Winter Storm Uri: Resource Loss and Psychosocial Outcomes of Critical Infrastructure Failure in Texas

Liesel A. Ritchie,[1,2] Duane A. Gill,[3] Kathryn Hamilton[4]

[1] Professor of Sociology and Associate Director, Center for Coastal Studies at Virginia Polytechnic Institute and State University

[2] Corresponding Author, liesel14@vt.edu

[3] Research Professor of Sociology at Virginia Polytechnic Institute and State University

[4] Graduate Student, Department of Sociology at Virginia Polytechnic Institute and State University

Abstract

In February of 2021, Winter Storm Uri affected parts of the United States, Mexico, and Canada. Texas was particularly hard hit, as the state's primary power provider, ERCOT (the Electric Reliability Council of Texas), proved to be unprepared for the event—despite similar storms in 1989 and 2011 that revealed weaknesses in the state's electric grid system. This article investigates psychosocial outcomes of individuals who experienced Winter Storm Uri. Drawing upon survey data collected in Texas in April and May of 2022, we illustrate ways in which loss of critical infrastructure and compounding results influence levels of stress among respondents. Using Hofoll's (1989, 1991) Conservation of Resources model of stress, we find that Uri-related losses of objects and conditions resources contribute to elevated stress as measured by the Avoidance subscale of the Impact of Event Scale (Horowitz 1976; Horowitz, Wilner, and Alvarez 1979)— more than one year after the disaster. Our regression model consisting of indicators of objects resource loss, conditions resource loss, and demographic characteristics explains approximately 33 percent of the variance in the Avoidance subscale. Findings suggest that more attention should be paid to the social impacts of critical infrastructure failures and that such impacts should be addressed by improving critical infrastructure policy and regulations, as well as the physical structures.

Keywords: Conservation of Resources Model, Impact of Event Scale, Psychosocial Stress, Winter Storm Uri, ERCOT, Critical Infrastructure

 doi: 10.18278/jcip.3.1.6

Introduction

The February 2021 North American winter storm—also known as Winter Storm Uri—was an intense ice storm that ravaged parts of the United States, Mexico, and Canada, leaving devastation in its path. The storm began in the Pacific Northwest and rapidly advanced to the Midwestern and Northeastern regions of the United States. The National Weather Service issued winter weather alerts to millions of Americans. In the U.S., Uri caused blackouts for nearly ten million people and, most notably, was the root of the 2021 Texas power crisis.

As noted by Popik and Humphreys (2021), Texas maintains its own electric grid managed by the Electric Reliability Council of Texas (ERCOT). This grid is separate from the nation's other systems, a move intended to reduce the cost of power by eliminating federal tariffs and regulation of transmission lines. Despite experiences associated with extreme cold weather conditions in 1989, 2011, and 2014 that demonstrated that ERCOT was ill-prepared to handle such situations, little was done to weatherize plants or to plan for future power outages (Popik and Humphreys 2021; Vogel and Vogel 2021). As stated by Vogel and Vogel (2021):

> Ultimately, the Texas authorities' faith in their markets reinforced their propensities not to plan, coordinate, and invest; to favor low costs over resilience; and to privilege industry profits over the protection of retail consumers. Yet the market design flaws were not so fundamental that the system could not have avoided massive blackouts with a little bit of good old-fashioned planning, coordination, regulation, and public investment.

Consequently, Winter Storm Uri caused a major power grid failure in Texas, resulting in water, heat, and food shortages (Hobby School of Public Affairs 2021).

On February 15, 2021—the height of the blackouts around the state—roughly one-third of ERCOT's customers had no electricity (Popik and Humphreys 2021). According to a research report by the University of Houston's Hobby School of Public Affairs (2021), more than 4.5 million homes were without power for several days; approximately 69 percent of Texans lost electricity for an average of 42 hours at some point during the storm; and almost one-third of those who responded to an on-line survey indicated they had water damage to their homes (Stipes 2021). Death toll estimates range from 246 (Texas Department of State Health Services 2021) to more than 700 (Aldhous, Lee, and Hirji 2021), depending on the source. In total, Winter Storm Uri left an estimated $295 billion in damages in its wake (Stipes 2021). Yet, while residents of Texas suffered during the crisis, some energy firms made billions through an increase of wholesale prices (Vogel and Vogel 2021).

Although there are numerous peer reviewed articles and reports reviewing the technical causes, policy drivers, and consequences of the power grid failure

resulting from Winter Storm Uri (e.g., see Glazer at al.; Li et al. 2022; Nejat et al. 2022; Popik and Humphreys 2021; Smead 2021; Vogel and Vogel 2021), there is surprisingly limited published information on the social dimensions of the event in Texas (for exceptions see Bottner et al. 2021; Hobby School of Public Affairs 2021; Li et al. 2022). In this article, we address the following research question: *What is the relationship between critical infrastructure failure and psychosocial stress in the context of Winter Storm Uri?* To attend to our research question, we rely on Hobfoll's (1989, 1991) Conservation of Resources (COR) theory and characterize critical infrastructure failure as a type of resource loss (Hobfoll 1989, 1991). In our analysis, we operationalize stress using the Avoidance subscale of the Impact of Event Scale (Horowitz 1976; Horowitz, Wilner, and Alvarez 1979).

Theoretical Framework

Typically, studies using COR theory measure losses and gains of different types of resources related to a particular event or situation (e.g., see Binder et al. 2020; Gill, Picou, and Ritchie 2012; Gill et al. 2014; Ritchie, Gill, and Long 2020; Ritchie, Little, and Campbell 2018). The COR model of psychosocial stress employs four types of resources that people value: (1) objects, such as physical possessions, and natural and built environments; (2) conditions, such as good interpersonal relationships, employment, stable living arrangements, or other stabilizing social circumstances; (3) personal characteristics, including self-efficacy, self-esteem, and sense of optimism; and (4) energies, among which are time, financial savings, and knowledge (Hobfoll 1989, 1991).

In this article we focus on objects resource losses and conditions resource losses associated with Winter Storm Uri. Among the former are damages to respondents' residences or neighborhoods, financial losses, and loss of access to various services and modes of communication. The latter, conditions resources, include experiences with the storm, storm-related social disruption, and personal serious injury or serious injury of someone close to survey respondents.

The bases of the COR theory are that stress is caused when people experience resource loss, threat of resource loss, or invest resources without return on such investments (Hobfoll 1989, 1991). This is especially the case when losses are sudden, as is the case in most disasters, or when disasters produce impacts that threaten further losses. "Resource caravans," which represent the combination of the four different types of resources mentioned above (Hobfoll 2011a, 2011b), have the potential to either temper resource losses or to lead to resource loss spirals or "stalled resources," particularly in the context of distinct events (Halbesleben et al. 2014; Hobfoll 1991). Although disasters may offer some opportunities for resource gains among some groups, this is rare (e.g., see Tierney 2014).

As summarized in work by Halbesleben and colleagues (2014), the impacts of resource loss are greater than resource gain. Moreover, acquisition of resources

(resource gain) necessitates resource investment; investments tend to provide a buffer against resource loss and support recovery from resource loss. Additional research (Halbesleben 2010; Halbesleben and Bowler 2007; Mäkikangas, Bakker, Aunola, and Demerouti 2010) shows that individuals who have limited resources are more likely than those who have more abundant resources to experience resource losses (Benight, Swift, Sanger, Smith, and Zeppelin 1999; Halbesleben and Bowler 2007; Hobfoll 2001). Finally, where losses are widespread, community-level stress has a tendency to create what Hobfoll (1991) refers to as a "pressure cooker effect," which can result in diminished social capital (Ritchie 2012). Clearly, COR theory is applicable to disaster studies and has increased in use since its inception (Arata, Picou, Johnson, and McNally 2000; Benight et al. 2007; Binder et al. 2020; Campbell, Vickery, and Ritchie 2018; Clay and Greer 2019; Gill and Ritchie 2018; Ritchie 2012; Sattler, Whippy, Graham, and Johnson 2018). Thus, we employ COR theory in our research on Winter Storm Uri.

Methods

We created our survey instrument using or adapting existing items from previous post-disaster research (e.g., see Binder et al. 2020; Gill, Picou, and Ritchie 2012; Gill et al. 2014; Ritchie, Gill, and Long 2020; Ritchie, Little, and Campbell 2018). Our questions captured information about critical infrastructure failures and damages; storm experiences; evacuation behaviors; social disruption; and other factors hypothesized to influence stress avoidance behaviors. The survey also included a module of questions from the Impact of Event Scale Avoidance subscale, described in detail in the Analytic Approach and Results section, below.

Qualtrics, a survey research firm, administered the on-line survey using a panel, quota sampling approach. This helped to ensure that the final sample reflected Texas demographics (e.g., see Evensen et al. 2017). Eligible participants were Texas residents living in the state at the time of the storm, ages 18 and older. We field tested the instrument with 65 individuals, which resulted in minor revisions (deletions) of some response categories that yielded little to no data. Data collection took place in April and May of 2022. Upon quality checking, the total number of completed surveys was 1,567. The median time for survey completion was 17 minutes. Of the 1,567 respondents, this article focuses only on those who indicated they resided in an area that was affected by the storm.

Subsample Characteristics

A total of 1,295 respondents (82.7%) indicated they resided in an area that was adversely affected by Winter Storm Uri. Within this subsample, there was an even split between females (50.1%) and males (49.9%), and 70 percent identified as white, which is comparable to the state of Texas as a whole (50.3% female and 79% white) (U.S. Census 2020). The subsample was higher educated than the state as a

whole with 96 percent of respondents aged 25 or older reporting having at least a high school degree compared to 84 percent of the state population of similar age. In terms of annual household income before taxes, slightly more than one-fourth of the subsample reported less than $35,000 and about one-third reported more than $100,000. The subsample median household income was in the $50,000 to $74,999 range, which was comparable to the state's $63,826 median household income.

In terms of household composition, the median household size for respondents was 3.1 persons compared to the state average of 2.8 persons per household. Almost 45 percent of the households had children under the age of 18 and one-third had disabled or elderly household members. About two-thirds (64.2%) owned their residences, which is close to the state percentage of 62.3. Almost 45 percent of the group had lived in their neighborhood for 10 years or more.

Analytic Approach and Results

Our analysis focuses on relationships between avoidance behaviors and background characteristics, loss of access to various services and modes of communication, physical damages, storm experiences, social disruption, and other forms of resource loss. We begin with a description of the Avoidance subscale as our dependent variable. We then proceed with bivariate analysis examining the subscale's relationship with background characteristics, objects resource losses, and conditions resource losses. This is followed by a multivariate analysis using Ordinary Least Squares (OLS) regression.

Dependent Variable: The Avoidance Subscale

The Avoidance subscale from the Impact of Event Scale (IES) is our measure of psychosocial stress. Horowitz and colleagues developed the IES as a self-reported indicator of posttraumatic stress employing the rationale that highly stressful events are likely to elicit intrusive thoughts and feelings, as well as efforts to cope with these intrusions by avoiding reminders of the traumatic event (Horowitz 1976; Horowitz, Wilner, and Alvarez 1979). The IES is anchored in a specified event asking, "Thinking of the (event) please indicate how often each one (item) was true for you during the past seven days." There are 15 items measured on a four-point scale to record how often each item was experienced during the previous seven days (0 = not at all; 1 = rarely; 3 = sometimes; 5 = often). The following eight items comprise the Avoidance subscale: I had to stop myself from getting upset when I thought about it; I tried to remove it from my memory; My feelings about it were kind of numb; I had a lot of feelings about it that I didn't know how to deal with; I stayed away from reminders of it; I felt as if it had not really happened; I tried not to talk about it; and I tried not to think about it. Avoidance behaviors are of par-

ticular importance from a sociological perspective because such behaviors tend to adversely affect communication, social interactions, and social networks, which in turn, weakens social connections, reduces trust, and diminishes social capital.

The IES and its subscales have been used in several studies of technological disasters. Green and colleagues (1994) used it in their longitudinal study of child survivors of the 1972 Buffalo Creek dam collapse and flood, and Davidson and Baum (1986) used the IES in their study of the 1978 Three Mile Island nuclear disaster. More recently, the scale and subscales were used as measures of initial and chronic psychosocial stress associated with the 1989 *Exxon Valdez* oil spill (Gill, Ritchie and Picou 2016), the 2010 BP *Deepwater Horizon* oil spill (Gill, Picou and Ritchie 2012; Gill et al. 2014; Ritchie, Gill and Long 2018), and the 2008 Kingston, TN coal ash spill (Ritchie, Little and Campbell 2018; Ritchie, Gill and Long 2020; Ritchie and Long 2021). Most of these studies directly or indirectly linked various types of resource loss with higher IES and subscale scores.

Analysis of our Uri data reveals a high degree of reliability for the Avoidance subscale with an alpha of .90. The mean for the Avoidance subscale is 11.6 for the subsample, which is comparable to Avoidance subscale means of 11.3 for a sample of south Mobile County residents five months after the BP *Deepwater Horizon* oil spill and 11.0 for a sample of Cordova residents five months after the *Exxon Valdez* oil spill. Extrapolating from clinical scoring of the IES, scores on the Avoidance subscale indicate that approximately 16 percent of subsample respondents are in the 'severe' clinical range 14 months after Winter Storm Uri.

Background Characteristics and Avoidance Behaviors

Drawing on subsample characteristics previously described, we examined relationships between them and avoidance subscale scores. As shown in Table 1, significantly higher levels of avoidance behaviors were reported for female and nonwhite respondents compared to their counterparts. Respondents from households with children under the age of 18 and those with disabled or elderly household members had significantly higher avoidance scores relative to those who did not have those types of dependents. Younger respondents and those with lower household incomes reported significantly higher levels of avoidance than older respondents and those with higher household incomes. Residential owners and those who had lived longer in the community reported lower levels of avoidance than those who rented and were more recent community members.

Objects Resource Loss: Critical Infrastructure and Services

One type of resource involves access to critical infrastructure such as utilities and means of communication, as well as access to various goods and services such as groceries, gasoline, banking, medical and the like. It is expected that respondents

Table 1. Descriptive and Bivariate Statistics for Background Characteristics and the Avoidance Subscale for Winter Storm Uri Impact Group

Background Variable	N	Percentages		Avoidance t value
Gender	1289	Female = 50.1	Male = 49.9	3.29***
Race	1295	White = 70.3	Non-white = 29.7	-3.82***
Marital Status	1283	Married/partner = 61.7	Not married = 38.3	-1.55
Residential Status	1295	Own = 64.2	Rent = 35.8	3.17 **
		Mean	Avoidance Correlation (*r*)	
Age[a]	1289	40-44 years	-.285 ***	
Education[a]	1293	Some College	.005	
Household Income[a]	1295	$50,000 -$74,999	-.099 ***	
Years in Community[a]	1295	4-6 years	-.065*	
Household size	1289	3.15	.171***	
Household members under 18	1289	0.84	.208***	
Disabled or Elderly Household members	1289	0.53	.096***	

[a] Variables were measured using ordinal categories: age (18-24 = 11.4%; 25-29 = 8.6%; 30-34 = 13.6%; 35-39 = 9.5%; 40-44 = 9.3%; 45-49 = 8.4%; 50-54 = 6.6%; 55-59 = 8.1%; 60-64 = 5.9%; 65+ = 18.8%); education (less than 9th grade = 0.5%; some high school = 3.1%; high school diploma = 19.0%; some college or vocational school = 33.7%; BA or BS degree = 22.8%; some graduate work = 3.4%; advance degree = 17.4%); household income (less than $10,000 = 6.3%; $10,000 to $14,999 = 3.7%; $15,000 to $24,999 = 7.8%; $25,000 to $34,999 = 8.6%; $35,000 to $49,999 = 10.2%; $50,000 to $74,999 = 19.5%; $75,000 to $99,999 = 11.5%; $100,000 to $149,999 = 20.8%; $150,000 to $199,999 = 7.6%; $200,000 or more = 3.9%); and years in the community (0-3 = 24.6%; 4-6 = 19.0%; 7-10 = 11.9%; more than 10 years = 44.5%).
* p < .05 level; ** p < .01 level; *** p < .001 level (two-tailed)

Table 2. Loss of Access to Utilities, Communication, and Services and their Relationship to the Avoidance Subscale for Winter Storm Uri Impact Group

Type of Service	Length of time without access (percent)						Correlation with Avoidance Subscale Coefficient
	Never had or lost access	1-12 hours	13-24 hours	2-3 days	4-7 days	Longer than 1 week	
Utilities							
Electricity	15.4	19.2	15.8	27.7	17.2	4.8	.223**
Water	38.4	12.8	9.5	19.8	13.5	5.9	.219**
Natural Gas	71.7	5.7	5.4	8.7	5.5	3.0	.401**
Communication							
Television	21.0	19.9	13.9	24.7	15.8	4.7	.237**
Radio	54.1	11.4	8.7	13.7	9.3	2.8	.258**
Internet	23.4	20.5	13.4	22.1	14.9	5.7	.250**
Land line phone	68.4	7.0	6.0	9.0	6.7	2.9	.307**
Cell Phone	67.6	11.2	7.3	7.7	4.4	1.7	.319**
Text messaging	67.7	11.8	6.7	8.0	3.9	1.8	.331**
Social Media	60.8	13.4	8.2	9.7	5.5	2.4	.297**
Services							
ATMs	47.5	7.5	9.4	19.1	12.1	4.3	.222**
Banks	39.5	6.0	11.1	23.6	14.2	5.6	.191**
Gas Stations	38.5	11.3	13.3	24.5	9.9	2.6	.197**
Grocery stores	29.2	10.9	15.5	27.5	12.9	3.9	.196**
Pharmacies	38.4	9.9	12.8	22.9	12.6	3.4	.194**
Hospitals/medical facilities	62.8	5.6	7.2	13.5	8.3	2.7	.169**
Transportation	54.3	5.7	7.3	17.5	10.4	4.7	.254**
Place of work	44.2	4.2	6.9	21.4	16.1	7.2	.210**
Schools	42.0	3.8	6.1	19.3	19.7	9.0	.238**
Childcare	73.9	2.9	4.6	8.4	6.7	3.5	.288**

** p <.01 (two-tailed)

who experienced longer periods of lost access and those who suffered physical damages and losses will have greater levels of psychosocial stress as measured by the Avoidance subscale.

Respondents were asked to indicate how long they were without access to various goods and services—never had access or never lost access (= 0), 1-12 hours (= 1), 13-24 hours (= 2), 2-3 days (= 3), 4-7 days (= 4), or longer than one week (= 5). Table 2 shows the results. For utilities, almost one-half of respondents indicated a loss of electricity and 40 percent were without water for two days or more. An examination of access to various forms of communication reveals that approximately two-thirds of respondents never had or lost access to cell phones, land line phones, text messaging, and social media, while more than 40 percent lost access to TV and the Internet for two days or more. Almost one-half (48%) of the respondents lost access to schools for two days or more and about four out of 10 respondents lost access to their place of work (45%), grocery stores (44%), banks (43%), pharmacies (39%), and gas stations (37%) for two days or more. Loss of access to each type of utility, form of communication, and category of service was significantly correlated with the Avoidance subscale.

A Utilities Access Loss scale was created by combining responses to length of loss access to electricity, water, and natural gas. This resulted in a scale with a range of 0 to 15, a mean of 4.7, a standard deviation of 3.5, and an alpha of .63, which was significantly correlated with the Avoidance subscale (.36; $p < .01$). A Communication Access Loss scale was created by combining responses to television, radio, internet, land line phone, cell phone, text messaging, and social media. This resulted in a scale with a range of 0 to 35, a mean of 8.6, a standard deviation of 7.6, and an alpha of .88, which was significantly correlated with the Avoidance subscale (.37; $p < .01$). Finally, a Services Access Loss scale was created by combining service items (gas stations, banks, ATMs, grocery stores, pharmacies, hospital/medical facilities, transportation, schools, childcare, and place of work), which resulted in a scale with a range of 0 – 50, a mean of 15.8, a standard deviation of 12.1, and an alpha of .90, which was significantly correlated with the Avoidance subscale (.27; $p < .01$). These scales were used in the regression analysis.

Objects Resource Loss: Property Damage

Respondents reported property damage by answering a series of questions where yes = 1 and no = 2. As shown in Table 3, damages include residential, other property, neighborhood/community, and financial losses. More than one-third of respondents (36%) reported damages to their place of residence and 29 percent indicated they experienced other property damage. A majority (62%) observed damages to their neighborhood and 46 percent experienced financial losses. T-test results indicted significant relationships ($p<.001$) between these forms of property damage/loss and the Avoidance subscale.

Table 3. Descriptive and Bivariate Statistics for Reported Property Damage and the Avoidance Subscale for Winter Storm Uri Impact Group

Type of Loss	Percent		Avoidance t value
	Yes	No	
Residential Damage	36.1	63.9	10.66***
Other Property Damage	28.7	71.3	6.59***
Neighborhood/Community Damage	61.7	38.3	8.41***
Financial Losses	45.9	54.1	8.55***

*** $p < .001$ level (two-tailed)

A Physical Damages scale was created by adding the following variables: residential damage, other property damage, neighborhood damage, and financial losses. The scale was recoded (0 = no loss to 4 = high loss) and had a mean of 1.7, a standard deviation of 1.4, an alpha of .71, and was significantly correlated with the Avoidance subscale (.32; $p < .01$). This scale was used in the regression analysis.

Conditions Resource Loss: Storm Experiences, Social Disruption, and Serious Injuries

Conditions resource loss consisted of storm experiences, social disruption, and serious injuries. As measures of resources in the context of COR theory, these variables are indicators of threats to stable conditions of daily life. For example, fear associated with storm experiences threatens stability, as do social disruption and serious injuries. It is expected that severe storm experiences, high levels of social disruption, and serious injuries to oneself or loved ones will contribute to increased levels of psychosocial stress as measured by the Avoidance subscale.

Storm Experiences

Three items served as indicators for storm experiences: "to what extent did you feel safe during the storm?" (1 = perfectly safe – 5 = life-threatening danger); "to what extent did you feel afraid during the storm? (1 = not at all afraid – 5 = very afraid); and "during the storm, I felt unable to control the important things in my life (1= strongly disagree – 5 = strongly agree). As shown in Table 4, almost 40 percent of respondents reported life-threatening or near life-threatening feelings and being afraid or very afraid. More than 40 percent agreed or strongly agreed that they felt unable to control the important things in life. All three indicators were significantly correlated with the Avoidance subscale.

A Storm Experience Scale was created by adding the three indicators. The scale ranged from 3 to 15, had a mean of 9.1, a standard deviation of 2.9, an alpha

of .70, and was significantly correlated with the Avoidance subscale (.44; p <.001). This scale was used in the regression analysis.

Table 4. Descriptive and Bivariate Statistics for Storm Experiences and the Avoidance Subscale for Winter Storm Uri Impact Group

Experience	Response (Percent)					Avoidance Subscale Correlation
To what extent did you feel safe?	Perfectly safe 11.0	20.1	31.3	28.6	Life-threatening 9.0	.234***
To what extent did you feel afraid?	Not at all afraid 17.1	17.8	26.6	28.4	Very afraid 10.1	.437***
I felt unable to control the important things in my life	Strongly disagree 14.9	17.1	25.4	26.5	Strongly agree 16.1	.372***

*** p < .001 level (two-tailed)

Social Disruption

Social disruption was measured by asking respondents the extent to which they agreed or disagreed with statements indicating disruptions in the household, community, and the State of Texas, as well as statements regarding resolution of impacts at these three levels. Responses were scored 1 = strongly disagree; 2 = disagree; 3 = neither; 4 = agree; and 5 = strongly agree. Results found in Table 5 indicate that more than two-thirds of the respondents agreed or strongly agreed that the storm disrupted their household (69%) and community (68%). Eight out of ten respondents agreed that the state of Texas experienced social disruption. At the same time, the vast majority agreed or strongly agreed that storm impacts had been resolved for their household (77%) and community (72%), but less than half (43%) thought that impacts to the state of Texas had been resolved. All individual items were significantly correlated with the Avoidance subscale.

A Social Disruption Scale was computed by adding the six indicators. The scale had a range of 6 to 30, a mean of 22.8, a standard deviation of 3.7, an alpha of .62, and was significantly correlated with the Avoidance subscale (.09; p<.001). This scale was used in the regression analysis.

Serious Injuries

Respondents reported property serious injuries by answering a series of questions where yes = 1 and no = 2. Serious injuries included those experienced by the respondent and those experienced by someone close to the respondent. More than

Table 5. Descriptive and Bivariate Statistics for Social Disruption and the Avoidance Subscale for Winter Storm Uri Impact Group

Level of Disruption	Response (Percent)					Avoidance Subscale Correlation
	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	
The impacts of the storm caused disruption in my household	6.9	8.6	15.1	39.0	30.4	.163***
The impacts of the storm caused social disruption in my community	6.0	7.7	18.1	38.3	30.1	.201***
The impacts of the storm caused social disruption in the State of Texas	3.8	3.6	11.8	33.7	47.2	.129***
The impacts of the storm on my household have been resolved	1.8	5.8	15.1	46.5	30.8	-.171***
The impacts of the storm on my community have been resolved	2.1	6.9	19.3	46.1	25.6	-.148***
The impacts of the storm on the State of Texas have been resolved	8.8	18.6	29.4%	29.7	13.5	.073***

*** p < .001 level (two-tailed)

Table 6. Unstandardized (b) and Standardized (β) Regression Coefficients and Standard Errors (SE) for Determinants of Avoidance Behaviors for Winter Storm Uri Impact Group

	Avoidance Subscale			
Independent Variables	*b*	β	SE	Sig
Objects Resource Loss Variables				
Utility Access Loss Scale	.26	.09	.10	.009
Communication Access Loss Scale	.14	.16	.05	.003
Services Access Loss Scale	.01	.01	.03	.667
Property Damage Scale	.87	.10	.05	.000
Conditions Resource Loss Variables				
Storm Experience Scale	.93	.26	.10	.000
Serious Injury Scale	2.32	.10	.66	.000
Social Disruption Scale	.156	.06	.07	.024
Demographic and Control Variables				
Age	-.52	-.15	.10	.000
Gender (Female or Male)	.39	.02	.55	.479
Race (White or Non-White)	1.67	.07	.58	.004
Married/Partner or Not Married/Partner	.53	.03	.56	.342
Education	.38	.05	.21	.071
Household Income	-.22	-.05	.14	.107
Household Size	-.19	-.03	.28	.502
Number of Dependent Children	.70	.08	.32	.027
Number of Disabled or Elderly	.53	.04	.32	.099
Number of Years Lived in Community	.15	.02	.22	.502
Own or Rent?	.44	.02	.62	.482
Constant	-5.42		3.28	.098
Adjusted R^2	.325			
N	1200			

90 percent of the respondents escaped serious injury to themselves and to someone close to them. As expected, these were significantly related to the Avoidance subscale.

A Serious Injury scale was created by recoding two variables—personal serious injury and serious injury to someone close to you—where yes = 1 and no = 0, then adding the two. This resulted in a scale with a range of 0-2, a mean of 0.1, a standard deviation of 0.4, and an alpha of .62, which was significantly correlated with the Avoidance subscale (.29; $p < .01$). This scale was used in the regression analysis.

Regression Analysis

Next, we estimated a series of regression models to examine the effects of the independent variables affecting avoidance behaviors, controlling for alternative explanations and socio-demographic characteristics. We evaluated three sets of predictors (indicators of objects resource loss, conditions resource loss, and demographic variables) on the Avoidance subscale. All models were tested for multicollinearity, and no problems were detected. All VIF values were under 2.4.

As shown in Table 6, two of the three objects resource loss variables—utilities access loss and communication access loss—were found to have positive effects on the Avoidance subscale (p\.009 and p\.003 respectively). All three conditions resource loss variables—storm experiences (p\.000), serious injuries (p\.000), and social disruption (p\.024) —were positively related to avoidance. With the exception of age (p\.000), race (p\.004), and number of dependent children in the household (p\.027), the demographic and control variables had minimal impact on the Avoidance subscale. The adjusted R^2 values indicate a good model fit with 33 percent of the variance in the Avoidance subscale explained by the combined predictors.

Discussion

Based on findings of a 2022 on-line household survey conducted in Texas, this article addresses the research question, "*what is the relationship between critical infrastructure failure and psychosocial stress in the context of Winter Storm Uri?*" Using the Conservation of Resources framework, we have shed light on ways in which resource losses associated with the storm influence levels of stress within a subsample of the population residing in an area adversely affected by Winter Storm Uri, as measured by the Avoidance subscale of the Impact of Event Scale. Results presented in this article are based on preliminary analyses of our quantitative data and further investigation is under way. With that said, the independent variables in our regression model explain approximately 33 percent of the variance in the Avoidance subscale, based on the Adjusted R^2.

In particular, we find that objects losses such as loss of utilities; loss of access to forms of communication; damages to homes, other property damages, and neighborhood damages; as well as financial losses related to critical infrastructure failure tend to heighten psychosocial stress. Results also show that conditions resource losses such as storm experiences, social disruption, and serious personal injuries or serious injuries to someone close to respondents can heighten avoidance behaviors.

Overall, as found in previous disaster studies employing the IES (e.g., see Gill, Picou, and Ritchie 2012; Gill et al. 2014; Ritchie, Gill, and Long 2020; Ritchie, Little, and Campbell 2018), there is a direct, positive relationship between objects and conditions resource losses and psychosocial stress. Although this is not surprising, it is notable that survey findings from more than one year after the storm reveal that approximately 16 percent of respondents reported engaging in clinical levels of avoidance behaviors as measured by the IES. Although some avoidance behaviors might be considered healthy coping mechanisms and positive strategies for moving on from impacts of the disaster, we argue that avoidance behaviors among this proportion of the population where individuals are withdrawn are not healthy. From a sociological perspective, such behaviors have the potential to diminish social capital by decreasing social interaction (Ritchie 2012).

Although males and females are significantly different with respect to avoidance behaviors in the bivariate analysis, gender becomes insignificant when other factors are considered in the regression model. Notably, younger respondents and respondents who reported loss of communication services were more likely than others to report engaging in avoidance behaviors. We suspect that loss of access to various forms of communication among this population reduces social support and accentuates avoidance behaviors. In the context of the COVID-19 pandemic, we speculate that the need for access to a variety of communication modes was of particular importance to most respondents. For those used to having and using such access—like younger adults—loss of it and diminished social interaction could contribute to increased avoidance behaviors and other forms of psychosocial stress.

The relationship between age and avoidance behaviors is an interesting one that warrants further examination. It suggests that a population not usually defined as "vulnerable"—adults between the ages of 18 and 45—might be vulnerable in some disaster situations. We refer to this phenomenon as a "new vulnerable" population, much like empirical research has shown in prior technological disasters. For example, research conducted in the wake of the *Exxon Valdez* and BP *Deepwater Horizon* oil spills revealed that those dependent upon renewable natural resources for their livelihoods and way of life were more likely to experience psychosocial stress than those who did not.

Future analyses will explore other factors that have been shown to affect

psychosocial stress, including involvement in compensation processes, as well as perceptions of recreancy associated with issues of preparedness, response, recovery, and mitigation associated with Uri.

Conclusions

The impacts of Winter Storm Uri highlight the importance of critical physical infrastructure resilience—as well as social resilience—as recommended by the National Institute of Standards and Technology in its Community Resilience Planning Guide (2016). The keys to developing and maintaining physical infrastructure include identifying and characterizing the built environment. Similarly, social resilience necessitates characterizing social functions and dependencies and linking these with the built environment (National Institute of Standards and Technology 2016). This did not happen in the case of Uri and seems not to be happening now with ERCOT's lack of preparedness for power grid demands as the summer of 2022 approaches (Douglas and Ferman 2021; Morehouse 2022). Some clues as to the implications of this lack of preparedness may be found in our study.

Although data for this study were collected at the individual level, there are broader sociocultural implications. The situation in Texas is certainly worth monitoring as the unpredictability of ERCOT's ability to provide its constituents with the power they need to live and function on a daily basis continues to persist. Given the importance of water in generating electrical power, increasing temperatures and drought conditions strain many power-generating plants by limiting the supply of water, increasing the stress on equipment (warmer water increases the stress), and interfering with routine and needed maintenance. Hotter, drier weather this summer and future summers will very likely increase power plants failures as demand for electricity increases (Morehouse 2022). Already, the Texas grid operator has called on customers to conserve as much power as possible as the state has experienced a hard-hitting combination of record-breaking heat and high demand, coupled with low wind generation and the simultaneous failure of six thermal generators (Morehouse 2022). Ensuring there are enough resources to create power does not solve the entire problem and leaves the reliability of the power plants up to question (Douglas and Ferman 2021).

For those experiencing Uri-related stress, ongoing power outages can be constant reminders of the storm's impacts and the precarious context of their personal, household, and community wellbeing. As of the writing of this article (June 2022) ERCOT is experiencing current outages and is anticipating more throughout the summer of 2022 (Douglas and Ferman 2021; Morehouse 2022). The chronic nature of these circumstances has the potential to foment uncertainty and stress. At the same time, substantial increases in energy costs (Vogel and Vogel 2021) are likely to contribute to additional psychosocial stress and other adverse outcomes for community wellbeing. Given the high percentages of our respondents whose

Uri-related avoidance behaviors are at the clinical level and persisting over time, we contend that there is an important need for professional counseling that is going unmet or is not being sought, for whatever reasons. Policy- and decision-makers must start to take this into account as they work to address Texas's critical infrastructure—one that will both meet energy needs and the need to support the state's critical social infrastructure. Other states should take note and learn from the unfortunate example provided by Winter Storm Uri and ineffective human decision-making.

Acknowledgements

The authors would like to thank the College of Liberal Arts and Human Sciences and the Department of Sociology at Virginia Polytechnic Institute and State University for funding this research. We also extend our appreciation to Dr. Michael Edelstein and Dr. Michael Long for their feedback on our survey instrument, and to Dr. Long for his comments on early drafts of this manuscript.

Author Capsule Bios

Liesel A. Ritchie is a Professor of Sociology and Associate Director of the Center for Coastal Studies at Virginia Polytechnic Institute and State University. During her career, Dr. Ritchie has studied a range of disaster events, including the *Exxon Valdez* and BP *Deepwater Horizon* oil spills; the Tennessee Valley Authority coal ash release; Hurricane Katrina; earthquakes in Haiti and New Zealand; and Winter Strom Uri in Texas. Since 2000, her focus has been on the social impacts of disasters and community resilience, including conducting social impact assessments, with an emphasis on technological hazards and disasters, social capital, and rural renewable resource communities.

Duane A. Gill is a Research Professor of Sociology at Virginia Polytechnic Institute and State University. Dr. Gill is a disaster scholar specializing in technological hazards and disasters and has conducted extensive research on the 1989 Exxon Valdez oil spill, Hurricane Katrina, and the 2010 BP Deepwater Horizon oil spill. His research activities generally seek to understand community capacity to respond to and recover from disasters, as well as ways to enhance community preparedness and resilience.

Kathryn Hamilton is a graduate student in the Department of Sociology at Virginia Polytechnic Institute and State University. Her research interests include psychosocial impacts of hazards and disasters.

References

Aldhous, Peter; Lee, Stephanie M.; and Hirji, Zahra. 2021. "The Texas Winter Storm and Power Outages Killed Hundreds More People Than the State Says." Retrieved May 30, 2022, from https://www.buzzfeednews.com/article/peteraldhous/texas-winter-storm-power-outage-death-toll.

Arata, Catalina M.; Picou, J. Steven; Johnson, G. David; and McNally, T. Scott. 2000. "Coping With Technological Disaster: An Application of the Conservation of Resources Model to the *Exxon Valdez* Oil Spill." *Journal of Traumatic Stress* 13(1):23-39. https://doi.org/10.1023/A:1007764729337.

Benight, Charles C.; Ironson, Gail; Klebe, Kelli; Carver, Charles S.; Burnett, Kent; Greenwood, Debra; Baum, Andrew; and Schneiderman, Neil. 2007. "Conservation of Resources and Coping Self-efficacy Predicting Distress Following a Natural Disaster: A Causal Model Analysis Where the Environment Meets the Mind. *Anxiety, Stress, and Coping* 12(2):107-126.

Benight, Charles C.; Swift, Erika; Sanger, Jean; Smith, Anne; and Zeppelin, Dan. 1999. "Coping Self-Efficacy as a Mediator of Distress Following a Natural Disaster." *Journal of Applied Social Psychology*, 29(12), 2443–2464. https://doi.org/10.1111/j.1559-1816.1999.tb00120.x

Binder, Sherri B.; Ritchie, Liesel A.; Bender, Rose; Thiel, Alexis; and Baker, Charlene K. 2020. "Limbo: The unintended Consequences of Home Buyout Programs on Peripheral Communities." *Environmental Hazards* 19(5):488-507.

Bottner, Richard; Weems, John; Hill, Lucas G.; Ziebell, Christopher; Long, Sharon; Young, Sara; Sasser, Mike; Ferguson, Aaron; and Tirado, Carlos. 2021. "Addiction Treatment Networks Cannot Withstand Acute Crises: Lessons from 2021 Winter Storm Uri in Texas." *NAM Perspectives*. Retrieved May 30, 2022, at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8406583/.

Campbell, Nnenia M.; Vickery, Jamie; and Ritchie, Liesel A. 2018. *Community Impacts and Risk Perceptions of Induced Seismicity, Report 1: Qualitative Findings.* Report prepared for the National Science Foundation, Award #1520846. Available from Liesel Ritchie at liesel14@vt.edu.

Clay, Lauren A. and Greer, Alex. 2019. "Association Between Long-term Stressors and Mental Health Distress Following the 2013 Moore Tornado: A Pilot Study." *Journal of Public Mental Health* 18(2): 124-134. doi:10.1108/JPMH-07-2018-0038

Davidson, Laura M. and Baum, Andrew. 1986. "Chronic Stress and Posttraumatic

Stress Disorders." *Journal of Consulting Clinical Psychology* 54(3):303-308.

Douglas, Erin and Ferman, Mitchell. 2021. "Another Texas power outage unlikely; This week, but severe weather this summer could prompt an electricity crisis." *The Texas Tribune*. Retrieved June 12, 2022, from https://www.texastribune.org/2021/04/15/texas-ercot-blackouts-summer-climate/.

Evensen, Darrick; Stedman, Richard; O'Hara, Sarah; Humphrey, Mathew; and Andersson-Hudson, Jessica. 2017. "Variation in Beliefs About 'Fracking' Between the UK and US." *Environmental Research Letters* 12(12) 124004.

Gill, Duane A., and Picou, J. Steven. 1998. "Technological Disaster and Chronic Community Stress." *Society and Natural Resources* 11:795-815.

Gill, Duane A.; Picou, J. Steven; and Ritchie, Liesel A. 2012. "The *Exxon Valdez* and BP Oil Spills: A Comparison of Initial Social and Psychological Impacts." *American Behavioral Scientist* 56(1):3-23.

Gill, Duane A.; Ritchie, Liesel A.; and Picou, J. Steven. 2016. "Sociocultural and Psychosocial Impacts of the *Exxon Valdez* Oil Spill: Twenty-Four Years of Research in Cordova, AK." *The Extractive Industries and Society* 3:1105-1116.

Gill, Duane A. and Ritchie, Liesel A. 2018. "Contributions of Technological and Natech Disaster Research to the Social Science Disaster Paradigm." In Rodriguez, Havidán., Donner, William., and Trainor, Joesph E. (Eds.), *Handbook of Disaster Research* (pp. 39-60). Springer, Cham. https://doi.org/10.1007/978-3-319-63254-4_3

Gill, Duane A.; Ritchie, Liesel A.; Picou, J. Steven; Langhinrichsen-Rohling, Jennifer; Long, Michael A.; and Shenesey, Jessica W. 2014. "The Exxon and BP Oil Spills: A Comparison of Psychosocial Impacts." *Natural Hazards* 74:1911-1932.

Glazer, Yael R.; Tremaine, Darrel M.; Banner, Jay L.; Cook, Margaret; Mace, Robert E.; Nielsen-Gammon; John, Grubert, Emily et al. 2021. "Winter Storm Uri: A Test of Texas' Water Infrastructure and Water Resource Resilience to Extreme Winter Weather Events." *Journal of Extreme Events* 2150022.

Green, Bonnie L.; Grace, Mary C.; Vary, Marshall G.; Kramer, Teresa L.; Gleser, Goldine C.; and Leonard, Anthony C. 1994. "Children of Disaster in the Second Decade: A 17-year Follow-up of Buffalo Creek Survivors." *Journal of the American Academy of Child and Adolescent Psychiatry* 33:71-79.

Halbesleben, Jonathon R.B. 2010. "The Role of Exhaustion and Workarounds in

Predicting Occupational Injuries: A Crosslagged Panel Study of Health Care Professionals." *Journal of Occupational Health Psychology* :1-16.

Halbesleben, Jonathon R.B. and Bowler, W. Matthew. 2007. "Emotional Exhaustion and Job Performance: The Mediating Role of Motivation." *Journal of Applied Psychology* 92:93-106.

Halbesleben, Jonathon R.B.; Neveu, Jean Pierre.; Paustian-Underdahl, Samantha C.; and Westman, Mina. 2014. "Getting to the 'COR': Understanding the Role of Resources in Conservation of Resources Theory." *Journal of Management* 40(5):1334-1364. https://doi.org/10.1177/0149206314527130.

Hobby School of Public Affairs. 2021. *The Winter Storm of 2021*. Hobby School of Public Affairs, University of Houston. Retrieved May 30, 2022, from https://uh.edu/hobby/winter2021/storm.pdf.

Hobfoll, Stevan E. 1989. "Conservation of Resources: A New Attempt at Conceptualizing Stress." *American Psychologist* 44(3):513-524.

Hobfoll, Stevan E. 1991. "Traumatic Stress: A Theory Based on Rapid Loss of Resources." *Anxiety Research* 4:187-197.

Hobfoll, Stevan E. 2011a. "Conservation of Resources Caravans in Engaged Settings." *Journal of Occupational and Organizational Psychology* 84:116-122.

Hobfoll, Stevan E. 2011b. "Conservation of Resources theory: Its Implication for Stress, Health, and Resilience." In Folkman, Susan. (Ed.), *The Oxford handbook of stress, health, and coping* (pp. 127-147). Oxford, England: Oxford University Press.

Horowitz, Mardi J. 1976. *Stress Response Syndromes*. New York: Aronson.

Horowitz, Mardi J.; Wilner, Nancy; and Alvarez, William. 1979. "Impact of Event Scale: A Measure of Subjective Stress." *Psychosomatic Medicine* 41(3):209-218.

Li, Dongying; Zhang, Yue; Li, Xiaoyu; Meyer, Michelle; Bazan, Marissa; and Brown, Robert. "'I Didn't Know What to Expect or What to Do': Impacts of a Severe Winter Storm on Residents of Subsidized Housing in Texas." Retrieved May 30, 2022, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4047541.

Li, Xiaoyu; Zhang, Yue; Li, Dongying; Xu Yangyang; and Brown, Robert D. 2022. "Ameliorating Cold Stress in a Hot Climate: Effect of Winter Storm Uri on Residents of Subsidized Housing Neighborhoods." *Building and Environment* 209. Retrieved May 30, 2022, from https://doi.org/10.1016/j.buildenv.2021.108646.

Mäkikangas, Anne; Bakker, Arnold B.; Aunola, Kaisa; and Demerouti, Evangelia. 2010. "Job Resources and Flow at Work: Modeling the Relationship Via Latent Growth Curve and Mixture Model Methodology." *Journal of Occupational and Organizational Psychology* 83:795-814.

Morehouse, Catherine. 2022. "Spiking temperatures could cause more blackouts this summer. They won't be the last." *POLITICO*. Retrieved June 12, 2022, from https://www.politico.com/news/2022/05/31/spiking-temperatures-could-cause-more-blackouts-this-summer-they-wont-be-the-last-00034858/.

National Institute of Standards and Technology. 2016. *Community Resilience Planning Guide*. Retrieved June 10, 2022, from https://www.nist.gov/community-resilience/planning-guide.

Nejat, Ali; Solitare, Laura; Pettitt, Edward; and Mohsenian-Rad, Hamed. 2022. "Equitable Community Resilience: The Case of Winter Storm Uri in Texas." Retrieved May 30, 2022, from https://arxiv.org/abs/2201.06652.

Popik, Thomas and Humphreys, Richard. 2021. "The 2021 Texas Blackouts: Causes, Consequences, and Cures." *Journal of Critical Infrastructure Policy* 2(1):47-73.

Proffer, Erica. 2022. "Here is why death totals from Winter Storm Uri may vary." Retrieved May 30, 2022, from https://www.kvue.com/article/weather/winter-storm/here-is-why-death-totals-from-winter-storm-uri-may-vary/269-f2bf277f-74d9-443b-ab2e-ff89f336f3ec#:~:text=The%20Texas%20Department%20of%20State,the%20way%20deaths%20were%20counted.andtext=The%20State's%20report%20shows%20how%20it%20measured%20the%20amount.

Ritchie, Liesel A. 2012. "Individual Stress, Collective Trauma, and Social Capital in the Wake of the *Exxon Valdez* Oil Spill." *Sociological Inquiry* 82(2):187-211. https://doi.org/10.1111/j.1475-682X.2012.00416.x.

Ritchie, Liesel A.; Gill, Duane A.; and Long, Michael A. 2018. "Mitigating Litigating: An Examination of Psychosocial Impacts of Compensation Processes Associated with the 2010 BP *Deepwater Horizon* Oil Spill." *Risk Analysis* 38(8):1656-1671.

Ritchie, Liesel A.; Gill, Duane A.; and Long, Michael A. 2020. "Factors Influencing Stress Response Avoidance Behaviors following Technological Disasters: A Case Study of the 2008 TVA Coal Ash Spill." *Environmental Hazards* 19(5):442-462.

Ritchie, Liesel A.; Little, Jani; and Campbell, Nnenia M. 2018. "Resource Loss and Psychosocial Stress in the Aftermath of the 2008 TVA Coal Ash Spill." *International Journal of Mass Emergencies and Disasters* 36(2):179-207.

Ritchie, Liesel A. and Long, Michael A. 2021. "Psychosocial Impacts of Post-Disaster Compensation Processes: Community-Wide Avoidance Behaviors." *Social Science and Medicine* 270:113640.

Sattler, David N.; Whippy, Albert; Graham, James M.; and Johnson, James. 2018. "A Psychological Model of Climate Change Adaptation: Influence of Resource Loss, Posttraumatic Growth, Norms, and Risk Perceptions Following Cyclone Winston in Fiji. In Filho, Leal W. (Ed.), *Climate Change Impacts and Adaptation Strategies for Coastal Communities* (pp. 427-443). Cham, Switzerland: Springer.

Smead, Richard G. 2021. "ERCOT—The Eyes of Texas (and the World) Are Upon You: What Can be Done to Avoid a February 2021 Repeat." *Climate and Energy* 37(10):14-18.

Stipes, Chris. 2021. "New report details impact of Winter Storm Uri on Texans." Retrieved May 30, 2022, from https://uh.edu/news-events/stories/2021/march-2021/03292021-hobby-winter-storm.php.

Texas Department of State Health Services. 2021. *February 2021 Winter Storm-Related Deaths–Texas*. Retrieved May 30, 2022, from https://www.dshs.texas.gov/news/updates/SMOC_FebWinterStorm_MortalitySurvReport_12-30-21.pdf

United Stated Census. 2020. Retrieved June 17, 2022, from https://www.census.gov/quickfacts/TX.

Vogel, Eve and Vogel, Steven K. 2021. "The Texas Power Failure: How One Market Model Discovered Its Natural Limits." *Promarket*. Retrieved June 10, 2022, from https://www.promarket.org/2021/03/25/texas-power-outage-market-ercot-failure/.