on Spanish-speaking populations, the findings also have broader implications for other multilingual communities. The use of AI-supported translation systems, combined with human involvement and attention to cultural and linguistic context, has the potential to improve access to critical weather information across diverse populations. Ultimately, investing in high-quality translation practices regardless of whether messages are

generated by humans or AI represents an important step toward more inclusive and effective weather risk communication.

Limitations

This study has limitations that should guide future work. The survey sample, which included 640 participants, provides insight into Spanish-speaking individuals' perceptions of translated weather information; however, it may not fully represent the diversity of Spanish-speaking populations across different regions or communication contexts. Findings may differ for other hazard types, message formats, or populations with different levels of familiarity with weather information. Demographic factors such as age, ethnicity, and dialect were not significant predictors in this sample. Although this finding suggests that translation quality is a stronger driver than demographic variation, future research should continue exploring potential interactions across different subgroups and contexts. In addition, while survey based evaluations capture perceptions and self-reported intentions, qualitative studies such as interviews or focus groups could provide deeper insights into how translation quality influences actual behavior during hazard events. Further work is also needed to evaluate AI translation performance across diverse dialects and hazard types, and to examine how trust in AI evolves as these systems become more integrated into operational warning practices.

References

Abukhalaf, A. H. I., and J. von Meding, 2021: Psycholinguistics and emergency communication: A qualitative descriptive study. *International Journal of Disaster Risk Reduction*, 55, 102061, https://doi.org/10.1016/j.ijdrr.2021.102061.

Bitterman, A., M. J. Krocak, J. T. Ripberger, S. Ernst, J. E. Trujillo-Falcón, A. Gaviria Pabón, and H. Jenkins-Smith, 2023: Assessing public interpretation of original and linguist-suggested SPC risk categories in Spanish. *Weather and Forecasting*, 38, 1095–1106.

Bostrom, A., Demuth, J. L., Wirz, C. D., Cains, M. G., Schumacher, A., Madlambayan, D., ... & Williams, J. K. (2024). Trust and trustworthy artificial intelligence: A research agenda for AI in the environmental sciences. *Risk Analysis*, *44*(6), 1498-1513.

Castilho, S., and S. O'Brien, 2017: Acceptability of machine-translated content: A multi-language evaluation by translators and end-users. *Linguist. Antverp. N. S.–Themes Transl. Stud.*, 16, 1–19.

Castillo, L. M., 2015: Acquisition of translation competence and translation acceptability: An experimental study. *Translation & Interpreting: The International Journal of Translation and Interpreting Research*, 7, 72–85.

Chen, M., 2024: Trust, understanding, and machine translation: The task of translation and the responsibility of the translator. *AI & Society*, 39, 2307–2319.

Colón-Pagán, I. C., 2021: Disseminating weather information to Spanish-speaking communities from the NWS/WFO San Juan perspective. *Preprints, 101st Amer. Meteor. Soc. Annual Meeting*, Amer. Meteor. Soc., Virtual, Joint Abstract.

Dietrich, S., and E. Hernandez, 2022: *Language use in the United States: 2019*. American Community Survey Reports, No. ACS-50, U.S. Census Bureau, 12 pp.

Funk, C., and M. H. Lopez, 2022: *A brief statistical portrait of U.S. Hispanics*. Pew Research Center, 14 June 2022, https://www.pewresearch.org/science/2022/06/14/a-brief-statistical-portrait-of-u-s-hispanics/, accessed 4 Feb. 2026.

Gaviria Pabón, A. R., M. J. Krocak, J. T. Ripberger, and J. E. Trujillo-Falcón, 2025: Linguistic challenges in severe weather communication: Comparing English- and Spanish-speaking populations. *Bull. Amer. Meteor. Soc.*, 106, E1940–E1954.

Gaviria, A. R., 2022: The role of disaster subcultures in Spanish-speaking Hispanic/Latino immigrants in the United States. M.S. thesis, University of Oklahoma, 122 pp., https://shareok.org/handle/11244/336948.

Koby, G. S., P. Fields, D. Hague, A. Lommel, and A. Melby, 2014: Defining translation quality. *Rev. Tradumàtica*, **12**, 413–420, https://ddd.uab.cat/pub/tradumatica/tradumatica_a2014n12/tradumatica_a2014n12p413.pdf

Kunst, J. R., and K. Bierwiaczonek, 2023: Utilizing AI questionnaire translations in cross-cultural and intercultural research: Insights and recommendations. *International Journal of Intercultural Relations*, 97, 101888.

Lindell, M. K., and R. W. Perry, 2012: The protective action decision model: Theoretical modifications and additional evidence. *Risk Anal.*, **32**, 616–632.

Maldonado, A., T. Collins, S. Grineski, and J. Chakraborty, 2016: Exposure to flood hazards in Miami and Houston: Are Hispanic immigrants at greater risk than other social groups? *Int. J. Environ. Res. Public Health*, **13**, 775, https://doi.org/10.3390/ijerph13080775.

Mileti, D. S., and J. H. Sorensen, 1990: *Communication of Emergency Public Warnings: A Social Science Perspective and State-of-the-Art Assessment*. ORNL-6609, Oak Ridge National Laboratory, 150 pp.

National Hurricane Center, 2024: *National Hurricane Center products and services update for the 2024 hurricane season*. National Oceanic and Atmospheric Administration, accessed 4 Feb. 2026, https://www.nhc.noaa.gov/pdf/NHC_New_Products_Updates_2024.pdf.

Negrón-Hernández, K., and L. Johnson, 2018: Providing Spanish translations to build a Weather-Ready Nation. *Preprints, 98th Amer. Meteor. Soc. Annual Meeting*, Amer. Meteor. Soc., Austin, TX, 8–9.

Onís, C. M., E. Cubelos, and M. del Rocio Ortiz Chavarria, 2021: “No había humanidad”: Critiquing English monolingualism and other entwined systems of white supremacy in local emergency management responses. *Social Justice*, **47**, 135–170.

Scharowski, N., S. A. Perrig, N. von Felten, and F. Brühlmann, 2022: Trust and reliance in XAI—Distinguishing between attitudinal and behavioral measures. *arXiv preprint*, arXiv:2203.12318, https://arxiv.org/abs/2203.12318.

Sledge, D., and H. F. Thomas, 2019: From disaster response to community recovery: Nongovernmental entities, government, and public health. *American Journal of Public Health*, 109, 437–444.

Trujillo-Falcón, J. E., M. L. Bozeman, L. E. Llewellyn, S. T. Halvorson, M. Mizell, S. Deshpande, and T. Fagin, 2025: From binary to bilingual: How the National Weather Service is

using artificial intelligence to develop a comprehensive translation program. *arXiv preprint*, arXiv:2510.14369.

Trujillo-Falcón, J. E., 2024: Examining warning response among Spanish speakers in the United States to enhance multilingual wireless emergency alerts. Ph.D. dissertation, University of Oklahoma.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. Reedy, and K. E. Klockow-McClain, 2024: 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. *Nat. Hazards Rev.*, **25**, 04023059.

Trujillo-Falcón, J. E., and Coauthors, 2022: ¿Aviso o alerta? Developing effective, inclusive, and consistent watch and warning translations for U.S. Spanish speakers. *Bull. Amer. Meteor. Soc.*, **103**, E1542–E1556, https://doi.org/10.1175/BAMS-D-22-0050.1.

Trujillo-Falcón, J. E., and Coauthors, 2021: Hazardous weather communication en Español: Challenges, current resources, and future practices. *Bull. Amer. Meteor. Soc.*, **102**, E765–E773.

Uekusa, S., 2019: Disaster linguicism: Linguistic minorities in disasters. *Language in Society*, 48, 353–375, https://doi.org/10.1017/S0047404519000150.

U.S. Census Bureau, 2024: New estimates highlight differences in growth between the U.S. Hispanic and non-Hispanic populations. *U.S. Census Bureau Press Release*, 27 June 2024, https://www.census.gov/newsroom/press-releases/2024/population-estimates-characteristics.html, accessed 4 Feb. 2026.

Chapter 4: La voz de la experiencia: Phenomenological Insights into Spanish-Language Weather Communication

Introduction

Spanish speakers

Spanish-speaking communities in the United States do not experience or interpret weather risk communication in the same way. Their responses can be shaped by their lived experiences, culture, and exposure to hazards in current or previous locations (Gaviria-Pabón 2022; Keul et al. 2018). In the U.S. for more than 41 million individuals that identify as Hispanic or Latino, Spanish is their primary language and form of communicating and receiving information (Fernández Vitores 2024). The U.S. Census Bureau defines this group as those of Mexican, Puerto Rican, Cuban, Central and South American, or other Spanish cultural origins, and notes that it is expanding at a much faster rate than the non-Hispanic population (U.S. Census Bureau 2020, 2024). This growth makes Spanish the second most spoken language in the country, as well as the primary form of communication for millions (Dietrich & Hernandez 2022).

Disasters are not experienced equally across populations. Blaikie, Wisner, Cannon, and Davis in *At Risk* 2004 reframes disasters as socially constructed phenomena shaped by political, economic, and social processes. Rather than viewing disasters as purely natural events, they argue that impacts are closely tied to everyday vulnerabilities influenced by factors such as class, gender, ethnicity, immigration status, and disability (Blaikie et al. 2004, pp. 6–10). As Verchick (2012) notes, natural disasters disproportionately affect those with the least social and economic power, while wealthier communities are better equipped to reduce and manage risk, reinforcing inequality over time (Simon 2014). Vulnerability is therefore not only about exposure to hazards, but also about unequal access to resources, information, and opportunities. This framing is particularly relevant for Spanish-speaking communities in the United States, who often face barriers related to language, socioeconomic status, immigration status, and unfamiliarity with hazard-specific

terminology and recommended protective actions (Maldonado et al. 2016; Mendez et al. 2020).

Spanish speakers face more challenges when receiving, interpreting, and understanding weather risk information in comparison to English speaking populations (Gaviria-Pabón et al. 2025). Language barriers can increase the level of vulnerability for Hispanic/Latino immigrant communities. Mast and Ruiz (2023) report that 39% of Spanish speakers in the U.S. speak English "less than very well," suggesting a significant portion of the population may not fully understand weather alerts if only presented in English. The majority of weather warning information in the United States is in English, and the one that is available in Spanish does not incorporate factors such as cultural background and language dialects into their translations (Trujillo-Falcón et al. 2022; Aguirre 1988). Having these inequities in bilingual weather risk communication can transfer to ineffective preparedness when it comes to a weather threat (Aguirre 1988).

In addition, those that immigrate from other places have developed their own disaster subcultures that have been shaped by hurricanes, floods, earthquakes, or other hazards that may be different from hazards in the U.S. (Gaviria-Pabón 2022; Trujillo-Falcón et al. 2024). As they adjust to a newer place, barriers such as limited English proficiency, cultural differences, and lack of culturally tailored resources can often complicate the interpretation of weather risk information (Maldonado et al. 2016; Mendez et al. 2020; Trujillo-Falcón et al. 2022). Therefore, highlighting and exploring Spanish speakers' perspectives and experiences is essential: it is not only about whether messages are translated, but also about how people draw on past experiences, cultural frameworks, and linguistic identities to decide how or whether to act.

Disaster Subcultures and Risk Perceptions

Anderson (1965) introduced the concept of disaster subcultures to describe subcultural

patterns that arise in communities that are regularly exposed to hazards. These subcultures represent how through shared experiences people have adapted to deal with recurring disasters. These responses are shaped by not only cultural worldviews but also by place attachment, meaning depending on where you are you may experience different hazards that develop those subcultures. For example, in Chile, where earthquakes are frequent, during the 2010 earthquake, local residents drew upon generational knowledge and historical experience to respond effectively, while tourists without such cultural understanding were less prepared (Engel et al. 2022).

Disaster subcultures highlight how lived experiences influence preparedness and protective actions. Galveston, Texas, provides another example: during Hurricane Ike, some residents made the decision not to evacuate due to skepticism toward officials and media, whom they perceived were exaggerating threats (Baer et al. 2019). This type of behavior and attitudes can arise from repeated false alarms. This lack of trust shows how disaster subcultures are entwined with selective trust in information sources. Kahan et al. (2011) found that individuals are more inclined to believe scientific information when it aligns with their cultural worldview, allowing them to dismiss credible information that does not. Similarly, Shi et al. (2015) showed that prior distrust in officials shapes skepticism toward evacuation orders. These findings emphasize that disaster subcultures reflect both local histories and broader cultural values, shaping how communities interpret and act on weather risk information.

Disaster subcultures can arise from social innovation and learning processes (Warner & Engel 2014). Communities develop different cultural actions as a response to unique challenges posed by disasters. However, for recent immigrants, such as many Spanish speakers in the United States, adapting to new hazard conditions can be difficult. Individuals often bring with

them risk perceptions from their home countries, which may not be the same hazards they face in the United States (Fischhoff 1995; Burns & Slovic 2012). For example, someone from Guatemala may be more familiar with earthquakes, rather than tornadoes or winter storms. Without prior exposure, personal risk perceptions can be lower. Therefore, taking protective actions can be less likely. (Klockow et al. 2014; Botzen & Van Der Bergh 2009).

Research has shown how Hispanic/Latino populations in the U.S. are highly vulnerable to weather risks (Maldonado et al. 2016; Trujillo-Falcón et al. 2021; Méndez et al. 2020). For many immigrants, immediate needs such as securing housing and employment outweigh prioritizing disaster preparedness for hazards they have not experienced before, such as tornadoes or floods (Donner & Rodriguez 2008). Benavides and Arlikatti (2010) note that without targeted communication efforts, language differences can exacerbate susceptibility to hazards.

At the same time, prior experiences and cultural backgrounds shape how immigrants perceive their risks in the United States. Gaviria-Pabón (2022) found that Spanish speaking communities drew upon beliefs, knowledge, and cultural interpretations to take protective action during a tornado outbreak. These findings show that risk communication cannot be separated from culture. For Hispanic/Latino communities, messages that fail to align with cultural worldviews or prior experiences may be met with skepticism, indifference, or confusion. As Trujillo-Falcón (2024) emphasize, warning responses are deeply influenced by personal experiences and collective cultural patterns.

Disaster subcultures among Spanish-speaking communities are informed by experiences in countries of origin while also evolving in response to new hazards in the U.S. context. Understanding these lived cultural experiences is critical to designing warnings that resonate

with these communities.

Cultural Worldviews

Culture plays an important role in how people understand risk and decide how to act. Matsumoto et al. (1996) define culture as the shared set of beliefs, values, attitudes, and behaviors that are passed down through generations. These shared cultural elements shape how individuals interpret uncertainty, responsibility, and control, especially in the context of hazards and environmental risks.

The Cultural Theory of Risk helps explain how these cultural differences influence risk perception and behavior. Douglas and Wildavsky (1982) argue that cultural groups can be understood through two dimensions: group, which reflects how strongly people identify with and feel obligations toward others, and grid, which reflects acceptance of rules, authority, and social structure. Together, these dimensions shape cultural worldviews and influence how risks are evaluated and responded to. Cultural worldviews help explain why people exposed to the same hazard may interpret its seriousness differently and make different decisions about preparedness and action (Douglas and Wildavsky 1982; Shi et al. 2015; Morss et al. 2020). Building on this framework, the psychometric paradigm shows that risk perception is not purely rational but is also shaped by emotions, experience, and subjective judgments (Slovic 2000).

Cultural cognition theory integrates these ideas by showing how deeply held values guide how people interpret scientific information and risk related evidence (Shi et al. 2015). One important distinction within this work is between individualistic and collectivist orientations. In U.S. and Western European contexts, individualistic values emphasize autonomy, self-reliance,

and personal responsibility, whereas East Asian and Latine cultures tend to place greater emphasis on relationships, family, and collective well-being (Naiman et al. 2023).

These orientations influence how people approach decision-making during hazards. In more collectivist contexts, decisions are often made in consultation with family members and are shaped by a sense of obligation to protect and support others. Marin (1991) notes that Hispanics often feel a strong responsibility toward family, both emotionally and economically, and may prioritize collective needs when making decisions. This relational orientation can influence how people evaluate risk, when they choose to act, and whose safety they prioritize during hazardous events.

Cultural beliefs about control and fate also shape responses to environmental risk. Marin (1991) describes how fatalism, which is common in agricultural societies exposed to unpredictable weather, is reflected in familiar sayings that suggest outcomes are determined by external forces. Fatalistic beliefs may reduce planning when people feel outcomes are beyond individual control. At the same time, other equally common cultural expressions emphasize prevention, effort, and responsibility, suggesting that planning and action can coexist with faith-based or externally oriented beliefs (Marin 1991). This highlights that cultural worldviews are not fixed and can include both fatalistic and action-oriented elements.

Research on environmental risk supports the idea that values and concern do not always translate directly into behavior. Studies show that people with strong individualistic values tend to be more skeptical of environmental risks and less trusting of official information, which can reduce protective action (Kahan et al. 2011; Morss et al. 2020). In contrast, egalitarian values are associated with stronger belief in scientific consensus and greater support for action (Kahan et al. 2011; Arbuckle et al. 2015). However, these relationships vary across groups. Liu and Segev

(2017) found that environmental concern is a weaker predictor of sustainable behavior among Hispanic immigrants than among non-Hispanic Whites, suggesting that concern alone is not always enough to drive action.

Taken together, this literature shows that cultural worldviews shape how people interpret risk, weigh uncertainty, and decide whether and how to act during weather hazards. Decisions are influenced not only by information or knowledge, but also by values related to individualism and collectivism, beliefs about control, and responsibilities to others. These cultural factors help explain why responses to hazards vary across individuals and groups, even when exposure and access to information are similar (Douglas and Wildavsky 1982; Kahan et al. 2011; Morss et al. 2020).

A Phenomenological Approach

Phenomenology provides both methodological and theoretical lenses to examine lived experiences of risks and hazards. Originating in Husserl's work, phenomenology focuses on understanding how people experience and make meaning of phenomena as they appear in everyday life (Qutoshi 2018; Tomasulo 1990). Rather than treating risk as an abstract concept, phenomenology centers how individuals perceive, feel, and respond to events based on their direct experiences.

In geography, Anne Buttimer (1976) extended phenomenology through the concept of the lifeworld, emphasizing that people's understandings of place and space are inseparable from their lived realities. From this perspective, risk perceptions are shaped by cultural identity, emotional attachments, social relationships, and personal histories. Experiences with hazards are

therefore embedded within everyday life and place-based meanings rather than detached evaluations of probability or severity.

Environmental perception research supports this view by showing that repeated exposure to extreme events can transform climate risks from abstract concerns into lived realities (Pidgeon 2012; Leiserowitz et al. 2013; Morss et al. 2020). Localized experiences further demonstrate this process. For example, residents of the Southern High Plains often interpret drought as part of a natural cycle rather than as evidence of climate change, reflecting how lifeworld perspectives shape interpretations of environmental risk (Colston et al. 2018). From a phenomenological standpoint, these perceptions are not static; they evolve through continued exposure and are filtered through cultural frameworks and embodied experience (Merleau-Ponty 1962).

Phenomenology is also particularly useful for understanding how people cope with and respond to disasters because it captures how emotions are experienced and how those emotions shape action. Emotions are not simply "reactions" that come after interpretation; they are part of how individuals make sense of risk in the moment and decide what to do next. Emotion theorists have argued that emotions are linked to different patterns of action. For example, Plutchik (1962, 1980) described basic emotions as connected to adaptive behavioral responses, such as fear aligning with withdrawal or escape. Arnold (1960) similarly emphasized that emotions relate to action tendencies, and Frijda (1986) described emotions as forms of action readiness meaning that emotions prepare people to move toward certain behaviors, such as avoiding danger or seeking support (Frijda, 1986). Building on this line of work, Roseman (1984; Roseman et al. 1994) proposed that emotions are tied to distinctive motives or goals what he termed *emotivations* such as fear motivating avoidance of danger or sadness motivating efforts to recover from loss. Taken together, this work supports a key point that aligns with

phenomenology: lived emotional experiences shape how hazards are understood and how protective action becomes possible or constrained.

Green (2018) illustrates the value of this approach in disaster contexts through a phenomenological study of Haitian survivors of the 2010 earthquake. Green (2018) showed how cultural beliefs, religion, and social relationships shaped both emotional responses and coping behaviors. Participants described long-term fear and exhaustion after the disaster, alongside resilience and collective efforts to restore normalcy. Their narratives revealed how deeply rooted religious beliefs influenced how they understood the disaster, accepted uncertainty, and made sense of survival and loss. Green (2018) identified deterministic acceptance to describe how participants believed the earthquake was predetermined by God while simultaneously engaging in collective recovery and mutual support. This finding demonstrates how phenomenology captures the coexistence of emotion, meaning-making, and action-oriented behavior, rather than treating them as separate processes.

Phenomenology also underscores the role of broader social contexts, including media and public discourse, in shaping lived experiences of risk. Kasperson and Kasperson (2012) describe how media can amplify or attenuate risk perceptions, while Pidgeon (2012) highlight processes such as uncertainty transfer. From a phenomenological perspective, these influences become part of an individual's horizon of experience, shaping how information is interpreted, trusted, and acted upon. Together, these insights show that responses to hazards are grounded in lived experience, cultural meaning, and everyday life, rather than solely in technical assessments of risk.

Research Framework

Applying phenomenology to the study of Spanish speakers in the United States helps center how people experience, interpret, and make sense of risk in their everyday lives. As Buttimer (1976) explains, lived experiences are inseparable from how individuals perceive their environment and decide how to act within it. For Spanish-speaking communities, tropical weather alerts are not understood only as pieces of information or translations. Instead, they are interpreted through broader lifeworlds shaped by previous disaster experiences, migration histories, cultural ties, family responsibilities, and trust in institutions. These lifeworlds provide the context through which alerts gain meaning.

For many Spanish-speaking immigrants, disaster subcultures formed in their countries of origin remain influential after migration. Experiences with hurricanes, earthquakes, floods, or other hazards shape expectations about risk, preparedness, and appropriate responses. For example, someone from Puerto Rico may bring long-standing knowledge of hurricanes, while someone from Peru or Guatemala may be more familiar with earthquakes than storm surge or flooding. Prior research shows that Spanish-speaking communities draw on cultural knowledge, past experiences, and available resources to make protective decisions, even when language barriers and structural constraints are present (Gaviria-Pabón 2022; Trujillo-Falcón et al. 2024). A phenomenological approach makes it possible to understand these decisions as part of everyday life rather than isolated or purely individual choices.

Disaster subculture research highlights how memory, familiarity, and trust influence protective behavior (Anderson 1965; Engel et al. 2022; Baer et al. 2019). Similarly, phenomenology emphasizes that risk perceptions develop through lived encounters with hazards over time (Pidgeon 2012; Leiserowitz et al. 2013; Morss et al. 2020). When warning messages

do not align with people's cultural or experiential frameworks, they may be met with skepticism, confusion, or inaction (Kahan et al. 2011; Shi et al. 2015). For Spanish speakers in the United States, these challenges are further shaped by language access, diverse cultural backgrounds, and experiences with hazards that differ from those commonly encountered in the U.S. context (Benavides & Arlikatti, 2010; Klockow et al. 2014; Donner & Rodriguez 2008).

This study builds on that literature by focusing on how Spanish speakers describe their own experiences with tropical weather alerts. Guided by phenomenology, the analysis centers on how participants explain what alerts mean to them, how they feel when receiving information in Spanish, and how these messages connect to their sense of place, family, and community. Rather than evaluating messages only in terms of technical accuracy, this approach emphasizes meaning, emotional response, and cultural relevance. These reflections align with previous findings showing that effective risk communication depends not only on accuracy but also on trust, resonance, and perceived relevance (Trujillo-Falcón et al. 2022; Trujillo-Falcón 2024; Aguirre 1988; Gaviria-Pabón 2022).

By placing Spanish speakers' voices at the center, this research extends disaster subculture theory and phenomenological approaches to show how message interpretation and protective action are shaped by lived experience. Weather alerts are treated not as static texts but as experiences that are felt, interpreted, and acted upon through memory, identity, and social relationships.

Data & Methods

We conducted semi-structured interviews in Tampa, Florida, a region highly vulnerable to hurricanes and home to a large Spanish-speaking population. Tampa was selected as the study

site due to its exposure to recent tropical cyclone impacts and the opportunity it provided to engage Spanish-speaking residents with diverse national and cultural backgrounds. Recruitment began through a local broadcast meteorologist, who referred the research team to a community-based agency serving Spanish-speaking populations. Working in partnership with this agency and using snowball sampling, we conducted 25 interviews with Spanish-speaking adults (18 years and older). Data collection occurred between October 10 and October 17, 2025, and included participants representing diverse countries of origin, ages, and lengths of residence in the United States. All interviews were conducted in Spanish, lasted approximately 35 minutes, and participation was voluntary. This study was approved by the University of Oklahoma Institutional Review Board (IRB #18912).

The interviews were designed to elicit participants' lived experiences with tropical weather information, guided by the phenomenological focus on lifeworlds and cultural meaning. Each interview began with introductory questions about personal background, place of origin, current residence, and community ties. These opening questions allowed participants to situate themselves and provided insight into the social and geographic contexts in which they understood weather risk. Participants were also asked about prior experiences with tropical storms or hurricanes, which served as reference points for understanding how past encounters with hazards shape present day risk perception and protective behaviors. This section was closely tied to the concept of disaster subcultures (Anderson 1965), highlighting how cultural memory and language intersect in shaping responses to recurring hazards.

Building on this foundation, the interviews moved to more reflective questions that explored how participants experienced receiving tropical weather information in Spanish. These questions invited individuals to describe how Spanish-language messages made them feel,

whether they influenced protective actions, and how the use of Spanish compared with English-language messages.

Questions also addressed perceptions of geographic relevance and place-based meaning. Participants evaluated whether alerts reflected local conditions, hazards, and community concerns, and how this affected their protective decision-making. These reflections connected directly to phenomenology's emphasis on lifeworlds, illustrating how place-based knowledge shapes the interpretation of environmental risks (Buttimer 1976; Colston et al. 2018). Participants were also asked how receiving Spanish-language alerts shaped their sense of responsibility to protect their families and neighbors, connecting risk communication to broader themes of community belonging and collective action.

Participants also reflected on the types of messages, tones, or cultural references that would make alerts feel more personal, familiar, and culturally aware. These questions helped to understand how protective action is tied not just to comprehension but also to emotional connection, inclusion, and cultural resonance, key concerns in both disaster subculture theory and phenomenological inquiry.

All interviews were transcribed using Sonix.ai and analyzed using thematic analysis. An inductive coding approach was employed in Dedoose, allowing codes, categories, and themes to emerge directly from participants' narratives rather than being guided by predefined theoretical frameworks. This iterative analytic process identified recurring themes related to previous experience, emotions, disaster subcultures, barriers to action, cultural and community dynamics, and the meaning and significance of alerts.

After the themes were identified and finalized, the distribution of coded excerpts across themes was examined to assess their relative prevalence within the dataset. Coding was

conducted using Dedoose, which provides counts of how many excerpts are associated with each code. Related codes were grouped into broader thematic categories, and the total number of excerpts associated with the codes within each theme was calculated. Because excerpts were occasionally assigned multiple codes during analysis, each code was assigned to a single thematic category when estimating theme prevalence in order to avoid double counting. The proportion of coded excerpts associated with each theme was then calculated relative to the total number of coded excerpts across interviews. This procedure allowed for an approximate estimate of the relative prominence of themes within the dataset without requiring a second round of coding.

The analysis indicated that themes related to message clarity accounted for approximately 31% of coded excerpts, followed by experiences with hazards (16%), culture and community (15%), dialect and language (11%), emotional responses (9%), language and comprehension (8%), barriers to protective action (6%), and the meaning and significance of alerts in Spanish (4%). These percentages are reported to illustrate the relative prominence of themes within the dataset rather than as statistical measures.

By centering Spanish speakers' voices, the analysis illustrates how lived experience and cultural context shape interpretations of risk and protective action. These findings highlight the importance of aligning tropical weather communication with the everyday realities of Spanish-speaking communities, moving beyond linguistic accuracy to support trust, clarity, and cultural resonance.

Results

Analysis of the interview data resulted in five major themes that illustrate the ways Spanish-speaking participants interpret tropical weather alerts and navigate preparedness and protective action.

Theme 1: Experiences with Hazards

Participants described a range of experiences with natural hazards in both their home countries and the Tampa Bay area. For many, Hurricane Milton was the most significant hazard they had experienced since living in Florida and, in several cases, it was their first direct experience with a hurricane. Participants often described this experience as unexpected and overwhelming. Many explained that not having prior experience with hurricanes made it difficult to understand the level of risk and know what actions to take during Hurricane Milton.

Experiences in participants' home countries differed widely. Some participants reported having experienced hurricanes in the past, while many others said they had never experienced hurricanes before moving to the United States. Instead, they were more familiar with other hazards such as earthquakes, heavy rainfall, or flooding, and some reported little or no prior exposure to major natural hazards. Participants frequently compared these past experiences with their experiences in Tampa, highlighting how unfamiliarity with hurricanes shaped their understanding of risk and made decision-making during the storm more challenging.

Previous Experience in Home Country:

"En Perú siempre hay que estar alertas… Yo vivo en una zona de constantes temblores, terremotos, muy sísmica y zona también que ha sufrido de inundación… nosotros no tenemos el aviso del pre, pero sí siempre estamos en constante alerta." — Participante #2

“In Peru, you always have to stay alert… I live in an area with frequent earthquakes, a very seismic zone, and also an area that has experienced flooding… we do not have advance warnings, but we are always in constant alert.” — Participant #2

“En Guatemala… a veces uno no sabe cuando vienen huracanes… ha sido una sorpresa cuando nos cae… no hay comunicación o no hay aviso.” — Participante #18

“In Guatemala, sometimes you don’t really know when hurricanes are coming… it comes as a surprise when it hits… there is no communication, or there is no warning.” — Participant #18

“Venezuela es un país… bastante tranquilo a nivel de clima… muy pocos días de lluvia y cuando hay lluvia… ni los habitantes ni la ciudad están preparados… siempre que hay lluvia hay inundaciones.” — Participante #8

“Venezuela is a fairly calm country in terms of climate… there are very few rainy days, and when it does rain… neither the residents nor the city itself are prepared… whenever it rains, there are floods.” — Participant #8

“En Cuba… hemos pasado por dos o tres ciclones… categoría cuatro o cinco… y también hemos pasado por temblores de tierra.” — Participante #12

“In Cuba… we have gone through two or three cyclones, approximately category four or five… and we have also experienced earthquakes.” — Participant #12

“En Colombia… el único informe era sobre lluvias… no se enfrentan cosas de gran magnitud, como por acá.” — Participante #16

“In Colombia… the information was mostly about rainfall… we did not really face events of that magnitude, like the ones experienced here.” — Participant #16

Experience in Tampa Bay:

“Sí, he pasado varias… la del año pasado… donde vivo se inundó todo… el lago se desbordó… quedamos en el agua.” — Participante #1

“Yes, I’ve been through several storms… the really strong one was last year… everything flooded… the lake overflowed… we were left standing in the water.” — Participant #1

“Fue la experiencia más terrible… nunca había vivido un huracán… no sé la magnitud de eso… fue una experiencia bien dura… hoy puedo decir que nos documentamos más… revisamos zonas de inundación y evacuación.” — Participante #8

“It was the most terrible experience… I had never experienced a hurricane before… I didn’t know the magnitude… it was a very hard experience… now we make sure to inform ourselves more… review flood zones and evacuation zones.” — Participant #8

“Ya son tres huracanes… el primer año fue muy angustiante… no sabía qué hacer… miraba a mis vecinos… el último nos afectó más como comunidad… perder luz, gas, internet… la información no era muy informativa.” — Participante #3

“I’ve already experienced three hurricanes… the first year was very distressing… I didn’t really know what to do… I watched my neighbors… the last one affected the community more… losing power, gas, internet… the information was not very informative.” — Participant #3

“Nunca había experimentado algo así… fue caótico… nos tuvimos que salir… mi bebé tenía meses… se acababa la gasolina… fue horrible.” — Participante #5

“I had never experienced anything like that… it was chaotic… we had to leave… my baby was only a few months old… we ran out of gas… it was horrible.” — Participant #5

“Nunca había vivido un huracán como el del año pasado… fue terrible… fue un momento muy difícil… viví en varios lugares… fue una mala experiencia.” — Participante #11

“I had never experienced a hurricane like the one last year… it was terrible… it was a very difficult moment… I lived in several places… it was a very bad experience.” — Participant #11

Theme 2: Emotional Responses

During the interviews, especially when participants described their first experience with a hurricane in the United States, they frequently expressed strong emotional responses. Many participants described feeling fear, shock, and vulnerability, particularly when they had never experienced a hurricane before. These emotions were often linked to uncertainty about the severity of the storm and concern for personal safety and family members. Participants explained that these emotional reactions directly influenced the actions they took during the hurricane. Feelings of fear and vulnerability motivated decisions such as evacuating, seeking safer shelter, closely following information, or prioritizing the protection of children and family members. In

several cases, emotional responses rather than technical knowledge about hurricanes played a central role in shaping how participants prepared for and responded to the event.

“Sí, me asusté mucho… fue una situación muy tensa… cuando eres mamá… tu prioridad es mantenerlos a ellos a salvo… decidimos salir de Tampa porque teníamos que cuidarlos… sí me hizo sentir muy vulnerable. Esa es la palabra: vulnerable.” — Participante #24

“Yes, I was very scared… it was a very tense situation… when you are a mother, your priority is keeping your children safe… that’s why we decided to leave Tampa… yes, it made me feel very vulnerable. That’s the word—vulnerable.” — Participant #24

“Uno tiene que irse preparando emocionalmente y psicológicamente… vivir un desastre de esa magnitud afecta mucho… al final lo que más le pedimos a Dios fue que nos ayudara a salir de esto.” — Participante #10

“You have to start preparing emotionally and psychologically… living through a disaster of that magnitude really affects you… in the end, what we asked of God was just to help us get through it.” — Participant #10

“Yo estuve con ellos durante María… todos nos movimos al hotel… yo estaba debajo de la cama… somos muy al miedo de que pueda pasar.” — Participante #14

“I was with them during María… we all moved to a hotel… I was under the bed… we are very afraid of what could happen.” — Participant #14

“Yo estaba asustada… es la primera vez que uno vive esto… pero traté de tomar acción… me fui a la zona que era menos peligrosa.” — Participante #11

“I was scared… it was the first time I experienced something like this… but I tried to take action… I went to the area that was less dangerous.” — Participant #11

“Yo nunca había visto un huracán de esa inmensidad… claro que sí, me espanté… yo quería salir huyendo con mis hijas… peleándose en las gasolineras… yo decía, esto es terrible.” — Participante #5

“I had never experienced a hurricane of that magnitude… of course I was scared… I wanted to run away with my daughters… people fighting at gas stations… I thought, ‘this is terrible.’” — Participant #5

Theme 3: Barriers to Protective Action

Even when participants received warning messages and alerts, many were not able to take protective action. Participants described several barriers that made evacuation difficult, including language barriers, limited resources, and uncertainty about where to go. When information was only available in English, participants felt it was harder to understand what actions to take. Economic constraints, such as the cost of hotels, gas, and concerns about shelters being full, also limited evacuation options.

Family responsibilities further complicated decision-making. Participants described caring for infants, family members with disabilities, or relatives with health and anxiety-related conditions, which made evacuation more challenging. In some cases, emotional attachment to

the home or disagreement within households led some family members to stay behind despite evacuation orders.

“Vivimos en un país multicultural… mucha gente viene sin saber hablar inglés… al no tener los mensajes en inglés y no tener comunicación en español, va a ser mucho más difícil… sería muy bueno que hubieran mensajes en todos los idiomas para que todos pudiéramos saber qué hacer frente a un huracán.” — Participante #14

“We live in a country that is multicultural and multilingual… many people come without knowing how to speak English… when messages are only in English and there is no communication in Spanish, everything becomes much harder… having messages in multiple languages would allow everyone to know what to do when facing a hurricane.” — Participant #14

“Dijeron que venía un huracán… todos tenían que evacuar… yo le dije a mi esposo que se fuera con nosotros… pero él no quiso irse. Dijo que se iba a quedar porque era su casa.” — Participante #6

“They said a storm was coming and everyone had to evacuate… I told my husband that he should come with us… but he did not want to leave. He said he was going to stay because it was his house.” — Participant #6

“Es difícil… tienes que hacer mucho research para saber a dónde ir… el tema económico es otro gran pilar… pagar un hotel, si los albergues están llenos… ponerle gas al carro… todo eso se vuelve una dificultad.” — Participante #17

“It’s difficult… you have to do a lot of research to figure out where to go… the economic issue is another major factor… paying for a hotel, whether shelters are full… putting gas in the car… all of that becomes part of the difficulty.” — Participant #17

“Fue algo sorpresivo… su tío es ciego y se quedó enclaustrado en la casa… fue algo traumático… por eso la segunda vez nos fuimos.” — Participante #4

“It was very unexpected… one of his uncles is blind and was trapped inside the house… it was traumatic… that’s why the second time we left.” — Participant #4

“No tenía dónde irme… Orlando también se veía afectado… tengo una niña especial… mi esposo y mi hija mayor sufren de ansiedad social… no es fácil ir a la casa de otros.” — Participante #1

“I didn’t really have anywhere to go… Orlando also seemed affected… I have a child with special needs… my husband and my older daughter struggle with social anxiety… it’s not easy to go stay at other people’s houses.” — Participant #1

Theme 4: Culture and Community

Participants described how culture and community played an important role in how they experienced and responded to the hurricane. Many emphasized the importance of staying connected with others, whether through prayer, phone calls, or shared communication, which helped them feel calmer and less alone during the storm. Religious practices, such as praying

with friends and family, were described as a source of emotional support and reassurance in moments of uncertainty.

Participants also highlighted how cultural norms influenced preparedness and response. Some noted that within Latino communities, preparation is sometimes left until the last minute, which can create challenges during fast-moving events like hurricanes. At the same time, strong social networks made it easier to share information in Spanish and ensure that others understood what was happening. Living in areas with large Hispanic and Latino populations, particularly with groups more experienced with hurricanes such as Cubans and Puerto Ricans, allowed participants to learn from others' experiences and improve their own preparedness. Participants also described strong community support at the neighborhood level. Neighbors checked on one another, shared information, and offered help, especially to those living in more vulnerable areas. These collective efforts show how culture, shared experience, and community ties shaped both emotional coping and practical responses before, during, and after the hurricane.

"Ellos estaban como en oración conmigo… todo el mundo estaba orando mucho… para que Dios o las fuerzas naturales… se calmaran. Y entonces yo estaba relativamente tranquila allí." — Participante #3

"They were praying with me… everyone was praying a lot… so that God, or the natural forces… would calm down. And because of that, I felt relatively calm there." — Participant #3

*"*Lo único que nosotros los latinos hispanos, dejamos todo de último. O sea, el problema."- Participante #25

"The only thing is that we Latinos, Hispanics, leave everything until the last minute. I mean,

that's the problem." — Participant #25

"Es más fácil compartir un mensaje en español… como te juntas con tanto latino… la otra persona lo puede entender… es más fácil repartir el mensaje." — Participante #17

"It's easier to share a message in Spanish… when you're around so many Latinos… the other person can understand it… it's easier to spread the message." — Participant #17

"Aquí te encuentras muchos cubanos y boricuas… ellos nos han enseñado a vivir esto… y a estar preparados." — Participante #2

"Here you find many Cubans and Puerto Ricans… they've taught us how to live through this… and how to be prepared." — Participant #2

"Las alertas sí nos ayudaron a prepararnos… entre los vecinos nos dimos apoyo… muchos sí se fueron… cuando regresaron encontraron sus casas perdidas." — Participante #1

"The alerts helped us prepare… among the neighbors we supported each other… many did leave… when they came back, they found their homes completely lost." — Participant #1

Theme 5: Meaning and Significance of Alerts in Spanish

Participants described weather alerts as essential for understanding risk and making decisions during hurricanes. Many emphasized that receiving alerts in Spanish helped them clearly understand what was happening, especially in Florida, where large Hispanic and Latino communities include people with different levels of English proficiency. When alerts were only

available in English, participants often relied on others for information or observed what was happening without fully understanding the situation.

Spanish-language alerts were also described as meaningful beyond comprehension. Participants explained that receiving alerts in Spanish made them feel included and recognized by public agencies, which increased trust in the information. Alerts in Spanish also helped entire households stay informed, including children and family members who do not speak English fluently. Participants noted that when alerts were in Spanish, they paid close attention and felt more confident making decisions about whether to evacuate or prepare. Overall, alerts were seen as important not only for individual safety but also for protecting the broader community.

“Es muy importante… hay mucho latino… mayormente los hispanos no dominan el inglés… ves los movimientos pero no sabes lo que está pasando… sería muy importante que los mensajes fueran en inglés y español.” — Participante #12

“It’s very important… there are a lot of Latinos… most Hispanics don’t really speak English… you see what’s happening but you don’t really know what’s going on… it would be very important for messages to be in both English and Spanish.” — Participant #12

“Es muy importante… sentirse identificado y que realmente importas dentro de las agencias… es una inclusión muy buena.” — Participante #17

“It’s very important… it makes you feel included and that you actually matter to the agencies… it’s a very good kind of inclusion.” — Participant #17

"Cuando los recibo en español… decido tomar acción… en estas situaciones tienes que tomar una decisión o te quedas o te vas." — Participante #24

"When I receive them in Spanish… I decide to take action… in these situations you have to make a decision, you either stay or you leave." — Participant #24

"Mis hijos aún no hablan muy bien inglés… eso sirvió para que ellos también estuvieran enterados… fue de gran ayuda." — Participante #17

"My children still don't speak English very well… this helped them stay informed too… it was a great help." — Participant #17

"Hay una inmensa población hispana… si no está informada, no solamente se pone en riesgo a sí misma, sino que pone en riesgo a los demás." — Participante #8

"There's a huge Hispanic population… if that population isn't informed, they're not only putting themselves at risk, but they're also putting others at risk." — Participant #8

Discussion

Previous experience and cultural background strongly influence how Spanish speakers respond to hazards, particularly when they have never experienced a specific hazard before (Gaviria-Pabón 2022). In this study, participants described different hazard experiences in their countries of origin. While some had prior experience with hurricanes or cyclones, many reported

that they had never experienced a hurricane before moving to the United States. Instead, they were more familiar with other hazards such as earthquakes, heavy rainfall, or flooding. Several participants also explained that even when hazards were common in their home countries, there were no formal warning systems in place that provided clear guidance on how to prepare or what actions to take.

These findings align with disaster subcultures, which emphasize that communities develop shared patterns of preparedness, risk perception, and response based on repeated exposure to specific hazards and local histories (Anderson 1965). As prior research shows, lived experience with specific hazards shapes what people consider normal, credible, and necessary when responding to risk (Engel et al. 2022; Baer et al. 2019). Participants in this study often drew comparisons between hazards they knew from their home countries and hurricanes in Florida, highlighting how unfamiliar hazards disrupted previously learned ways of understanding and responding to risk.

The absence of prior experience with hurricanes, combined with limited guidance in participants' home countries, contributed to uncertainty and difficulty in decision making. This mirrors findings from a phenomenological study with farmers, which showed that disaster preparedness and response are often shaped by uncertainty and challenges in decision making when individuals lack clear information or prior experience (Okolo et al. 2025). Similarly, many participants in this study described Hurricane Milton as their first direct hurricane experience in Florida and emphasized feeling overwhelmed, unsure, or unprepared while trying to understand both the hazard and the actions required.

Not being familiar with hazards influenced participants' protective decisions. This is consistent with previous studies. Gaviria-Pabón (2022) found that Guatemalan immigrants

struggled to take appropriate action during a tornado event due to a lack of prior experience with that hazard. Trujillo-Falcón 2024 showed that foreign-born Spanish speakers were especially vulnerable after arriving in the United States, particularly when encountering extreme weather hazards they had not experienced before. Participants in this study described a similar challenge of learning about hurricanes while simultaneously learning how U.S. warning systems functioned, which often created confusion and delayed confidence in how to respond.

Disaster subculture research suggests that individuals rely on past experiences, cultural knowledge, and shared community norms when making decisions under risk (Kahan et al. 2011; Shi et al. 2015). In this study, participants frequently relied on personal judgment, family members, or community knowledge shaped by experiences in their home countries when interpreting hurricane risk in Florida. This reflects how disaster subcultures formed in countries of origin continue to influence risk perceptions and behaviors, even as individuals adapt to new hazard environments in the United States (Gaviria-Pabón 2022; Trujillo-Falcón 2024).

Together, these findings show that disaster response among Spanish-speaking immigrants is deeply shaped by prior hazard experience and culturally learned ways of understanding risk. Disaster subcultures do not disappear after migration; instead, they interact with new hazards and warning systems, influencing how risk is interpreted and how protective actions are taken.

Emotions play an important role in how people experience and respond to weather hazards, particularly when the hazard is unfamiliar or when it is their first direct encounter. From a phenomenological perspective, emotions are not separate from decision making but are part of how people experience risk in their everyday lives. Prior research shows that emotions are closely tied to action tendencies. Plutchik (1962, 1980), for example, described basic emotions as linked to adaptive behavioral responses, such as fear leading to withdrawal or escape. These

emotion–action connections were evident in participants' experiences, as many described intense fear during their first hurricane experience, which then shaped how they interpreted risk and what actions they took.

Participants' emotional responses were deeply embedded in their lived experiences and social roles. Many described fears not only for themselves but especially for their children and family members. This aligns with research showing that Hispanic communities often emphasize strong family responsibility and collective care when making decisions (Marin 1991). From a phenomenological standpoint, these emotions are situated within participants' lifeworlds, where family relationships and caregiving roles shape how danger is perceived and prioritized. Fear, in this sense, was not just an internal feeling but a relational experience that guided protective actions such as evacuating, seeking safer shelter, or remaining alert throughout the storm. It also played an important role in how participants made sense of their emotional experiences.

Some participants described turning to prayer or relying on faith as a way to cope with fear and uncertainty during the hurricane. Previous research suggests that faith-based beliefs do not necessarily replace planning or responsibility but can coexist with action-oriented responses (Marin 1991). Phenomenologically, these religious practices can be understood as meaning-making strategies that help individuals emotionally navigate risk while still engaging in protective behaviors. Similar emotional coping patterns have been observed in other crisis contexts. During the COVID-19 pandemic, participants reported relying on religious practices such as prayer, spiritual reflection, and ritual behaviors to seek protection and maintain hope (Siddiqui & Qamar 2021). These practices provided emotional reassurance and a sense of control in uncertain situations. Participants in this study expressed comparable experiences, describing

faith as a source of comfort that helped them endure fear while facing a dangerous and unfamiliar hazard.

A phenomenological lens helps reveal how emotions, culture, and lived experience are intertwined in shaping hazard responses. Participants' fear, vulnerability, and reliance on family and faith were not separate from their actions but central to how they understood and navigated risk. These findings highlight that emotional responses are a key part of Spanish speakers lived experiences with hurricanes and play a critical role in guiding protective decisions during extreme weather events.

Participants described several barriers that prevented them from taking protective action during the storm. One of the most common barriers was language. Participants explained that not having alerts available in Spanish made it difficult to understand what was happening and what decisions to make. This finding is consistent with Gaviria-Pabón (2022), which showed that Guatemalan immigrants were unable to take protective actions during a tornado because information was not available in Spanish, as well as earlier work by Aguirre (1988). Language inaccessibility has long been recognized as a vulnerability. In 1970, the National Weather Service formally identified this issue after an F5 tornado struck Lubbock, Texas. As the tornado approached, the only Spanish-language radio station stopped broadcasting, and of the 26 people who died, half were identified as Spanish speakers (Environmental Science Services Administration 1970). Similar consequences have continued over time. On 20 May 2013, a Spanish-speaking family died in floodwaters after seeking shelter in a storm drain during a widely covered tornado event (NWS 2014).

More recent research suggests that language barriers can persist even when Spanish-language alerts exist. Trujillo-Falcón 2024 found that Spanish-language Wireless Emergency

Alerts are only received if a user's phone language settings include Spanish, a requirement many limited English proficiency individuals are unaware of. Some individuals intentionally keep their phones set to English as a way to practice and learn the language, not realizing that doing so prevents them from receiving alerts in Spanish. As a result, lifesaving warnings may never reach people in a language they can fully understand, highlighting how language barriers are reinforced by technological and structural factors beyond simple message translation (Trujillo-Falcón 2024).

Another barrier was disbelief or difficulty personalizing the risk. One participant explained that they chose not to evacuate because they did not believe the storm would affect them. According to the warning response model, when people are unable to personalize risk, they are less likely to comply with warnings or take protective action (Mileti and Sorensen 1990).

Participants also described economic constraints and limited resources as reasons for not evacuating. Research shows that households are often divided between those who evacuate and those who remain in at-risk areas, largely based on access to financial resources (Yusuf et al. 2023). Households with greater vulnerability to hazards and public health crises, such as hurricanes and COVID-19, face additional challenges when evacuating. Higher-income households are more likely to have the financial means to evacuate and are less likely to experience long-term economic consequences, while racial minorities face greater resource barriers and higher levels of vulnerability during evacuation (Yusuf et al. 2023). Foreign-born Hispanics may be particularly vulnerable due to insecure residency status, lower incomes, and limited English proficiency, which can further restrict evacuation options during disasters (Maldonado et al. 2016).

Family responsibilities also played a role in evacuation decisions. Participants mentioned that concerns about family members with disabilities made it difficult to take action. Research shows that people are less likely to comply with evacuation warnings unless they are confident that their family members can evacuate safely (Perry and Lindell 1991). Risks are especially high for older adults with disabilities, including cognitive impairments, mobility limitations, and sensory impairments, which can delay or prevent evacuation. For example, during the Eaton wildfire in Los Angeles in January 2025, the average age of those who died was 77, highlighting the severe risks faced by this population (Jimenez 2025). Broader social and cultural factors also influence evacuation behavior. Lazo et al. (2015) found that Florida respondents with more egalitarian worldviews were more likely to evacuate under both forecast and evacuation order conditions, while those with more individualistic worldviews were less likely to evacuate under an evacuation order. Evacuation intentions also varied by age and information source. Intentions decreased with age when an evacuation order was issued but increased with age when participants only saw a forecast. Additionally, reliance on public information sources increased evacuation intentions under evacuation orders, while reliance on personal sources increased evacuation intentions when participants viewed forecasts (Lazo et al. 2015).

Overall, these findings show that even when Spanish-speaking individuals receive alerts that include clear protective actions, evacuation may still not occur. Language access alone does not eliminate other barriers such as limited resources, disbelief, family responsibilities, disability-related challenges, and broader social and cultural factors. These barriers can work together to hinder evacuation decisions, even when risk information is available and understood.

During the interviews, participants shared experiences that show how culture shaped the way they behaved during the hurricane. Several participants described staying in contact with

friends and family, even those who lived far away, as a way to manage fear and feel supported during the storm. Others talked about sharing information with neighbors, checking in on one another, and offering help before and during the hurricane. These behaviors reflect the importance of social ties and collective support in shaping how people respond to risk during hazardous events (Douglas and Wildavsky 1982; Shi et al. 2015; Morss et al. 2020).

Participants also mentioned that Latinos often leave preparation until the last minute, which they described as a common challenge. This behavior highlights how cultural norms and past experiences can delay protective action, even when risk information is available. Emotional responses, personal judgment, and prior experiences can shape when people decide to act, rather than responses being based only on forecasts or official messages (Slovic 2000).

At the same time, participants described learning how to prepare for hurricanes from other Hispanic and Latino groups with more experience, such as Cubans and Puerto Ricans. These interactions show how disaster-related knowledge is shared through social networks and lived experience. This process reflects how people rely on cultural values and shared experience to interpret risk information (Shi et al. 2015), and it is consistent with the Protective Action Decision Model, which shows that individuals often use social cues from others when deciding how to prepare for a hazard (Lindell and Perry 2012).

Overall, these findings show that cultural worldviews influence both supportive behaviors and barriers to action during hurricanes. Social connections can encourage communication, learning, and mutual support, while cultural norms and emotional responses can also shape when and how protective actions are taken (Naiman et al. 2023).

Participants discussed what it meant to them to receive alerts in Spanish. Overall, they described Spanish-language alerts as very important because they helped them better understand the situation and make more informed decisions during the hurricane. Participants emphasized that having alerts in Spanish is especially critical for Hispanic and Latino individuals who do not speak English, as it allows them to clearly understand what actions they need to take to stay safe. Prior research has consistently recommended providing tailored alerts in Spanish and other languages to support comprehension and effective response among these communities (Trujillo-Falcón et al. 2022; 2024; Gaviria-Pabón 2022; Gaviria-Pabón et al. 2025; Ahlborn and Franc 2012; Nelson 2015; Bernhardt et al. 2024; First et al. 2025).

Conclusion

Understanding how Spanish speakers make sense of risk and weather hazards is complex. This community is not a single, uniform group, and people's responses are shaped by different cultures, disaster subcultures, worldviews, lived experiences, and values. These factors influence how individuals interpret weather alerts, how seriously they perceive a threat, and whether they feel able to take protective action. Decisions are often made within family and community contexts, where trust, past experiences, and shared knowledge play an important role.

Phenomenology helps us better understand these processes by focusing on lived experiences, emotions, cultural meaning, and social connections. Through this lens, weather alerts and messages are not just pieces of information but experiences that are interpreted through fear, memory, faith, responsibility to others, and prior encounters with hazards. This approach highlights how people actively make sense of risk rather than simply receiving and following messages.

Recognizing this complexity is important when issuing information to Spanish speaking communities. Even when alerts are available and understood, other factors such as resources, family responsibilities, beliefs, and social dynamics can shape how people respond. Taking these realities into account can help improve how risk information is shared and how decisions to take protective actions are made.

Limitations

This study has several limitations. First, the research was conducted in the Tampa Bay region and focused specifically on hurricane experiences. As a result, the findings may not be fully generalizable to Spanish-speaking communities in other geographic regions or to other types of weather hazards. Experiences, risk perceptions, and responses may differ in areas with different hazard profiles or levels of hurricane exposure.

The study also included a relatively small sample of 25 participants, which is appropriate for in-depth qualitative research but limits the breadth of perspectives captured. Participation was limited to individuals who were willing and available to take part in interviews, which may introduce self-selection bias. Participants who chose to participate may have had stronger opinions, more experience with hurricanes, or greater interest in weather information than those who did not participate. Additionally, the study relied on self-reported experiences and perceptions, which may be influenced by recall bias or by how participants interpret and describe past events.

Finally, although this study captures rich qualitative insights into lived experiences, it does not aim to represent all Spanish-speaking populations or all Hispanic and Latino subgroups. Differences in nationality, immigration status, language proficiency, and length of time living in

the United States may shape experiences in ways that are not fully captured in this sample. In addition, the thematic analysis was conducted by a single researcher, which may introduce subjectivity in coding and interpretation. Although steps were taken to ensure a systematic and transparent analytic process, the absence of inter-coder reliability assessment represents a limitation. Future research could incorporate multiple coders or collaborative coding approaches to further strengthen analytic rigor.

References

Aguirre, B. E., 1988: Feedback from the field: The lack of warnings before the Saragosa tornado. *International Journal of Mass Emergencies and Disasters*, 6, 65–74, http://www.ijmed.org/articles/133/download/.

Ahlborn, L., J. M. Franc, and D. S. Med, 2012: Tornado hazard communication disparities among Spanish-speaking individuals in an English-speaking community. *Prehospital and Disaster Medicine*, 27, 98–102, https://doi.org/10.1017/S1049023X12000015.

Anderson, W., 1965: Some observations on a disaster subculture: The organizational response of Cincinnati, Ohio to the 1964 flood. Disaster Research Center Rep., University of Delaware, https://udspace.udel.edu/bitstream/handle/19716/1242/RN6.pdf.

Arbuckle, J. G., L. W. Morton, and J. Hobbs, 2015: Understanding farmer perspectives on climate change adaptation and mitigation: The roles of trust in sources of climate information, climate change beliefs, and perceived risk. *Environment and Behavior*, 47, 205–234, https://doi.org/10.1177/0013916513503832.

Arnold, M. B., 1960: *Emotion and personality*. Columbia University Press, New York.

Baer, R. D., S. C. Weller, and C. Roberts, 2019: The role of regional cultural values in decisions about hurricane evacuation. *Human Organization*, 78, 133–146.

Benavides, A., and S. Arlikatti, 2010: The role of the Spanish-language media in disaster warning dissemination: An examination of the Emergency Alert System. *Journal of Spanish Language Media*, 3, 41–58, https://www.researchgate.net/publication/309043369.

Blaikie, P., T. Cannon, I. Davis, and B. Wisner, 2004: *At risk: Natural hazards, people's vulnerability and disasters*. Routledge, 284 pp.

Botzen, W. J. W., and J. C. J. M. van der Bergh, 2009: Managing natural disaster risks in a changing climate. *Environmental Hazards*, 8, 209–225, https://doi.org/10.3763/ehaz.2009.0023.

Burns, W. J., and P. Slovic, 2012: Risk perception and behaviors: Anticipating and responding to crises. *Risk Analysis*, 32, 579–582, https://doi.org/10.1111/j.1539-6924.2012.01791.x.

Buttimer, A., 1976: Grasping the dynamism of lifeworld. *Annals of the Association of American Geographers*, 66, 277–292.

Colston, N., J. M. Vadjunec, and T. Fagin, 2018: "It is always dry here": Examining perceptions about drought and climate change in the Southern High Plains. *Environmental Communication*, 12, 1–17.

Dietrich, S., and E. Hernandez, 2022: *Language use in the United States: 2019*. American Community Survey Reports, No. ACS-50, U.S. Census Bureau, 12 pp.

Donner, W., and H. Rodriguez, 2008: Population composition, migration, and inequality: The influence of demographic changes on disaster risk and vulnerability. *Social Forces*, 87, 1089–1114, https://doi.org/10.1353/sof.0.0141.

Douglas, M., and A. Wildavsky, 1982: How can we know the risks we face? Why risk selection is a social process. *Risk Analysis*, 2, 49–58.

Engel, K., G. Frerks, L. Velotti, J. Warner, and B. Weijs, 2014: Flood disaster subcultures in the Netherlands: The parishes of Borgharen and Itteren. *Natural Hazards*, 73, 859–882, https://doi.org/10.1007/s11069-014-1116-5.

Engel, K., J. Warner, and G. Frerks, 2022: Disaster subculture in greater Concepción, Chile. *International Journal of Mass Emergencies & Disasters*, 40, 1–34.

Environmental Science Services Administration, 1970: The Lubbock, Texas, tornado May 11, 1970. Natural Disaster Survey Rep. 70-1, 33 pp., www.weather.gov/media/publications/assessments/Lubbock%20Tornado%201965.pdf.

Fernández-Vítores, D., 2024: *Spanish: A Living Language. 2024 Report*.

First, J. M., A. Castillo, E. Galvez, S. Lee, M. L. Held, and K. Ellis, 2025: Examining intraethnic disparities in tornado hazard understanding, reception, and response in Latinx/e communities in the Southeast United States. *Weather, Climate, and Society*, **17** (1), 101–113.

Fischhoff, B., 1995: Risk perception and communication unplugged: Twenty years of process. *Risk Analysis*, 15, 137–145, https://doi.org/10.1111/j.1539-6924.1995.tb00308.

Frijda, N. H., 1986: *The emotions*. Cambridge University Press, Cambridge, United Kingdom, 544 pp.

Gaviria Pabón, A. R., M. J. Krocak, J. T. Ripberger, and J. E. Trujillo-Falcón, 2025: Linguistic challenges in severe weather communication: Comparing English- and Spanish-speaking populations. *Bulletin of the American Meteorological Society*, 106, E1940–E1954.

Gaviria Pabón, A. R., 2022: The role of disaster subcultures in Spanish-speaking Hispanic/Latino immigrants in the United States. M.S. thesis, University of Oklahoma, 122 pp., https://shareok.org/handle/11244/336948.

Green, C., 2018: Exploring cultural belief systems and coping behavior in rural Haiti after the 2010 earthquake: A phenomenological study. Ph.D. dissertation, The Chicago School of Professional Psychology, 210 pp.

Kahan, D. M., H. Jenkins-Smith, and D. Braman, 2011: Cultural cognition of scientific consensus. *Journal of Risk Research*, 14, 147–174.

Kasperson, R. E., and J. X. Kasperson, 2012: *Social contours of risk: Publics, risk communication and the social*. Routledge, 384 pp.

Keul, A., and Coauthors, 2018: Multihazard weather risk perception preparedness in eight countries. *Weather, Climate, and Society*, 10, 501–520, https://doi.org/10.1175/WCAS-D-16-0064.1.

Klockow, K., R. Peppler, and R. McPherson, 2014: Tornado folk science in Alabama and Mississippi during the 27 April 2011 tornado outbreak. *GeoJournal*, 79, 791–804, https://doi.org/10.1007/s10708-013-9518-6.

Lazo, J. K., Bostrom, A., Morss, R. E., Demuth, J. L., & Lazrus, H. 2015: Factors affecting hurricane evacuation intentions. *Risk analysis*, *35*(10), 1837-1857.

Leiserowitz, A., E. Maibach, C. Roser-Renouf, G. Feinberg, and P. Howe, 2013: *Extreme weather and climate change in the American mind*. Yale Project on Climate Change Communication, New Haven, CT.

Lindell, M. K., and R. W. Perry, 2012: Protective action decision model. *Risk Analysis*, 32, 616–632.

Liu, Y., and S. Segev, 2017: Cultural orientations and environmental sustainability in households: A comparative analysis of Hispanics and non-Hispanic Whites in the United States. *International Journal of Consumer Studies*, 41, 587–596.

Maldonado, A., T. Collins, S. Grineski, and J. Chakraborty, 2016: Exposure to flood hazards in Miami and Houston: Are Hispanic immigrants at greater risk than other social groups? *International Journal of Environmental Research and Public Health*, 13, 775, https://doi.org/10.3390/ijerph13080775.

Marin, B., 1991: Hispanic culture: Effects on prevention and care. *Focus*, 6, 1.

Mast, B. D., and T. Ruiz, 2023: Visualizing Spanish-speaking limited English proficiency and Hispanic populations in Fort Collins, Colorado. *Cityscape*, 25, 281–286.

Matsumoto, D., T. Kudoh, and S. Takeuchi, 1996: Changing patterns of individualism and collectivism in the United States and Japan. *Culture & Psychology*, 2, 77–107, https://doi.org/10.1177/1354067X9621005.

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.

Merleau-Ponty, M., 1962: *Phenomenology of perception*. Translated by C. Smith, Routledge & Kegan Paul, London, 466 pp.

Mileti, D. S., and J. Sorensen, 1990: Communication of emergency public warnings: A social science perspective and state-of-the-art assessment. ORNL-6609 Rep., Oak Ridge National Laboratory.

Morss, R. E., H. Lazrus, A. Bostrom, and J. L. Demuth, 2020: The influence of cultural worldviews on people's responses to hurricane risks and threat information. *Journal of Risk Research*, 23, 1620–1649, https://doi.org/10.1080/13669877.2020.1750456.

Naiman, S. M., R. C. Stedman, and J. P. Schuldt, 2023: Latine culture and the environment: How familism and collectivism predict environmental attitudes and behavioral intentions among U.S. Latines. *Journal of Environmental Psychology*, 85, 101902.

Nelson, J. E., 2015: *The effects of severe weather warnings on limited English proficient (LEP) Hispanics/Latinos in rural Nebraska*.

Okolo, E. C., R. Landaverde, D. Doerfert, J. M. Piñeiro, D. Hudson, C. Elbert, and K. Opat, 2025: Preparedness, response, and communication preferences of dairy farmers during extreme weather events: A phenomenological case study. *Climate*, **13** (2), 29.

Perry, R. W., and M. K. Lindell, 1991: The effects of ethnicity on evacuation decision-making. *International Journal of Mass Emergencies & Disasters*, **9** (1), 47–59.

Pidgeon, N., 2012: Climate change risk perception and communication: Addressing a critical moment? *Risk Analysis*, 32, 951–956, https://doi.org/10.1111/j.1539-6924.2012.01856.x.

Plutchik, R., 1980: A general psychoevolutionary theory of emotion. In *Theories of Emotion*, R. Plutchik and H. Kellerman, Eds., Academic Press, 3–33.

Plutchik, R., 1962: *The emotions: Facts, theories, and a new model*. Random House, New York, 350 pp.

Qutoshi, S. B., 2018: Phenomenology: A philosophy and method of inquiry. *Journal of Education and Educational Development*, 5, 215–222.

Roseman, I. J., 1984: Cognitive determinants of emotions: A structural theory. In *Review of Personality and Social Psychology*, Vol. 5, P. Shaver, Ed., Sage, 11–36.

Roseman, I. J., C. Wiest, and T. S. Swartz, 1994: Discrete emotions. *Journal of Personality and Social Psychology*, 67, 206–221.

Siddiqui, S., and A. H. Qamar, 2021: Risk perception and protective behavior in the context of COVID-19: A qualitative exploration. *Asian Bioethics Review*, **13** (4), 401–420.

Simon, G. L., 2014: Vulnerability-in-production: A spatial history of nature, affluence, and fire in Oakland, California. *Annals of the Association of American Geographers*, 104, 1199–1221, https://doi.org/10.1080/00045608.2014.941736.

Shi, J., V. H. Visschers, and M. Siegrist, 2015: Public perception of climate change: The importance of knowledge and cultural worldviews. *Risk Analysis*, 35, 2183–2201.

Slovic, P., 2000: *The perception of risk*. Earthscan, 473 pp.

Tomasulo, F. P., 1990: Phenomenology: Philosophy and media theory—An introduction. *Quarterly Review of Film and Video*, 12, 1–8.

Trujillo-Falcón, J. E., 2024: Examining warning response among Spanish speakers in the United States to enhance multilingual wireless emergency alerts. Ph.D. dissertation, University of Oklahoma.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. Reedy, and K. E. Klockow-McClain, 2024: 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. *Natural Hazards Review*, 25, 04023059.

Trujillo-Falcón, J. E., and Coauthors, 2022: ¿Aviso o alerta? Developing effective, inclusive, and consistent watch and warning translations for U.S. Spanish speakers. *Bulletin of the American Meteorological Society*, 103, E1542–E1556, https://doi.org/10.1175/BAMS-D-22-0050.1.

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. *Bulletin of the American Meteorological Society*, 102, E765–E773.

U.S. Census Bureau, 2020: P2: Hispanic or Latino, and not Hispanic or Latino by race. 2020 Decennial Census, https://data.census.gov/, accessed 22 Aug. 2022.

U.S. Census Bureau, 2024: New estimates highlight differences in growth between the U.S. Hispanic and non-Hispanic populations. U.S. Census Bureau Press Release, 27 June 2024, https://www.census.gov/newsroom/press-releases/2024/population-estimates-characteristics.html, accessed 4 Feb. 2026.

Verchick, R. R., 2012: Disaster justice: The geography of human capability. *Duke Environmental Law & Policy Forum*, 23, 23–48.

Vitores, D. F., 2024: *Spanish: A living language*. Publisher information not specified.

Warner, J., and K. Engel, 2014: Disaster culture matters. *Environment & Society*, 17, 1–8, https://doi.org/10.1590/1809-4422ASOCEx002V1742014.

Yusuf, J. E., J. L. Whytlaw, N. Hutton, T. Olanrewaju-Lasisi, B. Giles, K. Lawsure, G. McLeod, et al., 2023: Evacuation behavior of households facing compound hurricane–pandemic threats. *Public Administration Review*, **83** (5), 1186–1201.

Chapter 5: ¿Qué información necesito? Informed Weather Alerts for Spanish Speakers

Introduction

In the United States, the National Weather Service (NWS) is the main agency that provides weather risk information to the public. Most of this information is shared in English, which creates challenges for people who do not speak English well. Over time, the number of people in the United States who speak a language other than English at home has grown. Between 1980 and 2019, this number increased from 23.1 million to 67.8 million people (Dietrich and Hernandez 2022). Spanish is the most common non-English language spoken in the country, largely because the Hispanic and Latino population is the largest minority group in the United States. About 62 percent of non-English speaking households speak Spanish, which is much higher than other languages such as Chinese, Tagalog, Vietnamese, and Arabic (Dietrich and Hernandez 2022). The U.S. Census Bureau reported in 2024 that the Hispanic population is growing much faster than the non-Hispanic population. This growth makes it even more important to ensure that weather information is easy to access and understand for Spanish speakers. Mast and Ruiz (2023) report that 39% of Spanish speakers in the U.S. speak English "less than very well." Barriers such as limited English skills, literacy challenges, unfamiliar weather terms, and limited access to bilingual resources continue to make weather risk communication less effective in these communities (Aguirre 1988; Mast and Ruiz 2023; Trujillo Falcón et al. 2022, 2024; Gaviria-Pabón et al. 2025).

Literature Review

Spanish Weather Risk Information

Even though most weather risk information in the United States is shared in English, there have been recent efforts by different agencies to translate this information into Spanish. While

these efforts have helped increase access, they have also faced important challenges. For example, Trujillo Falcón et al. (2022) found that FEMA, the National Weather Service, and broadcast meteorologists often used different Spanish terminology for watches and warnings. These inconsistencies created confusion and led Spanish speakers to feel less urgency when responding to alerts (Trujillo Falcón et al. 2022). Similarly, Bitterman et al. (2023) showed that early Spanish translations used by the Storm Prediction Center for convective outlooks created barriers for Spanish speaking audiences. Their study suggested alternative translations developed by linguistic experts that more clearly communicated severe weather risk. As a result of this research, the Storm Prediction Center updated its Spanish translations.

The National Weather Service has also taken steps to improve access through organized translation efforts. Since 2013, the Spanish Outreach Team has supported the translation of preparedness materials and helped coordinate Spanish language products across regional offices (Negrón Hernández and Johnson 2018). In addition, the Multimedia Assistance in Spanish program and staff at the San Juan Weather Forecast Office regularly provide Spanish translations for forecasts, ENSO discussions, and outreach materials (Colón Pagán 2021). More recently, the National Weather Service introduced an Artificial Intelligence translation program to support Spanish and other non-English language products. This program combines automated translations with review by bilingual forecasters to help improve consistency and efficiency. Early testing has shown that these tools can reduce translation time while maintaining high accuracy for certain weather products, though human review remains essential to ensure quality and trust (Trujillo Falcón et al. 2025).

Content in Weather Risk Information

Having weather information available in Spanish and ensuring that translations are accurate is important. However, the content of weather alerts and messages is just as critical. When individuals are unable to correctly understand a message, they may not engage in protective actions, which increases their risk during a hazard (Aguirre 1988; Trujillo Falcón et al. 2022). In the Warning Response Model, Mileti and Sorensen (1990) emphasized that warning messages should include key information about the hazard, guidance, location, time, and the message source to support protective decision making.

An effective warning message should begin by clearly describing the hazard. This includes the level of threat, the likelihood of risk, and the potential impacts for populations at risk (Wood et al. 2018). When individuals are not familiar with a hazard, this lack of knowledge can prevent them from taking protective action (Gaviria Pabón 2022; Trujillo-Falcón et al. 2024). Clear descriptions of the hazard help improve understanding and reduce confusion.

Guidance information in warning messages plays an important role in shaping self-efficacy, or how confident individuals feel in their ability to take protective action. When warnings clearly explain what actions should be taken and how to take them, people are more likely to feel capable of responding during a weather risk (Bandura 2010; Janssen et al. 2006). Findings from Trujillo-Falcón (2024) show that message length and content can strongly influence self-efficacy among Spanish speakers. In their study, the 360-character Wireless Emergency Alert significantly increased participants' confidence because it included detailed sheltering instructions that made them feel more empowered to act. In contrast, the shorter 90-character message left many participants feeling resigned during the most critical moments of the emerging disaster. These findings highlight that self-efficacy is not only shaped by receiving a

warning, but by whether the message provides enough clear and actionable information to help individuals feel confident in their decisions (Trujillo-Falcón 2024).

Location information is a critical component of effective weather warnings because it helps individuals determine whether a hazard applies to them. When warnings clearly specify where the threat is occurring and who is at risk, people are better able to recognize the urgency of the situation and decide how to respond. When location information is missing or unclear, individuals may struggle to personalize the risk and may delay action while seeking additional confirmation. Findings from Trujillo-Falcón et al. (2024) show that the absence of location information in the Spanish-language version of the 90-character Wireless Emergency Alert prevented many Spanish speakers from recognizing the urgency of the situation. This lack of specificity about the hazard, potential impacts, and timing led individuals to spend more time milling and confirming warning information rather than developing an actionable plan for response (Wood et al. 2018).

In addition to hazard information and guidance, warning messages must include clear timing and source information. People want to know when protective actions should begin, when they should be completed, and when messages will be updated (Mileti & Peek 2000). Individuals are also more likely to respond to warnings from familiar and trusted sources rather than unfamiliar or unofficial ones, making the message source an important part of warning communication (Cox & Wogalter 2006).

For individuals to make better decisions and take protective action during a weather hazard, they must be able to understand, believe, and personalize the risk being communicated (Wood et al. 2018). Understanding refers to how individuals attach meaning to the content of a warning message, and people can interpret the same message differently based on their

experiences and perceptions (Gaviria Pabón 2022; Klockow et al. 2014). Effective understanding requires knowing what the threat is, what is happening, which locations and populations are at risk, what actions should be taken, who is sending the message, when action is needed, and how long protective actions should continue (Sutton et al. 2021).

Once individuals understand the hazard, know what actions to take, and trust the source of the message, they must see the risk as personally relevant. Effective warning messages should therefore help individuals personalize risk. Research shows that people are more likely to take protective action when they perceive the threat as relevant to their own situation (Sutton et al. 2021; Trujillo Falcón et al. 2024; Wood et al. 2018). Messages should include information about geographic location, clearly identify who is and is not at risk, and specify who should take protective action (Wood et al. 2018). Personalizing risk can influence an individual's confidence in their ability to respond and the perceived effectiveness of the recommended actions.

Trujillo-Falcón (2024) found that disaster subculture and prior experience shaped how Spanish speakers personalized risk, with recently arrived immigrants often struggling to see tornado warnings as personally relevant, while those with more experience in the United States were better able to recognize the urgency of the threat. These findings highlight how cultural background, nativity, immigration experiences, and language use shape how Spanish speakers understand warning systems and respond to bilingual Wireless Emergency Alerts.

Together, these elements align with the Warning Response Model and help explain how Spanish speakers process weather warnings. Trujillo-Falcón (2024) showed that Spanish speakers relied on this framework to understand warning messages, believe the risk, personalize the threat, make decisions, and seek additional information during a simulated tornado event (Mileti & Sorensen 1990; Mileti & Peek 2000). Importantly, the study also demonstrated that

Spanish speakers in the United States are not a single or uniform group, as participants navigated warning systems through multiple cultural perspectives.

Building on these findings, the goal of this study is to better understand whether the weather information Spanish speakers are currently receiving is meeting their needs. While agencies continue to invest time and effort into translating and distributing warnings, it is important to assess whether this information is clear, complete, and useful from the perspective of the audience. This study examines whether Spanish speakers feel that warning messages include all the information they need, whether anything feels missing or unclear, and whether the messages help them make the right decisions and feel confident about those decisions. Understanding how Spanish speakers evaluate the usefulness of warning information can help determine whether current communication efforts are effective or whether additional improvements are needed to better support protective decision making.

Data & Methods

We conducted semi-structured interviews in Tampa, Florida, a region highly vulnerable to hurricanes and home to a large Spanish-speaking population. Tampa was selected due to its recent exposure to tropical cyclone impacts and the opportunity to engage Spanish-speaking residents from diverse national and cultural backgrounds. Recruitment began through a local broadcast meteorologist, who connected the research team with a community-based agency serving Spanish-speaking populations. Using this partnership and snowball sampling, we conducted 25 interviews with Spanish-speaking adults (18 years and older). Data collection occurred between October 10 and October 17, 2025. Participants represented a range of countries of origin, ages, and lengths of residence in the United States. All interviews were conducted in

Spanish, lasted approximately 35 minutes, and participation was voluntary. This study was approved by the University of Oklahoma Institutional Review Board (IRB #18912).

The interview guide was designed to examine how Spanish speakers evaluate the clarity, completeness, and usefulness of tropical weather information. Each interview began with brief background questions, including place of origin, length of residence in the United States, and prior experience with tropical storms or hurricanes. These questions provided context for understanding how participants interpreted and responded to weather warnings.

Interviews then focused on participants' experiences receiving tropical weather alerts in Spanish. Participants were asked whether the information felt clear and easy to understand, how it compared to English-language alerts, and whether it helped them decide what actions to take. Additional questions explored perceptions of information sources, including trust in alerts issued by official agencies.

Questions also addressed language and comprehension. Participants were asked what aspects of alerts made them feel clear or confusing, whether any information felt missing, and whether the wording reflected how Spanish is commonly spoken in their communities. These discussions highlighted the role of tone, phrasing, and dialect in shaping comprehension and perceived usefulness.

The interview guide further examined inclusive alerting by asking participants whether alerts felt relevant to them and their communities. Participants reflected on the presence or absence of location information, how this affected their ability to recognize urgency, and whether alerts helped them feel included as part of the intended audience.

Finally, participants were asked about confidence and decision making. These questions focused on whether alerts helped them feel confident about what actions to take, whether the information supported timely responses, and what changes could improve their ability to act during future events.

All interviews were transcribed using Sonix.ai and analyzed using thematic analysis. An inductive coding approach was employed in Dedoose, allowing codes and themes to emerge directly from participants' narratives. This analytic process identified recurring themes related to message clarity, information sources, language and comprehension, and inclusive alerts. The analysis centered on how Spanish speakers assessed whether weather warning information met their needs and supported confident and effective protective decision making.

After the themes were identified and finalized, the distribution of coded excerpts across themes was examined to assess their relative prevalence within the dataset. Coding was conducted using Dedoose, which provides counts of how many excerpts are associated with each code. Related codes were grouped into broader thematic categories, and the total number of excerpts associated with the codes within each theme was calculated. Because excerpts were occasionally assigned multiple codes during analysis, each code was assigned to a single thematic category when estimating theme prevalence in order to avoid double counting. The proportion of coded excerpts associated with each theme was then calculated relative to the total number of coded excerpts across interviews. This procedure allowed for an approximate estimate of the relative prominence of themes within the dataset without requiring a second round of coding.

The analysis indicated that themes related to message clarity accounted for approximately 31% of coded excerpts, followed by dialect and language (11%) and language and comprehension

(8%). These percentages are reported to illustrate the relative prominence of themes within the dataset rather than as descriptive indicators of thematic emphasis rather than statistical measures.

Results

Theme 1: Message Clarity

This code captures how participants talked about the use of simple and clear language in weather warning messages and how this affected their ability to understand the information and make decisions. Participants discussed what made messages feel clearer and more useful, including the use of plain language, the inclusion of location information, the level of urgency conveyed through the wording of the message, and the presence of clear guidance on what actions to take.

Simple and clear language:

Participants emphasized the importance of using plain, everyday language in weather alerts rather than technical or scientific terminology. Many explained that complex language, numbers, and meteorological terms made messages harder to understand, especially for those without a background in weather or science. Instead, participants wanted messages that clearly explained what was happening, what it meant for them, and what actions they should take.

Participants also noted that during high-stress situations, such as hurricanes, they were less interested in detailed explanations about the causes of a storm and more focused on clear, concrete guidance. Messages that were concise, direct, and action-oriented helped reduce confusion and made it easier to decide how to respond. Several participants suggested that alerts should prioritize simple explanations, while still offering the option to access more detailed information for those who want it.

Overall, participants viewed simple and clear language as essential for understanding risk, reducing uncertainty, and supporting timely protective action during weather hazards.

"Cuando se utiliza un lenguaje coloquial, una cosa sencilla… uno puede entender cuándo va a ocurrir, qué puede ocurrir y qué hay que hacer… a mí lo que me interesa es qué hay que hacer cuando hay que hacerlo… los mensajes deben ser más concretos, más específicos, sin entrar en demasiados tecnicismos… que haya la opción de leer más." — Participante #8

"When simple, everyday language is used… it's easier to understand when something is going to happen, what could happen, and what needs to be done… what matters most to me is knowing what to do and when to do it… messages should be more concrete and specific, without too much technical language… with the option to read more." — Participant #8

"No muy técnico… hablan de números, de la intensidad… y yo no entiendo absolutamente nada… tiene que ser más fácil de entender para las personas que no tenemos conocimiento de meteorología." — Participante #3

"Not very technical… they talk about numbers and intensity… and I don't understand any of it… it has to be easier to understand for people who don't have a background in meteorology." — Participant #3

"Algo sencillo de entender… que no haya tanto tecnicismo… muchas personas se confunden con el grado de los huracanes… que sea más fácil entender la gravedad con la que viene." — Participante #17

“Something that is easy to understand… not so much technical language… many people get confused about hurricane categories… it should be easier to understand how serious the hurricane is.” — Participant #17

Location:

Participants discussed how clearly weather alerts communicated *where* a hazard was occurring and whether they could tell if the message applied to them. Several participants explained that alerts using broad geographic terms, such as “the coast” or “west coast,” were confusing and made it difficult to know if they were personally at risk. When locations were described using unfamiliar geographic labels, participants were unsure how close the hazard was and whether they needed to take action.

Participants found alerts more useful when they included specific place names, counties, or neighborhood-level information. Clear references to well-known locations helped participants better understand their proximity to the hazard and decide how seriously to take the message. Some participants suggested that alerts tied directly to their ZIP code or displayed on a map would make it easier to know if the warning applied to them.

Overall, participants emphasized that clear, specific location information was essential for understanding personal risk and deciding whether to prepare or evacuate.

“A veces dice que va a afectar a la costa oeste… ¿y por dónde es la costa oeste?… si dijera el área de Sarasota… yo no me alarmo tanto porque estoy en Tampa… pero a veces solo dicen la costa… y por desconocer el tema geográfico yo no tomo mis precauciones.” — Participante #6

“Sometimes they say it will affect the west coast… and I think, where exactly is the west coast?… if they said the Sarasota area… I wouldn’t be as alarmed because I’m in Tampa… but

sometimes they just say the coast… and because I don't understand the geography, I don't take the right precautions." — Participant #6

"Me gustaría que cogiera el zipcode de uno y te enviara un mapa… específicamente desde tu zipcode… que no tengas que entrar a un sitio web… que te lo mande directamente." — Participante #17

"I would like it to use your zip code and send you a map… specifically for your zip code… without having to go to a website… just send it directly to you." — Participant #17

"Al principio no sabía qué zona estaban hablando… ahora te dicen Condado Pinellas… la información me ayuda… yo lo entiendo y me ha funcionado." — Participante #24

"At first I didn't know which area they were talking about… now they say Pinellas County… the information helps me… I understand it and it has worked for me." — Participant #24

Urgency:

Participants discussed how weather alerts communicated the seriousness of a situation and whether the tone of the message prompted them to take action. Many felt that messages were more effective when they clearly signaled urgency and encouraged people to prepare for the worst, even if the event did not end up being severe. Strong wording helped participants take alerts seriously and motivated them to gather supplies, secure their homes, or consider evacuation.

Participants also emphasized the importance of clear labels and signals that indicated when a situation was truly urgent. Terms such as "emergency" or "state of emergency," as well

as strong alert sounds or notifications, were seen as effective ways to communicate seriousness. Participants noted that these signals helped reduce hesitation and made it easier to decide when immediate action was needed.

Overall, participants viewed urgency as an important feature of alerts, especially during fast-moving events. Clear, strong signals of seriousness helped them recognize risk quickly and respond in a timely way.

“Sí te preparan… a veces exageran, pero nunca está de más prepararse… guardar suficiente comida, suficiente agua… no sabemos cuánto tiempo podemos quedarnos sin luz… deberían seguir haciendo lo que están haciendo y decirnos que nos preparemos para lo peor.” — Participante #1

“They do help you prepare… sometimes they may exaggerate, but it never hurts to be prepared… storing enough food, enough water… we don’t know how long we might be without power… they should keep doing what they’re doing and tell us to prepare for the worst.” — Participant #1

“Debería decir emergencia o estado de emergencia… que alerte… decirte que es necesario que abandones el área… urgente, por favor sal de esta zona… y estar en constante comunicación.” — Participante #2

“It should say emergency or state of emergency… something that really alerts you… tell you that it is necessary to leave the area… urgently, please leave this zone… and stay in constant communication.” — Participant #2

“Me parece muy bueno… como la alerta Amber… ese sonido… una llamada… que aparezca una llamada y diga SOS… sería muy contundente.” — Participante #8

“I think the Amber Alert system works very well… that sound… even a phone call… having a call pop up that says SOS… that would be very strong and effective.” — Participant #8

Guidance:

Participants discussed whether weather alerts provided clear and useful instructions on what actions to take and how to take them. Many felt that messages were often too general and did not include enough practical guidance. Alerts that only directed people to click a link for more information were especially frustrating, particularly when internet access was limited or unreliable during storms.

Participants emphasized the need for alerts to include specific, actionable steps within the message itself, such as how to prepare, when to leave, and where to go. Several noted that families, especially those new to the area, may not understand what options like shelters involve or how evacuation works. Clear instructions, advance notice, and explanations of what to expect were seen as essential for reducing confusion and supporting timely protective action.

Overall, participants viewed clear guidance as critical for turning warning information into action, especially during high-stress situations when quick decisions are required.

“Recibo el mensaje y lo único que dice alerta de huracán… si necesitas información, presiona este link… a veces el internet no está funcionando… sería mejor recibir el mensaje con la información en el mismo mensaje… porque después te pierdes.” — Participante #3

"I receive the message and all it says is hurricane alert… if you need more information, click this link… sometimes the internet is not working… it would be better to receive the message with the information in the message itself… because then you get lost." — Participant #3

"Que dé tips… qué es lo que uno debería hacer… no ser tan general… muchas familias no saben qué significa ir a un albergue… debería ser más informativo… más específico." — Participante #14

"That it gives tips… what we should do… not being so general… many families do not know what it means to go to a shelter… it should be more informative… more specific." — Participant #14

"Que nos dé esa seguridad de que algo viene… en cinco minutos viene un huracán, prepárense para esto… un anticipo para poder prepararnos… porque a veces llega y uno no sabe." — Participante #10

"That it gives us that sense of security that something is coming… in five minutes a hurricane is coming, prepare for this… advance notice so we can prepare… because sometimes it arrives and you don't know." — Participant #10

Theme 2: Language and Comprehension

Participants described language as a key factor in how well they understood weather alerts and warnings. Many explained that they either do not speak much English or feel more comfortable

receiving information in Spanish, which made it easier to understand the message. Receiving alerts in Spanish helped participants better process the information, understand the risks, and decide what actions to take. This theme highlights how language preference directly affects comprehension and plays an important role in supporting effective responses during weather hazards.

“Yo sí hablo un poco inglés… sí le entendí las órdenes en inglés… pero hay mucha gente que no habla inglés… deberían mandarlo en dos idiomas… porque hay gente… que no sabe inglés… sería un aporte que se emitieran también en español.” — Participante #6

“I do speak some English… I did understand the orders in English… but there are many people who do not speak English… they should send it in two languages… because there are people who do not know English… it would be a contribution if these messages were also issued in Spanish.” — Participant #6

“Soy bilingüe… pero me gustaría que fuera en español… es la primera lengua que uno habla… es más fácil explicarlo en español a la familia que no habla inglés.” — Participante #15

“I am bilingual… but I would prefer it in Spanish… it is the first language we speak… it is easier to explain things in Spanish to family members who do not speak English.” — Participant #15

“Hay bastantes latinos que les cuesta aprender inglés… si estuviera en español la gente se informaría más rápido… hay ancianitos y traducir es muy complicado.” — Participante #3

“There are many Latinos who struggle to learn English… if it were in Spanish people would get informed faster… there are elderly people and translating is very complicated.” — Participant #3

Theme 3: Dialect and Language

Participants discussed how differences in dialect and word choice affected their understanding of weather alerts. Many explained that direct translations from English to Spanish or the use of regional expressions could change the meaning of a message and create confusion. Participants emphasized the importance of using neutral, clear Spanish that avoids slang, country-specific terms, or vague expressions.

This theme highlights how even when alerts are provided in Spanish, differences in dialect and phrasing can influence how people interpret risk, timing, and severity. Clear and consistent language was seen as essential for ensuring that messages are understood across diverse Spanish-speaking communities.

“No es lo mismo… traducir del inglés al español… ayudaría bastante redactar una alerta exactamente en español… una neutral, sin jergas o palabras de cada país.” — Participante #2

“Sometimes it is not the same… translating from English to Spanish… it would help a lot to write an alert directly in Spanish… a neutral Spanish, without slang or country-specific words.” — Participant #2

“En cuestión del dialecto es muy importante… yo puedo decir ‘ahorita llego’ y no entienden… no utilizar descripciones que nos pongan en duda… usar números… algo más preciso.” — Participante #20

“Dialect is very important… I might say ‘ahorita llego’ and they do not understand… we should not use descriptions that create doubt… using numbers… something more precise.” — Participant #20

“Hay tantas culturas… sería muy bueno que nos explicaran… tipos de alerta… que si te dicen código cuatro o código rojo, uno ya sepa qué significa.” — Participante #8

“There are so many cultures… it would be very good if they explained… types of alerts… so that if they say code four or code red, you already know what that means.” — Participant #8

Discussion

Participants were asked questions about their experiences with weather warning information and alerts during hazard events in the United States. Most participants referred to their most recent experience, Hurricane Milton, when describing how they received and interpreted warning messages. They discussed what types of information made messages clearer and more useful, and how this information helped them make better decisions during the event.

One of the first themes that emerged was the importance of using simple and clear language. Participants explained that messages were easier to understand when they avoided technical jargon and focused on straightforward wording. Several participants noted that they did not need detailed meteorological explanations and instead preferred messages that clearly stated what was happening and what actions were needed. Previous research supports this finding, showing that eliminating jargon and using plain language helps individuals focus on their safety rather than trying to interpret technical terms (Sutton et al. 2021; Trujillo-Falcón 2024).

Location information emerged as a key factor shaping how participants understood and responded to warning messages. Many participants explained that unfamiliarity with local geography made it difficult to determine whether they were part of the affected area, especially for those who were new to the region or to the United States. Because participants come from different places, geographic references commonly used in warnings were not always meaningful to them, which made it harder to know if the risk applied to their location. When individuals do not believe a message applies to where they are, they are less likely to take protective action because they cannot personalize the risk (Sutton et al. 2021; Trujillo-Falcón 2024; Wood et al. 2018).

Findings from Trujillo-Falcón 2024 show that the absence of location information in the Spanish-language version of the 90-character Wireless Emergency Alert prevented many Spanish speakers from recognizing the urgency of the situation. As a result, participants often sought additional information from other sources to confirm whether they would be affected. This behavior, known as milling, involves searching for more information before deciding how to respond (Wood et al. 2018). Previous research has shown that foreign-born participants, in particular, tend to mill extensively by verifying information with community members and media sources before making safety decisions (Trujillo-Falcón 2024).

Providing clear and specific location information can help reduce uncertainty, limit the need for additional information seeking, and support quicker protective decision making. When participants are able to clearly identify whether their location is at risk, they are better able to personalize the warning and respond in a timely manner during hazards such as hurricanes.

Participants also reflected on the wording and tone of warning messages. While some felt satisfied with the messages they received, others noted that messages could sometimes feel

alarming. However, many participants expressed that they preferred messages with stronger wording and higher urgency, even if the event did not end up being severe, rather than messages that lacked urgency and led to delayed action. Participants mentioned that words such as "SOS" or other strong indicators of danger helped signal urgency and prompted them to respond more quickly. Research has shown that current Spanish translations of watches and warnings often rank lower in perceived urgency compared to English versions, and that Spanish speakers prefer terms such as "emergencia" or "alerta" because they convey a stronger sense of risk (Trujillo-Falcón et al. 2022). Bitterman et al. (2023) similarly found that Spanish speakers sometimes misinterpreted risk categories when wording did not clearly communicate urgency. Trujillo-Falcón (2024) suggests an interim solution of translating "tornado warning" as "alerta de tornado," a term shown to convey higher urgency among Spanish speakers (Trujillo-Falcón et al., 2022). Increased urgency, when paired with clear instructions, can significantly motivate protective action (Sutton et al. 2021).

Guidance was another area participants felt needed improvement. Several explained that short messages that only provided a link were not helpful, especially when internet access was limited, and often led them to seek additional information elsewhere. Research shows that milling decreased considerably when participants received 360-character Wireless Emergency Alerts that included clear and complete information (Trujillo-Falcón 2024). Participants also suggested that links and landing pages could be useful if they guided them directly to relevant resources. Importantly, not all participants were familiar with what it means to go to a shelter or how shelters operate. Some expressed confusion and uncertainty about what to expect, which reduced their confidence in taking action. Providing clear and empowering guidance has been shown to increase both self-efficacy and response efficacy, making individuals feel more capable

of protecting themselves during a weather hazard (Bandura 2010). Disaster subcultures may further shape unfamiliarity with protective actions in the United States, particularly among immigrants (Gaviria-Pabón 2022; Trujillo-Falcón 2024). For this reason, messages should provide clearer guidance tailored to Spanish speakers who may not be familiar with the U.S. warning system.

Finally, participants emphasized the importance of lead time. Receiving alerts earlier allowed them to better prepare, gather information, and plan their response. This aligns with prior research showing that individuals want to know when protective actions should begin, when they should be completed, and when messages will be updated (Mileti & Peek 2000).

Overall, participants highlighted that clear language, specific location information, appropriate urgency, actionable guidance, and adequate lead time all play an important role in how Spanish speakers interpret and respond to weather warnings. When these elements are missing or unclear, individuals are more likely to seek information elsewhere or delay action. These findings suggest that while agencies are making efforts to improve Spanish-language warnings, continued evaluation is needed to ensure that messages are not only accessible, but also clear, complete, and supportive of confident and timely protective decision making.

Although the themes identified in this study were not developed using the Warning Response Model as an organizing framework, it is notable that participants' responses closely reflected key components of the model. Participants discussed challenges related to message reception, comprehension, risk personalization, evaluation of recommended actions, and response constraint processes that align with core stages of the Warning Response Model. This suggests that even when explored inductively, Spanish speakers' decision-making during hazards follows patterns consistent with established warning response theory.

Another theme that emerged from the interviews was language and comprehension. Participants talked about how receiving weather warning information in Spanish made messages easier to understand and helped them better identify what actions to take. Several participants noted that some of the warnings they received were in English and expressed a clear preference for receiving this information in Spanish. Even participants who spoke some English explained that Spanish, as their native language, allowed them to process information more easily, especially during stressful situations. Participants also emphasized that many family members, particularly elders, do not speak English and are not comfortable using technology, which makes it more difficult for them to understand warnings that are not available in Spanish.

Previous research has identified additional barriers that can limit access to Spanish-language warning information. Some of the most vulnerable Spanish speakers, particularly immigrants with limited English proficiency, may unintentionally miss Spanish-language alerts due to language and technology settings on their devices. Immigrants are often motivated to adopt English-language settings because the host culture tends to respond more positively to those who appear integrated or assimilated (Montgomery et al. 2021). However, this preference can unintentionally reduce access to emergency information in Spanish, leaving individuals without critical information during hazardous events (Santos-Hernández & Morrow 2010; Trujillo-Falcón et al. 2021).

When official warning information is not consistently accessible in Spanish, prior research shows that Spanish-speaking immigrants are more likely to rely on unofficial sources such as family members, friends, and community networks to obtain information (Reedy 2015; Trujillo-Falcón et al. 2024). Although agencies have made efforts to translate warnings into Spanish, findings from this study suggest that some Spanish speakers are still not receiving information in

their preferred language. These gaps appear to be influenced by a combination of language barriers, technological challenges, and structural limitations in how warning information is delivered.

During the interviews, participants frequently discussed how language and dialect shape their understanding of weather messages and influence their decision-making. A key point raised was the importance of creating messages originally in Spanish, rather than simply translating messages written in English. Prior research has shown that direct or literal translations of weather information can lead to confusion, and scholars recommend prioritizing meaning-based translation focusing on conveying intent rather than word-for-word equivalence (Trujillo-Falcón et al. 2022). This challenge has long been recognized in the literature. Aguirre (1988) noted that the common Spanish translation of "warning," *aviso*, does not carry the same sense of urgency as the English term. In English, "warning" signals an immediate threat to life and property, yet this meaning does not have a direct equivalent in Spanish. As a result, literal translations can weaken the urgency of the message and create barriers to equitable disaster communication in multilingual contexts.

Participants also emphasized the role of dialectal variation. Spanish speakers in the United States come from many different regions of Latin America, each with distinct dialects and linguistic norms. These differences affect how certain terms are interpreted and understood. Research on multilingual tornado warning disparities has consistently shown inequities in warning reception and response between English- and Spanish-speaking populations, largely driven by linguistic and cultural differences. Specifically, previous work includes early studies on mistranslations of "watch" and "warning" (Aguirre 1988), a case study of the 2011 tornado outbreak in Georgia and Alabama (Stewart et al. 2014), and a study conducted in northeast

Oklahoma (Ahlborn and Franc 2012). Across these studies, Spanish-speaking individuals were less likely to correctly receive, interpret, and act upon tornado warnings than their English-speaking counterparts. To address these challenges, Trujillo-Falcón et al. (2021) argue that risk terminology, rather than scientific jargon, should be neutral and understandable across Spanish dialects. More broadly, scholars emphasize the importance of centering the perspectives of marginalized communities and recognizing Spanish-speaking populations as heterogeneous, shaped by diverse cultures, dialects, and lived experiences not simply by language use alone.

Participants also highlighted the importance of clear explanations of what alerts mean and what actions they require. Because Spanish speakers come from countries with different hazard profiles and disaster subcultures, many may be unfamiliar with U.S.-specific warning systems and terminology. Supporting this, Gaviria-Pabón et al. (2025) found that Spanish speakers demonstrated lower levels of warning reception, comprehension, and response compared to English speakers. Similarly, Trujillo-Falcón et al. (2022) reported that Spanish speakers were less successful than English speakers at correctly identifying the meaning of tornado watches and warnings. In the case of watch information, the gap was especially pronounced, with 38% of Spanish speakers identifying the correct definition compared to 67% of English speakers.

Overall, these findings highlight that effective weather risk communication for Spanish-speaking communities requires more than simply translating messages from English to Spanish. Language choices, dialectal differences, and how risk terms are interpreted all shape whether warnings are understood, trusted, and acted upon. Creating messages that reflect meaning, context, and cultural experience rather than relying on literal translations can help reduce confusion and support more equitable warning communication. Recognizing Spanish-speaking

communities as diverse groups with distinct linguistic and disaster experiences is essential for improving how alerts are designed and communicated across multilingual settings.

Conclusion

Efforts to improve translations and expand access to weather information for Spanish-speaking communities have increased in recent years, particularly using multilingual products and emerging technologies. However, the findings from this study show that important gaps remain in how weather information is communicated and how effectively it reaches Spanish-speaking audiences. Even when information is available in Spanish, many participants still experience challenges in receiving, understanding, and responding to warnings in ways that support timely protective action. This disconnect highlights an ongoing gap between agencies that produce weather information and the communities they aim to serve.

Traditional Warning Response Models emphasize that effective messages should clearly communicate key elements such as the nature of the hazard, recommended actions, timing, location, and the credibility of the message source. While these components remain essential, this study demonstrates that they are not sufficient on their own for Spanish-speaking populations. Language-related factors such as dialect differences, culturally specific interpretations of risk terms, and the use of literal rather than meaning-based translations play a critical role in shaping how messages are understood and acted upon. Without accounting for these factors, even well-designed warnings may fail to achieve their intended impact.

Overall, the results suggest that improving weather risk communication for Spanish speakers requires moving beyond simple translation toward more meaningful, culturally informed, and dialect-aware communication strategies. Agencies must recognize Spanish-speaking

communities as diverse groups with varied linguistic backgrounds, disaster experiences, and levels of familiarity with U.S. warning systems. Addressing these complexities is essential for reducing communication gaps, strengthening trust, and ensuring that weather warnings support equitable understanding and decision-making across multilingual communities.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the research was conducted in the Tampa Bay region and focused primarily on participants' experiences with hurricane-related warning messages. As a result, the findings may not be fully generalizable to Spanish-speaking communities in other geographic regions or to warnings associated with different types of weather hazards. The information needs, perceptions of clarity, and confidence in decision-making may vary across hazard contexts and local warning environments.

Second, participation was limited to individuals who were willing and available to take part in in-depth interviews, which may introduce self-selection bias. Participants who chose to participate may have had stronger opinions about weather warnings, more experience with hazards, or greater engagement with weather information than those who did not participate. Additionally, the study relies on participants' self-reported perceptions and reflections, which may be influenced by recall bias or by how individuals interpret past warning messages rather than how they would respond during an active event.

Finally, while this study provides rich qualitative insights into how Spanish speakers evaluate the usefulness, clarity, and completeness of weather warning information, it does not aim to represent all Spanish-speaking populations or all Hispanic and Latino subgroups. Differences in

nationality, dialect, language proficiency, familiarity with U.S. warning systems, and length of time living in the United States may shape perceptions of what information feels missing or unclear in ways that are not fully captured in this sample. Future research should examine these questions across a wider range of Spanish-speaking communities and hazard contexts to better understand how warning messages can more effectively support protective decision-making.

References

Aguirre, B. E., 1988: Feedback from the field: The lack of warnings before the Saragosa tornado. *International Journal of Mass Emergencies and Disasters*, 6, 65–74.

Ahlborn, L., J. M. Franc, and D. S. Med, 2012: Tornado hazard communication disparities among Spanish-speaking individuals in an English-speaking community. *Prehospital and Disaster Medicine*, 27, 98–102, https://doi.org/10.1017/S1049023X12000015.

Bandura, A., 2010: Self-efficacy. In *The Corsini Encyclopedia of Psychology* (I. B. Weiner and W. E. Craighead, Eds.), Wiley, 1–3.

Bitterman, A., M. J. Krocak, J. T. Ripberger, S. R. Ernst, J. E. Trujillo-Falcón, A. R. Gaviria Pabón, and H. Jenkins-Smith, 2023: Assessing public interpretation of original and linguist-suggested SPC risk categories in Spanish. *Weather and Forecasting*, 38, 1095–1106.

Colón-Pagán, I. C., 2021: Disseminating weather information to Spanish-speaking communities from the NWS/WFO San Juan perspective. *Preprints, 101st American Meteorological Society Annual Meeting*, American Meteorological Society, Virtual, Joint Abstract.

Cox III, E. P., and M. S. Wogalter, 2006: Warning source. In *Handbook of Warnings* (M. S. Wogalter, Ed.), Lawrence Erlbaum Associates, 111–122.

Dietrich, S., and E. Hernandez, 2022: Language use in the United States: 2019. *American Community Survey Reports*, No. ACS-50, U.S. Census Bureau, 12 pp.

Gaviria, A. R., 2022: The role of disaster subcultures in Spanish-speaking Hispanic/Latino immigrants in the United States. M.S. thesis, University of Oklahoma, 122 pp., https://shareok.org/handle/11244/336948.

Gaviria Pabón, A. R., M. J. Krocak, J. T. Ripberger, and J. E. Trujillo-Falcón, 2025: Linguistic challenges in severe weather communication. *Bull. Amer. Meteor. Soc.*, 106, E1940–E1954.

Janssen, A. P., R. R. Tardif, S. R. Landry, and J. E. Warner, 2006: Pandemic influenza messages. *Journal of Public Health Management and Practice*, 12, 388–394.

Klockow, K., R. Peppler, and R. McPherson, 2014: Tornado folk science in Alabama and Mississippi. *GeoJournal*, 79, 791–804.

Mast, B. D., and T. Ruiz, 2023: Visualizing Spanish-speaking limited English proficiency populations. *Cityscape*, 25, 281–286.

Mileti, D. S., and J. Sorensen, 1990: Communication of emergency public warnings: A social science perspective and state-of-the-art assessment. ORNL-6609 Rep., 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. *Journal of Hazardous Materials*, 75, 181–194, https://doi.org/10.1016/S0304-3894(00)00179-5.

Montgomery, G., Y. B. Zhang, and M. Imamura, 2021: The effects of Latino immigrants' acculturation strategy and U.S. Americans' assimilation attitudes on perceptions of accommodation satisfaction and willingness to communicate. *International Journal of Intercultural Relations*, 82, 157–167, https://doi.org/10.1016/j.ijintrel.2021.03.008.

Negrón-Hernández, K., and L. Johnson, 2018: Providing Spanish translations to build a Weather-Ready Nation. *Preprints, 98th American Meteorological Society Annual Meeting*, American Meteorological Society, Austin, TX, 8–9.

Reedy, J., 2015: Paths to the practices of citizenship: Political discussion and socialization among Mexican-heritage immigrants in the United States. *Journal of Intercultural Communication Research*, 44, 201–223, https://doi.org/10.1080/17475759.2015.1053823.

Santos-Hernández, J., and B. Morrow, 2010: Language and literacy. In *Social Vulnerability to Disasters*, 2nd ed. (D. Thomas, B. Phillips, W. Lovekamp, and A. Fothergill, Eds.), CRC Press, 243–256.

Stewart, A. E., C. Capielo, and I. Ocampo, 2014: Sources, perceptions, and needs for weather information by Spanish-speaking residents in Georgia. *9th Symposium on Policy and Socio-Economic Research*, American Meteorological Society, Athens, GA, https://ams.confex.com/ams/94Annual/webprogram/Paper236423.html.

Sutton, J., L. Fischer, and M. M. Wood, 2021: Tornado warning guidance and graphics: Implications of the inclusion of protective action information on perceptions and efficacy. *Weather, Climate, and Society*, https://doi.org/10.1175/WCAS-D-21-0097.1.

Trujillo-Falcón, J. E., M. L. Bozeman, L. E. Llewellyn, S. T. Halvorson, M. Mizell, S. Deshpande, and T. Fagin, 2025: From binary to bilingual: How the National Weather Service is using artificial intelligence to develop a comprehensive translation program. *arXiv preprint*, arXiv:2510.14369.

Trujillo-Falcón, J. E., 2024: Examining warning response among Spanish speakers in the United States to enhance multilingual wireless emergency alerts. Ph.D. dissertation, University of Oklahoma.

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. Meteor. Soc.*, 102, E765–E773.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. T. Ripberger, A. Bitterman, J. B. Thornton, M. J. Krocak, S. R. Ernst, E. Cassiani Obeso, and J. Lipski, 2022: ¿Aviso o alerta? Developing

effective, inclusive, and consistent watch and warning translations for U.S. Spanish speakers. *Bull. Amer. Meteor. Soc.*, 103, E1542–E1556, https://doi.org/10.1175/BAMS-D-22-0050.1.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. Reedy, and K. E. Klockow-McClain, 2024: Systemic vulnerabilities in Hispanic and Latinx immigrant communities. *Natural Hazards Review*, 25, 04023059.

Wood, M. M., D. S. Mileti, H. Bean, B. F. Liu, J. Sutton, and S. Madden, 2018: Milling and public warnings. *Environment and Behavior*, 50, 535–566, https://doi.org/10.1177/001391

6517709561.

Chapter 6: Conclusion

Dissertation Overview

The Spanish-speaking population in the United States continues to grow, increasing the need for accessible and culturally meaningful weather risk communication. As these communities expand, it becomes essential to provide information that is not only translated into Spanish but also linguistically appropriate, culturally relevant, and aligned with the lived experiences of diverse Spanish-speaking groups. Spanish-speaking communities often differ from the general U.S. population in ways that shape how warning messages are interpreted and acted upon. Many individuals bring prior experiences with hazards from their countries of origin, which may involve different warning systems, different hazard types, or limited exposure to hazards such as hurricanes or tornadoes (Gaviria-Pabón 2022; Trujillo-Falcón 2024). These prior experiences can influence how individuals evaluate the severity of a threat and determine appropriate protective actions.

Cultural perspectives and social dynamics can also influence warning response. For example, Hispanic communities often place a strong emphasis on family and collective decision-making, which may shape evacuation behavior and preparedness actions (Lazo et al. 2015). Cultural values such as responsibility to family members, community connections, and faith may therefore shape how warnings are interpreted and how quickly protective actions are taken.

In addition, linguistic diversity and dialect variation across Spanish-speaking communities can influence how warning messages are understood. Literal translations, unfamiliar terminology, or heavy technical language may create confusion or reduce trust in official messages, even when information is available in Spanish (Trujillo-Falcón et al. 2022; Bitterman et al. 2023; Villareal et al. 2025). These linguistic and cultural dynamics highlight that

effective risk communication requires more than direct translation; messages must reflect cultural context, dialectal variation, and community needs to support understanding and protective action (Trujillo-Falcón 2024; Trujillo-Falcón et al. 2022, 2024; Gaviria-Pabón 2022; Bitterman et al. 2023; Aguirre 1988; Gaviria-Pabón et al. 2025; Villareal et al. 2025).

In response to these growing communication needs, this dissertation adopts a mixed-methods approach to examine how emerging technologies, lived experiences, and communication practices shape Spanish speakers' interpretation of weather risk information.

Through three complementary studies, this research evaluates the effectiveness of tropical translated weather messages, explores how individuals interpret warnings through lived experience and disaster subcultures, and identifies gaps between the information currently provided and the information communities feel they need. Integrating quantitative analyses of translation quality and warning response with qualitative phenomenological insights allows for a more comprehensive understanding of how Spanish speakers evaluate, interpret, and act upon risk communication. This mixed-methods design provides both measurable evidence of communication outcomes and deeper insight into the social, cultural, and emotional contexts that shape decision-making, offering an approach that can be applied to other multilingual and multicultural communities facing similar challenges.

AI Translation Findings

To examine how translated information currently performs in practice, this research first evaluated whether AI-generated and human-translated messages produce similar levels of translation quality and warning response among Spanish speakers. The findings in Chapter 3 show that both AI and human-generated messages can achieve comparable levels of perceived translation quality and similar warning response outcomes. These results suggest that AI can

serve as a useful tool for expanding multilingual communication capacity, particularly as technologies continue to evolve and agencies seek scalable solutions. However, previous research has raised concerns about relying solely on automated translation systems. Studies have shown that automatic translation may introduce errors or mistranslations that can affect the clarity and reliability of hazard information (Baumgärtner et al. 2020; Biglow and Marshall 2023). In addition, MacPherson-Kutsky et al. (2025) emphasized that more attention is needed to better understand how automated translation systems perform in the context of weather alerts and warning communication.

Future communication systems

The findings of Chapter 3 raise important considerations for how current warning systems could better serve Spanish-speaking populations. Results from Chapter 4 show that individuals interpret warning messages differently based on their social contexts, cultural backgrounds, and prior experiences with hazards. Because of this variability, a single warning message may not resonate equally with all audiences. Emerging technologies such as artificial intelligence may offer new opportunities to address these challenges. The results of Chapter 3 suggest that AI, when combined with human oversight in translation processes, can serve as a useful tool for communicating weather risk information to Spanish-speaking communities. In addition, Wireless Emergency Alerts (WEAs) represent an important communication channel that can reach Spanish-speaking audiences directly through mobile devices (Trujillo-Falcón 2024).

Looking forward, AI-based tools may help support more personalized risk communication. One practical way to illustrate these recommendations is to consider how a

Wireless Emergency Alert (WEA) message could be structured to improve clarity and accessibility for Spanish-speaking audiences.

"AVISO DE HURACÁN NWS: Huracán categoría 4 tocará tierra cerca de Cabo Rojo, PR lunes 21 sept 10:00 AM. Vientos hasta 130 mph, lluvias intensas e inundaciones en el oeste de PR. Si vive en zona de evacuación o cerca de la costa evacúe ahora. Refugios abiertos en escuelas locales. Más info en medios locales y NWS."
"HURRICANE WARNING NWS: Category 4 hurricane expected to make landfall near Cabo Rojo, PR Mon Sept 21 at 10:00 AM. Winds up to 130 mph, heavy rain and flooding across western PR. If you live in an evacuation zone or near the coast evacuate now. Shelters open at local schools. More info from local media and NWS."

This example reflects several communication principles identified in this dissertation, including the use of clear and neutral Spanish, explicit protective action guidance, and references to location-specific resources such as evacuation zones and shelters.

In comparison to the standard WEA messages for hurricane warnings, this WEA message provides more explicit information about location and impacts accounting as well for more neutral language. Due to character limitation, the message cannot provide more information about exact locations, what the evacuation zones and routes are as well as specific schools or locations that serve as shelters. Some information that could also not be included in the WEA message is how to prepare and secure property, what supplies you will need, how long the impact will last, and indirect impacts such as power outages, among others. Providing concise instructions and directing individuals to additional resources can help reduce uncertainty and support protective decision-making among diverse audiences.

Another example is that mobile technologies could potentially synthesize information about approaching weather hazards using personal settings such as geographic location, evacuation zones, flood risk areas, shelter proximity, and other locally relevant information. Individuals could also input household characteristics or specific needs, allowing systems to generate tailored messages that explain potential risks and recommended protective actions. These tools could translate information into preferred languages or dialects and incorporate visual elements such as maps or interactive features to help users better understand local risks. In this way, agencies such as the National Weather Service could continue issuing broad warnings while emerging technologies help contextualize and personalize this information for diverse communities.

Taken together, these findings highlight that while AI has the potential to support multilingual risk communication, careful revisions should be made. Incorporating user perspectives and maintaining human review in the translation process remain essential to ensure that translated messages are accurate, clear, and culturally appropriate.

Lived experience and phenomenology

Spanish speakers in the United States come from diverse regions across Latin America, bringing distinct cultural backgrounds, linguistic preferences, and prior experiences with hazards. Because of this diversity, effective communication requires flexibility, cultural awareness, and continuous evaluation to ensure that messages remain understandable and actionable during hazardous weather events.

In Chapter 4 some of our findings suggest that disaster-related decision-making practices can persist and adapt when individuals encounter new hazards. Several participants described drawing on experiences from previous hurricanes when deciding how to respond to Hurricane

Milton. For example, participants who had experienced hurricanes such as Hurricane Helene or Hurricane María reported using lessons from those events to guide their preparedness actions, including evacuating earlier, protecting property, or gathering supplies. Others explained that after experiencing Hurricane Milton, they now felt more knowledgeable about how hurricanes develop and what actions are necessary to stay safe. These findings suggest that elements of disaster subcultures may evolve over time as individuals accumulate experience with hazards. Rather than approaching each event as entirely new, people often interpret emerging threats through previously learned practices, adapting earlier strategies to new situations.

While quantitative results provide insight into how translated messages are evaluated and how they influence warning response, understanding communication effectiveness also requires examining how individuals interpret warnings through lived experience. Using a phenomenological perspective and the concept of disaster subcultures, this dissertation explored how emotions, memory, cultural meaning, and social relationships shape the ways Spanish speakers make sense and understand weather risk communication. Through this lens, warnings are not simply informational products, but they become lived experiences through prior encounters with hazards, faith, culture, responsibility to others, and community connections. This perspective highlights that people do not passively receive warnings but actively interpret them through their social and cultural worlds.

Information gaps

Building on these insights into lived experience, this research also examined the types of information Spanish speakers feel they need but often do not receive. The findings from Chapter 5 reveal a persistent gap between the information produced by agencies and the information communities perceive as most useful. Even when alerts are available in Spanish, participants

described challenges related to clarity, relevance, and trust that can affect timely protective action. These results suggest that improving communication requires not only translating existing content but also reconsidering what information is prioritized, how it is framed, and how it reflects community realities and experiences.

Another important finding relates to the role of dialect in Spanish-language warning communication. Prior research has emphasized the importance of considering dialectal variation when translating weather information, noting that certain terms may be interpreted differently across Spanish-speaking communities (Trujillo-Falcón 2024). However, some participants in the interviews conducted for this study in Chapter 5 expressed a preference for messages written in more neutral or universally understandable Spanish rather than specific dialects. Participants suggested that while culturally familiar language can improve clarity, overly localized terminology may create confusion for audiences from different national backgrounds. These findings highlight the complexity of designing Spanish-language warning messages for diverse audiences. While dialect-sensitive communication remains important, the results of this study suggest that using clear, neutral and jargon free Spanish that avoids region-specific terminology may help ensure that messages are broadly understandable across multiple Spanish-speaking communities.

Model contributions

Taken together, the findings across this dissertation highlight important implications for traditional models such as the Warning Response Model. This model emphasizes that effective warnings should clearly communicate hazard characteristics, recommended actions, timing, location, and source (Mileti and Sorensen 1990). While these elements remain essential, the results of this research suggest including dialect variation, culturally specific interpretations of

risk terminology, heavy jargon messages, and literal translations that fail to capture the intended meaning play a significant role in shaping how messages are interpreted and acted upon.

The findings from this dissertation also suggest ways the Warning Response Model could be further expanded. In Chapter 5 the findings showcase how many participants expressed uncertainty about evacuation zones, shelter locations, and flood-prone areas, particularly when they were unfamiliar with the geography of their communities. Several participants noted that access to maps of evacuation zones, clearer geographic references, and information about nearby shelters would make it easier to understand what actions were necessary during a hurricane. These responses highlight that location information alone may not always be sufficient, especially for individuals who are new to an area or unfamiliar with local place names. Incorporating visual tools such as maps and clearly labeled geographic references alongside traditional message elements may therefore help strengthen comprehension and support protective decision-making among diverse populations.

The results of this dissertation also offer insights that can extend the Protective Action Decision Model. While PADM by Lindell and Perry (2012) recognizes the importance of information sources, prior experience, threat perceptions, and evaluations of protective actions, the findings from this study suggest that several additional contextual factors may influence how these processes unfold among Spanish-speaking populations. One important consideration is the role of prior hazard experiences in other countries. Many participants interpreted hurricane warnings through the lens of hazards they had previously experienced in their countries of origin. For individuals who had not previously experienced hurricanes, these prior experiences shaped how they evaluated the severity of the threat and the types of protective actions they considered appropriate. Expanding PADM to more explicitly account for transnational hazard experience

may therefore help explain how individuals interpret warnings when they encounter unfamiliar hazards.

The findings also highlight the importance of cultural perspectives and worldviews in shaping protective action decisions. Several participants described preparedness and evacuation as family-centered decisions rather than individual choices, reflecting more collectivistic approaches to evaluating risk and protective actions. Previous research has also shown that worldviews can influence evacuation intentions. For example, Lazo et al. (2015) found that individuals with more egalitarian worldviews in Florida were more likely to report intentions to evacuate, and that concerns about protecting family members were a strong motivator for evacuation behavior.

Evidence from the interviews conducted in Chapter 4 further illustrates how collective decision-making shaped participants' responses during Hurricane Milton. Many participants described discussing potential actions with family members before deciding whether to evacuate or remain at home. Some individuals chose to stay because family members had medical conditions, mobility limitations, or pets that made evacuation difficult. Others decided to evacuate specifically to protect children or other vulnerable household members. Several participants also described maintaining constant communication with relatives and friends during the storm through phone calls or messaging, seeking reassurance and emotional support. In some cases, participants relied on family members, friends, or community networks to help interpret the situation and guide their decisions, particularly for individuals experiencing their first hurricane.

These findings suggest that decision-making in collectivistic contexts may involve consultation, shared responsibility, and consideration of multiple household needs, which can

sometimes extend the time required to evaluate protective actions. This dynamic differs from many Western warning communication systems, which often assume that individuals will independently process warning information and take immediate action. Recognizing that protective action decisions may occur within family and social networks highlights the importance of designing warning messages that acknowledge household dynamics, caregiving responsibilities, and other social considerations that influence how individuals respond to risk.

Incorporating cultural orientations and collective decision-making processes into the Protective Action Decision Model may therefore help better explain how individuals evaluate self-efficacy and response efficacy, particularly in communities where protective actions are considered within the context of family responsibilities, shared decision-making, and social support systems.

In addition to cultural influences, the findings suggest that PADM may benefit from more explicitly recognizing response obstacles that limit the ability to take protective action. Participants frequently described barriers such as medical conditions, disabilities, pets, childcare responsibilities, and limited access to resources. In many cases, individuals understood the warning message and believed the recommended protective actions would reduce their risk, yet structural constraints prevented them from acting. Incorporating response obstacles as a more explicit component within PADM could help explain situations in which individuals intend to take protective action but are unable to do so due to practical or socioeconomic constraints.

Taken together, these findings suggest that extending PADM to incorporate transnational hazard experience, cultural worldviews, collective decision-making dynamics, and response obstacles could provide a more comprehensive framework for understanding protective action decisions among linguistically and culturally diverse populations.

The purpose of this dissertation was to better understand how Spanish speakers interpret weather information in an era of emerging technologies, how lived experiences, disaster subcultures, and cultural contexts shape risk perception and decision-making, and what communication gaps remain between the information currently provided and the information communities feel they need. By examining both the measurable outcomes of translated messages and the lived experiences through which individuals make sense of risk, this research demonstrates that mixed-methods approaches provide a stronger foundation for studying multilingual risk communication. As multilingual populations continue to grow across the United States, future research should prioritize participatory and interdisciplinary approaches that center community voices and examine how diverse cultural groups interpret evolving communication technologies. Strengthening these efforts will help ensure that emerging tools such as AI contribute to more inclusive, accessible, and equitable weather risk communication systems for Spanish-speaking communities and other multilingual and multicultural populations facing similar challenges.

Policy Recommendations

Emergency managers play a critical role in preparing communities before disasters occur. Effective preparedness and response often depend on strong coordination among institutions and support from elected leadership. When emergency managers receive support from elected officials, they are better able to carry out preparedness and response duties. In contrast, political conflict and lack of coordination can hinder response operations and delay essential services, as observed after Hurricane Katrina in 2005. During the active hurricane seasons of the early 2000s, many agencies relied heavily on mutual aid agreements and communication among cities, counties, and jurisdictions, highlighting the importance of intergovernmental collaboration (Kapucu 2008).

Preparedness strategies implemented by public managers in Florida, including pre season planning exercises, off season community awareness seminars, and public education initiatives, demonstrate how proactive engagement with communities can strengthen disaster readiness. Local governments must maintain open communication with elected officials and with the communities they serve. Kapucu (2008) also notes that emergency managers who communicate across cultures and address language barriers contribute to stronger community resilience before and after disasters.

Research also highlights the need for stronger institutional support for multilingual disaster communication. Liu (2007) argues that federal agencies such as Federal Emergency Management Agency are well positioned to develop Spanish language disaster communication materials because they have greater communication resources, while state and local agencies can adapt these materials to meet local needs and distribute them directly to residents. Partnerships with local volunteer, religious, and ethnic organizations can further expand the reach of Spanish language disaster information.

At the same time, emergency governance structures can disproportionately affect marginalized communities. Census based analyses show that emergency management policies in Michigan were more frequently implemented in communities with higher poverty rates and larger racial and ethnic minority populations, limiting local political representation and participation for many residents (Lee et al. 2016).

Together, these findings suggest that emergency managers are central to improving preparedness among linguistically diverse populations. One policy approach is to increase multilingual capacity within emergency management agencies by ensuring that a portion of emergency management personnel in regions with large Spanish speaking populations have

Spanish language proficiency. Agencies could also implement training programs focused on culturally informed risk communication and engagement with multilingual communities. When supported by elected officials, these efforts can strengthen trust and help ensure that preparedness information reaches diverse communities before hurricanes and other hazards occur.

Another policy recommendation is to strengthen Spanish language communication capacity within the National Weather Service. In regions with large Spanish speaking populations, local forecast offices could benefit from hiring a Spanish speaking risk communication specialist responsible for developing and disseminating weather information in Spanish. This role could support the translation and cultural adaptation of forecast products, assist with community outreach, and help ensure that warnings and preparedness information are communicated in ways that are clear and culturally relevant. Expanding multilingual communication capacity within local forecast offices could help improve trust, comprehension, and protective action among Spanish speaking communities.

Lastly, another policy recommendation is to expand the use of everyday public service spaces as channels for disaster preparedness communication. Agencies could partner with departments of motor vehicles to provide weather preparedness pamphlets and informational materials to individuals when they apply for, renew, or update driver's licenses or identification cards. Because these locations serve a wide and diverse population, they offer an opportunity to reach individuals who may not actively seek out hazard information. Providing these materials in multiple languages, including Spanish, could further improve access to preparedness information among linguistically diverse communities. Integrating weather risk communication into routine

public interactions can help increase awareness and support more informed decision making before hazards occur.

Future Work

The findings of this dissertation also highlight several opportunities for future research and improvements in weather risk communication practices. One important area involves strengthening efforts to communicate preparedness information before hurricane season begins. Many participants expressed uncertainty about evacuation zones, shelter locations, and flood-prone areas while storms were already approaching. This suggests that additional effort may be needed to provide information about shelters, evacuation routes, and preparedness actions throughout hurricane season, rather than only when a storm is imminent. Increasing familiarity with this information ahead of time may help reduce uncertainty and allow individuals to focus on protective actions when warnings are issued.

These findings also suggest that there may be a gap between the preparedness information produced by meteorologists and how that information reaches Spanish-speaking communities. Broadcast meteorologists and agencies such as the National Weather Service frequently provide guidance before hurricane season begins, including information about evacuation zones, shelters, and preparedness strategies. However, the results of this dissertation indicate that this information may not always effectively reach Spanish-speaking audiences. Future research should therefore explore how communication channels used by meteorologists can better connect with linguistically diverse communities and ensure that preparedness information is accessible before disasters occur.

Future research could also examine the original English versions of weather messages in greater depth. While much attention is often placed on the translation process, the clarity and structure of the source message itself may influence how effectively information can be translated and understood. Evaluating the readability, clarity, and level of detail in English-language warnings and preparedness messages may help identify aspects of the original communication that could be improved before translation occurs. Strengthening the clarity of the source message could ultimately support more accurate and effective multilingual communication.

Building on this, future research could use focus groups with bilingual participants to more directly examine how meaning is interpreted across languages. Participants could be presented with the original English message alongside both AI-generated and human-translated Spanish versions and asked to compare clarity, tone, urgency, and overall understanding. This approach would allow researchers to explore not only differences in translation quality but also how individuals navigate meaning between languages, identify inconsistencies, and express preferences. Such discussions could provide deeper insight into how translation choices shape comprehension and decision-making, and help identify specific features that support more effective multilingual weather communication.

Community-based outreach initiatives may provide one potential pathway to bridge this gap. For example, in Puerto Rico organizations such as the EcoExploratorio collaborate with meteorologists and educators to host public preparedness events before and during hurricane season. Programs such as the *Gira de Huracanes* travel to schools, shopping centers, and community spaces to educate residents about hurricane risks and preparedness strategies through interactive exhibits and educational activities (EcoExploratorio 2025). These initiatives allow

communities to learn about hazards in accessible and engaging ways before storms occur. Similar community-centered outreach efforts could potentially be expanded in regions of the continental United States with large Spanish-speaking populations to strengthen preparedness and improve communication between meteorologists and local communities.

Future research could also apply the framework developed in this dissertation to examine vulnerability in other contexts where cultural background, language, and hazard familiarity influence risk perception and decision-making. For example, this framework may be useful for studying the vulnerability of tourists to hazard events in coastal regions. In Puerto Rico, approximately 30 people drown each year on beaches, and some of these incidents involve visitors who may be unfamiliar with local ocean conditions (Morales Muñoz and Hernández González n.d.). Understanding how tourists interpret risk information and warnings could help improve communication strategies aimed at preventing these types of tragedies.

Finally, future studies could apply this framework to other multilingual and multicultural communities beyond Spanish-speaking populations. As demographic diversity continues to increase across the United States, understanding how different cultural groups interpret warnings, evaluate risk, and respond to evolving communication technologies will be essential for improving inclusive weather risk communication systems.

References

Aguirre, B. E., 1988: Feedback from the field: The lack of warnings before the Saragosa tornado. *International Journal of Mass Emergencies and Disasters*, 6, 65–74.

Baumgärtner, L., S. Jauss, J. Maucher, and G. Zimmermann, 2020: Automated sign language translation: The role of artificial intelligence now and in the future. *Proc. 4th Int. Conf. on Computer-Human Interaction Research and Applications (CHIRA 2020)*, Science and Technology Publications, 170–177.

Biglow, J., and H. Marshall, 2023: *Best practices in social media crisis communications for state and local emergency management agencies*. Center for Naval Analyses, Arlington, VA.

Bitterman, A., M. J. Krocak, J. T. Ripberger, S. R. Ernst, J. E. Trujillo-Falcón, A. R. Gaviria Pabón, and H. Jenkins-Smith, 2023: Assessing public interpretation of original and linguist-suggested SPC risk categories in Spanish. *Weather and Forecasting*, 38, 1095–1106.

EcoExploratorio, 2025: Gira de Huracanes 2025. EcoExploratorio: Museo de Ciencias de Puerto Rico, accessed 6 Mar. 2026, https://ecoexploratorio.org/gira-de-huracanes-2025/.

Gaviria Pabón, A. R., 2022: The role of disaster subcultures in Spanish-speaking Hispanic/Latino immigrants in the United States. M.S. thesis, University of Oklahoma, 122 pp., https://shareok.org/handle/11244/336948.

Gaviria Pabón, A. R., M. J. Krocak, J. T. Ripberger, and J. E. Trujillo-Falcón, 2025: Linguistic challenges in severe weather communication: Comparing English- and Spanish-speaking populations. *Bull. Amer. Meteor. Soc.*, 106, E1940–E1954.

Kapucu, N., 2008: Collaborative emergency management: Better community organising, better public preparedness and response. *Disasters*, **32**, 239–262.

Lazo, J. K., A. Bostrom, R. E. Morss, J. L. Demuth, and H. Lazrus, 2015: Factors affecting hurricane evacuation intentions. *Risk Analysis*, 35, 1837–1857.

Lee, S. J., A. Krings, S. Rose, K. Dover, J. Ayoub, and F. Salman, 2016: Racial inequality and the implementation of emergency management laws in economically distressed urban areas. *Children and Youth Services Review*, **70**, 1–7.

Lindell, M. K., and R. W. Perry, 2012: Protective action decision model. *Risk Analysis*, 32, 616–632.

Liu, B. F., 2007: Communicating with Hispanics about crises: How counties produce and provide Spanish-language disaster information. *Public Relations Review*, **33**, 330–333.

MacPherson-Krutsky, C., M. A. Painter, and M. Villarreal, 2025: Inclusive emergency alerts: Exploring whether agencies are ready, willing, and able. *Natural Hazards Review*, 27, 04025064.

Mileti, D., and J. Sorensen, 1990: Communication of emergency public warnings. ORNL-6609 Report.

Morales Muñoz, B., and C. Hernández González, n.d.: Estudio sobre ahogamiento en playas de Puerto Rico. Puerto Rico Sea Grant, University of Puerto Rico, https://estadisticas.pr/files/BibliotecaVirtual/estadisticas/biblioteca/UPR/EstudioSobreAhogamientoenplayas.pdf.

Trujillo-Falcón, J. E., 2024: Examining warning response among Spanish speakers in the United States to enhance multilingual wireless emergency alerts. Ph.D. dissertation, University of Oklahoma.

Trujillo-Falcón, J. E., A. R. Gaviria Pabón, J. Reedy, and K. E. Klockow-McClain, 2024: 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. *Natural Hazards Review*, 25, 04023059.

Trujillo-Falcón, J. E., and Coauthors, 2022: ¿Aviso o alerta? Developing effective, inclusive, and consistent watch and warning translations for U.S. Spanish speakers. *Bull. Amer. Meteor. Soc.*, 103, E1542–E1556, https://doi.org/10.1175/BAMS-D-22-0050.1.

Villarreal, M., C. MacPherson-Krutsky, and M. A. Painter, 2025: Barriers and best practices for inclusive emergency alerts and warnings. *International Journal of Disaster Risk Reduction*, 125, 105581.