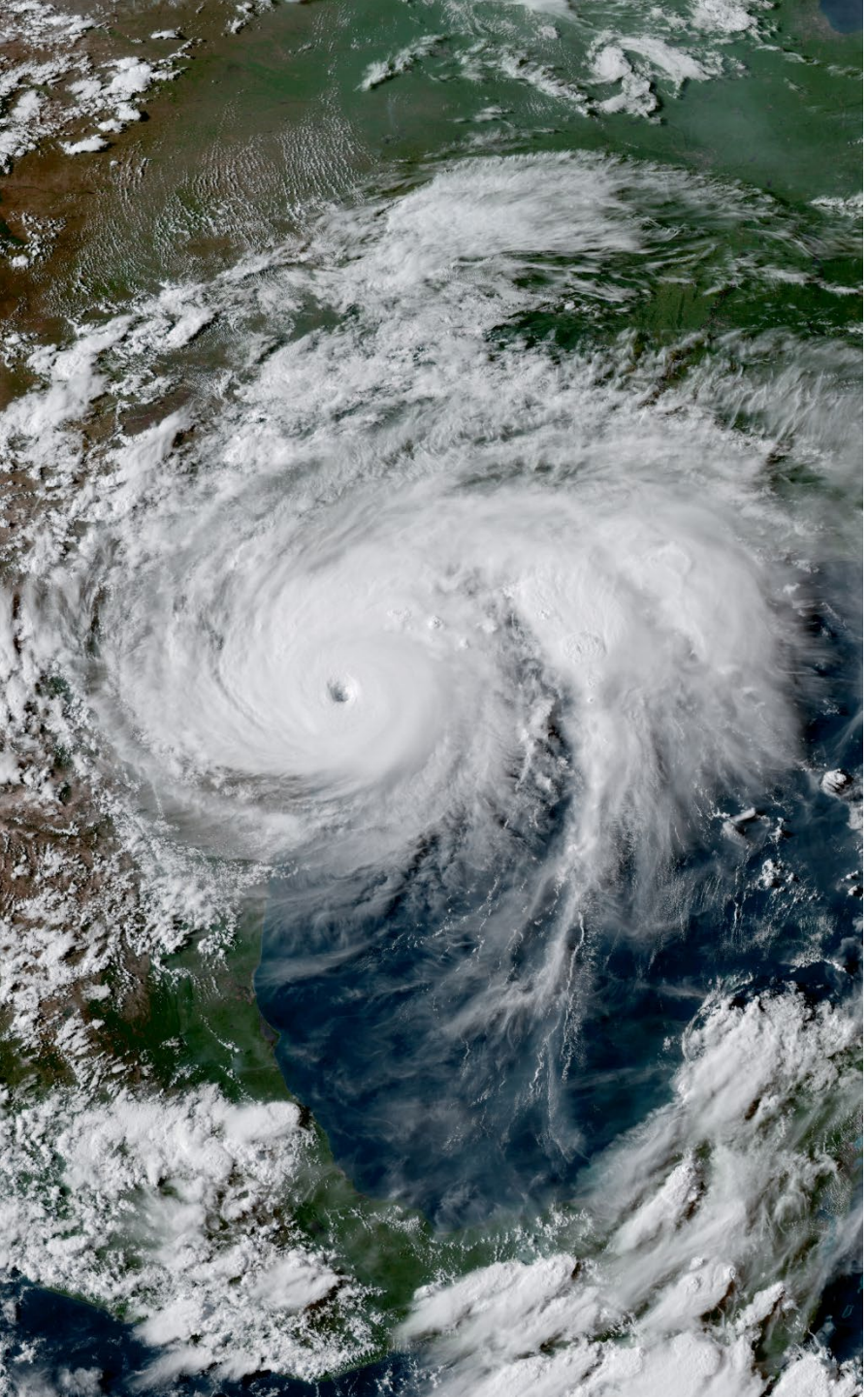

How Mitigation Helped Houston Households in Hurricane Harvey

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THE UNIVERSITY OF UTAH
CENTER FOR NATURAL & TECHNOLOGICAL HAZARDS

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Who are we?

- *Professor of Sociology and Environmental & Sustainability Studies*
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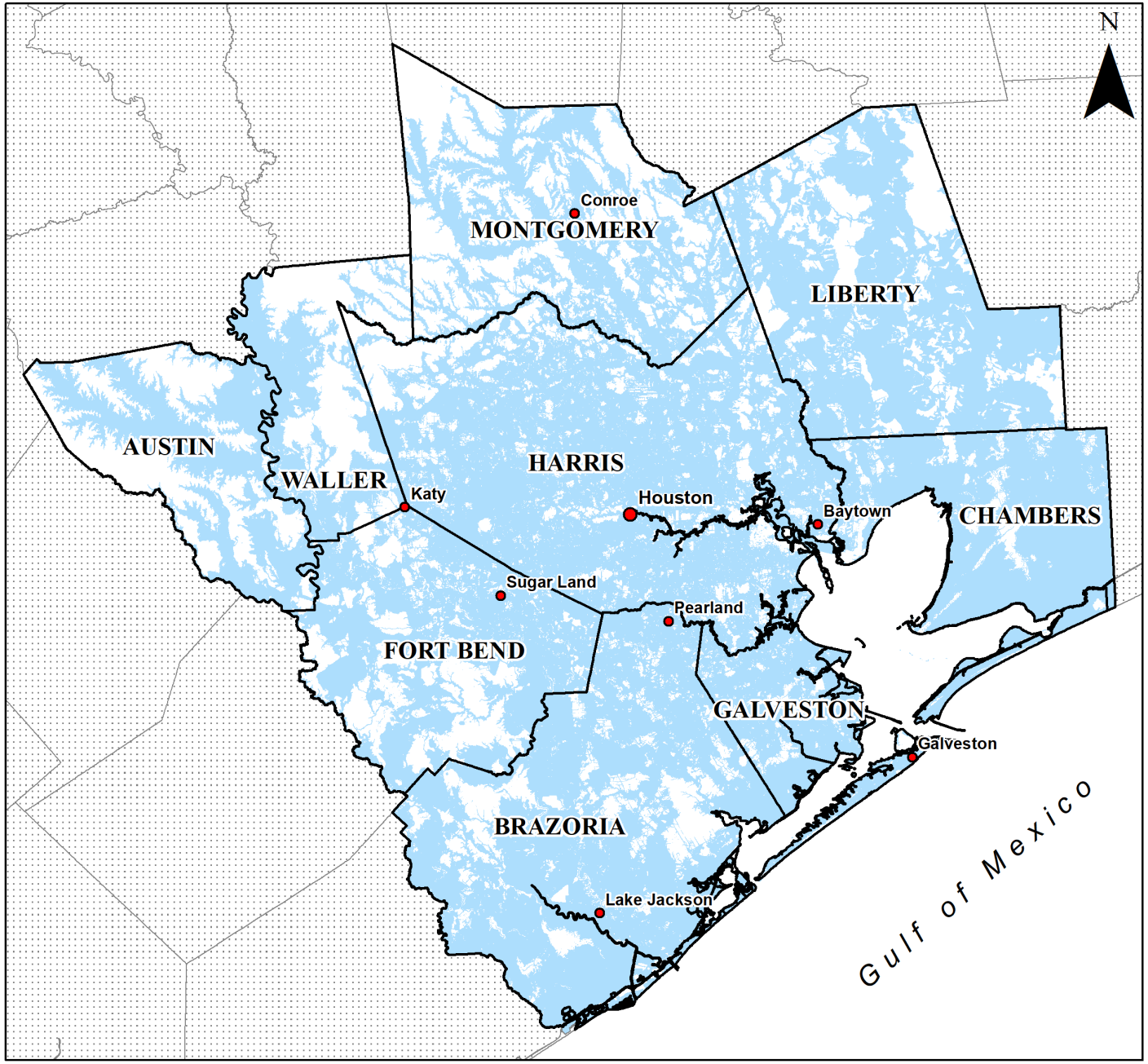
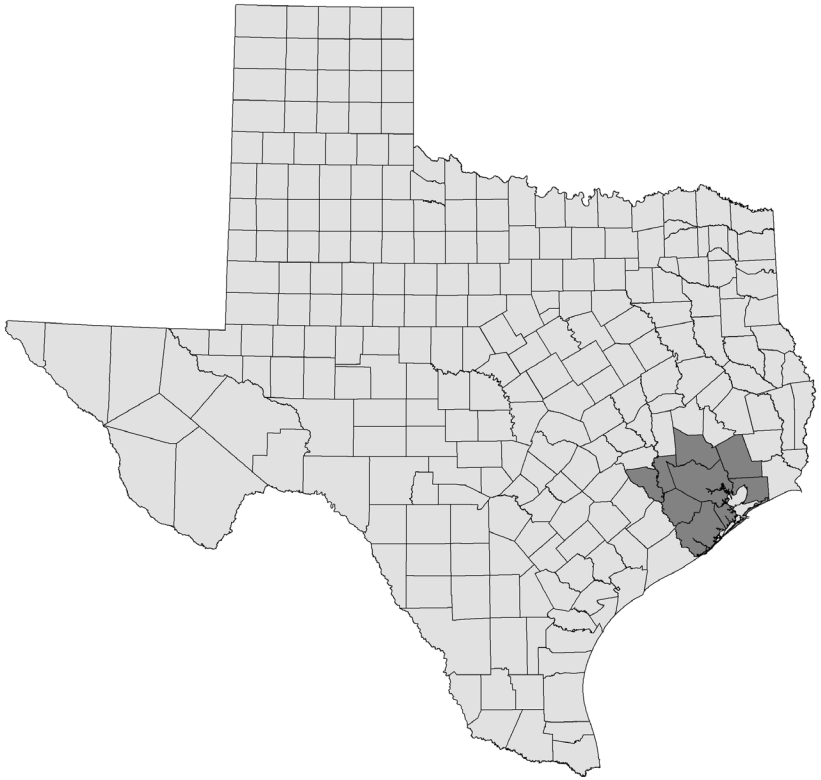
- *University of Utah*

- *Doctoral Student in Geography*
- *RA, Center for Natural and Technological Hazards*
- *University of Utah*

Hurricane Harvey in Greater Houston

- August 2017, Category 4, 200 km/hour winds
- Extreme storm surge and unprecedented rainfall (1 meter of rain)
- Among the 13 million people directly affected by the storm (Shultz and Galea, 2017):
  - 22,000 were rescued from floodwaters
  - 32,000 were temporarily housed in shelters
  - 450,000 applied for Federal Emergency Management Agency (FEMA) disaster assistance
  - Only 17% of those impacted had flood insurance
- Affected Greater Houston (nine-county metropolitan statistical area located in Texas)
  - Population: 6,892,427 in 2017
  - $125 billion in damages





Study Area

Other Texas Counties

Flooded Area

Study Background

- We leverage a unique pre- and post-event survey sample of Greater Houston households (not “after-only”, like the majority of studies (Horney et al., 2018)).
- We report pre-event baselines for general disaster preparedness and home structure flood hazard mitigation.
- To prepare for a hurricane-induced flood disasters, householders can engage in home site structural mitigation activities (e.g., installing an interior drainage system, elevating electrical components, building flood walls, installing hurricane shutters) as well as undertake general disaster preparedness measures (e.g., evacuation planning).

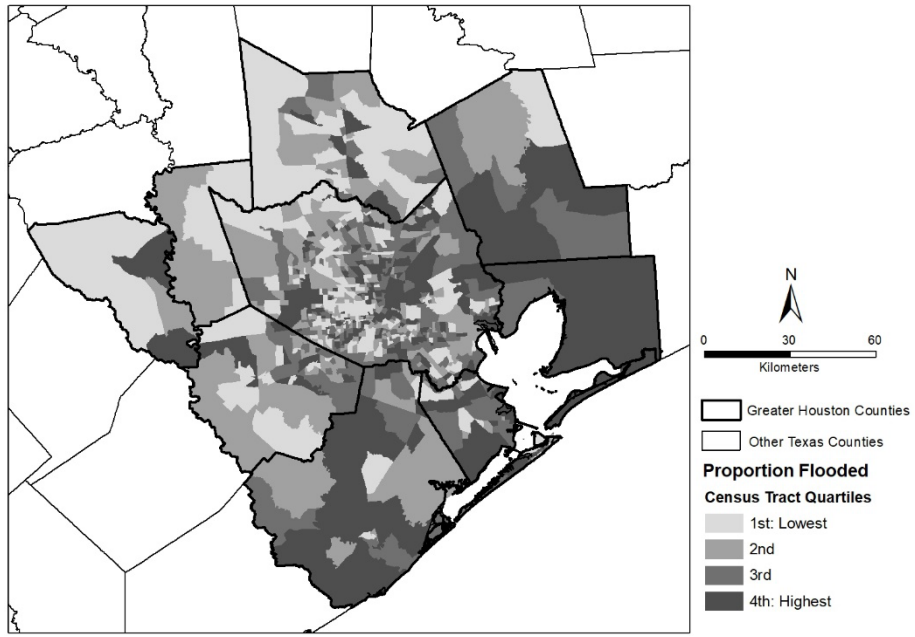
Background

- We report on household-level health effects, event exposures, and recovery in the 90 days following Harvey.
  - Research has shown that hurricanes and floods can impact households in various ways, including causing physical health problems and post-traumatic stress, creating dangerous experiences with which they must cope, and damaging their home (Brodie et al., 2006; Collins et al., 2014; Schwartz et al., 2018).
  - Yet, research on Harvey is still limited.
    - Our team has done some research on this.

Disproportionate exposure to Harvey-induced flooding: race/ethnicity and SES

- **Hispanic**, **black** and **other racial/ethnic minority** households experienced more extensive flooding than white households, and **lower SES** households faced more extensive flooding than higher SES households.

- The areal extent of Harvey-induced flooding was significantly greater in neighborhoods with a higher proportion of **non-Hispanic Black** and **socioeconomically deprived** residents after we controlled for contextual factors and clustering.



Environmental Injustice and Hurricane Harvey: A Household-level Study of Socially Disparate Flood Exposures in Greater Houston, Texas

Timothy Collins, Sara Grineski, Jayajit Chakraborty, Aaron Flores

Just Accepted: *Environmental Research*

AJPH

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Exploring the Environmental Justice Implications of Hurricane Harvey Flooding in Greater Houston, Texas

Jayajit Chakraborty PhD, **Timothy W. Collins** PhD, and **Sara E. Grineski** PhD

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Accepted: October 12, 2018 Published Online: January 16, 2019

Health Effects of Harvey

- Just over half (56%) of respondents experienced at least one physical health problem.
  - On average, respondents experienced three physical health problems, and 11% of respondents experienced ten or more physical health problems.
  - The most common physical health problems experienced were allergies or hay fever (33%), headaches (28%), nose irritation (27%), and throat irritation (27%).
- Just under one-fifth (18%) of the sample had PTS scores ≥ 40.
- Multivariate results:
  - Physical health problems disproportionately affected people who did not evacuate.
  - Post-traumatic stress had disparate impacts on African Americans, those experiencing post-Harvey unemployment, and older people.
  - Healthcare access was constrained for people experiencing post-Harvey unemployment and those with disabilities.

Disparities in Health Impacts and Access to Care among Houston Area Residents After Hurricane Harvey

Aaron Flores, Timothy Collins, Sara Grineski, Jayajit Chakraborty

Paper under review

Unmet Needs after Harvey

- UNs are things like: inadequate drinking water, transportation, food, or clothing; no bathroom access, no hot water; no access to medical care (we asked 11)
- Participants experienced an average of three UNs and 70% experienced at least one. Going without electricity (44%), money for living expenses (37%), and adequate transportation (33%) were most common.
- Multivariate model results indicate that NH **Blacks** (1.429; 95% CI=1.077-1.897), **US-Born Hispanics** [1.619; 1.168-2.244], **foreign-born citizen Hispanics** [1.595; 1.122-2.268], and **foreign-born non-citizen Hispanics** [2.150; 1.166-2.905] had significantly more UNs than NH **Whites**. In terms of **SES**, a one-unit increase in household income was associated with a 8.5% decrease in UNs (0.915; 0.878-0.954).

Social vulnerability and assessment of post-disaster needs: Insights from a population-based study following Hurricane Harvey

Aaron Flores, Timothy Collins, Sara Grineski, Jayajit Chakraborty

Paper Just Accepted. International Journal of Disaster Risk Reduction

Receipt of assistance and recovery

- Multivariate results showed:
- US-born Hispanics (compared to non-Hispanic whites, $p<0.01$) were more likely to have received post-Harvey assistance from any source
- Presence of children in the household increased the likelihood that the household received post-Harvey government assistance by 138% ($p<0.01$)
- Non-Hispanic blacks were 147% more likely ($p<0.05$) to have received post-Harvey NGO assistance than non-Hispanic whites
- But, receiving assistance was not associated with more complete household recovery. Higher income was associated with recovery.

Social Vulnerability, Recovery Assistance, and the Extent of Recovery: Results from a survey conducted after Hurricane Harvey in Greater Houston, Texas

Angel Griego, Aaron Flores, Timothy Collins, Sara Grineski

Paper in Progress

The focus today:

- We examine how baseline preparedness and mitigation are related to post-Harvey health effects, event exposures, and recovery.
  - This pre/post design uniquely enables an examination of how preparations taken in the years before Harvey translate into outcomes post-disaster.

Sample

- **Baseline data**: Responses to a structured survey collected in June 2012 from a probability-based sample of 600 Greater Houston area householders
- **Updated data**: Responses to a structured survey collected in 2017, within 4 months of Harvey
  - We used a rigorous multi-step procedure to locate 2012 respondents in Fall 2017, excluding those who did not consent
  - Contracted a marketing research firm specializing in sampling to:
    - Update addresses, so we could exclude those who were not living in GH as of Aug. 25, 2017. Sampling Frame: N=484.
    - Update phone numbers (landline and cell phone)
    - Append email addresses

Survey

- Multimodal (internet/phone) and bilingual (English/Spanish)
- Conducted between November 29 and December 19, 2017
- For those taking the survey online, it took between 15 and 53 minutes (27 minutes on average) and over the phone, the survey took between 15 and 65 minutes (35 minutes on average).
- Limitation: Despite using the best marketing research tools available, we were unable to reach 74% of 2012 survey respondents who had consented to a follow-up and still lived in Greater Houston. For those that we made contact with, 57% participated in this study. **N=71 respondents**.

Variables

Dichotomous	1 (Yes)	0 (No)	N	Year Measured
Older Age (74+)	15	53	68	2012
Non-White	26	45	71	2012
Flood insured	27	42	69	2017
Continuous	**Mean**	**Min-Max**	**N**	**Year Measured**
Pre-event preparedness	4.507	0-6	71	2012
Pre-event mitigation[1]	3.563	0-7	71	2012
Household income	5.180	1-10	65	2017
Flood depth index	0.157	0-0.982	70	2017
Post-traumatic stress (PTS) sum	24.40	17-61	65	2017
Physical health sum	2.557	0-12	70	2017
Adverse event experiences sum	6.529	1-25	68	2017
Home damage extent	1.630	1-5	70	2017
Recovery extent	8.210	1-10	67	2017
Perceived benefits	2.567	0-8	67	2017

[1]Updated to reflect accurate information for the 11 households that moved between 2012 and Hurricane Harvey

Statistical Methods/Research Questions

- **Univariate descriptive statistics**:
- (1) Before the event, how ready were households for a flood event like Harvey, based on their level of general disaster preparedness and home structure flood hazard mitigation?
- (2) What were the most common physical health effects experienced by respondents after Hurricane Harvey?
- (3) Did respondents experience PTS? What were the most common PTS symptoms experienced?
- (4) Which were the most common adverse event experiences associated with Hurricane Harvey among this group of respondents?
- (5) How extensive where the home damages experienced by the respondents and to what extent had they recovered ~90 days later?
- (6) Which were the most common perceived benefits to come out of Hurricane Harvey?
- **Generalized linear models (GzLM)**: (7) how are pre-event preparedness and mitigation related to post-Harvey health effects, event exposures, and recovery?

Poll 1

- Consider this list of general pre-event emergency preparedness actions. Which action was most common among our sample? Which was least common?

- **Developed and practiced an evacuation plan with all household members.**
- **Learned about your community's emergency plans, warning signals, evacuation routes, and locations of emergency shelters and medical emergency centers nearest you.**
- **Trained at least one household member in first aid and CPR.**
- **Learned how to turn off your current home's electrical power at the main switch, and how to turn off the gas and water supplies at the valves.**
- **Purchased a fire extinguisher and made sure that members of your household know where it is and how to use it.**
- **Created and maintained an easy-to-carry emergency kit for use at home or during evacuation that is stocked with supplies such as a flashlight, first aid kit and water.**

Pre-event Preparedness

Preparedness measures	%	N
Learned how to turn off your current home's electrical power at the main switch, and how to turn off the gas and water supplies at the valves.	87.3%	71
Learned about your community's emergency plans, warning signals, evacuation routes, and locations of emergency shelters and medical emergency centers nearest you.	76.1%	71
Purchased a fire extinguisher and made sure that members of your household know where it is and how to use it.	76.1%	71
Developed and practiced an evacuation plan with all household members.	74.6%	71
Created and maintained an easy-to-carry emergency kit for use at home or during evacuation that is stocked with supplies such as a flashlight, first aid kit and water.	70.4%	71
Trained at least one household member in first aid and CPR.	66.2%	71

Poll 2

- Consider this list of pre-event mitigation actions. Which action was most common among our sample? Which was least common?

- **Had interior drainage system installed, including a sump pump with back-up power, to remove any water that might enter the home.**
- **Home structure was originally built or later elevated above flood height**
- **Electric components of the home as and home's water heater, furnace, and washer and dryer ALL installed above flood height**
- **Home indoor HVAC system components installed above flood height**
- **Outdoor service equipment - such as air conditioning and heat pump compressors, electric and gas meters, and fuel tanks - anchored above flood height**
- **Have floodwalls, berms or levees built on site to protect the home**
- **Have hurricane shutters**
- **Have reinforced roof to protect against strong winds - for example, by installing hurricane straps or clips**

Pre-event Mitigation

Mitigation measures	%	N
Home indoor HVAC system components installed above flood height	83.1%	71
Electric components of the home as and home's water heater, furnace, and washer and dryer ALL installed above flood height	70.0%	70
Outdoor service equipment - such as air conditioning and heat pump compressors, electric and gas meters, and fuel tanks - anchored above flood height	61.4%	70
Have reinforced roof to protect against strong winds - for example, by installing hurricane straps or clips	56.3%	64
Home structure was originally built or later elevated above flood height	52.3%	65
Have floodwalls, berms or levees built on site to protect the home	34.3%	67
Have hurricane shutters	7.4%	68
Had interior drainage system installed, including a sump pump with back-up power, to remove any water that might enter the home.	6.1%	66

(Selected) Physical Health Effects

Health symptoms	%	N
Allergies or hay fever	44.9%	69
Nose irritation	28.6%	70
Headaches	27.1%	70
Eye irritation	25.7%	70
Throat irritation or dry, hacking cough	22.9%	70
Blurred vision	15.9%	69
Dizziness	15.9%	69
Diarrhea	14.3%	70
Lung or airway irritations or inflammation	12.9%	70
Nausea	11.4%	70
Skin irritation	11.4%	70
Fever	11.4%	70
Asthma	10.0%	70
Athlete's foot	7.1%	70

(Selected) PTS Items

PTS Symptom (Weathers et al., 1994)	% affected 'moderately,' 'quite a bit,' or 'very much'	N
Having repeated, disturbing memories, thoughts, or images of Hurricane Harvey	27.1%	70
Feeling very upset when something reminded you of Hurricane Harvey	24.3%	70
Being "super-alert" or watchful or on guard	23.2%	69
Having trouble falling or staying asleep	17.1%	70
Avoiding thinking about or talking about Hurricane Harvey or avoiding having feelings related to it	15.9%	69
Feeling distant or cut off from other people	14.5%	69
Suddenly acting or feeling as if Hurricane Harvey was happening again - as if you were reliving it	12.9%	70
Having difficulty concentrating	12.9%	70
Feeling jumpy or easily startled	12.9%	70

(Selected) Adverse Event Experiences

Adverse event experience	%	N
Worried about family members or close friends suffering from the disaster	78.3%	69
Were present when major flooding or hurricane damage occurred	65.7%	70
Worried about crime	41.4%	70
Went without electricity for some time	31.4%	70
Went without adequate transportation for some time	27.1%	70
Lacked money for living expenses for some time	24.3%	70
Smelled unpleasant chemical odors	20.0%	70
Were stranded in an unsafe place during the disaster, for example,	17.1%	70
Went without access to health care or medical services for some time	17.1%	70
Thought at least once that you might be injured or killed during the disaster	17.1%	70
Had to split up and stay in different location from some members of your household for any period of time	15.9%	69
Went without running hot water for some time	15.7%	70

Recovery

Benefits of Hurricane Harvey	%	N
Become closer to family members	54.3%	70
Become closer to friends	52.9%	70
Become more optimistic	40.6%	69
Developed more supportive relationships with neighbors	38.6%	70
Gained a sense of strength and control in facing problems	35.7%	70
Become more involved in church or other community groups	28.6%	70
Increased your financial income	5.7%	70
Found a better job	1.5%	68

Poll 3

- Higher levels of pre-event mitigation were significantly associated with which of the following?
- **Fewer numbers of physical health problems**
- **Fewer PTS symptoms**
- **Fewer numbers of adverse Harvey-associated events**
- **Less home damage**
- **Greater near-term recovery**
- **Greater benefits (more post-traumatic growth)**

GzLM Results

	Physical health sum [a]	PTS sum	Adv. event sum [a]	Home damage extent [b]	Recovery extent [c]	Benefits sum [a]
Independent Variable						
Intercept	-0.154	3.548	2.269	0.259	6.459**	0.758
Mitigation sum	-0.162**	-0.052*	-0.137**	-0.029	0.362**	-0.097*
Preparedness sum	0.477**	-0.003	0.108	0.055	-0.158	0.021
Older age (74+)	0.432	-0.348*	-0.443	-0.143	0.978	-0.504
Non-white	0.352	0.220**	0.326	0.134	-0.418	0.604**
Income	-0.277**	-0.085**	-0.238**	-0.022	0.417**	0.011
Flood insurance	-.0265	0.194*	0.073	-0.170	-0.007	0.203
Flood depth	2.210**	1.053**	2.735**	1.757**	-6.293**	0.668
Analysis N	59	54	57	59	58	58

** p<.05, * p<.10

[a] Used normal with log link, which fits better than normal with identity link according to AIC.

[b] Inverse Gaussian with log link, fit better than inverse Gaussian with identity link, gamma with log or identify link and normal with log or identity link,

[c] Used normal with identity link, which fits better than normal with log link according to AIC.

Discussion

- Substantial impacts of Harvey, even though 40% did not have home damage
- Diffuse benefits of home structure flood hazard mitigation extended well beyond the expected financial savings due to lesser home damage
  - Greater pre-event mitigation was associated with significantly fewer physical health problems, PTS symptoms, and adverse event experiences in the post-event period.
  - These findings suggest the hypothesis that protecting the home keeps the occupants safer as a storm approaches, both during and after the storm, and therefore seems to reduce some adverse post-event impacts, like poorer health and more challenging experiences.

Conclusion

- Pre-/post-comparisons can provide important insights that potentially improve disaster planning and preparedness.
  - Public should be made aware of the many benefits of taking home structure mitigation actions beyond just home protection
  - Non-governmental and governmental actors at all levels (e.g., municipal, state, and federal) must continue to promote the importance of home structure mitigation for households at risk to flooding.

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Any Questions?

thank-you

Disasters

Original Article

The impact of Hurricane Harvey on Greater Houston households: Comparing pre-event preparedness with post-event health effects, event exposures, and recovery

Sara E. Grineski, Aaron B. Flores, Timothy W. Collins, Jayajit Chakraborty

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Other Hurricane Harvey Papers

Contact Aaron if you would like a PDF – aaron.b.flores@utah.edu

- Grineski, Sara, Flores, Aaron, Collins, Timothy and Chakraborty, Jayajit. (2019). The impact of Hurricane Harvey on Greater Houston households: Comparing pre-event preparedness with post-event health effects, event exposures, and recovery. *Disasters*.
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