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ORIGINAL PAPER

Compounding impacts of hazard exposures on mental health in Houston, TX

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Abstract

Natural and anthropogenic hazards are increasingly becoming commonplace due to climate change and population pressures. The state of Texas is particularly vulnerable to these hazards and is ranked first in the USA due to the immense variety and frequency of large-scale events. While much research has looked at the immediate impacts these incidents have on mental health, little research has addressed the effects of compounding and repeated exposure to hazards. This cross-sectional study ($N=1224$) collected survey data from a representative sample within the Houston Metropolitan Statistical Area. Utilizing the 12 item Short Form Health Survey version 2, a general composite score assessing mental health was compared against the type and frequency of hazard exposures. Findings revealed an observed reduction in mental health scores as participants had repeated exposures to major disasters. Further, the only significant result ($p<0.001$) in dictating a reduced mental health scores was repeat exposure to hazards even after adjusting for demographic data and socioeconomic variables. This research reveals the long-term mental impact hazard exposures can have and underscores the need for target public health interventions and engaged community efforts.

Keywords Mental health · SF12 · Hazards · Natural disaster

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1 Introduction

Natural and anthropogenic disasters are large-scale traumatic events that often lead to the unanticipated destruction of property and death (Neria et al. 2008). These hazards threaten large groups of people and disrupt access to services and resources. Yearly, 90,000 people are killed in hazardous events, and approximately 160 million people are impacted worldwide (World Health Organization, W n.d.). Natural disasters are increasingly becoming commonplace due to climate change and population pressures (McFarlane and Williams 2012). The state of Texas is particularly vulnerable to natural disasters and is ranked first in the USA due to the immense variety and frequency of them (NASA 2017). Every year in Texas, at least one major disaster is declared (NASA 2017). This study aims to analyze the impact of repeated exposures to hazard disasters on mental health for the population in the Houston Metropolitan Statistical Area (HMSA), Texas.

Disasters are typically categorized into different types, which include natural disasters (i.e., hurricanes), anthropogenic disasters (human-made), non-intentional technological disasters (i.e., natural gas explosions), and intentional acts such as terrorist attacks. Studies claim that the type of disaster influences the gravity of the affected populations' mental health consequences (Galea et al. 2005). Relief response after disasters customarily focuses on the physical; however, there is an increased understanding of the importance of providing mental health support (O'donnell and Forbes 2016). Specific mental health concerns that present themselves after disasters include anxiety, post-traumatic stress disorder (PTSD), depression, substance abuse, and non-disordered psychological stress (Tol and Ommeren 2012). A majority of individuals demonstrate signs of emotional disturbance after a disaster (Burkle 1996). Researchers have found that the prevalence of mental health problems in populations experiencing a disaster is higher by two to three times compared to the general population (Math et al. 2015). People that live in disaster-prone areas and experience more than one event have more significant adverse health effects, leading to "chronic disaster syndrome" (Adams et al. 2009). The term signifies the physiological and psychological effects that arise because of the repeated social disruption and the socioeconomic and political conditions produced by these incidents (Adams et al. 2009).

In 1951, Tyhurst defined psychological responses to disasters in phases, including a "period of impact, a period of recoil, and a post-traumatic period" (Burkle 1996; Goldmann and Galea 2014; Tyhurst 1951). The "period of impact" is the initial exposure to stressors associated with experiencing a disaster whereas the "period of recoil" occurs when an individual can bounce back. The last phase, "post-traumatic period," occurs when an individual becomes aware of the immense toll a disaster may have on their individual lives, such as destroyed homes, belongings, financial security, and the death of a loved one (Tyhurst 1951). Some individuals are recovering from a disaster, unable to move from one phase to another, experience lifelong adverse effects on their mental health and well-being.

Researchers Goldmann and Galea (2014) state that several pre-disaster risk factors are indicators of post-disaster mental illness. These risk factors include prior mental health problems, gender, and younger age (Goldmann and Galea 2014). Additionally, a history of mental illness is a strong predictor of successive episodes of both depressive and anxiety disorders (Karsten et al. 2011). Researchers agree that the psychological effects experienced after a disaster are likely to be more severe among children, females, and dependent elderly populations (Makwana 2019). Young children under the age of eight are at risk for mental health issues after disasters and experience anxiety, fear, difficulty sleeping and concentrating, irritability, and outbursts of anger (CDC n.d.).

Maclean et al. (2016) suggest that children who experience a natural disaster by age five will likely experience adverse mental health and substance use outcomes in their lifetimes. Yet, others indicate that older populations are among the most vulnerable due to natural disasters' direct impact (Jia et al. 2010). After Hurricane Charley, a rapid needs assessment indicated that one-third of households had at least one adult with a preexisting condition that worsened due to the hurricane (Centers for Disease Control and Prevention, C 2004). Mental health effects of elderly populations may worsen after disasters owing to preexisting feelings of powerlessness brought on by changes in health, mobility, and sensory awareness (Maltz 2019). Residential evacuation may compound feelings of stress, uncertainty, and confusion for this population specifically (Maltz 2019; Woodhall-Melnik and Grogan 2019).

Disadvantaged populations that are physically, economically, culturally, politically, or otherwise are particularly vulnerable to experiencing disasters (O'donnell and Forbes 2016). Results from the National Comorbidity Survey showed that 18.9% of men and 15.2% of women reported a lifetime experience of a disaster (Kessler et al. 1995). Most studies concentrate on adults who were direct victims of the disaster. An analysis of PTSD of Turkish earthquake survivors suggested that females had higher rates (34.8%) of PTSD compared to males (19.1%) (Karamustafalioglu et al. 2006). According to a study that examined recovery from PTSD following Hurricane Katrina, 17.1% of respondents had a history of estimated hurricane-related PTSD at baseline and 29.2% after the follow-up survey was administered (McLaughlin et al. 2011).

2 Methods

2.1 Site location and population

The Houston Metropolitan Statistical Area (HMSA) is in Southeast Texas along the Gulf Coast (Fig. 1) with a 2019 population of 2,320,268, with 7.6% of the population under the age of 5, 25.1% under the age of 18, 10.5% ages 65 and over, and 50.1% female. Approximately 45% of the population is of Hispanic or Latino origin, 24.4% white (non-Hispanic origin), and 22.6% Black or African-American. The median household income from 2015 to 2019 was $52,338, with approximately 20.1% of the population living in poverty. The US Census Bureau (2019) also reports an estimated 78.9% of the population ages 25 and up is a high school graduate, with an estimated 32.9% completing a bachelor's degree or higher.

Texas has experienced 33 Federal Emergency Management Agency (FEMA)-declared major disasters from the year 2000 through 2020 (USCG National Response Center (NRC) 2020). Many of these declared disasters, such as hurricanes, winter weather, drought, and flooding, have impacted the Houston area. In addition, the HMSA is home to many industrial facilities, including oil and gas, that may present local emergencies such as explosions and chemical releases, with over 449 incidents reported to the National Response Center in 2020 alone (USCG National Response Center (NRC) 2020). This combination of natural and anthropogenic hazards creates a unique opportunity for observed impacts compared to other locations.

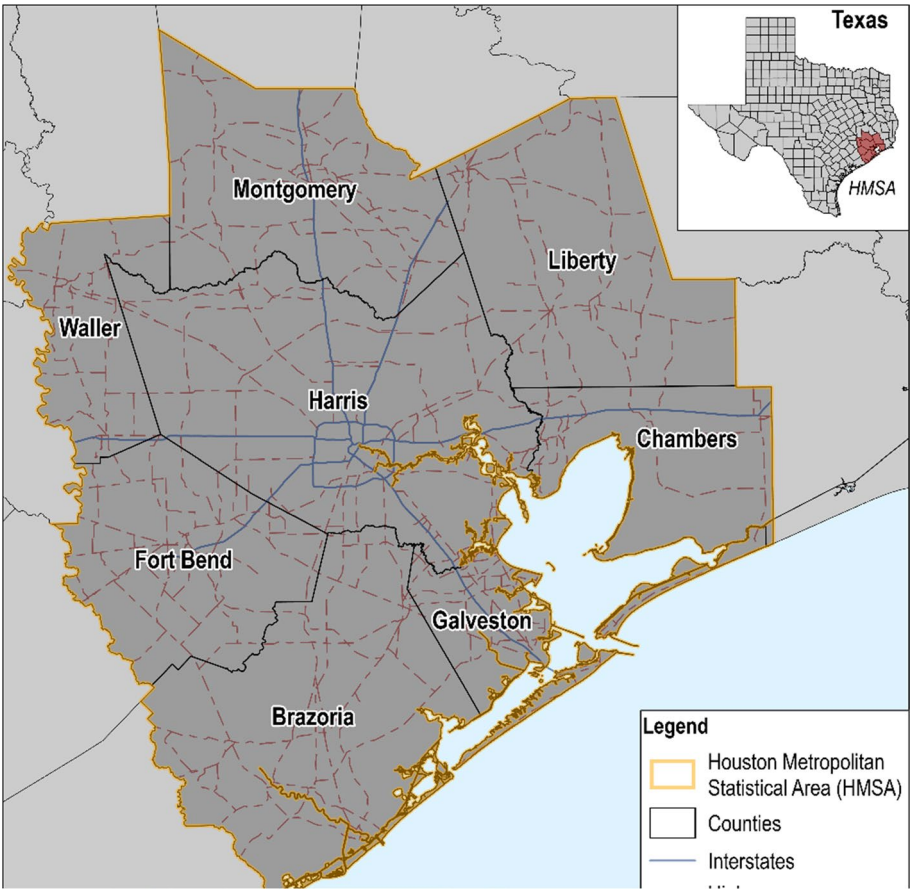

Fig. 1 Study area—Houston Metropolitan Statistical Area (HMSA)

2.2 Survey development

The survey included the 12 item Short Form Health Survey version 2 (SF12v2) that was adapted from the medical outcome study (Tarlov et al. 1989). Utilizing the SF12v2 has been validated for use in predicting populations' general mental and physical health without targeting specific health outcomes within a multitude of populations. The SF12v2 has been a tool in assessing community health in Houston, TX, within African-American communities (Sansom et al. 2020) and low-income Latinx neighborhoods (Sansom et al. 2017) who experience frequent hazards. Further, it has been a way for gauging the general health of homeless populations (Larson 2002), immigrant communities (Grant et al. 2004), and those with severe mental health conditions (Salyers et al. 2000). It also assesses cumulative impacts from exposure to evaluate changes over time (Oiamo et al. 2015). This survey produces a composite score for both mental and physical health between 0 and 100. A norm-based algorithm is used to create the composite scores (Ware et al. 2000), which allows for comparison between study populations and national averages. The mean for both the mental composite scores (MCS) and the physical composite scores (PCS) are normed to

50; therefore, easier comparisons can be made between groups. Scores over 50 represent an improved condition compared to national averages; the standard deviation is 10 after norming. Demographic information (age, income, educational attainment, race/ethnicity, sex) and questions on perceptions of environmental risk were also collected.

2.3 Data collection

Respondents were recruited using Qualtrics panels that identify and target respondents using the sampling limitations that mirror the current population makeup of the HMSA, including (1) residents must reside in a zip code located in the HMSA (which includes the following counties: Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller) (Fig. 1); (2) 15–25% of the sample must include populations with household median income below $25,000; 3) no more than 60% responses for either gender (male/female); 4) 6% to 12% of the responses must be from elderly populations (age 65 or older), and 5) 5–15% people who speak English as a second language. Only participants 18 years or older currently residing in a zip code located in the HMSA at the time of the survey were targeted. The first question in the survey provides an information sheet and is used to determine whether the respondent is willing to participate in the survey or whether the respondent would like to opt out. Follow-up questions for participating respondents include age and zip code to ensure inclusion criteria are met. The survey and accompanying consent materials were approved by the Texas A&M University Institutional Review Board (IRB2019-1550M).

2.4 Data analysis

Descriptive statistics were calculated for each variable, including demographics. Race was coded non-Hispanic white, nonwhite Hispanic, or African-American. Boxplots were utilized to compare mental health scores across hazard exposure experiences. Multiple regression was used to assess the impact of experiencing numerous hazards on MCS and age, gender, income, and racial categories. Coefficients of the covariates, along with respective corresponding 95% confidence intervals (95% CI) and p values, were reported. Statistics were calculated using STATA 16 (College Station, TX) and Microsoft Excel (Redmond, Washington).

3 Results

Data collection was concluded by recruiting more women ($n=660$) than men ($n=434$) and a high proportion of non-Hispanic white individuals ($n=564$) (Table 1). The second high proportion of respondents were African-American ($n=223$). The data indicate that ages 25–44 account for $n=463$ of the response data, with an additional 12.63% ($n=123$) of the sample size over the age of 65. The majority of the respondents had completed a high school level education or higher. In addition, 26.39% ($n=223$) of the respondents fell below an income level of $34,999.

The vast majority of respondents reported experiencing many hazardous events over the past 5 years: hurricanes and flooding (96.35%), tornados (79.82%), chemical spills (86.84%), and industrial fires (96.08%). While the overall MCS was within normal ranges compared to national averages, MCS = 47.48 with a standard deviation of 7.97, there is an

Table 1 Distribution of study respondents

Characteristic	*N* (%)[a]
Gender	
Male	434 (39.67)
Female	660 (60.33)
Race/ethnicity	
Non-Hispanic white	564 (57.91)
Nonwhite Hispanic	182 (18.58)
African-American	223 (22.90)
Refused	6 (0.62)
Age in years	
18–24	152 (15.61)
25–34	255 (23.10)
35–44	208 (21.36)
45–54	134 (13.76)
55–64	132 (13.55)
65+	123 (12.63)
Education	
Some high school	39 (4.00)
High school graduate	199 (20.43)
Some college	251 (25.77)
College degree	253 (25.98)
Some postgraduate college	42 (4.31)
Graduate degree	123 (12.63)
Trade/technical/vocational school	59 (6.06)
No answer	8 (0.82)
Income	
$15,000–$19,999	54 (6.39)
$20,000–$34,999	169 (20.00)
$35,000–$49,999	121 (14.32)
$50,000–$64,999	129 (15.27)
$65,000–$69,999	28 (3.31)
$70,000–$84,999	90 (10.65)
$85,000+	254 (30.06)
Language preference	
English	868 (93.74)
Spanish	50 (5.40)
Other	8 (0.86)

[a]Values may not equal 100% due to rounding

observed MCS reduction as participants had repeated exposures to hazard events (Fig. 2). When experiencing two or more events over the past 5 years, the MCS averages fell below expected national levels. When respondents had experienced 5 or more of these events, the levels were half a standard deviation below expectations.

Multiple linear regression was calculated comparing the covariates sex, race/ethnicity, age, educational attainment, and exposure to hazards on MCS (Table 2). The covariates

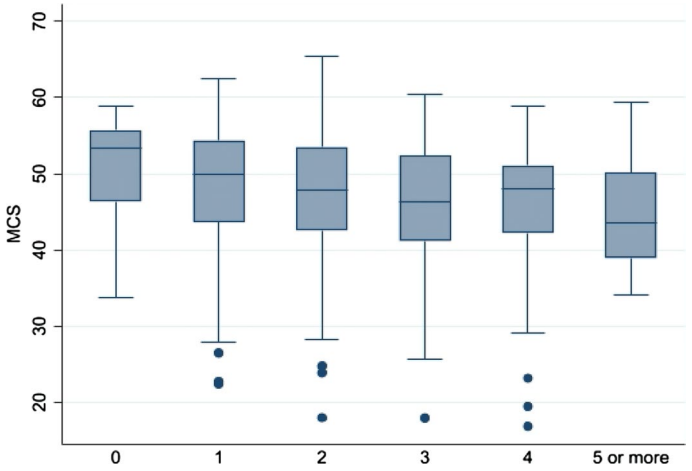

Fig. 2 Mental Composite Score (MCS) by number of hazard events experienced over the last 5 years

Table 2 Multiple linear regression comparing the covariates sex, race category, age, educational attainment, and exposure to hazards on MCS values

Mental composite score	Coef	SE	95% CI	*p* value
Sex (female)	0.189	0.533	−0.855 to 1.236	0.724
Race (nonwhite)	−0.096	0.056	−0.206 to 0.015	0.089
Age	1.353*	0.171	1.017 to 1.689	< 0.001
Educational attainment	−0.329*	0.122	−0.569 to −0.091	0.007
Exposure to hazard events	−0.839*	0.238	−1.305 to −0.372	< 0.001

*Significant at < 0.05

race and sex were not associated with an increase or decrease in mental health scores. However, age did show an improved MCS with older individuals (coef = 1.353, 95% CI 1.017–1.689). Those with higher educational attainment received slightly reduced MCS (coef = −0.329, 95% CI −0.569 to −0.091). The largest decrease in mental health was associated with repeat exposures to hazardous events with strong statistical significance (p value < 0.001) even after adjusting for the other covariates in the model. This result supports the dose–response correlation between the number of hazard experiences and reduced MCS shown in Fig. 2.

4 Discussion

The study indicates a statistically significant impact can be found on the mean mental health for individuals who experience repeated exposure to hazard events, as shown in Fig. 2. The study also shows a significant decrease in mental health associated with educational attainment. Future studies may research whether there is any correlation between the decreased mental health associated with educational attainment and exposure to disasters.

While sex and race did not indicate a noteworthy difference, older ages demonstrated a significant increase in the mental composite scores compared to younger age groups. This result contradicts some of the studies previously noted, such as Makwana (2019), which indicates that females and older generations are more likely to experience mental health impacts. This increase could be attributed to individuals developing more resiliency or coping skills with age.

A limitation to this study is the survey required respondents to opt in for participation. These self-selection criteria may have allowed data to be collected from participants already presenting with self-awareness of mental health impacts. Another limitation is that the survey was performed electronically, which prevents obtaining sample data from individuals with disparities and lack of internet access. It is also important to recognize the interplay between several conditions which can affect mental health, and conditions that can mitigate, or exacerbate, mental health outcomes based upon hazard exposures. For instance, researchers Peek et al. (2018) identified a host of covariates that should be taken into consideration when assessing youth populations, such as existing vulnerabilities and socioeconomic conditions, which were not included here. Tierney (2000), likewise concludes that a myriad of factors, including socially structured responses which reflect the influence of social and cultural conditions, should be taken into consideration when possible.

The continuation of understanding mental health impacts in relation to repeated exposure to hazard events is important. Understanding that overexposure has adverse reactions helps provide a foundation for determining the severity of each hazard that could potentially contribute to mental scores. With multiple potential triggers of mental health degradation, understanding how natural and anthropogenic hazards contribute to mental health decline is vital for determining treatments and intervention methods. Results may help community leaders develop appropriate programs to rebuild mental health resiliency post-event. In addition, future research may focus on the effects of educational and outreach efforts with vulnerable populations, identified in this and future studies, prior to impacts from hazard events and determining whether these efforts lessen the reduction of the mental composite scores. Future work should focus on data collection from populations with limited connectivity options as well and efforts may also focus on obtaining a higher representation of the Hispanic or Latino community due to the higher concentration of these demographics in the HMSA.

There is a need to repeat this research to help establish consistent results between populations. By repeating this study with various demographics in different geographic areas, a more substantial baseline could be established on the impact of multiple hazard events, independent of the experiences unique to the HMSA population.

Authors' contributions All authors contributed to study design, data interpretation and writing the paper. CT, GS, and LS created the survey design and assisted with data collection. CT conceived the methodology. GS performed the analysis. GS, CT, LS, LF, and EB contributed to writing and editing the manuscript.

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Availability of data and materials Data will be made available for any reasonable request.

Code availability Not applicable.

Declarations

Conflict of interest The authors declare no conflict of interest.

Consent to participate All participants provided written consent to participate.

Consent for publication Not applicable.

Ethical approval Ethical guidance and approval was obtained from the Texas A&M University Institutional Review Board (IRB2019-1550M).

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