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The Post Hurricane Harvey Respiratory Protection Training Program

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Objectives: This study evaluated the effectiveness of an outreach program which included safety training and the distribution of personal protection kits in the Houston area in the aftermath of Hurricane Harvey. **Methods:** *Outreach*: 71 volunteers conducted training sessions at 19 different sites and distributed a total of 1187 kits. *Follow-up study*: We conducted telephonic interviews to collect data on respiratory symptoms and obtain perceptions of the quality of the safety training provided among 83 participants. **Results:** Participants reported an increase in airway symptoms four weeks after Hurricane Harvey. Outreach efforts were felt to be effective by a majority of participants. **Conclusion:** Future studies may adopt some of the best practices from our training efforts in terms of utilizing a combination of verbal demonstrations and written training guidelines on proper respirator usage.

Keywords: climate change, disaster preparedness, education, flooding, outreach, respiratory disease, respiratory mask, social vulnerability index

BACKGROUND

Over the last decade, the United States (U.S.) has seen numerous flooding disasters both inland and in coastal areas.[1] Flooding due to hurricanes and heavy rainfall is the most common natural disaster in the U.S.; in the past ten years, over 70% of presidential disaster declarations were due to flooding.[2] Based on, the bulk of research on climate change, extreme weather events are likely to continue to increase in occurrence and severity.[3,4] The aftermath of a flooding event is associated with numerous health problems, particularly those associated with the respiratory system. Following Hurricane Harvey in Houston, Texas, the Southwest Center for Occupational and Environmental Health (SWCOEH) at The University of Texas Health Science Center at Houston (UTHealth) School of Public Health initiated disaster research response (DR2) activities,[5] including an outreach program to provide local residents and workers with personal protection equipment (PPE) and training to work safely on remediation activities in the aftermath of the storm's devastation. Six months later, we launched a follow-up study among residents and workers who received training. Our objectives were to: (1) obtain a profile of the respiratory health of participants six months after Hurricane Harvey and (2) obtain perceptions and feedback about the quality of the training they received regarding the proper use of PPE when remediating homes and businesses. All activities were reviewed and approved by the UTHealth Committee for the Protection of Human Subjects (CPHS).

METHODS

Outreach Efforts

Led by the SWCOEH Director, faculty and staff initially met the week after the hurricane to develop a plan and designate coordinators for outreach and research activities. We first obtained donations of supplies from a mask manufacturing company, VWR™. The SWCOEH and UTHealth School of Public Health also allocated funds for the relief effort. Following a school-wide call for volunteers, we recruited and trained 71 school staff, faculty, students, friends, and family as volunteers for the outreach program. As part of their training, volunteers watched an instructional video (developed by the SWCOEH with its community partner, the Environmental Defense Fund) detailing proper PPE use to help educate recipients. Volunteers assembled personal protective kits that contained English and Spanish instructions on proper PPE use, a NIOSH issued training handout on how to put on and remove a disposable respirator,[6] a NIOSH approved N-95 respirator, a pair of nitrile gloves and a card that included contact information for the SWCOEH outreach team. Coordinators reached out to personal and professional contacts from a variety of religious, charity, and academic organizations in Harris County (where Houston is located) to identify distribution sites for the program. These initial community contacts in turn connected the SWCOEH team with a much larger network of organizations working on similar relief efforts. After a review of available organizations, we focused our outreach efforts on working at selected civic/community centers embedded in areas most affected by flooding in the days immediately following the hurricane. Volunteers distributed 1187 of these personal protection kits at 19 different sites. 276 recipients of these kits gave permission to be re-contacted.

Follow-up Study

A questionnaire in both English and Spanish was administered by a staff member who was fluent in both of these languages.

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Clinical significance: This study helps clinicians becomes aware of the health problems associated with remediating buildings in the aftermath of a flood. The study also highlights how clinicians can provide support to areas damaged by natural disaster and how this support can be objectively evaluated afterwards.

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This questionnaire was largely adapted from a survey designed to interview post Katrina flood victims about health symptoms.[7] From the 276 residents who were re-contacted about 6 months after Harvey made landfall, 87 participants were recruited for the study; 83 of these individuals were reached via telephone contacts and four through email.

The questionnaire contained questions relating to the participant: (1) demographic information; (2) the degree to which the home was damaged by the storm; (3) the extent to which the distributed personal protection kit was used and where additional supplies were procured; and (4) participant's respiratory symptoms before and after the storm. A bilingual interviewer administered the 15 to 30 minute questionnaire based on participant's language preference (English or Spanish) after verbal consent was obtained and documented.

Statistical Analysis

All statistical analyses were conducted using SAS (version 9.4, Cary, NC). Data on three participants were eliminated due to inconsistent and missing responses. The social vulnerability index (SVI) was calculated for each participant based on their home address. The SVI utilizes U.S. census tract level data to identify communities that are likely to need additional external assistance to prepare for a potential hazard or recover from a disaster. It is calculated based on a 0 to 1 scale with 0 being the least vulnerable and 1 being most vulnerable.[8]

Questionnaire data were either recoded into categorical variables or simplified into binary variables to allow for more efficient analyses. Comparison of respiratory health-related symptoms (eg, nasal congestion, hoarseness/irritated throat, chest wheezing/whistling, chest tightness/shortness of breath, and coughing attacks) in the four weeks prior to and following Hurricane Harvey were evaluated utilizing McNemar's test. Significance was considered at $\alpha = 0.05$. Exact McNemar's tests were employed for discordant pairs with values less than 20. The impact of N-95 masks on respiratory symptoms in the four weeks following Hurricane Harvey were evaluated using Fisher's Exact tests.

RESULTS

Of the 84 interviews, half were conducted in English (51%) and the other in Spanish (49%). The mean age of participants was 51 years old and the majority self-identified as female (81%) and identified as Hispanic (56%) (Table 1). Mean (Standard Deviation) SVI score was 0.73 (0.29). The majority were homeowners (59%) whose residence had flooded (89%), and 85% of all respondents had not completed cleanup activities at the time of the interview (Table 1). The mean height of flood water reported inside the home was 2.4 feet. On average, flood waters remained in the house for 57 hours (Table 1).

Almost all respondents (98%) reported using the N-95 respirators contained in the kits and that they found the accompanying verbal and written instructions to be effective (94% and 96%, respectively). The majority (56%) reported using additional masks that were either provided through their employer, bought at a store or obtained through other means; most residents reported they replaced their mask when it became dirty (Table 2, Graphical Abstract, http://links.lww.com/JOM/A792).

Most respondents after Harvey reported upper airway symptoms, such as nasal congestion (63%) and coughing attacks (56%). Most notably, among those who had no respiratory symptoms four weeks prior to Harvey, the majority reported new onset of nasal congestion (59%) and coughing attacks (53%) four weeks after. To a lesser extent, respondents also reported new onset of lower air way symptoms (chest wheezing/whistling; 20% and chest tightness; 25%) (Table 3).

TABLE 1. Sociodemographic, Housing and Flood-Related Characteristics, Hurricane Harvey Respiratory Protection Educational Program Participants, Harris County, Texas, 2017 ($n = 83$)

Characteristic	*N* (%)
Sex	
Male	15 (19)
Female	66 (81)
Race	
Caucasian	40 (50)
African American	27 (34)
Other	13 (16)
Ethnicity	
Hispanic	45 (56)
Non-Hispanic	35 (44)
Language of interview	
English	40 (51)
Spanish	39 (49)
Age (y)	
20–39	
40–59	
60+	
Housing type	
Apartment	7 (8)
Attached single family house (duplex)	4 (5)
Free-standing single-family home	68 (83)
Other	3 (4)
Housing status before Harvey	
Owned	48 (59)
Rented	23 (28)
Other (staying with relatives or friends, etc)	11 (13)
Resident-volunteer-worker status	
Resident whose place of residence was flooded	75 (89)
Professional worker in flooded homes	2 (2)
Volunteer worker in flooded homes	4 (5)
Other	3 (4)
Status of home cleanup	
Cleanup completed	12 (15)
Cleanup not completed	70 (85)
Height of floodwater	
<1 foot	17 (20)
1–3 feet	48 (57)
>3 feet	19 (23)
Duration of floodwater in home	
<24 h	17 (20)
24–48 h	31 (37)
>48 h	36 (43)
Number of water-damaged homes cleaned	
1	39 (49)
>1	41 (51)
Social vulnerability index (SVI)	
0–<0.33 (least vulnerable)	14 (17)
0.33–<0.67 (middle third)	3 (4)
0.67–1 (most vulnerable)	67 (80)

DISCUSSION

Hurricane Harvey was unprecedented in terms of the amount of rainfall that occurred in a 48-hour time frame and the extensive amount of flooding it caused in Harris County, Texas and the surrounding areas. Understanding how our community was affected by this storm and identifying the best way to keep members healthy during recovery are essential for learning to cope with future occurrences. Our study helps to further illustrate the health risks that both residents and workers face when restoring flooded homes. Cummings and colleagues reported that Louisiana residents working in water-damaged homes from Hurricane Katrina

TABLE 2. N-95 Respirator-Related Characteristics Hurricane Harvey Respiratory Protection Educational Program Participants, Harris County, Texas, 2017 ($n = 83$)

Mask Use Characteristic	*N* (%)
N-95 masks usage	
Yes	80 (98)
No	2 (2)
Additional masks usage	
Yes	46 (56)
No	36 (44)
Method of additional mask retrieval	
Store	17 (37)
Work	2 (4)
Other	27 (59)
Mask/respirator usage	
Manufacturer's instructions	6 (13)
Television/radio/newspaper	–
Instructions given at work	1 (2)
Store employee/clerk	0
Friend/relative/neighbor	3 (6)
Website	–
Instructions hand-out in bag	8 (17)
Verbal instructions from volunteers	15 (32)
Previous experience	3 (6)
No information (simply used the mask)	9 (19)
Other	2 (5)
Mask replacement conditions	
When it became dirty	26 (55)
When it became damaged	4 (9)
When it became harder to breathe through the mask	5 (11)
Other	9 (19)
Have never replaced the mask	3 (6)

demonstrated a significant increase in upper and lower respiratory symptoms that increased with the length of time of exposure.[7] Rando surveyed workers restoring Katrina flooded homes and identified a significant increase in symptoms of cough and sinusitis in male workers and dyspnea for female workers.[9] Like these previous studies, we also demonstrated more of a significant increase in upper compared to lower airway symptoms. Several potential etiologies may explain this finding. The hot, humid conditions that mark the summer months in the Gulf Coast region serve as the ideal platform for allergen-inducing molds to grow on structures damaged by flood waters.[10,11] Moreover, the process of removing all of the interior furnishings and construction materials of a flooded home is also fraught with health hazards. Sheetrock material, for instance, becomes aerosolized in the process of removal and is an irritant for the upper and lower respiratory tract.[12] Adequate protection from these hazards includes the use of an approved N-95 respirator to minimize exposure to airborne contaminants such as dust and mold spores.[13] Our outreach project[5] and subsequent survey contributed to our understanding of how to effectively teach residents of flooded communities about how to properly wear and use a mask.

Previous studies of the quality of mask training programs has been assessed in a controlled office environment.[14–16] To our knowledge, this is the first study that evaluates the quality of a respiratory protection training program delivered in the field, in the immediate aftermath of a flooding disaster. The results of our study show that nearly all of our participants felt that both our verbal methods and our written material were effective means of communicating vital safety information on proper PPE use. Moreover, nearly all recipients of the masks reported using the distributed masks during remediation. These findings suggest that our outreach efforts were a successful approach to providing training. Additional research is needed that measures how well users are wearing their masks and if they are wearing them when they need to. NIOSH recommends that respirators be replaced when mask become damaged, soiled hours or when breathing becomes difficult.[17] It was unanticipated that only slightly over half of participants reported using additional masks, other than what was provided to them in the exposure prevention kits, which suggests that over half of the mask users did not replace, and perhaps did not have the means to replace, the initial set of masks distributed to them. The lack of continuous use, combined with the high percentage of participants who reported new onset respiratory symptoms after the storm, suggests that the participants in our program were poorly equipped to protect themselves during the many hours of working in restoring homes with poor indoor air quality. It is critical that disaster researchers and community support agencies improve the quality of safety training for at risk communities and develop improved plans for the rapid distribution of PPE in the advent of a flooding disaster. Finally, a large majority of respondents had not completed remediation on their homes at least six months after the hurricane. One explanation could be that many residents lack the financial means to restore their homes. For many, Harvey was the third flood in two years that affected their homes resulting in the lack of financial wherewithal to start renovation yet again. Harvey is estimated to have caused an estimated $125 billion dollars in damage in the area, displaced 30,000 people, and destroyed over 200,000 homes and businesses (4). The National Flood Insurance Program was not funded to deal with such overwhelming destruction and was not intended to fully compensate flooded insurance holders for the full value of their house.[18]

Strengths and Limitations

This study provides valuable insight into how participants of flooded communities are affected 6–8 months after the disaster. The survey also points to longer term benefits of safety training that is provided to them in the immediate aftermath of the flood. Nonetheless, our results suggest that educational programs that target flooded residents need to reinforce messages about continued use of masks and gloves while restoring damaged buildings. The relatively high average SVI of participants surveyed suggests that they lived in neighborhoods that were socially vulnerable to floods and other disasters and, hence, were representative of the population that we wished to serve in distributing safety kits and training. Reaching our target population was facilitated through interactions with, and support from, our community and faith-based partners. However, only about 1/3 of participants who received the kits agreed to be re-surveyed and this relatively small sample size limited analyses of associations between the degree of flooding and mask usage, mask usage and neighborhood-level indices of social vulnerability to floods and mask usage and development of new-onset respiratory symptoms.

RECOMMENDATIONS

The findings of this study identify a number of opportunities to improve how communities respond to natural flooding disasters.

Availability of Recovery Assistance for the Weeks and Months following a Flooding Event

Our preliminary research indicates that while most participants used the initial resources given to them they either did not have access to or did not choose to continue to use additional safety protection after the first few days of the storm. As was evident from this study, outreach programs need to be implemented in flooded communities that continue to provide both health and safety training as well as supplies for at least 6 months after the event.

TABLE 3. Comparison of Respiratory Health-Related Symptoms in the Four Weeks Prior to and Four Weeks Following Hurricane Harvey

	Nasal Congestion—4 Weeks Following Hurricane Harvey (*N*, %)		
Nasal Congestion—4 Weeks Prior (*N*, %)	**Yes (51, 63%)**	**No (30, 37%)**	***P* value***
	***N* (%)**	***N* (%)**	
Yes (15, 19%)	12 (80)	3 (20)	<0.0001
No (66, 81%)	39 (59)	27 (41)	
	Hoarseness/Irritated Throat—4 Weeks Following Hurricane Harvey (*N*, %)		
Hoarseness/Irritated Throat—4 Weeks Prior (*N*, %)	**Yes (40, 49%)**	**No (41, 51%)**	***P* value***
	***N* (%)**	***N* (%)**	
Yes (7, 9%)	5 (71)	2 (29)	<0.0001
No (74, 91%)	35 (47)	39 (53)	
	Chest Wheezing/Whistling—4 Weeks Following Hurricane Harvey (*N*, %)		
Chest Wheezing/Whistling—4 Weeks Prior (*N*, %)	**Yes (19, 24%)**	**No (61, 76%)**	***P* value***
	***N* (%)**	***N* (%)**	
Yes (4, 5%)	4 (100)	–	0.0001
No (76, 95%)	15 (20)	61 (80)	
	Chest Tightness/Shortness of Breath—4 Weeks Following Hurricane Harvey (*N*, %)		
Chest Tightness/Shortness of Breath—4 Weeks Prior (*N*, %)	**Yes (23, 29%)**	**No (57, 71%)**	***P* value***
	***N* (%)**	***N* (%)**	
Yes (4, 5%)	4 (100)	–	<0.0001
No (76, 95%)	19 (25)	57 (75)	
	Coughing Attacks—4 Weeks Following Hurricane Harvey (*N*, %)		
Coughing Attacks—4 Weeks Prior (*N*, %)	**Yes (45, 56%)**	**No (36, 44%)**	***P* value***
	***N* (%)**	***N* (%)**	
Yes (7, 9%)	6 (86)	1 (14)	<0.0001
No (74, 91%)	39 (53)	35 (47)	

*Significance $\alpha = 0.05$.

Further Research into Effective Ways to Deliver Flood Relief

More research is needed to identify the barriers that prevent residents of affected communities from continuing to use personal protection after initial educators and relief workers have left the area. There is a need for more studies that include objective measurements of the effectiveness of current personal protection guidelines

CONCLUSION

Overall, the Hurricane Harvey Outreach and Protection pilot study offered unique insights into how to better prepare for large-scale flooding disasters, which are expected to increase in severity and incidence due to a changing climate.[19] Proper training on the use of PPE for those working to recover an affected community is an important part of this preparation and future studies in this area are critical to continue to improve response efforts.

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