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Brief Report

Disability and subsidized housing residency: The adverse impacts of Winter Storm Uri in metropolitan Texas

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ABSTRACT

Background: While natural disasters have been found to affect both disabled and subsidized rental housing residents negatively and disproportionately, previous studies have not examined if adverse disaster impacts experienced by disabled individuals in subsidized housing developments differ from those living in other housing.
Objective: We focused on Winter Storm Uri in Texas, USA, which lasted from February 10–20, 2021. We sought to: (1) compare differences in adverse impacts suffered by households with and without disabled persons; and (2) examine how residency in US Department of Housing and Urban Development (HUD)-assisted rental housing influences the severity of impacts for households with disabled persons.
Methods: We collected data from 790 randomly selected households in eight Texas metropolitan areas through a bilingual phone survey. Bivariate and multivariable statistical methods were utilized to compare adverse impacts suffered by households, based on both disability status and HUD-assisted housing residency.
Results: Households with disabled persons were more severely impacted by Uri than households without disabled persons, in terms of service disruptions, colder temperatures, slower recovery, and adverse experiences that have important health implications. Households with disabled persons residing in HUD-assisted housing were more negatively impacted and suffered more adverse experiences than those living in other housing.
Conclusions: Residency in federally-assisted rental housing can worsen severity of adverse impacts and amplify disaster vulnerability for disabled individuals. These disparities based on disability and subsidized housing status emphasize the need for additional research to understand the impacts of disasters on disabled residents and formulate interventions that provide equitable protections.

Previous studies have collectively established that disasters and public health emergencies affect disabled persons both adversely and disproportionately.[1–5] Compared to non-disabled residents, disabled people are often the first victims of a disaster,[6] face greater exposure to related hazards,[7] take longer to recover,[8] and are more likely to face discrimination during multiple phases of the disaster cycle.[9] Disabled individuals are also more likely to lose their homes, suffer property damage, get separated from family members, suffer injuries and death, and experience other adverse impacts that have serious implications for their health and safety.[1,10]

Residents of federally subsidized housing represent another vulnerable group known to be unequally impacted by disasters[11,12] and experience health disparities.[13] By definition, federally assisted rental housing in the US is only available to low-income households. These housing developments are also characterized by relatively higher percentages of racial/ethnic minorities, people with pre-existing health conditions, and others with limited coping capacity.[12] Disabled people are often overrepresented in federally assisted housing, in part, due to supportive programs offered specifically for elderly (Section 202) and disabled (Section 811) residents. How the experiences of disabled individuals living in subsidized housing developments during disasters or health emergencies might differ from those living in other housing is an important question that has not been examined in previous disaster research.

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This brief report addresses the growing need for evidence-based research that examines how disability status combines with federally assisted rental housing residency to influence disaster vulnerability. Our study focuses on Winter Storm Uri in Texas, USA, which comprised three arctic fronts that lasted from February 10 to 20, 2021. As numerous Texas counties faced record low temperatures, the state's largest electric grid operator (i.e., Electric Reliability Council of Texas [ERCOT]) lost control of the power supply, and more than five million people lost access to electricity.[14] More than 69% of the Texas population was without power and 49% without running water at some point during the storm.[15] Uri caused 130 billion (USD) in economic losses and at least 111 deaths statewide.[14] While recent studies have examined socio-demographic disparities in power outages after Uri,[15–17] differences in adverse impacts have not been analyzed with respect to disability status of residents or households.

Here we present the first empirical study of the adverse impacts of Winter Storm Uri on households with disabled individuals that also seeks to determine whether residency in US Department of Housing and Urban Development (HUD)-assisted housing intersects with disability status to amplify the severity of adverse impacts that have serious public health implications. We utilize primary survey data collected from randomly selected households in eight metropolitan areas of Texas to answer two research questions:

1. Are there any differences in the adverse impacts suffered by households with disabled persons and households without disabled persons, during or soon after Winter Storm Uri?
2. How do the adverse impacts experienced by these households with disabled persons in HUD-assisted rental housing compare to households with disabled persons residing in other (i.e., not HUD-assisted) housing developments and households without disabled persons?

Methods

Data for this study were collected from Texas residents through a 35-minute telephone survey conducted in English and Spanish, in July 2021. The survey targeted randomly selected residents in counties that comprise eight Metropolitan Statistical Areas (MSAs) in Texas: Dallas-Fort Worth, Houston, San Antonio, Austin, McAllen, El Paso, Beaumont-Port Arthur, and Lubbock. Professional bilingual interviewers employed by a private survey research firm conducted these interviews. The sampling frame consisted of a random sample of adults aged 18 or more years with cellular telephones in proportion to the populations of each MSA ($n = 1964$). Participants were selected using random-digit dialing and we oversampled residents of federally subsidized rental housing developments. This included residents of HUD-assisted housing affiliated with the following rental assistance programs: public housing, Section 202 (supportive housing for the elderly), Section 811 (supportive housing for disabled persons), Section 8 project-based rental assistance, and Section 8 Housing Choice Vouchers. Of the 1764 eligible respondents contacted, 896 completed the survey, making the cooperation rate 50.8%.[18] We excluded 106 respondents who did not complete survey items associated with disability status and residency in federally subsidized/non-subsidized housing, which resulted in a final sample of 790 households. The distribution of households with a disabled person in our sample across the eight MSAs was approximately similar to the overall distribution of disabled individuals across these MSAs, based on the 2020 American Community Survey (ACS) five-year estimates.

Households with disabled persons in this study include those where the respondent or other member(s) experienced serious hearing, vision, cognitive, ambulatory, self-care, and/or independent living difficulties, based on questions used in the US Census Bureau's ACS to identify disability characteristics of the civilian non-institutionalized population.[19] As shown in Table 1, 355 (45%) of the 790 households in our final sample contained disabled persons and 96 (27%) of these households resided in HUD-assisted rental properties. The distribution of these 96 households with a disabled person across the five HUD-assisted housing categories was very similar to the distribution of all 790 survey respondents across these HUD categories.

Relevant items from our survey questionnaire were then used to derive dependent variables representing the adverse impacts of Uri (Table 1). The first three variables were constructed from questions that included the duration the household was under a drinking water or boiling water advisory, their home was without electricity, and the lowest indoor temperature experienced during the storm. We assessed the perceived level of disaster recovery using the survey question: “To what extent has your household recovered from the impacts of the storm? Please respond with a number on a scale ranging from 1 to 10.” We also included dichotomous variables derived from binary items that capture specific adverse experiences, based on responses to the question: “Which of the following happened to you during or soon after the Texas Winter Storm? If the following experience occurred, then please respond ‘yes’. If it did not, then please respond ‘no’.” We estimated a summed or composite index of respondents' answers to these 16 binary items; this was included as an additional continuous variable.

All independent variables used in this study are also listed in Table 1. Variables derived from survey data include household disability status (i.e., if there are any disabled members), residence in HUD-assisted (or other) housing, and several socio-demographic controls: older age (person in household aged 65 or more years), race/ethnicity (Hispanic, Non-Hispanic Black, or other non-Hispanic minority), gender (female), and household income level (10 categories). We geocoded all survey respondents based on their street address information and used their home locations to estimate two additional control variables. To capture the freeze severity at each home, we measured the deviation from the local normal temperature. This was calculated by determining the minimum temperature that occurred between February 10–20, 2021, at each household's home location based on High Resolution Rapid Refresh radar data,[20] which was subtracted from each respective MSA's annual average minimum temperature in February. We also determined whether or not each household was served by the ERCOT electrical grid, since these areas were associated with longer service outages during Uri.

For our bivariate analysis, we used an independent-sample *t*-test to compare mean values of continuous variables representing adverse impacts and *z*-test of proportions to compare binary (yes/no) items, between households with disabled and households without disabled persons. We then used generalized estimating equations (GEEs), a multivariable statistical technique that extends the generalized linear model to accommodate clustered data,[21] to predict the continuous dependent variables. GEEs are appropriate here since our survey data are clustered by design (e.g., respondents in eight MSAs) and because they relax several assumptions of traditional regression (e.g., normality). These models assume that observations from different clusters are not related to each other, while observations within clusters are correlated.[22]

We used two sets of multivariable models to separately answer our two research questions. The first set (stage one) uses households with disabled persons as the primary independent variable, with households without disabled persons representing the reference category. In the second set (stage two), households with disabled persons are disaggregated into two groups, based on their

Table 1
Descriptive statistics for variables used.

Household disability status and residency in US Department of Housing & Urban Development (HUD)-assisted rental housing:	N	Yes	Percent	No	Percent
Households with disabled persons:	790	355	44.94%	435	55.06%
- In HUD-assisted rental housing	790	96	12.15%	694	87.85%
- In other (not HUD-assisted) housing	790	259	32.78%	531	67.22%
Dependent variables:	**N**	**Min**	**Max**	**Mean**	**SD**
Drinking water or boil water advisory (days)	781	0	30	3.57	5.02
Without electricity at home (hours)	781	0	504	42.44	56.53
Lowest indoor temperature (degrees F)	709	−15	79	45.19	20.44
Level of recovery from storm impacts (scale: 1−10)	782	1	10	8.75	2.24
Total number of adverse experiences (composite)	788	0	16	3.40	3.05
Specific adverse experiences (yes/no):	**N**	**Yes**	**Percent**	**No**	**Percent**
Missed a COVID test appointment	790	25	3.2%	765	96.8%
Missed a COVID vaccine appointment	790	45	5.7%	745	94.3%
Suffered from gastrointestinal illness	790	49	6.2%	741	93.8%
Suffered from hypothermia	790	34	4.3%	756	95.7%
Ran out of food	790	153	19.4%	637	80.6%
Lacked money for living expenses	790	168	21.3%	622	78.7%
Children's school was cancelled	788	375	47.6%	415	52.4%
Experienced crowded living conditions	790	153	19.4%	637	80.6%
Feared for their life during the Winter Storm	790	191	24.2%	599	75.8%
Got separated from household members	790	130	16.5%	660	83.5%
Without needed prescription medications	790	84	10.6%	706	89.4%
Without access to health care/medical services	790	169	21.4%	621	78.6%
Without a comfortable place to sleep	790	269	34.1%	521	65.9%
Without adequate drinking water	790	291	36.8%	499	63.2%
Without access to a working toilet	790	326	41.3%	464	58.7%
Without adequate transportation	790	222	28.1%	568	71.9%
Independent variables:	**N**	**Min**	**Max**	**Mean**	**SD**
Household with disabled persons	790	0	1	0.45	n/a
Household in HUD-assisted rental housing	790	0	1	0.16	n/a
Household has a person aged 65 or more years	752	0	1	0.37	n/a
Householder is Hispanic or Latino	752	0	1	0.35	n/a
Householder is Non-Hispanic Black	748	0	1	0.11	n/a
Householder is Other (non-Hispanic) minority	748	0	1	0.09	n/a
Householder is female	758	0	1	0.54	n/a
Household income level[1] (1−10)	734	1	10	5.26	2.87
Freeze severity (Feb Average Min - Storm Min)	790	1.52	23.15	15.04	4.01
ERCOT power grid	790	0	1	0.89	n/a

NOTE: [1]Total annual household income (before taxes) coded as: 1: < $10,000; 2: $10,000−20,000; 3: $20,000−30,000; 4: $30,000−40,000; 5: $40,000−50,000; 6: $50,000−75,000; 7: $75,000−100,000; 8: $100,000−150,000; 9: $150,000−250,000; and 10: > $250,000.

residence in HUD-assisted rental or other housing. For each dependent variable and model, we selected the GEE specification that yielded the best statistical fit based on the quasi-likelihood under the independence model criterion.[22] All models control for clustering in terms of the MSA of residence ($n = 8$) by the median decade of housing stock ($n = 8$). Diagnostic testing indicated that our models were not affected by multicollinearity. All statistical analyses were performed using IBM SPSS Statistics 26.0 software.

Results

Bivariate results measuring differences between households with disabled persons and households without disabled persons are presented in Table 2. Households with disabled persons indicate significantly longer drinking/boil water advisories, more hours without electricity at home, and lower indoor temperatures ($p < 0.05$), compared to households without disabled members. Households with disabled persons also reveal significantly lower levels of recovery and more adverse event experiences ($p < 0.001$). The total number of adverse experiences for households with disabled individuals was approximately 1.6 times higher than those without disabled individuals.

In terms of specific adverse experiences, households with disabled persons were significantly ($p < 0.05$) more likely to suffer from gastrointestinal illness, run out of food, lack money for living expenses, experience crowded living conditions, fear for their life, and get separated from household members, as well as function without needed prescription medication, access to health care or medical services, a comfortable place to sleep, adequate drinking water, access to a working toilet, and adequate transportation.

Table 3 summarizes the multivariable GEE results associated with the continuous dependent variables. Compared to households without disabled persons, households with disabled people (stage one) experienced significantly longer drinking/boil water advisories, longer electricity outages, lower indoor temperatures, lower recovery levels, and higher number of adverse experiences ($p<0.005$ in all models), after accounting for socio-demographic and environmental factors and clustering. Residence in HUD-assisted housing also indicated significant independent effects, in terms of longer drinking/boil water advisories, longer power outages, and higher number of adverse experiences ($p<0.05$).

When households with disabled persons are disaggregated (stage two), those living in HUD-assisted housing indicate significantly longer drinking/boil water advisories and electricity outages ($p<0.05$), compared to households without disabled persons. However, no significant differences are observed for water and electricity outages between households with disabled persons in other housing and households without disabled persons ($p>0.05$). While both disability subgroups indicate significantly lower recovery levels and higher adverse impacts than households without disabled persons ($p<0.05$), the beta coefficients for these binary variables suggest lower recovery levels and more adverse experiences for households with disabled people residing in HUD-assisted housing. An exception to this pattern is found in the

Table 2
Comparison of adverse impacts during or soon after Winter Storm Uri by household disability status.

	Household with disabled persons	Household without disabled persons	Difference	*P* value
Comparison of means for adverse impacts:				*t-test*
Drinking water or boil water advisory (days)	4.13	3.13	1.00	0.006
Without electricity at home (hours)	47.06	38.79	8.27	0.048
Lowest indoor temperature (degrees F)	41.10	47.73	−6.63	<0.001
Level of recovery from storm impacts (1−10)	8.34	9.08	−0.74	<0.001
Total number of adverse experiences (0−16)	4.27	2.69	1.58	<0.001
Comparison of proportions for specific adverse experiences:				*z-test*
Missed a COVID test appointment	4.2%	2.3%	1.9%	0.126
Missed a COVID vaccine appointment	7.3%	4.4%	2.9%	0.076
Suffered from gastrointestinal illness	10.1%	3.0%	7.1%	<0.001
Suffered from hypothermia	5.6%	3.2%	2.4%	0.098
Ran out of food	24.7%	14.9%	9.8%	0.001
Lacked money for living expenses	30.3%	13.8%	16.5%	<0.001
Children's school was cancelled	47.6%	47.5%	0.1%	0.969
Experienced crowded living conditions	23.6%	15.9%	7.7%	0.006
Feared for their life during the Winter Storm	32.6%	17.2%	15.4%	<0.001
Got separated from household members	20.8%	12.9%	7.9%	0.003
Without needed prescription medications	17.1%	5.3%	11.8%	<0.001
Without access to health care/medical services	33.4%	11.7%	21.7%	<0.001
Without a comfortable place to sleep	38.8%	30.1%	8.7%	0.011
Without adequate drinking water	43.8%	31.0%	12.8%	<0.001
Without access to a working toilet	49.4%	34.7%	14.7%	<0.001
Without adequate transportation	36.5%	21.4%	15.1%	<0.001

model for the lowest indoor temperature; temperature values were significantly lower for households with disabled persons in non-HUD housing compared to both other groups.

Discussion

With regard to our first research question, our results indicated that households with disabled persons were more adversely and disproportionately impacted by Winter Storm Uri than those without disabled persons, in terms of significantly longer water advisories, longer electricity outages, and lower indoor temperatures, even after controlling for relevant socio-demographic and environmental factors, as well as geographic clustering. Households with disabled persons also indicated significantly lower levels of disaster recovery and higher number of adverse experiences, many of which have serious health and safety implications.

Table 3
Multivariable generalized estimating equations for predicting adverse impacts during or soon after Winter Storm Uri.

	Drinking water or boil water advisory (days)		Without electricity at home (hours)		Lowest indoor temperature (degrees F)		Level of recovery from storm impacts		Total number of adverse experiences	
Respondents with complete data (N)	703		704		684		643		706	
Stage One:	Beta[1]	P-value	Beta[1]	P-value	Beta[2]	P-value	Beta[3]	P-value	Beta[3]	P-value
Household with disabled persons	0.435	<0.001	0.702	<0.001	−0.101	0.001	−0.058	0.003	0.441	<0.001
Household in HUD-assisted rental housing	0.449	0.002	0.797	<0.001	0.034	0.528	−0.019	0.639	0.237	0.016
Household has a person aged 65 or more years	−0.152	0.121	−0.358	0.005	0.028	0.439	0.003	0.898	−0.269	0.001
Householder is Hispanic/Latino	0.226	0.048	0.610	<0.001	−0.241	<0.001	−0.054	0.017	0.455	<0.001
Householder is Non-Hispanic Black	0.407	<0.001	0.888	<0.001	−0.232	<0.001	−0.122	0.003	0.552	<0.001
Householder is Other minority	0.007	0.960	−1.037	0.149	−0.135	0.004	−0.054	0.035	0.344	0.003
Householder is female	0.031	0.729	0.143	0.045	0.022	0.483	−0.006	0.707	0.054	0.461
Household income level	−0.020	0.237	0.005	0.886	0.022	0.002	0.018	0.000	−0.008	0.605
Freeze severity	0.006	0.719	0.014	0.728	0.007	0.120	−0.003	0.305	0.000	0.987
ERCOT power grid	0.517	0.101	1.470	0.021	−0.225	<0.001	0.005	0.890	0.679	<0.001
Intercept	0.439	0.190	1.654	0.001	3.909	<0.001	2.190	<0.001	0.159	0.424
Stage Two:	Beta[3]	P-value	Beta[3]	P-value	Beta[2]	P-value	Beta[3]	P-value	Beta[3]	P-value
Household with disabled persons in HUD-assisted rental housing	0.516	0.010	0.431	0.005	−0.081	0.107	−0.105	0.035	0.654	<0.001
Household with disabled persons in other (not HUD-assisted) housing	0.121	0.336	0.106	0.263	−0.101	0.001	−0.048	0.010	0.412	<0.001
Household has a person aged 65 or more	−0.194	0.114	−0.030	0.817	0.029	0.422	0.003	0.884	−0.260	0.001
Householder is Hispanic/Latino	0.246	0.058	0.314	0.010	−0.241	0.000	−0.058	0.014	0.465	<0.001
Householder is Non-Hispanic Black	0.455	<0.001	0.624	<0.001	−0.230	0.000	−0.123	0.002	0.562	<0.001
Householder is Other minority	0.159	0.344	0.082	0.563	−0.134	0.004	−0.053	0.041	0.347	0.003
Householder is female	0.179	0.062	0.113	0.226	0.023	0.482	−0.006	0.730	0.054	0.459
Household income level	−0.033	0.108	−0.007	0.674	0.021	0.003	0.017	<0.001	−0.012	0.437
Freeze severity	0.005	0.798	0.000	0.988	0.007	0.107	−0.003	0.297	0.000	0.974
ERCOT power grid	0.504	0.139	1.295	0.086	−0.225	0.000	0.003	0.942	0.688	<0.001
Intercept	0.585	0.102	2.199	<0.001	3.914	<0.001	2.197	<0.001	0.176	0.374

NOTE: Households without disabled persons represent the reference group in both stages and all models.
GEE model specifications: [1]Tweedie with log link with an unstructured correlation matrix; [2]normal with log link with an independent correlation matrix; and [3]Tweedie with log link with an independent correlation matrix
All P-values are two-tailed and based on Wald Chi-Square test.

These findings appear to support the assertion that disabled individuals may be substantially more likely to be injured or die than non-disabled persons during public health emergencies caused by climate change or natural disasters mainly because their needs have not been adequately considered in public health policy and disaster planning.[2,23]

Our second research question explored how residency in federally subsidized housing affects the severity of disaster impacts for households with disabled residents. Among households with disabled persons, residence in HUD-assisted housing resulted in significantly longer water advisories, longer electricity outages, lower levels of recovery, and more adverse experiences compared to a residence in other housing properties. These results suggest that residents of federally-assisted rental housing with disabled household members may have experienced a 'double jeopardy' in terms of the severity of negative impacts associated with Uri. Our results clearly indicate that households without disabled individuals were least likely to be adversely affected by this disaster, compared to both groups of households with disabled people.

While our study provides important empirical insights on disparities in adverse impacts of disasters based on household disability status and subsidized housing residence, it is important to consider its limitations. First, our survey was conducted about five months after Uri and recall may have been difficult for some respondents. Given our focus on memorable events such as service disruptions, however, we do not think that recall bias significantly affected our results. Second, although we compared impacts among households with disabled persons based on residency/non-residency in subsidized rental housing, we were unable to disaggregate households without disabled persons in a similar fashion. The number of households without disabled persons living in HUD-assisted housing in our sample was too small to allow statistically reliable comparisons with the other groups. Finally, we treated disability as a homogenous category and did not examine types of disability reported by survey respondents that potentially influence disaster vulnerability and related health impacts. Our future research will utilize additional survey data on the type of difficulty (i.e., hearing, vision, cognitive, ambulatory, self-care, and independent living) to analyze how specific disability types intersect with other dimensions of social disadvantage to amplify or attenuate vulnerability to disasters such as Uri.

Conclusion

This brief report extends scholarship on the disproportionate impacts of disasters on disabled residents by focusing on Winter Storm Uri and analyzing both the disability and subsidized housing status of randomly selected households in metropolitan Texas. To our knowledge, no previous study has documented how residency in federally-assisted housing developments can worsen the severity of adverse impacts and amplify disaster vulnerability for disabled persons. We found substantial evidence to indicate that households with disabled members were more severely impacted than households without a disabled member, in terms of service disruptions, colder indoor temperatures, lower recovery levels, and multiple adverse experiences. Our findings also indicated that among households with disabled members, residents of HUD-assisted rental properties were more negatively impacted and more likely to suffer adverse experiences that have important implications for their health and safety than those living in other housing. These disparities based on both disability status and subsidized housing residency emphasize the need for additional research to understand the adverse impacts of disasters on disabled people, as well as formulate appropriate interventions that provide equitable protections.

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Conflicts of interest

The authors have no conflicts of interest or disclosures to report.

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