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# Natech or natural? An analysis of hazard perceptions, institutional trust, and future storm worry following Hurricane Harvey

**Tim Slack**[1] · **Vanessa Parks**[2] · **Lynsay Ayer**[3] · **Andrew M. Parker**[4] · **Melissa L. Finucane**[4] · **Rajeev Ramchand**[5]

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**Abstract**
Researchers have traditionally conceptualized hazards that give rise to disasters as "natural" or "technological." An extensive literature has documented differential social consequences based on this distinction, including the emergence of corrosive community dynamics in the context of technological disasters. There is also growing recognition that many disasters can be conceptualized as "natech"—processes characterized by a combination of natural and technological hazards. On August 25, 2017, Hurricane Harvey made landfall along the central Texas Gulf Coast, causing catastrophic flooding and extensive releases of industrial toxins. We examined variation in institutional trust and future storm worry in the aftermath of Harvey, paying special attention to differences between those who viewed the disaster as being primarily natech and natural. Drawing on the Survey of Trauma, Resilience, and Opportunity in Neighborhoods in the Gulf, we analyzed two waves of cohort panel data collected from households on the Texas Gulf Coast in 2016 and 2018 (before and after Hurricane Harvey). Our findings showed that those who perceived Harvey as natech (compared to natural) were significantly more likely distrust major institutional actors and be worried about the impacts of future storms, even after accounting for pre-hurricane characteristics. Implications for community dynamics and future research are then discussed.

**Keywords** Hurricane Harvey · Natech disaster · Institutional trust · Worry · Recreancy

✉ Tim Slack
slack@lsu.edu

[1] Department of Sociology, Louisiana State University, 126 Stubbs Hall, Baton Rouge, LA 70803, USA

[2] University of Mississippi, University, MS, USA

[3] RAND Corporation, Arlington, VA, USA

[4] RAND Corporation, Pittsburgh, PA, USA

[5] Bob Woodruff Foundation, New York, NY, USA

## 1 Introduction

On August 25, 2017, Hurricane Harvey, a Category 4 storm, made landfall on the central Texas Gulf Coast. According the National Hurricane Center (Blake and Zelinsky 2018), while the winds and storm surge were substantial, as would be expected from a storm of that category, even greater damage resulted from the hurricane stalling over the Texas coast for 4 days and dropping more than 60 inches of rain. The historic rainfall resulted in catastrophic flooding in the southeastern part of the state, including the Houston metropolitan area. Harvey now ranks as the second most costly hurricane in US history, behind only Hurricane Katrina in 2005. It is estimated that at least 68 people died from the direct effects of the storm—virtually all from freshwater flooding related to rainfall—and at least another 35 were killed due to indirect causes (e.g., electrocution, inability to reach medical services).

The human impacts from Harvey were particularly pronounced given the flooding in greater Houston. The city is among the largest urban areas in the USA, with approximately 7 million residents in the metropolitan area (US Census Bureau 2019). Research suggests that lax land-use regulations, zoning, and related urban sprawl exacerbated flood risk (Brody et al. 2013; Cutter et al. 2018; Zhang et al. 2018). Moreover, Houston is a major hub for the nation's petrochemical industry, and many industrial sites were compromised by the storm. In the week following Harvey's landfall, 46 facilities reported airborne emissions in excess of state standards, accounting for an estimated 4.6 million pounds of airborne toxins; 14 toxic waste sites were flooded or damaged; and nearly 100 oil spills and other types of chemical releases were reported (Griggs et al. 2017). Importantly, these statistics are based on voluntary industry reporting, so the actual levels of pollutants released during Harvey were likely higher.

Over the last few decades, an extensive literature has grown to document differential social consequences based on whether people perceive disasters as being of "natural" or "technological" (i.e., human-caused) origins (Cope et al. 2016; Cuthbertson and Nigg 1987; Erikson 1994; Freudenburg 1993, 1997, 2000; Gill and Picou 1998; Gill et al. 2014, 2016; Kroll-Smith and Couch 1991, 1993; Messer et al. 2019; Picou et al. 2004; Ritchie et al. 2018).[1] There is also growing recognition that many disasters can be conceptualized as "natech"—processes defined by a combination of natural and technological hazards (Cruz and Suarez-Paba 2019; Gill and Ritchie 2018). Indeed, natech disasters are not difficult to imagine in scenarios where hazards strike in highly populated and industrialized areas. Hurricane Katrina has been offered as a prime example of a natech disaster (Picou 2009). Katrina not only battered coastal Mississippi and southeastern Louisiana with high winds and major storm surge. In New Orleans, the storm also triggered the failure of human-made levees and substantial releases of industrial toxins, including one of the largest inland oil spills in US history (Picou 2009). More recently, researchers have conceptualized Hurricane Harvey's impacts in natech terms (Thomas et al. 2018).

[1] Researchers argue that disasters cannot in and of themselves be considered "natural" (e.g., Drabek 2013; Lindell 2013; Perry 2018; Quarantelli 1989; Tierney 2014; UNDRR 2019). Rather, it is *hazards*—the conditions or events that pose a threat to society and environment—that can be of natural (or human) origins. Disasters, in turn, are determined by the severity of a hazard's impact on social and environmental systems, with "severity" itself being a social calculus. An important distinction here is that we examine disaster *perceptions*, underscored by the Thomasian notion that what is perceived as real is real in its consequences.

The present study examined the relationships hazard perceptions had with institutional trust and future storm worry following Hurricane Harvey. The significance of these relationships as a topic of study was motivated by their implications for the emergence of corrosive community dynamics (e.g., Gill et al. 2016; Picou et al. 2004). To address our objective, we drew on data from the Survey of Trauma, Resilience, and Opportunity in Neighborhoods in the Gulf (STRONG), which provided two waves of cohort panel data collected from households on the Texas Gulf Coast in 2016 and 2018 (before and after Harvey). These data allowed a novel opportunity to gain insights into the aforementioned relationships because most disaster research has been conducted *after* a disaster process was set in motion (Parker et al. 2019).[2] This is an important limitation because disaster processes play out on a social landscape that existed prior to the risks of a hazard being realized (Tierney 2014). Moreover, because the STRONG explicitly asked respondents about their perceptions of the origin of the Harvey disaster (natech vs. natural), we were able to examine how such views were related to institutional trust and future storm worry in this context. This is especially salient given growing evidence that the frequency and severity of natech disasters are increasing worldwide (Cruz and Suarez-Paba 2019), and that risk perceptions following natech events shape not only peoples' attitudes but also their behaviors in disaster contexts (Yu et al. 2017).

## 2 Background

An established literature has documented differential social consequences based on whether people perceive the origins of a disaster as being either "natural" or "technological." Disaster contexts viewed as being born from natural hazards or "acts of God" tend to give rise to consensus definitions of the event and widespread mutual support, leading to "therapeutic" community dynamics (Cuthbertson and Nigg 1987; Drabek 1986; Dynes 1970; Erikson 1994; Fritz 1961; Kreps 1989). In contrast, disasters understood to be caused by technological or "human-made" hazards often "create a far more severe and long-lasting pattern of social, economic, cultural and psychological impacts than do natural ones" (Freudenburg 1997: 26). Heightened uncertainty and worry, competing narratives of responsibility and blame, and loss of trust in institutions tasked with protecting the public from risk act to catalyze "corrosive" community dynamics. Corrosive contexts are characterized by social fragmentation and discord, negative mental and physical health impacts, and protracted litigation (Cope et al. 2013, 2016; Drakeford et al. 2020; Erikson 1994; Freudenburg 1993, 2000; Gill and Picou 1998; Gill et al. 2012, 2016; Kroll-Smith and Couch 1991, 1993; Lee and Blanchard 2012; Parks et al. 2018, 2019; Picou et al. 2004; Ritchie et al. 2018).

There is also growing recognition that many disasters can be conceptualized as "natech"—processes defined by a combination of natural and technological hazards—often occurring in situations where natural hazards trigger subsequent technological hazards (Cruz and Suarez-Paba 2019; Gill and Ritchie 2018; Picou 2009). As noted previously, Hurricanes Harvey and Katrina both fit this definition, but so do a host of other disasters. These include the 1994 Milford Haven, UK, thunderstorm that caused the release of flammable gases, which were in turn ignited by a lightning strike; the 2008 Wenchuan, China,

[2] For recent exceptions, see Thomas et al. (2018) and Thompson et al. (2019).

earthquake which triggered major releases of ammonia and sulfuric acid; and the 2011 earthquake, tsunami, and related meltdown of the Daiichi nuclear power plant in Fukushima, Japan (Cruz and Suarez-Paba 2019; Miller 2016; Yu et al. 2017). It has also been suggested that earthquakes induced by natural gas extraction via hydraulic fracturing (i.e., fracking) represent a variant of natech disaster (Gill and Ritchie 2018). Again, research on such incidents indicates the frequency and severity of natech disasters are growing worldwide (Cruz and Suarez-Paba 2019) and that perceptions of risk in these contexts can influence both attitudes and behaviors among disaster affected populations (Yu et al. 2017). This reality is consistent with the forecasts of Beck's (1992) *risk society*, Perrow's (1984) warnings about the rise of *normal accidents*, and Erickson's (1994) diagnosis of a *new species of trouble*.

### 2.1 Institutional trust

Freudenburg (1993) identified *recreancy*—the perception that key institutional actors have failed in their responsibilities to protect public safety from technological hazards, and thus violated the public trust—as a key element of corrosive community dynamics. Perceptions of recreancy have been shown to figure prominently following technological disasters, including the Exxon Valdez and Deepwater Horizon oil spills (Cope et al. 2016; Gill et al. 2016; Ritchie et al. 2013). These are important considerations, in part, because a lack of trust in major institutional actors can create a gap between expert and lay assessments of risk (Finucane and Holup 2005; Slovic 1999). Moreover, generalized confidence and trust in institutions to manage risk are critical in modern society, where most people do not (and cannot) possess elaborated knowledge about the threats posed by various hazards (Earle and Cvetkovich 1995; Siegrist et al. 2005). Indeed, Beck (2006: 332) argued that a central project in modern society was "preventing and managing risks that it itself has produced." In the context of a natech disaster, it is logical to expect an erosion of institutional trust as awareness grows of public exposure to technological risks (Tierney 2014). However, research also suggests that the risks associated with technological hazards, like industrial toxin releases, can become normalized over time when such factors are a constant feature of social life (Auyero and Swistun 2009; Hamilton et al. 2012; Thomas et al. 2018). Such normalization might in turn temper changes in institutional trust. Ultimately, heightened and variable levels of institutional distrust (i.e., recreancy) can feed corrosive community dynamics (Cope et al. 2016; Gill et al. 2016; Picou et al. 2004; Ritchie et al. 2013).

### 2.2 Worry

Studies show that compared to disasters born from natural hazards, natech disaster contexts are characterized by greater chronic worry about the disaster's impacts and community well-being going forward (Gill et al. 2016; Picou et al. 2004). Worry is a cornerstone of many models of health promotion, such as the theory of planned behavior (Ajzen and Madden 1986), and is an important component of risk perception, which in turn influences planning and adaptation responses (Finucane et al. 2000; Grattan et al. 2011; Lerner and Keltner 2001; Lowenstein et al. 2001; Peters et al. 2006; Slovic 2010; Slovic et al. 2004). Worry has been linked to positive adaptation via its influence on behavioral intentions and attitudes aimed at risk reduction (Ajzen and Madden 1986; Schmiege et al. 2009). For instance, cancer-related worry has been associated with health-promoting behaviors such as exercise (Ferrer et al. 2013). In some cases, worry stemming from stressful life events

has been shown to lead to negative outcomes, including depression and anxiety (Lee et al. 2016; Schwarzer and Schulz 2003). Research in the context of the Deepwater Horizon oil spill showed that greater exposure to the spill was associated with higher levels of worry about ongoing disaster impacts (Parker et al. 2020). Finally, variable levels of worry in the wake of technological hazards have been identified as a key element of corrosive community dynamics, leading to psychosocial stress and divided discourses on risk (Gill et al. 2016; Picou et al. 2004).

## 3 Research questions and expectations

The considerations above culminated in the following research questions and expectations. Q1: How were natech versus natural disaster perceptions following Hurricane Harvey related to institutional trust? Our expectation was that those with natech disaster perceptions regarding Harvey would be more distrusting of major institutional actors compared to their counterparts with natural disaster perceptions, after accounting for pre-Harvey levels of trust. Q2: How were natech versus natural disaster perceptions following Hurricane Harvey related to worry about the impacts of future storms? Our expectation was that those with natech disaster perceptions regarding Harvey would be more worried about future storm impacts compared to those with natural disaster perceptions, after accounting for pre-Harvey worry.

## 4 Data and methods

### 4.1 Data

Our analysis drew on data from two waves of the STRONG. The first wave of the STRONG was based on a random probability sample of adult residents in 56 counties and parishes on the Gulf of Mexico coastline spanning Florida, Alabama, Mississippi, Louisiana, and Texas. Data were collected via telephone interviews from April through August of 2016. A more detailed description of the data and methods from the first wave of the STRONG was provided by Ramchand et al. (2019).

After Hurricane Harvey, STRONG respondents from Texas were recontacted. Of the 623 original Texas respondents, addresses were available for 463. Surveys were mailed to those with address information in March 2018 (approximately 7 months after Harvey made landfall), with a $5 cash incentive and a stamped envelope to return the survey. Postcards were sent at the end of April to encourage respondents to return the mail survey and to inform them that they would be contacted by telephone if no mail response was received. Beginning in May 2018, telephone interviews were conducted for respondents who did not provide an address in the original survey effort or did not respond to the second wave mail survey. Potential respondents were called up to 11 times in an effort to maximize the likelihood of contact. The mixed mail and telephone method ultimately yielded a total of 295 respondents: 184 via mail and 111 via telephone. This was a recontact rate of 47.4

percent between survey waves, a favorable outcome given the widespread social disruption wrought by Harvey.[3]

### 4.2 Measures

In what follows, we describe the measures used in our analysis. Descriptive statistics for all of these variables are given in "Appendix 1."

#### 4.2.1 Dependent variables

We considered two dependent variables, both of which were assessed post-Harvey using the second wave of the STRONG. The first dependent variable was *post-Harvey institutional distrust* (range 0–3). Respondents were asked: "Based on your experience during Hurricane Harvey, how much trust do you have in the following groups, agencies, or organizations?" Institutional actors included: the federal government; state government; local government; and oil/gas industry. Responses were coded as: 0 = much/great deal of trust, 1 = some trust, 2 = a little trust, and 3 = no trust at all. For use in the regression models, we calculated the mean value reported across the four items (Cronbach's alpha = .850).[4] The resulting variable ranged from 0 to 3 and had a mean value of 1.1. The second dependent variable was *post-Harvey worry about future storms* (range 0–3). Respondents were asked: "Consider another storm like Hurricane Harvey happening in the next 5 years. How much do you worry about…?" Topics included: having added financial difficulties; personal physical health or the physical health of one's immediate family; personal mental health or the mental health of one's immediate family; the local economy; and social relationships in the community. Responses were coded as: 0 = not at all worried, 1 = a little worried, 2 = moderately worried, and 3 = very worried. For use in the regression models, we calculated the mean value reported across the five items (Cronbach's alpha = 0.875).[5] The resulting variable ranged from 0 to 3 and had a mean value of 1.4.

#### 4.2.2 Independent variables

Our primary independent variable was whether respondents viewed Harvey as a *natural* or *natech* disaster. In the second wave of the STRONG, respondents were asked: "Do you view Hurricane Harvey as primarily a natural disaster, man-made disaster, or a combination of both?" We created an indicator variable for those who reported Harvey as being primarily a natural disaster (natural = 0), or human-made alone or in combination with natural factors (natech = 1).[6] The resulting measure showed a majority of respondents viewed

[3] Data quality analysis confirmed that 271 respondents were the same between the two waves, 19 were definitely different, and 5 were indeterminate. Sensitivity analysis dropping those who were definitely different produced similar substantive results.

[4] There were 41 cases with missing data on the items that comprise this measure. These cases were dropped in the regression models. Sensitivity analysis taking the mean from data available on any item (versus all of them) produced similar substantive results.

[5] There were 32 cases with missing data on the items that comprise this measure. These cases were dropped in the regression models. Sensitivity analysis taking the mean from data available on any item (versus all of them) produced similar substantive results.

[6] There were 12 cases with missing data on this item. These cases were dropped from the entire analysis. Those who viewed Hurricane Harvey as human-made alone (not in combination with natural forces) were

Harvey as primarily natural (62.9%), while a substantial minority viewed the disaster as natech (37.1%).

In addition, our models included a measure of *prior DHOS exposure* (i.e., Deepwater Horizon oil spill). In the first wave of the STRONG, respondents were asked a series of nine questions about whether their household had particular experiences during the DHOS. These included if respondents: worked on oil spill cleanup activities; had property lost or damaged because of the oil spill; had commercial fishing areas damaged; had subsistence activities disrupted; had exercise or recreational patterns disrupted; had dietary or eating patterns disrupted; lost money due to the oil spill; lost their jobs or worked fewer hours due to the oil spill; or filed economic or property damage claims in response to the oil spill. If respondents answered in the affirmative to any of these nine items, they were coded as having DHOS exposure (yes = 1). The resulting indicator variable showed just over one-third (34.9%) of respondents had DHOS exposure, while about two-thirds (65.1%) did not. This measure is motivated by the desire to capture the influence of a recent previous technological disaster experience.

In the model of institutional distrust, we included a measure for *pre-Harvey distrust in information*. In the first wave of the STRONG, respondents were asked a series of seven questions about their trust in information received from various entities. These included national media; local media; business leaders or business organizations; religious leaders or religious organizations; academic leaders or academic institutions; friends, family, and neighbors; and one's doctor. Responses were coded as: 0 = much/great deal of trust, 1 = some trust, 2 = a little trust, and 3 = no trust at all. Similar to the parallel dependent variable, for use in the regression models we calculated the mean value reported across the seven items (Cronbach's alpha = .709).[7] The resulting variable ranged from 0 to 3 and had a mean value of 0.9.

In the model of future storm worry, we included a measure of *pre-Harvey worry about the DHOS*. In the first wave of the STRONG, respondents were asked whether they worry about their own or their family members' physical health, their community's economic stability, or their own or their family members' social relationships due to impacts of the DHOS. Responses were coded as: 0 = not at all worried, 1 = a little worried, 2 = moderately worried, and 3 = very worried. Similar to the parallel dependent variable, for use in the regression models we calculated the mean value reported across the three items (Cronbach's alpha = .795).[8] The resulting variable ranged from 0 to 3 and had a mean value of 0.8.

Footnote 6 (continued)

a very small group (2.8% of the sample). Sensitivity analysis dropping this group from the natech measure produced similar substantive results. We elected to maintain these cases in the analysis presented, rather than dropping them, to maximize the use of observations without missing data given the relatively small sample size.

[7] There were 21 cases with missing data on the items that comprise this measure. These cases were dropped in the regression models. Sensitivity analysis taking the mean from data available on any item (versus all of them) produced similar substantive results.

[8] There were 25 cases with missing data on the items that comprise this measure. These cases were dropped in the regression models. Sensitivity analysis taking the mean from data available on any item (versus all of them) produced similar substantive results.

**Table 1** Percent with little or no trust in institutions

| | Natech | Natural |
|---|---|---|
| Federal government | 43.8** | 28.1 |
| State government | 37.1** | 20.8 |
| Local government | 30.5* | 19.1 |
| Oil/gas industry | 56.2** | 39.3 |

Natech N = 105. Natural N = 178. Statistical significance determined by two-tailed independent samples *t* tests

*$p < .05$; **$p < .01$; ***$p < .001$

#### 4.2.3 Controls

Our models controlled for a basic set of sociodemographic variables, including: *sex* (male = 1); *age* (years); *race/ethnicity* (non-Hispanic white = 1); and *education* (high school or less = 1). All were drawn from the first wave of the STRONG and motivated by previous research on differences in social vulnerability in disaster contexts (Tierney 2014).[9]

### 4.3 Analytic strategy

Our analysis began with a series of descriptive statistics. We first described whether those with natech versus natural disaster perceptions differed in their trust of major institutions responsible for mitigating risk during Harvey and whether natech natural disaster perceptions shaped group differences in worry about the impacts of future storms. Next, we assessed whether natech natural disaster perceptions were related to institutional trust and future storm worry, after accounting for pre-Harvey distrust, worry, and demographic characteristics. To do so, we estimated ordinary least squares (OLS) models that regressed institutional trust and future storm worry, respectively, on our independent variables and controls.

## 5 Results

### 5.1 Hazard perceptions

Over one-third (37.1%) of respondents reported perceiving Hurricane Harvey as a natech disaster, while the majority (62.9%) viewed the storm as a natural disaster. There is evidence that these two groups had somewhat different experiences during the disaster (see "Appendix 2"). A significantly greater share of those who perceived Harvey as natech versus natural reported being unsure of the safety of family or friends (77.2% vs. 43.4%), taking on debt due to the storm (34.3% vs. 21.3%), being exposed to chemicals (26.0% vs. 9.4%), and being unable to get to work in the disaster's aftermath (11.6% vs. 4.8%). It is

[9] Assessment of differences in sample selection between waves 1 and 2 of the survey (i.e., the degree to which there were differences between those who participated in both waves and those we were unable to recontact) showed no substantial differences between the two samples in terms of race, Hispanic ethnicity, sex, or education. Respondents in the wave 2 sample were older than those in wave 1. This further justified the inclusion of respondent age as control variable in our regression models.

**Table 2** Percent moderately or very worried about impact of future storms

| | Natech | Natural |
|---|---|---|
| Added financial difficulties | 64.8* | 52.8 |
| Physical health | 55.2 | 49.4 |
| Mental health | 55.2* | 40.6 |
| Local economy | 60.0* | 45.5 |
| Relationships in community | 32.4 | 24.7 |

Natech N = 105. Natural N = 178. Statistical significance determined by two-tailed independent samples *t* tests

*$p < .05$; **$p < .01$; ***$p < .001$

especially notable that those viewing Harvey as a natech disaster were nearly three times more likely to report exposure to chemicals than their counterparts.

### 5.2 Prevalence of distrust in institutions by hazard perception

Table 1 shows the percentage of respondents who reported little or no trust in key institutions based on their experience during Hurricane Harvey. Those who viewed Harvey as natech versus natural had significantly less trust in the federal government (43.8% vs. 28.1%), state government (37.1% vs. 20.8%), local government (30.5% vs. 19.1%), and oil/gas industry (56.2% vs. 39.3%). These differences in institutional distrust were not small, with those who viewed Harvey as a natech disaster being 15 percentage points more distrusting, on average.

### 5.3 Prevalence of worry about future storms by hazard perception

Table 2 shows the percentage of respondents who reported being moderately or very worried about the impacts of future storms based on their experience with Hurricane Harvey. Those who viewed Harvey as natech versus natural were significantly more likely to be worried about added financial difficulties (64.8% vs. 52.8%), negative impacts on their own mental health or that of their family (55.2% vs. 40.6%), and negative impacts on the local economy (60.0% vs. 45.5%). Moreover, while worry about negative impacts from future storms on physical health and social relationships in the community did not meet conventional levels of statistical significance (i.e., $p < .05$), differences between those with natech compared to natural disaster perceptions followed the same general pattern (55.2% vs. 49.4% and 32.4% vs. 24.7%, respectively).

### 5.4 Models predicting institutional distrust

Table 3 shows results from OLS regression models predicting institutional distrust. As detailed previously, the dependent variable was the mean level of distrust across four major institutional actors (i.e., federal government, state government, local government, and oil/gas industry), with higher values indicating greater distrust. The bivariate estimates showed significant positive relationships between institutional distrust and each of the three independent variables. Specifically, those who perceived Harvey as a natech disaster were significantly more distrusting of major institutional actors following the storm compared

**Table 3** OLS regression models predicting institutional distrust

| | Bivariate | | | Full model | | |
|---|---|---|---|---|---|---|
| | *B* | (SE) | *β* | *B* | (SE) | *β* |
| *Independent variables* | | | | | | |
| Natech (yes = 1) | 0.33 | 0.11 | 0.19** | 0.27 | 0.11 | 0.16* |
| Prior distrust in information | 0.56 | 0.10 | 0.34*** | 0.55 | 0.10 | 0.34*** |
| DHOS exposure (yes = 1) | 0.22 | 0.11 | 0.13* | 0.19 | 0.11 | 0.11† |
| *Controls* | | | | | | |
| Sex (male = 1) | −0.10 | 0.11 | −0.06 | −0.15 | 0.10 | −0.09 |
| Age (years) | −0.00 | 0.00 | −0.03 | 0.00 | 0.00 | 0.01 |
| Race/ethnicity (NH white = 1) | −0.13 | 0.11 | −0.08 | −0.10 | 0.11 | −0.06 |
| Education (HS or less = 1) | 0.18 | 0.11 | 0.10 | 0.18 | 0.11 | 0.10 |
| *R*-squared | – | | | 0.184 | | |
| *N* | 232–254 | | | 230 | | |

*DHOS* Deepwater Horizon oil spill; *NH* non-Hispanic; *HS* high school; *SE* standard error

†$p = .053$; *$p < .05$; **$p < .01$; ***$p < .001$

to those who viewed Harvey as a natural disaster. In addition, those who reported they were more distrustful of information prior to Harvey were significantly more distrustful of institutions in the wake of the storm. Last, those who experienced DHOS exposure were significantly more distrustful of institutional actors after Harvey than were those without DHOS exposure.

In the full model, accounting for all other predictors, natech perceptions and prior distrust maintained significant positive relationships with institutional distrust, while DHOS exposure only narrowly missed the conventional $p < .05$ threshold for statistical significance ($p = .053$). None of the control variables were statistically significant. The major finding was that, even after accounting for prior distrust and technological disaster exposure, those who perceived Harvey as a natech disaster remained more distrustful of major institutional actors.

Ancillary analysis (not shown) examined parallel models to those in Table 3 which estimated distrust in various levels of government (i.e., federal, state, and local) and the oil/gas industry specifically. The intent was to disentangle generalized recreancy from that aimed at particular institutional actors. Doing so helps shed light on recreancy associated with failures to regulate industrial activity and non-industrial development (i.e., government) versus being directly responsible for toxic industrial releases (i.e., industry). Results showed that for distrust in the federal and state government natech perceptions remained a significant positive predictor ($p < .05$), while for local government ($p = .099$) and the oil/gas industry ($p = .064$) natech perceptions were marginally significant. The implication is that people's perceptions of the genesis of the disaster had a varied influence on distrust of governmental and industrial actors, and in this case was especially salient in terms of distrust of federal and state government.

Further analysis (not shown) also examined parallel models to those in Table 3 which estimated generalized institutional distrust (i.e., the same dependent variable), but included a control for Harvey impact. The intent was to disentangle natech perceptions from particular storm experiences. Results from a model controlling for any impacts from Harvey listed in "Appendix 2" (any impact = 1) showed storm exposure was not a significant predictor of

**Table 4** OLS regression models predicting worry about impacts of future storms

| | Bivariate | | | Full Model | | |
|---|---|---|---|---|---|---|
| | *B* | (SE) | *β* | *B* | (SE) | *β* |
| *Independent variables* | | | | | | |
| Natech (yes = 1) | 0.30 | 0.11 | 0.16** | 0.26 | 0.11 | 0.15* |
| Prior worry about DHOS | 0.42 | 0.06 | 0.39*** | 0.39 | 0.07 | 0.37*** |
| DHOS exposure (yes = 1) | 0.36 | 0.11 | 0.19** | 0.05 | 0.13 | 0.03 |
| *Controls* | | | | | | |
| Sex (male = 1) | −0.03 | 0.11 | −0.02 | −0.02 | 0.11 | −0.01 |
| Age (years) | −0.00 | 0.00 | −0.02 | 0.00 | 0.00 | 0.08 |
| Race/ethnicity (NH white = 1) | −0.12 | 0.11 | −0.07 | −0.06 | 0.11 | −0.03 |
| Education (HS or less = 1) | 0.133 | 0.12 | 0.07 | 0.06 | 0.12 | 0.03 |
| *R*-squared | – | | | 0.182 | | |
| *N* | 238–263 | | | 235 | | |

*DHOS* Deepwater Horizon oil spill; *NH* non-Hispanic; *HS* high school; *SE* standard error

*$p < .05$; **$p < .01$; ***$p < .001$

institutional distrust, while natech perceptions remained statistically significant ($p < .05$). Results from a model controlling for exposure to chemicals specifically showed chemical exposure was a significant predictor of institutional distrust ($p < .01$), while natech perceptions were rendered marginally significant ($p = .081$). The implication is that the influence of natech perceptions on general institutional distrust following Harvey was explained in part by the experience of exposure to industrial toxins.

### 5.5 Models predicting worry about future storms

Table 4 shows results from OLS regression models predicting worry about the impacts of future storms. As detailed previously, the dependent variable was the mean level of worry across four domains (i.e., added financial difficulties, physical health impacts, mental health impacts, local economic impacts, and impacts on social relationships in the community). Similar to the results presented in Table 4, the bivariate estimates showed significant positive relationships between future storm worry and each of the three independent variables. Specifically, those who perceived Harvey as a natech disaster were significantly more worried about future storm impacts compared to those who viewed Harvey as a natural disaster. In addition, those who reported greater worry about the DHOS prior to Harvey were significantly more worried about the impacts of future storms after Harvey. Last, those who experienced DHOS exposure were significantly more worried about future storm impacts than were those without DHOS exposure.

In the full model, accounting for all other predictors, natech perceptions and prior worry about the DHOS maintained significant positive relationships with future storm worry. DHOS exposure was no longer significant in the full model. Again, none of the control variables were statistically significant. The major finding was that, even after accounting for prior worry and technological disaster exposure, those who perceived Harvey as a natech disaster remained more worried about the impacts of future storms.

Ancillary analysis (not shown) examined parallel models to those in Table 4 which estimated future storm worry (i.e., the same dependent variable), but included a control for

Harvey impact. Again, the intent was to disentangle natech perceptions from particular storm experiences. Results from a model controlling for any impacts from Harvey listed in "Appendix 2" (any impact = 1) showed storm exposure was a significant predictor of future storm worry ($p < .01$), while natech perceptions narrowly missed the conventional $p < .05$ standard for statistical significance ($p = .054$). Results from a model controlling for exposure to chemicals specifically showed chemical exposure was a significant predictor of future storm worry ($p < .01$), while natech perceptions were rendered marginally significant ($p = .099$). The implication is that the influence of natech perceptions on worry about the impacts of future storms was explained in part by people's storm experiences during Harvey.

## 6 Discussion and conclusions

This study examined the relationships Hurricane Harvey hazard perceptions (natech vs. natural) had with institutional trust and future storm worry in the aftermath of the storm. We took these relationships as a point of focus given their implications for corrosive community dynamics (e.g., Cope et al. 2016; Gill et al. 2016; Picou et al. 2004; Ritchie et al. 2013). Specifically, we asked two questions: (1) how were natech versus natural disaster perceptions following Hurricane Harvey related to institutional trust? And (2) how were natech versus natural disaster perceptions following Hurricane Harvey related to worry about the impacts of future storms? Data drawn from the STRONG provided the novel opportunity to assess panel data collected from a cohort of households on the Texas Gulf Coast in 2016 and 2018 (before and after Harvey). Further, because the STRONG explicitly asked respondents about their perceptions of the origin of the Harvey disaster (natech vs. natural), we were able to examine how such views were related to institutional trust and future storm worry in this context. Understanding natech perceptions is important because disasters of this type are increasing in frequency and severity worldwide (Cruz and Suarez-Paba 2019). Contributing factors include changes in technology, risk governance, socioeconomic factors, and environmental/climate change (Krausmann et al. 2019). Moreover, perceptions of risk in the context of natech disasters have been shown to not only influence peoples' attitudes, but to translate into behavior (Yu et al. 2017). Our findings showed that those who perceived Harvey as natech (compared to natural) were significantly more likely distrust major institutional actors and be worried about the impacts of future storms, even after accounting for pre-hurricane characteristics. Such differences hold implications not only for attitudinal but also behavioral divergence going forward.

These findings contributed to the extant literature documenting differential social consequences based on whether people perceive the origins of a disaster to be "natural" or "technological" (e.g., Cope et al. 2013, 2016; Drakeford et al. 2020; Erikson 1994; Freudenburg 1993, 2000; Gill and Picou 1998; Gill et al. 2012, 2016; Kroll-Smith and Couch 1991, 1993; Lee and Blanchard 2012; Parks et al. 2018, 2019; Picou et al. 2004; Ritchie et al. 2018), and expanded this to the consideration of "natech" disasters (e.g., Cruz and Suarez-Paba 2019; Gill and Ritchie 2018; Picou 2009). We also contributed to the emerging social science literature on Hurricane Harvey specifically (e.g., Thomas et al. 2018). This body of research has shown that heightened worry, competing narratives of responsibility and blame, and loss of trust in institutions tasked with protecting the public from risk (i.e., recreancy) have acted to catalyze corrosive community dynamics in past disaster contexts. Thus, an implication of our findings is that natech

versus natural disaster perceptions may foreshadow important points of division along which social fissures will develop in the future.

Our findings related to trust emphasize the need for federal, state, and local leaders to rebuild confidence with affected communities following a disaster, or else risk its further deterioration over time. Research has shown that trust takes a long time to build, but can be destroyed very quickly in a disaster context (Siegrist and Cvetkovich 2000). Transparency in efforts to create more disaster-resilient built infrastructures, honest communication about the causes, impacts, and responses to a disaster, and partnering with trusted local organizations that have deep roots in their community are some strategies to consider toward this end. Relatedly, adopting land-use regulations and zoning practices that explicitly privilege protecting the public from hazard events over other interests are implied (Brody et al. 2013; Cutter et al. 2018; Zhang et al. 2018)

It is also important not to discount the realities of a political economy in places like Texas that heavily favor petrochemical industry interests over environmental justice concerns. There is a long history in Texas of the state legislature, state agencies, state courts, and industry working in concert to legitimate pollution and toxic risk, and reduce accountability, transparency, and the power of local residents (Willyard 2019). Indeed, research focused on Houston prior to Harvey predicted extensive potential impacts from compromised petrochemical facilities on local residents in the event of major hurricane-related flooding (Burleson et al. 2015). In short, the risks were not unknown.

Our findings related to worry suggest the potential for development of longer-term health disparities. Persistent worry has been demonstrated to factor prominently in most anxiety disorders and, over longer periods of time, physical illnesses like heart disease (Brosschot et al. 2006; Kubzansky et al. 1997). Indeed, disaster-related worry specifically has been linked to psychological distress and physical health problems (Holman and Silver 2005). The implication is that worry can become a pathway to health vulnerability and thus differential levels of worry to group health disparities.

This study had a number of additional strengths and limitations worth noting. A key strength of this research was that we were able to draw on panel data collected from the same cohort of households *before* and *after* Hurricane Harvey. This is an important contribution because the bulk of disaster research has been conducted only *after* a disaster process was set in motion (Parker et al. 2019), despite the acknowledgment that disaster processes play out on a preexisting social landscape (e.g., Tierney 2014). That said, our data only allowed the assessment of relationships at two time points over a 2-year period. The best time horizon over which to observe these types of dynamics is unclear, though research on the Exxon Valdez oil spill continues to document corrosive community dynamics 25 years after that disaster began (Gill et al. 2016). This strongly suggests that continued social surveillance is warranted to understand people's recovery trajectories in relation to Harvey as well.

In addition, while the original regional probability sample design of the STRONG represents a strength over non-probability-based studies (Ramchand et al. 2019), the sample size available for this study is nonetheless small. Future research using a larger sample would build on the strengths of the research presented here. Ways in which it would do so include allowing for the detection of greater variability in outcomes over time, reducing the possibility of Type II error, and facilitating the examination of the experiences of smaller population subgroups (e.g., occupational or racial/ethnic minority groups). Longer time frames, larger samples, and replication across diverse settings will be required to determine the generalizability of this study's findings.

In conclusion, the social impacts of Hurricane Harvey can be expected to play out over many years, and the unfortunate reality is that additional environmental shocks are likely to threaten residents of the Texas Gulf Coast during that time, making them subject to multiple exposures (O'Brien and Leichenko 2000). Indeed, the study conducted here was only made possible by ongoing research in the region by the Consortium for Resilient Gulf Communities (2019) aimed at monitoring the social impacts of the DHOS disaster. Efforts like CRGC are in line with growing recognition that research on disaster resilience must be multidimensional and transdisciplinary (Finucane et al. 2020; National Academies of Sciences, Engineering, and Medicine 2019). The findings from this study may be useful to stakeholders and decision-makers interested in risk mitigation and disaster recovery.

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## Appendix 1. Descriptive statistics

| | Percent/mean | SD | N |
|---|---|---|---|
| *Dependent variables* | | | |
| Distrust in institutions | 1.1 | 0.84 | 254 |
| Worry about future storms | 1.4 | 0.88 | 263 |
| *Independent variables* | | | |
| Natech (yes = 1) | 37.1 | – | 283 |
| Prior distrust in information | 0.9 | 0.52 | 271 |
| Prior worry about DHOS | 0.8 | 0.84 | 267 |
| DHOS exposure (yes = 1) | 34.9 | – | 295 |
| *Controls* | | | |
| Sex (male = 1) | 37.3 | – | 295 |
| Age (years) | 59.1 | 17.06 | 295 |
| Race/ethnicity (NH white = 1) | 56.6 | – | 295 |
| Education (HS or less = 1) | 31.2 | – | 295 |

*NH* non-Hispanic; *HS* high school; *SD* standard deviation

## Appendix 2. Percent by self-reported Hurricane Harvey exposure

| | Natech | *N* | Natural | *N* |
|---|---|---|---|---|
| Unsure about family/friend safety | 77.2*** | 101 | 43.4 | 175 |
| Took on additional debt | 34.3* | 102 | 21.3 | 169 |
| Had to stay outside of home | 32.3 | 105 | 32.0 | 178 |
| Did not meet essential expenses | 27.0 | 100 | 29.3 | 167 |
| Exposed to chemicals | 26.0*** | 100 | 9.4 | 170 |

| | Natech | *N* | Natural | *N* |
|---|---|---|---|---|
| Applied for federal assistance | 24.0 | 104 | 16.6 | 175 |
| More than $10 k damage | 23.5 | 102 | 16.0 | 175 |
| Home affected by mold | 21.0 | 100 | 15.5 | 174 |
| Did not pay full rent/mortgage | 19.6 | 102 | 14.5 | 165 |
| Did not have adequate food | 18.2 | 99 | 18.0 | 167 |
| Unable to get to work | 11.6* | 95 | 4.8 | 165 |
| Household income lower | 10.9 | 101 | 12.1 | 174 |
| Someone you know injured or killed | 10.5 | 105 | 9.6 | 178 |
| Personally injured | 3.9 | 103 | 1.1 | 175 |
| Lost job | 3.8 | 104 | 2.3 | 172 |
| Pet injured or killed | 1.0 | 103 | 1.2 | 173 |

Statistical significance determined by two-tailed independent samples *t* tests

*$p < .05$; **$p < .01$; ***$p < .001$

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