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Floodwater Exposure and the Related Health Symptoms Among Firefighters in New Orleans, Louisiana 2005

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Background *Concerns over increased reports of physical health symptoms thought to be related to floodwater exposure among New Orleans firefighters prompted a health hazard evaluation of firefighters following Hurricane Katrina.*

Methods *A questionnaire assessing health symptoms possibly related to the response to Hurricane Katrina was administered to all New Orleans Fire Department (NOFD) personnel within 3 months of the disaster. Descriptive statistics were compiled and prevalence ratios (PR) were estimated for covariates using generalized linear models with Log link and Poisson distribution.*

Results *Of the 525 firefighters who completed the questionnaire (77% participation), 201 (38%) reported one or more new-onset respiratory symptoms, such as sinus congestion (145 [28%]), throat irritation (92 [17%]), and cough (124 [24%]). Skin rash was reported by 258 (49%) of respondents, 414 (79%) reported skin contact with floodwater, and 165 (32%) reported contact with floodwater on multiple days. In multivariate analyses adjusting for age, gender, and smoking, firefighters who had floodwater contact with skin and either nose/mouth or eyes (224, 44%) had an increased rate of new-onset upper respiratory symptoms (PR = 1.9; 95% confidence interval [CI], 1.1, 3.1), and skin rash (PR = 2.1; 95% CI, 1.4, 3.2) compared to those not exposed to the floodwater.*

Conclusions *Response workers involved with floodwater should minimize direct skin and mucosal contact with floodwater if possible through the use of appropriate personal protective equipment, such as goggles, safety glasses with side shields, or full-face shields.* Am. J. Ind. Med. 50:377–382, 2007. *© 2007 Wiley-Liss, Inc.*

KEY WORDS: floodwater; firefighter; hurricane; Katrina; respiratory symptoms; skin rash; response workers

INTRODUCTION

In August and September 2005, Hurricanes Katrina and Rita made landfall in the United States, passing New Orleans, Louisiana. Heavy winds and rain damaged and breached several levees protecting the city. The levee breaches flooded up to 80% of the city with water reaching a depth of 7 m in some areas [Knabb et al., 2005]. When the Hurricanes made landfall in New Orleans, more than 600 career firefighters worked for the New Orleans Fire Department (NOFD). Both during and after the hurricanes, firefighters participated in rescue and

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recovery activities, while maintaining their normal fire suppression duties [International Association of Fire Fighters, 2005].

Following the hurricanes, reports of increased injuries, symptoms of physical illness, and psychological strain among the NOFD personnel prompted the National Institute for Occupational Safety and Health (NIOSH) to conduct a health hazard evaluation of firefighters to determine the scope of these injuries and illnesses [CDC, 2006b].

Previous studies have found increased rates of respiratory symptoms among residents after flooding in community settings [Siddique et al., 1991; Biswas et al., 1999; Ursano et al., 1999; Kunii et al., 2002]. Although mental health concerns among firefighters following natural disasters are well documented [Fullerton et al., 2004; Simons et al., 2005], little is known about the prevalence of physical health symptoms and their relationship to floodwater exposure. Because firefighters are relied upon to provide emergency life saving services during and following a disaster, it is essential that they remain healthy. This study examined the associations between floodwater exposure and physical health symptoms reported 12 weeks after Hurricane Katrina.

METHODS

The questionnaire survey was conducted at 15 fire stations, 8 of which were temporary staging areas, in New Orleans Parish from November 29, 2005 to December 5, 2005. An anonymous and self-administered questionnaire asked about demographics, past medical history, smoking history, work duties and location, hurricane-related activities, and symptoms experienced during and after the hurricanes.

Floodwater Exposure

We asked participants whether they were exposed to floodwater with skin contact as well as nose/mouth or eye contact. The duration of contact with floodwater was assessed as follows: (1) not at all, (2) for a few minutes, (3) for a few hours, and (4) for a few days. Combining the types of contact with floodwater and the duration of exposure, respondents were categorized into four exposure groups: (1) those whose skin and as well as nose/mouth or eyes were in contact with floodwater for longer than an hour up to a few days, (2) those whose skin as well as eyes or nose/mouth were exposed to floodwater for a few minutes only, (3) those whose exposure was limited to skin only for longer than a few hours, and (4) those with no exposure to floodwater. Nine participants who did not answer the question of nose/mouth or eye exposure to floodwater but answered ''not at all'' to the question about exposure duration were classified as having no contact with floodwater.

Health Outcomes

Information was obtained on physical symptoms (i.e., upper respiratory symptoms, cough, lower respiratory symptoms, gastrointestinal symptoms, and skin problems). New-onset symptoms were defined by a positive response to the question, ''Have you had any of the following symptoms after Hurricane Katrina?'' and having these symptoms ''Almost everyday or everyday'' and no symptoms of interest during the week prior to Hurricane Katrina. ''Lower respiratory symptoms'' were defined as wheezing, shortness of breath, or chest tightness. ''Upper respiratory symptoms'' were defined as head/sinus congestion or nose/throat irritation. Individuals who reported either cough with phlegm or cough without phlegm were grouped as ''Cough.'' Skin rash included boil, blister, pimple, itching, redness, or swelling. Participants who reported skin rash were asked which body parts were affected.

Statistical Analysis

Post-hurricane prevalences of new-onset health outcomes were calculated. The relationships between floodwater exposure and reported health symptoms were evaluated. Results are presented as prevalence ratios (PR) and 95% CI. The generalized linear model with Log link and Poisson distribution assumption was employed to estimate PRs and 95% CIs for covariates adjusting for age, gender, smoking status, and other terms in the models [McCulloch and Searle, 2000; Barros and Hirakata, 2003]. PROC GENMOD in SAS (v.9.12) was used for multiple regression analyses.

RESULTS

Of 683 employees on the latest pre-hurricane roster, 525 (77%) completed the questionnaire. There were 774 employees recorded on the roster, 59 employees were out due to on-the-job injury, 20 employees were on annual leave, and 12 resigned after the hurricanes.

The average age of participants was 42 years (range 20–64) and 4% were female. Of the 521 respondents who provided job titles, 101 (19%) were fire truck/ladder truck operators or engineers, 222 (43%) were line firefighters, and 161 (31%) were officers including 29 chief officers. Thirty-seven employees (7%) were in fire service administration, such as dispatchers, employees of the deputy office, and human resource personnel (Table I).

Seventy-nine percent reported skin contact with floodwater and 51% reported nose/mouth or eye contact

TABLE I. Characteristics of Participating NOFD Personnel

Characteristics	N	%[a]
Age (years)		
≤34	150	29.1
35–44	137	26.6
45–54	178	34.6
55 and above	50	9.7
Gender		
Male	502	96.0
Female	21	4.0
Job title		
Line firefighters	222	42.6
Officer	132	25.3
Operator/engineer	101	19.4
Fire service administration	37	7.1
Chief officer	29	5.6
Smoking status		
Never smoked	308	58.9
Current smoker	107	20.5
Former smoker	108	20.6
Skin contact with floodwater		
Yes	414	79.0
No	110	21.0
Nose, mouth, or eye contact with floodwater		
Yes	254	50.8
No	246	49.2
Skin contact with sediment after floodwater receded		
Yes	394	75.8
No	126	24.2
Combination of exposure variables		
Skin contact with floodwater and sediment, and nose/mouth or eye contact with floodwater	230	44.0
Skin contact with floodwater and sediment	110	21.0
Skin and nose/mouth or eye contact with floodwater	22	4.2
Only skin contact with floodwater	52	9.9
Only skin contact with sediment	53	10.1
No contact with floodwater or sediment	56	10.7
Duration of floodwater contact		
Not at all	90	17.5
Few minutes	86	16.7
Few hours	173	33.7
Few days	165	32.1

[a]Denominators range from 489 to 525 due to missing values.

with floodwater. Among 414 persons who reported skin contact with floodwater, 340/414 (82%) also reported skin contact with sediment after the floodwater receded and 252/414 (61%) reported floodwater contact with their nose/mouth, or eyes. After the floodwater receded, 394 persons (76%) reported skin contact with sediment; 165 (32%) reported they had contact with floodwater for multiple days.

Table II lists the prevalence of new-onset health symptoms since the hurricanes by job title, age group, and gender. Of the 525 firefighters, 162 (31%) reported new-onset upper respiratory symptoms, lower respiratory symptoms (55 [11%]), and cough (124 [24%]). Skin rash was reported by 258 (49%) of respondents. Prevalence of health symptoms varied by job title and age. Women reported a higher prevalence of health symptoms than men except for skin rash (43% vs. 50%).

Table III lists the prevalence and PR of health symptoms by categories of exposure to floodwater. The PR of each health symptom was adjusted for age, gender, and current smoking status in multiple regression models. Those who had floodwater exposure to their skin and either eyes or nose/mouth for longer than a few hours reported a higher prevalence of upper respiratory symptoms (PR = 1.9; 95% CI: 1.1, 3.1), cough (PR = 1.9; 95% CI: 1.0, 3.3), and skin rash (PR = 2.1; 95% CI: 1.4, 3.2) than those with skin exposure only or those not exposed to floodwater. Exposure to sediment was not significantly associated with physical symptoms (results not shown) when adjusted for floodwater contact. An increased prevalence of gastrointestinal symptoms was found among firefighters who were exposed to floodwater, but the relationship was not statistically significant (results not shown).

DISCUSSION

The prevalences of respiratory symptoms and skin rashes reported by firefighters are similar to those found among relief workers reported through the Centers for Disease Control and Prevention (CDC) active surveillance system in the Greater New Orleans area [CDC, 2005a,b, 2006a].

Hazards in floodwaters vary but can include varying amounts of sewage, household and industrial chemicals, petroleum products, pesticides, and flammable liquids. Floodwaters also can obscure physical hazards (e.g., storm debris or drainage openings); other threats are posed by displaced domestic animals [U.S. Environmental Protection Agency, 2005; National Institute of Environmental Health Sciences, 2005]. New-onset health symptoms reported by firefighters were significantly associated with floodwater exposure. Elevated rates of new-onset upper respiratory symptoms were found among firefighters who directly contacted their skin and nose/mouth or eyes with floodwater for longer than a few hours. Firefighters reportedly used floodwater and contaminated water from the municipal supply to suppress fires during the flooding. This could have resulted in mucosal exposure (through nose/mouth or eyes) to airborne materials from the contaminated waters. Mucosal exposure to the floodwater may also imply more

TABLE II. Prevalence (%) of Health Outcomes by Participants' Characteristics

		Health outcomes[a]			
	N	Upper respiratory symptoms[b]	Lower respiratory symptoms[c]	Cough[d]	Skin rash[e]
Total	525	30.9	10.5	23.6	49.1
Job title					
Officer	161	39.1	7.3	29.8	52.8
Fire service administration	37	35.1	10.5	16.2	46.0
Line firefighter	222	26.1	11.1	21.2	48.2
Operator/engineer	101	26.7	10.9	21.8	46.5
Total	521				
Age (years)					
≤34	150	28.0	10.0	20.7	46.0
35–44	137	30.7	7.3	24.1	52.6
45–54	178	34.3	11.2	26.4	50.0
55 and above	50	30.0	16.0	24.0	54.0
Total	515				
Gender					
Female	21	42.9	14.3	23.8	42.9
Male	502	30.5	10.4	23.7	49.6
Total	523				

[a]New-onset individual symptoms were defined by a positive response to the question, "Have you had any of the following symptoms after the hurricane Katrina?" and having these symptoms "Almost everyday or everyday" and "Had no symptoms prior to hurricane Katrina."
[b]Upper respiratory symptom defined as having either (1) head/sinus congestion or (2) nose/throat irritation.
[c]Lower respiratory symptoms defined as having (1) shortness of breath, (2) wheezing, or (3) chest tightness.
[d]Cough defined as having either (1) dry cough or (2) cough with phlegm.
[e]Skin rash defined as experiencing (1) bumps, (2) blisters, (3) boils, (4) itching, (5) swelling, or (6) redness.

vigorous engagement in activities, which could result in increased exposures to substances in the floodwater.

The causal relationship between exposure to substances in the floodwater and reported symptoms is uncertain. However, this investigation presented differential relationships between respiratory symptoms and skin rash and floodwater exposure by route of exposure (through skin vs. mouth/nose or eye) and the duration of exposure (a few minutes vs. longer than a few hours). These findings imply that ingested or inhaled floodwaters may pose more risk of respiratory symptoms than skin contact with floodwater, and the longer exposure to floodwater (i.e., longer than a few hours), the more risk of respiratory symptoms and skin rash. This study suggests the need for further efforts to obtain objective measures of occupational exposures to potential hazards in floodwaters.

A relatively high response rate was obtained (77%) for available firefighters, minimizing the potential for selection bias. However, the participants included current firefighters only and excluded those who were on sick leave and on-the-job injury leave. Therefore, there may be a potential underestimation of the prevalence of health symptoms. The findings in this investigation are also subject to a recall bias. Respondents who experienced physical health symptoms may have over-reported the duration of floodwater contact and exposure through the nose or mouth.

Due to the limitation of this cross-sectional survey, the investigation cannot confirm a causal relationship between physical health symptoms and the exposure to floodwater. However, to better prepare for future disasters, it is important to understand the patterns of occupational health symptoms that may result from responding to natural disasters. Improving preparedness efforts aimed at protecting emergency responders can benefit national preparedness against the inevitable consequences of natural or technological disasters. This study examined the extent of physical symptoms reported among firefighters and described associated factors, knowledge of which could be helpful in identifying appropriate steps to reduce long-term impact from these events. Early during the rescue period post-hurricane, NIOSH provided interim guidance that response workers involved with floodwater should minimize direct skin contact with floodwater if possible through the use of appropriate personal protective equipment, such as goggles, safety glasses with side shields, or full face shields [NIOSH, 2005a].

Full clinical diagnostic assessment of health conditions is necessary to determine the breadth and scope of

TABLE III. Prevalence (%) and the Adjusted PR* of Physical Symptoms** by Types of Exposure to Floodwater (N = 514)

Exposure category	N		Upper respiratory symptoms[a]	Lower respiratory symptoms[b]	Cough[c]	Skin rash[d]
Skin and either nose/mouth or eye contact with floodwater longer than a few hours	224	%	39.7	14.3	32.1	65.2
		PR (95% CI)	1.86 (1.12, 3.11)	1.85 (0.78, 4.37)	1.85 (1.04, 3.30)	2.11 (1.38, 3.23)
Skin and either nose/mouth or eye contact with floodwater for a few minutes	86	%	29.1	8.1	22.1	43.0
		PR (95% CI)	1.34 (0.73, 2.45)	1.03 (0.34, 3.11)	1.42 (0.72, 2.82)	1.40 (0.85, 2.31)
Skin contact only with floodwater for longer than a few hours	125	%	21.6	6.4	13.6	37.6
		PR (95% CI)	1.06 (0.58, 1.92)	0.90 (0.32, 2.54)	0.84 (0.41, 1.70)	1.24 (0.77, 2.02)
No contact with floodwater	90	%	23.3	8.9	17.8	31.1
		Reference	1	1	1	1

*Prevalence ratios adjusted for age, gender and smoking (current smoker/non smoker).

**Individual symptoms but skin rash were defined by a positive response to the question, "Have you had any of the following symptoms after the hurricane Katrina?" and having these symptoms "Almost everyday or everyday" and "Had no symptoms prior to hurricane Katrina".

[a]Upper respiratory symptom defined as having either (1) head/sinus congestion or (2) nose/throat irritation.

[b]Lower respiratory symptoms defined as having (1) shortness of breath, (2) wheezing, or (3) chest tightness.

[c]Cough defined as having either 1) dry cough or 2) cough with phlegm.

[d]Skin rash defined as experiencing (1) bumps, (2) blisters, (3) boils, (4) itching, (5) swelling, or (6) redness.

illness in persons with persistent symptoms, and to reduce the burden of current and possible long-term effects of illness and injury among NOFD personnel. The NOFD should consider phasing in annual medical evaluations of fire fighter personnel. These medical evaluations should adhere to published fire service standards and/or initiatives [International Association of Fire Fighters (IAFF) and International Association of Fire Chief, 1997; National Fire Protection Association, 2003] and be implemented after joint approval by management and union representatives. The NIOSH has prepared guidance for medical screening to assess the fitness of persons for deployment as recovery workers after a hurricane [NIOSH, 2005b]. These guidelines also can be used as a part of periodic medical evaluations to assess whether emergency responders meet minimal physical requirements to perform work duties.

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