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.
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

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

| Characteristic                                    | $N$ (%) |
|--------------------------------------------------|---------|
| 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) |

*Values may not equal 100% due to rounding
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).

References

Adams V, Van Hattum T, English D (2009) Chronic disaster syndrome: displacement, disaster capitalism, and the eviction of the poor from New Orleans. Am Ethnol 36(4):615–636
Burkle FM Jr (1996) Acute-phase mental health consequences of disasters: implications for triage and emergency medical services. Ann Emerg Med 28(2):119–128
(CDC), C. f. D. C. a. P (n.d.) Caring for children in a disaster. Retrieved from https://www.cdc.gov/childremindisasters/features/disasters-mental-health.html
Centers for Disease Control and Prevention, C (2004) Rapid assessment of the needs and health status of adults after Hurricane Charley—Charlotte, Desoto, and Hardee Counties, Florida, August 27–31, 2004. Retrieved from https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5336a2.htm#tab
FEMA (n.d.) Declared disasters: FEMA.gov. Retrieved from https://www.fema.gov/disasters/disaster-declarations
Galea S, Nandi A, Vlahov D (2005) The epidemiology of post-traumatic stress disorder after disasters. Epidemiol Rev 27(1):78–91
Goldmann E, Galea S (2014) Mental health consequences of disasters. Annu Rev Public Health 35:169–183
Grant B, Stinson F, Hasin D, Dawson D, Chou P, Anderson K (2004) Immigration and lifetime prevalence of DSM-IV psychiatric disorders among Mexican Americans and non-Hispanic whites in the United States results from the National Epidemiologic Survey on alcohol and related conditions. Arch Gen Psychiatry 1226(12):1233. https://doi.org/10.1001/archpsyc.61.12.1226
Jia Z, Tian W, Liu W, Cao Y, Yan J, Shun Z (2010) Are the elderly more vulnerable to psychological impact of natural disaster? A population-based survey of adult survivors of the 2008 Sichuan earthquake. BMC Public Health 10(1):172
Karamustafalioglu OK, Zohar J, Güveli M, Gal G, Bakim B, Fostick L, Karamustafalioglu N, Sasson Y (2006) Natural course of posttraumatic stress disorder: a 20-month prospective study of Turkish earthquake survivors. J Clin Psychiatry. https://doi.org/10.4088/JCP.v67n0604
Karsten J, Hartman CA, Smit JH, Zitman FG, Beekman AT, Cuijpers P, van der Does AJW, Ormel J, Nolen WA, Penninx BW (2011) Psychiatric history and subthreshold symptoms as predictors of the occurrence of depressive or anxiety disorder within 2 years. Br J Psychiatry 198(3):206–212
Kessler RC, Sonnega A, Bromet E, Hughes M, Nelson CB (1995) Posttraumatic stress disorder in the National Comorbidity Survey. Arch Gen Psychiatry 52(12):1048–1060
Larson CO (2002) Use of the SF-12 instrument for measuring the health of homeless persons. Health Serv Res 37(3):733–750
Maclean JC, Popovici I, French MT (2016) Are natural disasters in early childhood associated with mental health and substance use disorders as an adult? Soc Sci Med 151:78–91
Makwana N (2019) Disaster and its impact on mental health: a narrative review. J Fam Med Primary Care 8(10):3090
Maltz M (2019) Caught in the eye of the storm: the disproportionate impact of natural disasters on the elderly population in the United States. Elder LJ 27:157
Math SB, Nirmala MC, Moirangthem S, Kumar NC (2015) Disaster management: mental health perspective. Indian J Psychol Med 37(3):261
McFarlane AC, Williams R (2012) Mental health services required after disasters: learning from the lasting effects of disasters. Depression Res Treat. https://doi.org/10.1155/2012/970194
McLaughlin KA, Berglund P, Gruber MJ, Kessler RC, Sampson NA, Zaslavsky AM (2011) Recovery from PTSD following hurricane Katrina. Depress Anxiety 28(6):439–446
(NASA), N. A. a. S. A (2017) Natural and manmade hazards in the State of Texas. Retrieved from: https://nisar.jpl.nasa.gov/files/nisar/NISAR_Applications_Hazards_Texas.pdf
Neria Y, Nandi A, Galea S (2008) Post-traumatic stress disorder following disasters: a systematic review. Psychol Med 38(4):467–480
O’donnell ML., Forbes D (2016) Natural disaster, older adults, and mental health—a dangerous combination. Int Psychogeriatr 28(1):9–10
Oiamo TH, Luginaah IN, Baxter J (2015) Cumulative effects of noise and odour annoyances on environmental and health related quality of life. Soc Sci Med 146:191–203
Peek L, Abramson DM, Cox RS, Fothergill A, Tobin J (2018) Children and disasters. In: Handbook of disaster research. Springer, Cham, pp 243–262
Salyers MP, Bosworth HB, Swanson JW, Lamb-Pagone J, Osher FC (2000) Reliability and validity of the SF-12 health survey among people with severe mental illness. Med Care 38:1141–1150
Sansom G, Parra J, Nieto Y, Arellano Y, Berke P, McDonald T, Shipp E, Horney J (2017) The impacts of exposure to environmental risk on physical and mental health in a small geographic community in Houston, TX. J Community Health. https://doi.org/10.1007/s10900-017-0322-y
Sansom G, Kirsch K, Horney J (2020) Using the 12-item Short Form Health Survey (SF-12) to assess self-rated health of an engaged population impacted by Hurricane Harvey, Houston, TX. BMC Public Health (springer Nature) 20:257. https://doi.org/10.1186/s12889-020-8349-
Tierney KJ (2000) Controversy and consensus in disaster mental health research. Prehosp Disaster Med 15(4):55–61
Tol WA, Van Ommeren M (2012) Evidence-based mental health and psychosocial support in humanitarian settings: gaps and opportunities. Royal College of Psychiatrists
Tyhurst J (1951) Individual reactions to community disaster: the natural history of psychiatric phenomena. Am J Psychiatry 107(4):764–769
U.S. Census Bureau (2019) Quick facts: Houston city, TX. Retrieved from https://www.census.gov/quickfacts/houstontexas
USCG National Response Center (NRC) (n.d.) CY 2020 report. Retrieved from https://nrc.uscg.mil/Default.aspx
Ware JE, Kosinski M, Dewey JE (2000) How to score version 2 of the SF-12 health survey (standard & acute forms). Quality Metric Incorporated, Lincoln
Woodhall-Melnik J, Grogan C (2019) Perceptions of mental health and wellbeing following residential displacement and damage from the 2018 St. John River Flood. Int J Environ Res Public Health 16(21):4174
World Health Organization, W. (n.d.). Environmental Health in Emergencies. Retrieved from https://www.who.int/environmental_health_emergencies/natural_events/en/

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