BRIEF REPORT

Tornado Hazard Communication Disparities among Spanish-Speaking Individuals in an English-Speaking Community

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Abbreviations:
ACS: American Community Survey
LEP: limited English proficient
NES: native English speaking
NSS: native Spanish speaking
NWS: National Weather Service (US)
SWIR: Severe Weather Information Reception Score

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Abstract

Background: The state of Oklahoma, known for destructive tornados, has a native Spanish-speaking (NSS) population of approximately 180,241, of which 50% report being able to speak English "very well" (US Census Bureau). With almost 50% of these native Spanish-speaking persons being limited English proficient (LEP), their reception of tornado hazard communications may be restricted. This study conducted in northeast Oklahoma (USA) evaluates the association between native language and receiving tornado hazard communications.

Methods: This study was a cross-sectional survey conducted among a convenience sample of NSS and native English-speaking (NES) adults at Xavier Clinic and St. Francis Trauma Emergency Center in Tulsa, OK, USA from September 2009 through December 2009. Of the 82 surveys administered, 80 were returned, with 40 NES and 40 NSS participants. A scoring system (Severe Weather Information Reception (SWIR)) was developed to quantify reception of hazard information among the study participants (1–3 points = *poor* reception, 4–5 = *adequate* reception, 6–8 = *excellent* reception). Pearson's chi-squared test was used to calculate differences between groups with Yates' continuity correction applied where appropriate, and SWIR scores were analyzed using ANOVA. *P*-values <.05 were considered significant.

Results: NSS fluency in English was 25.6%. No significant association was found between native language and those who watch television, listen to radio, have a National Oceanic and Atmospheric Administration (NOAA) All Hazards radio or telephone, or are in audible range of a tornado siren. NSS were less likely to have Internet access ($P < .004$), and less likely to know of local telephone warning programs ($P < .03$). The mean NSS SWIR score was 3.2 (95% CI, 2.8-3.7) while LEP NSS averaged 2.8 (95% CI, 2.4-3.2). The mean NES SWIR score was 4.5 (95% CI, 4.1-5.0).

Conclusion: Results demonstrate a disparity in tornado warning reception between NSS and NES. Poor English proficiency was noted to be 75% among NSS, which is approximately 25% more than estimated by the US Census Bureau. This study demonstrates a need for emergency managers to recognize when appropriate and overcome communication disparities among limited English proficient populations.

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Introduction

Over the past decade, tornados have caused an average of 56 deaths and 751 injuries per year in the United States despite installation of a network of Weather Surveillance Radar including Doppler (WSR-88D) by the National Weather Service (NWS) in the 1990s.[1] This network has helped reduce tornado-related fatalities by 45% and injuries by 40%. The reduction of death and injuries is believed to be the result of several factors, including a 70% increase in storm warnings, an 80% increase in mean warning lead time (time between issuance of a warning and actual tornado touchdown), and a slight decrease in the false alarm rate.[2]

Storm warnings are transmitted through a number of modalities, including those issued directly from the NWS via a National Oceanic and Atmospheric Administration (NOAA) All-Hazards radio, local television and radio stations, Internet websites and

alert systems, and tornado sirens. Also available in some tornado-prone areas are telephone warning systems in which residents may register, for a small annual fee, to receive an automated call in case of a warning issued for the area of their residence or business. At the heart of a region called Tornado Alley, an L-shaped region in the United States from Iowa to Oklahoma to Mississippi, Oklahoma has been shown to have the greatest probability of an F2 or greater intensity tornado.[3]

According to the US Census Bureau's 2005-2009 American Community Survey, 8.4% of the population of Oklahoma reported speaking a language other than English at home. Of the population, 5.5% reported the other language as Spanish, the largest subset of languages other than English spoken in Oklahoma. The total number of persons who speak Spanish in the home was estimated at 184,973. Approximately 50.5% of those who speak Spanish at home considered themselves able to speak English "very well," leaving 49.5% who reported speaking English less than "very well."[4]

With almost half the native Spanish-speaking population (NSS) considered limited English proficient (LEP), the resulting language and cultural isolation may limit their receiving tornado hazard communications, increasing their vulnerability in severe weather events compared to native English-speakers (NES). The objective of this study was to evaluate for possible variation in the reception of tornado hazard warnings between the native Spanish language and native English language subgroups of the population.

Methods

This study used a cross-sectional cohort survey developed to compare access to the various forms of tornado hazard communication among NSS and NES in Tulsa (Oklahoma, USA). NES was the control group with NSS as the test group. Evaluation was accomplished using a 38-question survey, which included basic demographic information such as gender, age, education, and state and county of residence, followed by inquiry regarding native language and the individual's ability to communicate in both spoken and written English. Access to specific sources of tornado warning information (radio, television, telephone call, Internet, NOAA All Hazards radio, and tornado siren) was determined. In addition, study subjects were asked to report which of the communication sources they had used during previous severe weather events.

The survey was developed and validated for clarity in English, then translated into Spanish. Native Spanish-speakers fluent in English reviewed the survey for post-translation validity. The survey was then piloted among NES and NSS, and further refinements were made. Prior to distribution, application was made to the St. Francis Hospital Institutional Review Board, Tulsa, OK, which approved the study.

A convenience sample of NSS and NES subjects ≥18 years of age was recruited from those persons waiting at St. Francis Hospital Trauma Emergency Center and Xavier Clinic. St. Francis was selected as the study site because of a patient population that reflects a cross-section of the local community. The Xavier Clinic (an indigent clinic run by volunteers from the St. Francis Hospital system) was selected for its predominant NSS population to obtain a more significant sample size for that test group. The study survey was conducted such that anonymity was assured for study subjects.

Demographic Variable	NES[b] % (n)	NSS[c] % (n)
Gender		
Male	32.5 (13/40)	46 (18/39)
Female	67.5 (27/40)	54 (21/39)
Age		
18 - 25	13 (5/39)	15 (6/39)
26 - 35	36 (14/39)	44 (17/39)
36 - 45	23 (9/39)	21 (8/39)
46 - 55	10 (4/39)	15 (6/39)
56 - 65	13 (5/39)	5 (2/39)
66 - 75	0	0
Over 75	5 (2/39)	0
Education		
Grade 1-5	0	22 (8/37)
Grade 6-8	5 (2/39)	24 (9/37)
Grade 9-12	31 (12/39)	49 (18/37)
College 1-4 yrs	41 (16/39)	3 (1/37)
Bachelors	15 (6/39)	3 (1/37)
Masters	8 (3/39)	0

Table 1. Demographic distribution[a]

[a]denominators <40 represent the number of question specific responses
[b]NES = native English speaking
[c]NSS = native Spanish speaking

Surveys were distributed periodically between September and December 2009. Forty NES volunteered and returned the questionnaires (100%), and a total of forty-two NSS volunteered of which 40 (95%) returned questionnaires (Table 1). All participants resided in the state of Oklahoma. Data were entered into an Excel Version 12.3.2 (Microsoft Corporation, Redmond, Washington, USA) spreadsheet.

Statistical analysis was performed using the "R" statistics package Version 2.10.1 (The R Foundation, Vienna, Austria) for SuSe Linux Version 9.2 (Novell, Waltham Massachusetts, USA), and MySQL Version 5.0 (Sun Microsystems, Santa Clara, California, USA). Differences between groups were calculated using Pearson's chi-squared test with Yates' continuity correction where appropriate.

A scoring system, titled the Severe Weather Information Reception (SWIR) Score, was developed for the study to test for existing disparity in receiving tornado warning information among NSS versus NES (Table 2). The scoring system awarded points for each mode of communication to which a study subject had access, and for each mode they had actually accessed for information during prior periods of severe weather. Points were weighted more heavily for actual application of the warning mode. No points were given for having been alerted by tornado siren in prior severe weather events, as there is no personal control over activation of that medium designed to warn only persons who are out-of-doors. A total of eight score points were possible, with one to three points defined as *poor reception* of information. Four to five points were defined as *adequate*

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reception of information and six to eight points were defined as *excellent reception* of information. Final scores were analyzed using ANOVA (analysis of variance). *P*-values <.05 were considered significant for all statistical tests.

Results

Mean age of study participants was 37.5 years. Of the 79 participants specifying gender, 31 were male (39.2%) and 48 female (60.8%). Fifty out of 79 participants defined themselves as *fluent* in English (63.3%), while 66.3% (53/80) felt they could understand spoken English. Fifty-nine percent (47/80) stated that they were able to read English well. Among NSS, 25.6% reported themselves *fluent* in English.

Forty-one percent (33/80) of the surveyed population had experienced a previous tornado event. It was more likely for a participant to have experienced a tornado event if his or her native language was English (*P* <.0003), with only 20% of NSS surveyed having experienced a tornado event compared to 63% of NES.

Data was evaluated for an association between native language and access to the specific modes of tornado warnings in northeast Oklahoma. There was no significant association found between native language and those who reported watching television, listening to radio, having an NOAA All Hazards radio, or having a telephone (cellular and/or landline). Likewise, there was no difference between native language and residential proximity to an audible tornado siren (67/80 = 84%). Two access disparities were Internet access and awareness of the telephone call alert programs. Of the NES surveyed, 67.5% (27/40) were found to have Internet access, whereas only 32.5% (13/40) NSS reported to have similar access (*P* <.004). While there was no significant association between telephone access and native language, more NES (*P* < .03) versus NSS were aware of the existence of local telephone alert programs with 57% (23/40) of NES reporting such knowledge compared to 28% (11/40) of NSS.

While NES and NSS accessed the same top three modes of communication in severe weather events, their frequency of use varied according to language (Table 3). The most common warning modes used in times of severe weather by NES were television (90%), tornado siren (83%), and local radio (72.5%). Comparatively, those modes utilized by NSS were tornado siren (73%), television (65%), and local radio (45%).

The mean SWIR Score among NSS was 3.2 (95% CI, 2.8-3.7) compared to NES at 4.5 (95% CI, 4.1-5.0). Further investigation revealed a SWIR Score of 2.8 (95% CI, 2.4-3.2) among LEP speakers and a mean of 4.5 (95% CI, 4.1–4.9) among fluent English-speakers. The SWIR Score was significantly associated with native language (*P* <.0001) and fluency in English (*P* <.007). There was no statistically significant association between the SWIR Score and ability to understand spoken English or proficiency with reading English.

Mode of Alert	Points for Access	Points for Use
Radio	0.5	1
Television	0.5	1
Internet	0.5	1
Telephone	0.5	1
NOAA weather radio	0.5	1
Tornado siren	0.5	N/A
Total possible points	3	5

Table 2. Severe Weather Information Reception scoring[a]
[a]1-3 = poor access, 4-5 = adequate access, 6-8 = excellent access

Discussion

Demographics for this study compared to the 2005-2009 American Community Survey (ACS) reveal distinct similarities and differences. Median age of participants in this study is comparable to the calculated Oklahoma demographic of 35.9 years. Male to female ratio of participants in this study was calculated at 64.58 versus 97.4 per the ACS.[5] This may be due to increased willingness of females to participate, or females may be more likely than males to seek medical attention for themselves or to accompany a family member.

Of significance is the incongruence found between the percentage of NSS reporting to be fluent in English in this study compared to that of the ACS. Twenty-six percent of NSS study respondents were self-described fluent English-speakers, while approximately double that amount were reported fluent English-speakers in the ACS (50.5%).[4] This study implies the LEP population may actually approach 75% compared to 50% calculated by the ACS. This difference may be a result of the smaller sample size of this study, use of a convenience rather than random sample, or geographical focus of participants in northeast Oklahoma. While the American Community Survey is anonymous, it is conducted in the home (by mail or telephone interview) by persons who may be viewed as government officials.[6] This study, on the other hand, was conducted

Source of Severe Weather Information	Mean (Confidence Interval) English	Mean (Confidence Interval) Spanish
Listen to local radio	72.5% (95% CI, 58%-87%)	45% (95% CI, 29%-61%)
Watch television	90% (95% CI, 80%-100%)	65% (95% CI, 50%-80%)
Internet	48% (95% CI, 31%-64%)	15% (95% CI, 3%-27%)
Registered for telephone warning	10% (95% CI, 0.3%-20%)	0
NOAA weather radio	10% (95% CI, 0.3%-20%)	3% (95% CI, -3%-8%)
Tornado siren	83% (95% CI, 70%-95%)	73% (95% CI, 58%-87%)

Table 3. Utilized tornado warning modes in severe weather, English vs. Spanish

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by community health care providers with the assurance of anonymity, which may have made undocumented persons more comfortable with study participation. As in any study of non-native US residents, there may be underreporting of undocumented NSS due to concern for deportation or other penalties. This underreporting can result in a Type II Error with respect to English fluency.

Those modes of communication most commonly used to receive hazard warnings in this study are comparable to the results of a survey conducted by Hammer *et al.* among residents of homes that sustained F4 or F5 tornado damage during the Oklahoma City May 3, 1999 tornados. Eighty-nine percent of Hammer *et al.* survey respondents cited television as the most common source of the tornado warning, compared to 90% NES in this study.[7] However, this study showed that only 65% of NSS reported use of television for past severe weather information; it can therefore be a concern that transmission through this source is not as effective for NSS. It is recommended that emergency managers work with leaders of the NSS community to determine the cause of this variance and whether it is the result of English-only transmission or other factors. It is also suggested if Spanish-language messages are available, community education efforts be initiated to increase awareness and use of this mode in severe weather events.

The findings of this study were in conflict with the study of Hammar *et al.* which listed telephone call as the second most utilized mode at 37% (versus 10% NES and zero NSS), sirens 37% (versus 83% NES and 73% NSS), AM/FM radio 25% (versus 72.5% NES and 45% NSS), and NOAA All Hazards radio 3% (versus 10% NES and 3% NSS).[7] This study did not account for variables that may explain this divergence between the two communities within the same state. Until further research is conducted, communication analysis should be performed to best inform and protect community residents.

The calculated SWIR Scores reveal a disparity in reception of severe weather warnings among NSS versus NES in northeast Oklahoma, a disparity magnified in the LEP NSS population. It can be inferred that as a result, NSS are placed at increased risk of tornado-related morbidity and mortality due to decreased reception of hazard communication. Emergency managers and community leaders should address this disparity, and take action to decrease this vulnerability of the NSS and other non-English speaking populations.

Andrulis *et al.* identified three key elements that should be addressed when communicating risk to diverse communities: (1) the actual message; (2) the channel through which it is communicated; and (3) who delivers the message.[9] While development and comprehension of the message itself and the role of trust in the messenger is beyond the scope of this study, the SWIR Score and survey tool may prove useful for emergency managers and community stakeholders to identify the key channels utilized by the various LEP populations of the community. This allows for cost- and time-efficient application of resources to communicate effective emergency messages. Those same communication channels may be used pre-and post-event to provide instruction to the varied LEP communities regarding preparedness and recovery, as well as to promote additional utilization of other, less common, information sources such as NOAA All Hazard weather radios and telephone call alerts allowing for redundancy of communication modes in case of equipment failure, power outage, or other interference.

Recent research has found a lack of metrics to evaluate and measure outcomes of disaster planning and response efforts.[8,9] Wingate *et al.* noted a particular lack of such measures among a broad spectrum of vulnerable populations including Spanish-speakers and other ethnic and racial minorities.[9] The SWIR Score can serve as a standard metric to evaluate the efficacy of current emergency risk communication, direct the development of interventions to improve efficacy, and measure the outcome of such interventions. While risk of tornado events is not equal in all geographic areas, the SWIR Score can be adapted to area-specific hazards as well as to the available modes of communication, allowing its application to be more generalizable. In the process of adaptation, the scoring scale should be maintained with four as the minimum score for adequate access, as this allows for redundancy of modes assuring transmission of messages in case of mode-specific communication interference or failure.

Limitations were inherent in the design of this study. Potentially important factors such as socio-economic status, personal past experiences, level of education, and objective measures of language comprehension are difficult to assess using survey methodology. While the survey accounts for official forms of communication available in most areas, it was not able to capture all modes of communication such as smart phones and unofficial sources of hazard warning such as personal verbal communication. Information reception may be underestimated in that the SWIR Score does not account for the contagion effect described by Rogers *et al.*, in which a message is received, processed, and then spread to others.[10] Evaluation of the effectiveness of the message, as well as linguistic and cultural comprehension, was beyond the scope of this study. Lastly, inclusion of tornado sirens as a method of hazard communication may be deceptive as this mode may not be effective for persons indoors. The results of this survey demonstrate a need for further study in this area. Further studies should consider such methods as interview or direct testing to delineate further the true differences between native English and Spanish-speakers.

Population vulnerability can stem from various sources including socioeconomics, race, gender, age, and as highlighted in this article, language. Communication is vital to mitigating morbidity and mortality among communities in times of disaster, making it incumbent upon emergency managers to direct hazard communication to all subgroups of the community. The SWIR score and survey tool can be used to identify communication disparities, and serve as a measurement of the influence of appropriate interventions. Further research is needed to account for multiple variables and their significance, as well as measure the influence of informal communication and newer technologies.

Conclusion

This study showed differences in the use of tornado warning communication modes by English proficient and limited English proficient subpopulations in northeastern Oklahoma. In the process of improving hazard communication reception among LEP populations, it is necessary to work with existing television channels and radio stations to evaluate the possibility of broadcasting messages in appropriate native languages. Where established non-English mass communication modes do not exist, emergency managers and community stakeholders should consider transmitting language-specific messages through English-speaking modes.

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