NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2006-0023-3003
New Orleans Fire Department
New Orleans, Louisiana

June 2006

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

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This report was prepared by SangWoo Tak and Chad H. Dowell of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Bruce Bernard, Rick Driscoll, Linda Ewers, Tom Hales, Brad King, Andrea Markey, Elena Page, and Lauralynn Taylor McKernan. Analytical support was provided by DataChem Laboratories, Salt Lake City, Utah. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

Copies of this report have been sent to employee and management representatives at the New Orleans Fire Department (NOFD) and the OSHA Regional Office. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

In October 2005, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the New Orleans Fire Department (NOFD) and the International Association of Fire Fighters Local 632 (IAFF). They were concerned about exposure to the floodwater and sediment and mental health issues among fire fighters following hurricanes Katrina and Rita. NIOSH personnel conducted an investigation in October, November, and December 2005.

What NIOSH Did

- We conducted a questionnaire survey to NOFD personnel at all fire houses and staging areas
- We looked at the prevalence of mental and physical health symptoms
- We analyzed relationships between health symptoms and factors related to hurricane Katrina

What NIOSH Found

- Fire fighters whose skin and mouth/nose were in contact with floodwater reported more upper respiratory symptoms and skin rash compare to those not exposed to the floodwater.
- Fire fighters with lower respiratory symptoms and skin rash reported more depressive symptoms than those without lower respiratory symptoms and skin rash.
- Fire fighters involved in gunshot incidents and body recovery reported more posttraumatic stress disorder symptoms than those not involved in these activities.

What New Orleans Fire Department Managers Can Do

- Provide clinical evaluation and appropriate medical follow-up for physical and psychological health conditions for fire fighters
- Provide specific health and safety protective measures for fire fighters during and after natural disasters.
- Strengthen the existing health and safety program, and integrate training programs specifically for future emergency responses.
- Establish a committee to encourage communication within the NOFD and between supervisors and employees.

What the New Orleans Fire Department Employees Can Do

- Report potential work-related physical and psychological symptoms to supervisors and participate in clinical evaluation and medical follow-up programs.
- Use appropriate personal protective equipment such as goggles when responding to future flood emergencies.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2006-0023-3003

Health Hazard Evaluation Report 2006-0023-3003
New Orleans Fire Department
New Orleans, Louisiana
June 2006

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SUMMARY

In October 2005, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the New Orleans Fire Department (NOFD) and the International Association of Fire Fighters Local 632 (IAFF). This HHE request concerned health hazards from exposure to the floodwater and sediment and the mental health of fire fighters following the NOFD's response to Hurricanes Katrina and Rita. Reported health problems included respiratory, throat, and sinus irritation; and symptoms suggestive of depression and anxiety.

NIOSH representatives conducted a survey to evaluate health concerns among fire fighters; 525 NOFD personnel participated in the survey. This self-administered questionnaire contained questions about demographics, job characteristics, lifestyle, work duties and location, hurricane-related activities, and symptoms that occurred during and after the hurricanes. The Center for Epidemiologic Study-Depression scale (CES-D) was used to assess symptoms associated with depression, and the Veterans Administration posttraumatic stress disorder (PTSD) checklist was used to define posttraumatic stress symptoms among participants.

Of the 525 fire fighters 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, 165 (32%) reported they had contact with floodwater on multiple days, 133 of 493 respondents (27%) had major depressive symptoms, and 114 of 518 (22%) showed posttraumatic stress disorder (PTSD) symptoms.

In multivariate analyses adjusting for age, gender, and smoking, fire fighters who had floodwater contact with skin and either eyes or nose/mouth (224, 44%) had increased risk of new-onset upper respiratory symptoms (prevalence ratio [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. Depressive symptoms were associated with new-onset lower respiratory symptoms (PR=1.8; 95% CI, 1.2-3.0), skin rash (PR=1.7; 95% CI, 1.2-2.6) and low supervisor support (PR=1.6; 95% CI, 1.1-2.3). Fire fighters housed with their family were less likely to report depressive symptoms (PR=0.7; 95% CI, 0.5-1.0) compared to those not living with their family. Higher prevalence of PTSD symptoms were reported from fire fighters involved in one or more gunshot incidents (PR=2.4; 95% CI, 1.6-3.7), guard duty (PR=1.8; 95% CI, 1.2-2.7), and body retrieval (PR=1.7; 95% CI, 1.1-2.6).

The results of the questionnaire survey showed that fire fighters who reported floodwater contact with their skin and nose/mouth or eyes for longer than a few hours at the time of the hurricanes reported

significantly more upper respiratory symptoms than those who reported no contact with the floodwater. Fire fighters with respiratory symptoms and skin rash also reported more depressive symptoms than those without respiratory symptoms and skin rash. Fire fighters involved in gun shot incidents and body retrieval in response to the hurricanes were more likely to report PTSD symptoms. Clinical follow-up of affected fire fighters for physical and psychological conditions should be implemented.

This report, along with the environmental survey conducted at the Jackson Barracks temporary staging area (Appendix A) should be construed as the final report. The environmental evaluation looked at fire fighter activities during simulated apparatus runs, and included air sampling to evaluate fire fighter exposures to dust. For the fire fighters working out of the Jackson Barracks temporary staging area, airborne exposures to respirable particulates and silica, total particulates, and elements (metals and minerals) were below all applicable exposure criteria.

NIOSH investigators determined that a work-related hazard existed among New Orleans fire fighters due to Hurricane Katrina-related exposures. We found that physical and mental health symptoms were associated with work-related exposures. This report includes recommendations pertaining to these findings.

Keywords: NAICS 922160, fire fighter, Katrina, Rita, hurricane, depression, floodwater, emergency response, natural disaster, respiratory symptoms, skin rash

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INTRODUCTION

In October 2005, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the New Orleans Fire Department (NOFD) and the International Association of Fire Fighters Local 632 (IAFF). The HHE request concerned health hazards from exposure to the floodwater and sediment from Hurricanes Katrina and Rita and mental health of the fire fighters following the NOFD's response to the hurricanes. Reported health problems included respiratory, throat, and sinus irritation; and symptoms suggestive of depression and anxiety.

NIOSH representatives met with the NOFD and the IAFF to discuss the concerns listed in the HHE request on October 17, 2005, and October 19, 2005, respectively. The meetings included an overview of the NIOSH HHE program, a review of the issues that prompted the HHE request, and a discussion of the scope of the NIOSH evaluation.

Between November 29, 2005, and December 5, 2005, after a joint meeting with NOFD and IAFF, NIOSH investigators made site visits to all of the fire stations in New Orleans Parish, Louisiana and conducted a health survey to examine the extent of physical and mental health symptoms among NOFD personnel.

On October 19, 2005, in response to concerns about sediment exposures during apparatus movement, NIOSH investigators conducted a site visit at the Jackson Barracks temporary staging area. The site visit included observations of fire fighter activities during simulated apparatus runs and environmental air sampling to evaluate fire fighter exposures to dust. Preliminary results for the environmental survey were reported in a letter dated December 21, 2005. The final results of the environmental survey are enclosed as Appendix A.

BACKGROUND

In August and September 2005, Hurricanes Katrina and Rita made landfall, passing within miles of 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 20 feet in some areas.[1] When the hurricanes made landfall in New Orleans, more than 600 career fire fighters worked for the NOFD. Because of the flooding in sections of New Orleans, a number of fire stations were closed and relocated to temporary headquarters in Algiers, Louisiana. As the floodwaters receded, fire fighters were moved back to their fire houses or temporary staging areas. During and after the hurricanes, fire fighters participated in rescue and recovery activities in addition to their normal fire suppression duties. Fire fighters worked long hours because of the vast devastation and limited personnel. During this time period, many of the fire fighters were separated from their family.

Following the hurricanes, the NOFD and the IAFF received anecdotal reports from fire fighters about health effects thought to be related to exposure to the floodwater and sediment. Fire fighters reported respiratory, throat, and sinus irritation. There were also concerns about symptoms suggestive of depression and anxiety. Fire fighters were dealing with complicated issues such as extended working hours, sleep deprivation, violent threats, and lack of communication with coworkers and families. Many also experienced personal stressors such as displacement of family members and the destruction of their homes.[2]

METHODS

Study Design

This cross-sectional survey included fire fighters working in all locations throughout New Orleans Parish. The survey was confidential and anonymous (no personal identifiers were obtained on the questionnaire). The self-

administered questionnaire asked about demographics, past medical history, smoking history, work duties and location, hurricane-related activities performed, and symptoms experienced during and after the hurricanes. NIOSH investigators visited each fire station or temporary staging area and were accompanied by representatives from the NOFD management or IAFF. The questionnaire was distributed to all fire fighters who worked in New Orleans Parish from November 29, 2005 to December 5, 2005.

Health Outcomes

Information was obtained on physical symptoms (i.e., upper airway irritation, 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 "Had no symptoms 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. Those who had either cough with phlegm or cough without phlegm were defined as "Cough." Skin problems included boil, blister, pimple, itching, redness, skin cut or laceration, and pain. Participants who reported skin problems were asked which body parts were affected.

The Center for Epidemiologic Study-Depression scale (CES-D)[3] was used to assess symptoms associated with depression, and the Veterans Administration posttraumatic stress disorder (PTSD) [4] checklist was used to define posttraumatic stress symptoms among participants. The CES-D scale has shown high levels of reliability and validity to detect both clinical and nonclinical symptoms of depressed mood for a wide range of study populations,[5,6] including psychiatric populations.[3] The CES-D was not originally designed for administration to those experiencing traumatic natural disaster; however there is no available instrument specifically designed for a survey in natural disasters. Because of the nature of the hurricanes and resultant floods, and the likelihood that respondents would be experiencing common acute symptoms similar to those found on the depression scale, we chose to narrow our focus to those having major depressive symptoms, and used a cut-off score of 22 out of 60 possible.

Factors Related to Hurricane Response

The questionnaire asked fire fighters about locations/activities at the time of the disaster, family safety, extent of home devastation, evacuation, contact with the floodwater and sediment, and job duties during the hurricanes.

For data analysis, combining the route of floodwater exposure and the duration, respondents were categorized into one of four exposure groups; 1) those whose skin **and** either eyes or nose/mouth were in contact with floodwater for longer than an hour up to a few days, 2) those whose skin **and** either 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.

Social support during and after the hurricanes was measured by asking the participant's satisfaction with communication and supportiveness from co-workers, supervisors, and the NOFD. We also asked participants whether or not they were staying with their families at the time of the survey and about changes in lifestyle, such as smoking, alcohol consumption, and social interactions. Participants were also asked about their perceptions of their family's safety during the disaster and the extent to which they were able to contact their family.

Statistical Analysis

Potential confounding factors, such as age, gender, smoking, and prior history of physical or mental health diagnoses, were taken into account in the multiple regression models. Because prior studies have found that persons with physical symptoms are more likely to report depressive symptoms,[7,8] we also analyzed the depressive

symptoms considering physical symptoms as covariates.

Descriptive statistics of demographic characteristics such as age, gender, and job title, were generated. The post-hurricane prevalence of physical, depressive, and PTSD symptoms were obtained. The relationships between factors related to the hurricanes and symptoms were examined. SAS (v.9.12) was used for statistical analyses. We employed the generalized linear models with LOG link and Poisson distribution to estimate prevalence ratios (PR) and the 95% confidence intervals for covariates adjusting other terms in the models. If the 95% confidence intervals (95% CI) excluded one, the PR was considered statistically significant at a significance level of $p = 0.05$. The PR represents the prevalence of the symptom in the exposed group (i.e., floodwater contact) relative to the prevalence in the unexposed group (i.e., no floodwater contact). A PR of one means that the prevalence of symptom in the exposed group is the same as the unexposed group, indicating no association between the symptom/illness and exposure. A PR of greater than one indicates that there is evidence of an association. For example, a PR of 1.5 would mean that prevalence of symptom in the exposed group is 50% higher than the unexposed group.

RESULTS

The questionnaire survey was conducted at 15 fire stations, eight of which were temporary staging areas. Each staging area housed one or more fire suppression units. One fire suppression unit consists of one captain, one operator who operates either a ladder truck or a fire truck, and two fire fighters who fight the fire. There were 774 employees recorded on the latest roster; 59 employees were out due to on-the-job injury, 20 employees were on annual leave, and 12 resigned after the hurricanes. Of the remaining 683 employees, 525 (77%) completed the questionnaire.

Characteristics of Study Participants

The average age of participants was 42 years (range 20 to 64 and median 42); 4% were female. The average number of years worked for NOFD was 15 (range 0 to 40, median 13). Of the 521 respondents, 101 (19%) were fire truck/ladder truck operators or engineers, 222 (43%) were line fire fighters, and 161 (31%) were officers (29 chief officers). Thirty-seven employees (7%) were in fire service administration, including dispatchers, employees of the deputy office, and human resource personnel. Among participants, 285 (56%) reported working in the same fire station as before the hurricanes and 107 (21%) reported being current smokers at the time of the survey. Additional characteristics of study participants are given in Table 1.

Factors Related to the Hurricane Responses

Factors related to the hurricane responses are shown in Table 2. Seventy-nine percent reported skin contact with floodwater and 51% reported nose or eye contact. 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. Of the respondents, 394 persons (76%) reported skin contact with sediment after the floodwater receded; 165 (32%) reported they had contact with floodwater on multiple days.

Only 105 employees (22%) were able to stay in contact with family at least once a day during the crisis; 150 (31%) were not staying with their family at the time of this survey. Among respondents, 69 (13%) were involved in gunfire incidents, 77 (15%) in recovery of bodies, and 217 (41%) reported experiencing hostile community situations. Some form of mental health service from the NOFD was used by 210 (40%); 158/495 (32%) participated in debriefings held post-crisis (within 1–4 weeks of incident conclusion), 107/502 (21%) participated in group meetings that were held at shift change

or when they left the work-site, and 80/497 (16%) participated in defusing meetings that were held within 72 hours of incident conclusion.

Social support and lifestyle change

Many (340) respondents (66%) reported slight, moderate, or strong dissatisfaction concerning communication within the NOFD (Table 3). Fifty (10%) reported dissatisfaction regarding communication between coworkers, 143 (28%) reported dissatisfaction regarding communication with supervisors. Two hundred and fifty participants (49%) reported being dissatisfied with equipment. Dissatisfaction regarding work schedule was reported by 203 (39%).

Many of the respondents reported that their lifestyle had changed since the hurricanes; 333 (65%) were exercising less, and 338 (65%) were sleeping less. Many of the respondents reported no change in smoking (83%) or alcohol consumption (62%) (Table 4).

Prevalence of health symptoms

Of the 525 fire fighters, 201 (38%) reported one or more new-onset respiratory symptoms such as sinus congestion (145 [28%]), throat irritation (92 [17%]), or cough (124 [24%]). Skin problems were reported by 328 (63%) of respondents, and 258 (49%) reported skin rash (Table 5). One hundred and thirty-three of 493 respondents (27%) had major depressive symptoms, and 114/518 (22%) had symptoms consistent with PTSD.

Table 6 lists the prevalence of health symptoms since the hurricanes by job title, age group, and gender. Prevalence of health symptoms was variable between job titles and age groups. Women reported a higher prevalence of health symptoms than men except for skin rash (43% vs. 50%).

Health symptoms and floodwater contact

Employees who were exposed to the floodwater on multiple days had a higher prevalence of new-onset lower respiratory symptoms (17%), new-onset upper respiratory symptoms (36%), and skin rash (60%), compared to those not exposed to the floodwater (Figure 1), although the differences were not statistically significant. Table 7 lists the prevalence and PR of health symptoms by types 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. The associations between health symptoms and the exposure to floodwater were essentially unchanged when the analysis was restricted to those without depressive symptoms (Table 8). Exposure to sediment was not significantly associated with physical symptoms (results not shown) when adjusted for floodwater contact.

Factors associated with depression and PTSD symptoms

In multiple regression analyses adjusting for age and gender, PTSD symptoms were more prevalent among those who were involved in gunfire incidents (PR=2.4; 95% CI: 1.6–3.7), guard duty (PR=1.8; 95% CI: 1.2–2.7), or recovery of bodies (PR=1.7; 95% CI: 1.1–2.6) compared to those not involved in these activities during the hurricanes (Table 9).

The prevalence of depressive symptoms by physical health symptoms and psychosocial factors is shown in Table 10. In multivariate analyses adjusting for all covariates in the model, we found that persons with new-onset

lower respiratory symptoms had significantly higher risk of depressive symptoms (PR=1.8; 95% CI: 1.2–3.0) compared to those without physical health symptoms (Table 11). Depressive symptoms were also associated with skin rash (PR=1.7; 95% CI: 1.2–2.6) and dissatisfaction with supervisory support (PR=1.6; 95% CI: 1.1–2.3). Fire fighters who answered that they are currently living with their family were less likely to report depressive symptoms (PR=0.7; 95% CI: 0.5–1.0) than those not living with their family. Participation in a group counseling service did not show a significant association with depressive symptoms. Those who had depression before the hurricanes were not included in the multiple regression models.

DISCUSSION AND CONCLUSIONS

The prevalences of respiratory symptoms, skin rashes, and injuries reported by fire fighters are similar to those found among relief workers reported through the active Centers for Disease Control and Prevention (CDC) surveillance system in the Greater New Orleans area.[9,10,11] New-onset health symptoms reported by fire fighters were significantly associated with hurricane-related factors. The health survey found no significant associations between health symptoms and contact with sediment; however, elevated risks of new-onset upper respiratory symptoms were found among fire fighters who directly contacted their skin and nose, mouth, or eyes with floodwater for longer than a few hours. Fire fighters had reportedly used floodwater and contaminated water from the municipal supply to suppress fires during the flooding. This could have resulted in mucosal exposure (through mouth, nose, or eyes) to airborne materials from the contaminated waters. Mucosal exposure to the floodwater may also imply more vigorous engagement in activities, which could result in increased exposures to substances in the floodwater and subsequently more physical health symptoms. Early during the rescue period post-hurricane, NIOSH provided interim guidance that response workers involved with floodwater should avoid 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.[12] An increased prevalence of gastrointestinal symptoms was found among fire fighters who were exposed to floodwater, but the relationship was not statistically significant.

Previous studies have found increased rates of respiratory symptoms among residents after flooding in community settings.[13,14,15] Little is known about the relationship between floodwater exposure and respiratory symptoms after a flooding disaster. This investigation attempted to explore the differential relationships between respiratory symptoms or 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). However, the contribution of exposure to substances in the floodwater to reported symptoms is still uncertain. This investigation adds more emphasis on the importance of further research efforts to obtain more objective exposure assessment of occupational exposures to floodwater and well-defined evaluation of the relationships between intensity or duration of floodwater exposure and related health symptoms.

Studies have shown that PTSD and depression are among the most common problems for populations exposed to natural disasters.[16,17] In a study involving the general population following an earthquake,[18] the authors suggested that the main risk factor for depression is the amount of loss that the person has sustained. Risk of depression was also higher among persons whose family members were injured. Regehr et al. suggested that low social support is an important determinant of depressive symptoms and PTSD among fire fighters.[19,20,21] Consistent with the previous findings[22, 23] psychosocial factors such as supervisor support and family support were also important factors related to depressive symptoms among NOFD personnel. Those who reported that they were living with

their families had a lower risk of depressive symptoms. Those who experienced gunfire incidents or recovered bodies had a higher risk of having PTSD symptoms.

We found that those with physical symptoms reported two times more depressive symptoms than those without physical symptoms. Coexistence of depression and physical symptoms has been reported in several studies.[24,25,26,27,28,29] However, little is known about relationships between depressive symptoms and physical symptoms among first responders after a natural disaster. It is possible that those with depressive symptoms may report more physical symptoms than those without depressive symptoms, and could over-report the exposure to floodwater. It is also possible that fire fighters who had physical symptoms may have reported more depressive symptoms than those without any physical symptoms after the disaster. Since we excluded those who had preexisting depression from the analysis, it is unlikely that preexisting depressive symptoms would have contributed to perceiving new-onset physical symptoms in a short period (3 months). Due to the nature of this cross-sectional survey, however, the results from this investigation could not confirm that depressive symptoms among fire fighters are attributed to persistent physical symptoms that limit their normal function in their job and personal life. While a study showed that workers with physical injury are at higher risk of developing acute psychological disorders, [30] it is not known whether physical health symptoms alone would have a similar effect on mental health. Nonetheless, considering comorbidity of depressive symptoms and physical health symptoms, appropriate clinical evaluation should address psychological health issues and physical health symptoms together.

A relatively high response rate was obtained (77%) for available fire fighters, minimizing the potential for selection bias. However, the participants included current fire fighters only and excluded those who were on sick leave and on-the-job injury leave. Therefore, there may be a potential selection bias that may lead to underestimation of the prevalence of symptoms, and relationships between health symptoms and exposure related to the hurricanes due to selection of healthier people.

Responses to extraordinary natural disasters, like the hurricanes, may provoke a number of physical and psychological reactions. Many of the symptoms fire fighters experienced may be normal and reversible reactions to a traumatic event. However, to better prepare for future disasters, it is important to understand the patterns of occupational illnesses and injuries that may result from responding to natural disasters. This HHE examined the extent of injury and illness reported among fire fighters and described contributing factors, knowledge of which could be helpful in identifying appropriate steps to reduce long term impact from these events. Lessons learned from the NOFD experience may help other fire departments and emergency responders prepare for and react to future natural disasters.

RECOMMENDATIONS

The following recommendations are offered to reduce the risk of health problems during and after the response to natural disasters. The NOFD should;

1. Implement clinical evaluation and appropriate medical follow-up to reduce the burden of current and possible long-term effects of illness and injury among NOFD personnel. The clinical programs should address the physical and mental health symptoms described within this report. NOFD may consider phasing in annual medical evaluations of fire fighter personnel. These medical evaluations should adhere to published fire service standards and/or initiatives[31,32] and be implemented after joint approval by management and union representatives.

2. Provide specific health and safety protective measures for emergency

responders to future disasters. For example, ensure that workers have current vaccinations, and make proper equipment and gear available prior to the event.

3. Develop a training program for emergency responders regarding potential illness and injuries after the response to natural disasters. Disaster preparedness training for first responders should be incorporated into the worker health and safety program for fire fighters to reduce the risk for illness and injuries in future responses to natural disasters.

4. Regarding organizational support such as work schedule modification, establish a committee to foster communications within the department and between supervisors and employees, and the quality of supervision. This could be done through existing joint management/union committees.

5. Consider repeating a symptom survey to estimate the change in prevalence compared to the initial NIOSH survey, and to estimate the incidence of new symptoms.

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Table 1
Characteristics of Survey Participants

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Demographic Characteristics	*N*	*%*
Age (years)		
20–29	82	15.9
30–39	133	25.8
40–49	172	33.4
50–above	128	24.9
Total	515	100.0
Gender		
Male	502	96.0
Female	21	4.0
Total	523	100.0
Job title		
Fire fighters	222	42.6
Officer	132	25.3
Operator/engineer	101	19.4
Fire service administration	37	7.1
Chief officer	29	5.6
Total	521	100.0
Job years		
< 5	128	24.9
5–<15	180	35.0
15–<25	106	20.6
≥ 25	101	19.6
Total	515	100.0
Smoking status		
Never smoked	308	58.9
Current smoker	107	20.5
Former smoker	108	20.6
Total	523	100.0
Working in the same fire station[a]		
Yes	228	44.4
No	285	55.6
Total	513	100.0

[a] Defined as those who were currently working in the same fire station as before Hurricane Katrina

Table 2
Frequencies of Factors Related to Hurricane Katrina

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Variables	*N*	*%*
Stayed in contact with family during the crisis		
Not at all	139	28.4
A few times only	245	50.1
About once a day	63	12.9
More than once a day	42	8.6
Total	489	100.0
Home damage		
No damage	14	2.7
Uninhabitable	306	58.9
Reparable	192	36.9
Reparable but uninhabitable	8	1.5
Total	520	100.0
Fire station damage		
No damage	79	15.7
Uninhabitable	230	45.6
Reparable	181	35.9
Reparable but uninhabitable	14	2.8
Total	504	100.0
Activities during the hurricane response efforts		
Fire suppression	423	80.6
Rescue of citizens/coworkers	330	62.9
Driving engine or ladder truck	244	46.5
Evacuation	225	42.9
Hostile community situation	217	41.3
Equipment maintenance	168	32.0
Inspection	137	26.1
Guard duty	110	21.0
Training	88	16.8
Administration	81	15.4
Recovery of bodies	77	14.7
Gunfire incidents	69	13.1
Other	85	16.2

Table 2 (continued)
Frequencies of Factors Related to Hurricane Katrina

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Variables	*N*	*%* [a]
Skin contact with floodwater		
Yes	414	79.0
No	110	21.0
Total	524	100.0
Nose, mouth or eye contact with floodwater		
Yes	254	50.8
No	246	49.2
Total	500	100.0
Skin contact with sediment after floodwater receded		
Yes	394	75.8
No	126	24.2
Total	520	100.0
Combination of exposure variables		
Skin contact with floodwater and sediment, and as well as 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
Total	523	100.0
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
Total	514	100.0
Currently staying with family		
No	150	30.6
Yes, sometime	138	28.2
Yes, always	202	41.2
Total	490	100.0
Mental health service sought after the hurricane		
Debriefing	158	31.9
Group meeting	107	21.3
Defusing	80	16.1
Individual counseling	64	12.9
Peer support counseling	40	8.4
Counseling follow-up	19	3.8
Family counseling	13	3.6

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

Table 3
Perception of Work Organization Factors after Hurricane Katrina

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Social support [a]	***N***	***%*** [b]
Communication within department		
Dissatisfied	340	65.9
Satisfied	176	34.1
Total	516	100.0
Equipment		
Dissatisfied	250	49.0
Satisfied	260	51.0
Total	510	100.0
Quality of supervision		
Dissatisfied	212	41.4
Satisfied	300	58.6
Total	512	100.0
Work schedule		
Dissatisfied	203	39.3
Satisfied	313	60.7
Total	516	100.0
Supervisor support		
Dissatisfied	162	31.4
Satisfied	354	68.6
Total	516	100.0
Recognition of supervisor		
Dissatisfied	156	30.4
Satisfied	357	69.6
Total	513	100.0
Communication with supervisors		
Dissatisfied	143	27.9
Satisfied	370	72.1
Total	513	100.0
Coworker communication		
Dissatisfied	50	9.7
Satisfied	465	90.3
Total	515	100.0

[a] Six scales were dichotomized (very, moderately or slightly dissatisfied/very, moderately or slightly satisfied).
[b] Denominators range from 510 to 516 due to missing values.

Table 4
Lifestyle Change after Hurricane Katrina

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Life style	*N*	*%*[a]
Exercise		
More	42	8.1
No change	141	27.3
Less	333	64.5
Total	516	100.0
Alcohol consumption		
More	140	27.8
No change	311	61.7
Less	53	10.5
Total	504	100.0
Eating		
More	145	28.1
No change	231	44.8
Less	140	27.1
Total	516	100.0
Social interaction		
More	45	8.7
No change	183	35.4
Less	289	55.9
Total	517	100.0
Smoking		
More	72	14.8
No change	405	83.2
Less	10	2.0
Total	487	100.0
Sleeping		
More	35	6.7
No change	147	28.3
Less	338	65.0
Total	520	100.0

[a] Denominators range from 487 to 520 due to missing values.

Table 5
Physical and Mental Health Symptoms Reported among New Orleans Fire Fighters (N=525)

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Health symptoms and injury	*N*	*Prevalence (%)*[a]
New onset respiratory symptoms [b]		
Any respiratory symptoms [c]	201	38.3
Upper respiratory [d]	162	30.9
Head or sinus congestion	145	27.6
Nose/throat irritation	92	17.3
Cough [e]	124	23.6
Dry cough	89	17.0
Cough with phlegm	84	16.0
Lower respiratory [f]	55	10.5
Shortness of breath with minimal activity	36	6.9
Wheezing/whistling in the chest	29	5.5
Chest tightness	17	3.2
Gastrointestinal symptoms [g]		
Diarrhea	9	1.7
Abdominal pain	9	1.7
Nausea or vomiting	7	1.3
Skin problems		
Any skin problem	328	62.5
Skin rash [h]	258	49.1
Cut	196	37.3
Itch	178	33.9
Pimple	135	25.7
Redness	112	21.3
Pain	108	20.6
Blister	57	10.9
Swell	53	10.1
Boil	31	5.9
Injury		
Sprain/strain	130	24.8
Laceration	127	24.2
Fall	54	10.3
Animal bite/sting	41	7.8
Burn	21	4.0
Eye injury	19	3.6
Vehicle accident	17	3.2
Assault	2	0.4
Concussion	1	0.2
Psychological symptoms		
Depressive symptoms [i]	133	27.0
PTSD symptoms [j]	114	21.7

[a] Denominator was 525 except depressive symptoms (n=492).
[b] 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."
[c] Respiratory symptom defined as having any of respiratory symptoms listed
[d] Upper respiratory symptom defined as having either 1) head/sinus congestion or 2) nose/throat irritation
[e] Cough defined as having either 1) dry cough or 2) cough with phlegm
[f] Lower respiratory symptoms defined as having 1) shortness of breath, 2) wheezing, or 3) chest tightness
[g] New onset gastrointestinal 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."
[h] Skin rash defined as experiencing 1) bumps, 2) blisters, 3) boils, 4) itching, 5) swelling, or 6) redness.
[i] Depressive symptom was defined using the Center for Epidemiologic Study-Depression scale and above the score of 22.
[j] The Veterans Administration Posttraumatic Stress Disorder (PTSD) checklist was used to define post traumatic stress symptoms among participants.

Table 6
Prevalence (%) of Health Outcomes by Participants' Characteristics
New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Characteristics	*N*	*Health Outcomes*						
		Upper respiratory symptoms [a]	**Lower respiratory symptoms** [b]	**Cough** [c]	**Skin rash** [d]	**Injury** [e]	**Depressive symptoms** [f]	**PTSD symptoms** [g]
TOTAL	525	30.9	10.5	23.6	49.1	47.8	27.0 [h]	21.7
Job title								
Officer	161	39.1	7.3	29.8	52.8	54.0	23.5	19.3
Fire service administration	37	35.1	10.5	16.2	46.0	35.1	37.8	32.4
Line fire fighter	222	26.1	11.1	21.2	48.2	46.0	31.5	24.8
Operator/engineer	101	26.7	10.9	21.8	46.5	46.5	18.3	14.9
Total	521							
Age (years)								
20 - 29	82	19.5	13.0	15.9	40.2	46.3	24.4	19.5
30 - 39	133	31.6	10.8	23.3	51.9	43.6	32.3	24.8
40 - 49	172	35.5	9.5	27.9	49.4	51.7	25.6	22.1
50 - above	128	32.0	8.9	24.2	54.7	48.4	25.0	20.3
Total	515							
Gender								
Female	21	42.9	14.3	23.8	42.9	33.3	50.0	33.3
Male	502	30.5	10.4	23.7	49.6	48.4	26.2	21.3
Total	523							

[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
[e] Injury includes any type of injury, such fall, laceration, animal bite, vehicle accident, concussion, burn, assault, eye injury, sprain, and strain.
[f] Depressive symptom was defined using the Center for Epidemiologic Study-Depression scale and above the score of 22.
[g] The Veterans Administration Post Traumatic Stress Disorder (PTSD) checklist was used to define post traumatic stress symptoms among participants.
[h] Total numbers of respondents are 488, 484 and 490 for Job title, Age and Gender, respectively.

Table 7
Prevalence (%) and the Adjusted Prevalence Ratios (PR)[a] of Physical Symptoms[b] by Types of Exposure to Floodwater (N=514)

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Exposure category	N		Upper respiratory symptoms [c]	Lower respiratory symptoms [d]	Cough [e]	Skin rash [f]
Skin AND either nose or eyes 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 or eyes 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	1.00	1.00	1.00	1.00

[a] Prevalence ratio adjusted for age, gender and smoking (current smoker/non smoker).
[b] 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."
[c] Upper respiratory symptom defined as having either 1) head/sinus congestion or 2) nose/throat irritation
[d] Lower respiratory symptoms defined as having 1) shortness of breath, 2) wheezing, or 3) chest tightness
[e] Cough defined as having either 1) dry cough or 2) cough with phlegm
[f] Skin rash defined as experiencing 1) bumps, 2) blisters, 3) boils, 4) itching, 5) swelling, or 6) redness.
Note: Bold numbers indicate that the prevalence ratio is statistically significant at a significance level of p = 0.05.

Table 8
Adjusted Prevalence Ratios (PR) [a] of Physical Symptoms [b] Independent from Depressive Symptoms by Types of Exposure to Floodwater (N=389[c])

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Exposure category	N		Upper respiratory symptoms [d]	Lower respiratory symptoms [e]	Cough [f]	Skin rash [g]
Skin AND either nose or eyes contact with floodwater longer than a few HOURS	160	PR (95% CI)	**1.92** (1.03, 3.58)	2.54 (0.57, 11.30)	1.60 (0.81, 3.14)	**2.14** (1.29, 3.57)
Skin and either nose or eyes contact with floodwater for a few MINUTES	60	PR (95% CI)	1.45 (0.68, 3.10)	0.54 (0.05, 5.96)	1.24 (0.53, 2.89)	1.29 (0.68, 2.44)
Skin contact only with floodwater for longer than a few HOURS	99	PR (95% CI)	0.80 (0.37, 1.72)	0.99 (0.16, 5.94)	0.69 (0.30, 1.60)	1.20 (0.67, 2.14)
No contact with floodwater	70	Reference	1.00	1.00	1.00	1.00

[a] Prevalence ratio adjusted for age, gender and smoking (current smoker/non smoker)
[b] 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."
[c] Not included those with depressive symptoms
[d] Upper respiratory symptom defined as having either 1) head/sinus congestion or 2) nose/throat irritation
[e] Lower respiratory symptoms defined as having 1) shortness of breath, 2) wheezing, or 3) chest tightness
[f] Cough defined as having either 1) dry cough or 2) cough with phlegm
[g] Skin rash defined as experiencing 1) bumps, 2) blisters, 3) boils, 4) itching, 5) swelling, or 6) redness.
Note: Bold numbers indicate a statistical significance at a significance level of p = 0.05.

Table 9
Adjusted Prevalence Ratios (PR)* of PTSD Symptoms for Activities at the Time of Crisis

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Activities	N	PR[a]	95% CI
Inspection	137	0.78	(0.49, 1.22)
Fire suppression	423	1.01	(0.61, 1.67)
Evacuation	225	1.08	(0.74, 1.59)
Administration	81	1.21	(0.75, 1.98)
Driving engine or ladder truck	244	1.24	(0.85, 1.80)
Rescue of citizen/coworker	330	1.30	(0.87, 1.96)
Hostile community situation	217	1.42	(0.97, 2.08)
Equipment maintenance	168	1.42	(0.97, 2.08)
Recovery of bodies	77	**1.66**	(1.06, 2.60)
Guard duty	110	**1.82**	(1.22, 2.73)
Gunfire incidents	69	**2.42**	(1.58, 3.70)

[a] Prevalence ratio adjusted for age and gender
Note: Bold numbers indicate a statistical significance at a significance level of p = 0.05.

Table 10
Prevalence of Depressive Symptoms by Covariates
New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Variable	N	Prevalence (%) [i]	Total no. of participants
Lower respiratory [a]			525
Yes	54	64.8	
No	438	22.4	
Upper respiratory [b]			492
Yes	159	39.0	
No	333	21.3	
Cough [c]			492
Yes	122	39.3	
No	370	23.0	
Gastrointestinal symptoms [d]			525
Yes	18	72.2	
No	474	25.3	
Skin Rash [e]			525
Yes	250	35.6	
No	242	18.2	
Injury [f]			492
Yes	242	30.2	
No	250	24.0	
Supervisor support [g]			492
Dissatisfied	152	40.1	
Satisfied	340	21.2	
Group counseling [h]			492
Not Received	202	23.8	
Received	290	29.3	
Living with family			459
Yes	320	22.5	
No	139	36.0	

[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] Gastrointestinal symptoms were defined as having 1) diarrhea, 2) abdominal pain, or 3) nausea or vomiting
[e] Skin rash defined as experiencing 1) bumps, 2) blisters, 3) boils, 4) itching, 5) swelling, or 6) redness.
[f] Injury includes any type of injury, such fall, laceration, animal bite, vehicle accident, concussion, burn, assault, eye injury, sprain and strain.
[g] Six scales were dichotomized (very, moderately or slightly dissatisfied/ very, moderately or slightly satisfied)

[h] Those who received a group counseling service were defined as those who attended one of the following: 1) group meeting, 2) defusing or 3) debriefing after the incident.
Note: Denominators ranged from 459 to 525 due to missing values.

Table 11
Prevalence Ratios (PR) of Depressive Symptoms for Covariates

New Orleans Fire Department
HETA #2006-0023-3003
November 2005

Parameter	Crude		Adjusted [g]	
	PR	**95% CI**	**PR**	**95% CI**
Age				
20 - 29	0.97	(0.55, 1.74)	1.20	(0.63, 2.27)
30 - 39	1.29	(0.81, 2.07)	1.43	(0.87, 2.36)
40 - 49	1.02	(0.64, 1.65)	1.13	(0.68, 1.88)
≥50	1.00		1.00	
Sex				
Female	**1.91**	(1.00, 3.64)	1.36	(0.62, 2.95)
Male	1.00		1.00	
Lower respiratory symptoms [a]				
Yes	**2.90**	(1.97, 4.26)	**1.84**	(1.15, 2.96)
No	1.00		1.00	
Upper respiratory symptoms[b]				
Yes	**1.83**	(1.30, 2.57)	1.30	(0.86, 1.94)
No	1.00		1.00	
Gastrointestinal symptoms[c]				
Yes	**2.85**	(1.61, 5.06)	1.43	(0.74, 2.74)
No	1.00		1.00	
Skin rash [d]				
Yes	**1.96**	(1.36, 2.81)	**1.74**	(1.17, 2.58)
No	1.00		1.00	
Supervisor support [e]				
Dissatisfied	**1.90**	(1.35, 2.67)	**1.59**	(1.10, 2.30)
Satisfied	1.00		1.00	
Group counseling [f]				
Not received	1.23	(0.87, 1.76)	1.22	(0.84, 1.79)
Received	1.00		1.00	
Living with family				
Yes	**0.63**	(0.44, 0.90)	**0.67**	(0.46, 1.00)
No	1.00		1.00	

[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] Gastrointestinal symptoms were defined as having 1) diarrhea, 2) abdominal pain, or 3) nausea or vomiting
[d] Skin rash defined as experiencing 1) bumps, 2) blisters, 3) boils, 4) itching, 5) swelling, or 6) redness.
[e] Six scales were dichotomized (very, moderately or slightly dissatisfied/ very, moderately or slightly satisfied)

[f] Those who received a group counseling service were defined as those who attended one of the following: 1) group meeting, 2) defusing or 3) debriefing after the incident.
[g] Prevalence ratio adjusted for all covariates in the model (n = 450)
Note: Bold numbers indicate a statistical significance at a significance level of p = 0.05.

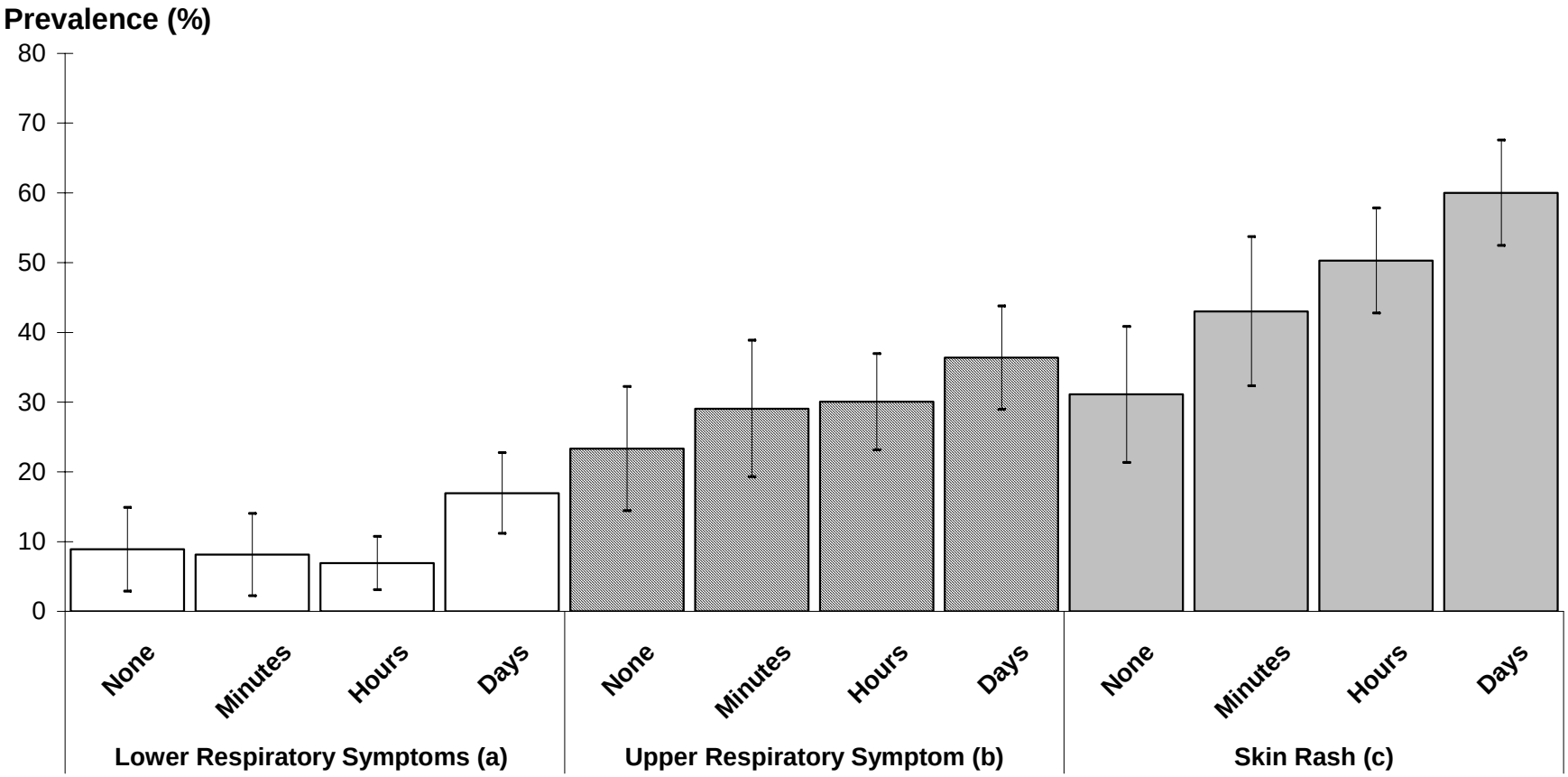

Figure 1. Prevalence (%) and the 95% Confidence Intervals of New Onset Physical Symptoms [d] by the Duration of Floodwater Contact (n=514). New Orleans Fire Department HETA #2006-0023-3003.

[a] Lower respiratory symptoms defined as having 1) shortness of breath, 2) wheezing, or 3) chest tightness
[b] Upper respiratory symptom defined as having either 1) head/sinus congestion OR 2) nose/throat irritation
[c] Skin rash defined as experiencing 1) bumps, 2) blisters, 3) boils, 4) itching, 5) swelling, or 6) redness.
[d] 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."
Note: Each vertical line of the bar indicates the 95% confidence intervals for the prevalence.

APPENDIX A

Environmental survey of fire fighter exposure to sediment during simulated apparatus movement

New Orleans Fire Department
New Orleans, Louisiana

Introduction

In October 2005, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the New Orleans Fire Department (NOFD) and the International Association of Fire Fighters Local 632 (IAFF). The HHE request concerned health hazards from exposure to the floodwater and sediment from Hurricanes Katrina and Rita and mental health of the fire fighters following the NOFD's response to the huricanes. Reported health problems included respiratory, throat, and sinus irritation; and symptoms suggestive of depression and anxiety.

In response to the concerns about sediment exposure during apparatus movement, NIOSH investigators conducted a site visit at the Jackson Barracks temporary staging area on October 19, 2005. The site visit included observations of fire fighter activities during simulated apparatus movement and environmental sampling to evaluate fire fighter exposures to dust.

Background

When the floodwaters receded following the hurricanes, several inches of sediment was left behind in many of the flood-affected areas. As the city dried out, the fire fighters reported that dust levels significantly increased. At the time of the environmental survey, fire fighters stationed in the Jackson Barracks temporary staging area were making approximately one or two responses daily. This number is lower than the number during the period before the hurricanes, mainly due to the limited number of residents in the city. During a response, three or four fire fighters travel in the passenger cabin of each fire apparatus. Responses require a varying number of apparatus (normally one to three). Overall response times can vary from a few minutes to several hours; however, the time required to arrive and return from a response is usually only a few minutes.

Following the hurricanes, fire fighters on each shift were required to conduct daily inspection/assessment tours in their assigned areas looking for hazardous materials, responding to structure collapses, inspecting buildings and fire hydrants, and performing search and recovery activities. These tours were conducted from the fire apparatus and by foot and lasted approximately 1–2 hours.

Methods

During the meeting with the NOFD on October 17, 2005, the area serviced by the Jackson Barracks temporary staging area (the Ninth Ward) was identified as one of the areas most heavily affected by sediment. On October 19, 2005, an environmental survey was conducted to evaluate fire fighter exposures to airborne dust from the sediment in this area. The survey consisted of collecting task-based personal breathing zone (PBZ) air samples for respirable particulates and silica, total particulates, and elements (metals and minerals). Samples were collected for 2–2½ hours during simulated apparatus movement, the period when airborne dust exposures were expected to be the highest.

Respirable Particulates and Silica

PBZ air samples for respirable particulates and silica were collected on tared 37-millimeter (mm) diameter, 5-micrometer (µm) pore size polyvinyl chloride (PVC) membrane filters mounted in 10-mm nylon cyclones. Samples were attached via flexible tubing to personal sampling pumps calibrated to draw air through the filter at a flow rate of 1.7 liters per minute (Lpm).

Samples were analyzed for respirable particulates by gravimetric analysis according to a modification of NIOSH Manual of Analytical Methods (NMAM) Method 0600.[33] The modifications included: 1) filters and backup pads were stored in an environmentally controlled room and were subject to the room conditions for at least 2 hours for stabilization prior to tare and gross weighing, and 2) two weighings of the tare weight and the gross weight were performed and the average of the weights was used for the total weight analysis. The total weight of each sample was determined by weighing the sample plus the filter on an electrobalance and subtracting the previously determined tare weight of the filter. The limit of detection (LOD) for this gravimetric analysis was 0.02 milligram (mg). The corresponding minimum detectable concentration (MDC) was 0.08 mg per cubic meter of air (mg/m^3), based on a 240-liter sample.

After the gravimetric analysis, the samples were analyzed for silica content using X-ray diffraction. NIOSH Method 7500[33] was used with the following modifications: 1) filters were dissolved in tetrahydrofuran rather than being ashed in a furnace, and 2) standards and samples were run concurrently, and an external calibration curve was prepared from peak heights rather than using the suggested

normalization procedures. The LODs for quartz and cristobalite for this method were 0.01 and 0.02 mg, respectively. The limit of quantitation (LOQ) for quartz and cristobalite was 0.03 mg for both. The corresponding MDCs for quartz and cristobalite were 0.04 and 0.08 mg/m^3, respectively, based on a 240-liter sample. The corresponding minimum quantifiable concentration (MQC) for both quartz and cristobalite was 0.1 mg/m^3, based on a 240-liter sample.

Total Particulates and Elements (Metals and Minerals)

PBZ air samples for total particulates and elements were collected on tared 37-mm, 5-µm pore size PVC membrane filters. The samples were attached via flexible tubing to personal sampling pumps calibrated to draw air through the filter at a flow rate of 3.0 Lpm. Samples were collected adjacent to the respirable samples.

The samples were analyzed for total particulates by gravimetric analysis according to a modification of NIOSH Method 0500.[33] The modifications used were the same as indicated for respirable dust. The LOD for this gravimetric analysis was 0.02 mg. The corresponding MDC was 0.05 mg/m^3, based on a 419-liter sample.

After the gravimetric analysis, the samples were analyzed for 29 elements (metals and minerals) by inductively coupled argon plasma atomic emission spectroscopy (ICP-AES) according to a modification of NIOSH Method 7300.[33] The method was modified to include microwave digestion of the PVC filter. The elements analyzed included: aluminum, antimony, arsenic, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, platinum, selenium, silver, sodium, tellurium, thallium, tin, titanium, vanadium, yttrium, zinc, and zirconium. Table 1 lists the analytical limits for the individual elements.

Evaluation Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace

exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[34] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[35] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[36] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Particulates

Often the chemical composition of the airborne particulate does not have an established occupational exposure limit (OEL). It has been the convention to apply generic exposure criteria in such cases. Formerly referred to as nuisance dust, OSHA's preferred terminology for the non-specific particulates is particulates not otherwise regulated (PNOR) and ACGIH's preferred terminology is particles not otherwise specified (PNOS).

The OSHA PEL for PNOR is 15 mg/m^3 for total particles and 5 mg/m^3 for respirable particles. These criteria were established to minimize mechanical irritation of the eyes and nasal passages, and to prevent visual interference. NIOSH does not have a REL for total or respirable particulate not otherwise classified.

ACGIH does not believe there is enough evidence to establish a TLV for PNOS, however it feels particles may have adverse effects. Thus in 2003, ACGIH withdrew the TLV for PNOS. ACGIH currently recommends keeping airborne concentrations below 3 mg/m^3 for respirable particles, and below 10 mg/m^3 for inhalable particles. These recommendations apply for particles that 1) have no applicable TLV, 2) are insoluble or poorly soluble in water, and 3) have low toxicity.[35]

Silica

Crystalline silica (quartz and cristobalite) has been associated with silicosis, a fibrotic disease of the lung caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and non-specific chest illnesses. Silicosis usually occurs after years of exposure, but may appear in a shorter period if exposure concentrations are very high.

The NIOSH RELs for crystalline silica (both quartz and cristobalite), as respirable dust, are 0.05 mg/m^3. These RELs are intended to prevent silicosis. The OSHA PEL for quartz is calculated as follows:

$$\text{PEL (mg/m}^3\text{)} = \frac{10\ \text{mg/m}^3}{\%\ \text{quartz} + 2}$$

The calculated OSHA PEL for the two samples with detectable levels of respirable quartz is 0.48 and 0.63 mg/m^3, based on a 19% and 14% respirable quartz content, respectively. The OSHA PEL for respirable cristobalite is half the calculated value for quartz. The corresponding respirable cristobalite PELs are 0.24 and 0.32 mg/m^3. The ACGIH TLV for respirable quartz and cristobalite are 0.1 and 0.05 mg/m^3, respectively.

Elements

The toxicity of most elements (metals and minerals) depends on numerous factors including the chemical form of the metal, immune status and age of the worker, and lifestyle factors. Most metals affect more than one organ system. However, at the lowest dose, each metal targets a primary organ or tissue. Table 2 lists the detectable elements and applicable OELs.

Results

PBZ air samples for respirable particulates and silica, total particulates, and elements (metals and minerals) were collected on 10 fire fighters during the simulated movement of three apparatus. Fire fighters were asked to drive through the area serviced by the Jackson Barracks temporary staging area in the Ninth Ward. At the time of the survey, portions of the Ninth Ward were closed to the general public. Many of the streets had not been cleared of sediment in the closed areas. The apparatus were driven as they may have been during a response. However, the speed of the apparatus was much slower than before the hurricanes due to down power lines, houses and general debris blocking the streets, and street barricades.

During the evaluation, the apparatus were used in the following order: Engine 22, Engine 39, and Ladder 4. All fire fighters were seated inside the cabin of the apparatus in their normal positions (driver, front passenger, and forward-facing rear passenger on either the driver or passenger side). Windows of the apparatus were opened or closed at the choice of the individual fire fighter; all apparatus during the simulated movement had a combination of closed and opened windows (at least one window closed). In addition to closing windows to limit dust exposure, some fire fighters were observed covering their nose and mouth with paper towels.

Respirable Particulates

Eight PBZ air samples were collected for respirable particulates. Fire fighter exposures to respirable particulates ranged from non-detectable (ND) (less than 0.1 mg/m^3) to 0.42 mg/m^3, with a mean of 0.20 mg/m^3. All respirable particulate concentrations were below the relevant occupational exposure criteria.

Respirable Silica

Eight PBZ air samples were collected for respirable silica, both quartz and cristobalite. Two of the respirable silica samples had trace levels (between 0.04 and 0.1 mg/m^3) of quartz; all other samples were ND (less than 0.04 mg/m^3). The samples with trace levels of quartz were collected from Ladder 4. All respirable silica samples for cristobalite were ND (less than 0.08 mg/m^3).

Total Particulates

Nine PBZ air samples were collected for total particulates. Fire fighter exposures to total particulates ranged from 0.45 to 2.6 mg/m^3, with a mean of 1.4 mg/m^3. All total particulate concentrations were below the relevant occupational exposure criteria.

Because of the short sampling time (2–2½ hours), the range for trace quartz concentrations (0.04 to 0.1 mg/m^3) overlaps the NIOSH REL of 0.05 mg/m^3 and the ACGIH TLV of 0.1 mg/m^3. Also, because of the short sampling time, the cristobalite MDC (less than 0.08 mg/m^3) exceeds the NIOSH REL of 0.05 mg/m^3 and the TLV of 0.05 mg/m^3. Assuming fire fighters are not exposed to additional respirable silica throughout the day, all respirable silica concentrations were below the relevant occupational exposure criteria.

Elements

Nine PBZ air samples were collected for elements (metals and minerals). Table 3 lists the concentrations of the detected elements. Aluminum, arsenic, calcium, iron, magnesium, manganese, sodium, titanium, and zinc were detected in quantifiable concentrations. Molybdenum was detected on one sample and tin was detected on two samples; however, the concentrations were not enough to quantify accurately and are considered trace concentrations. All other elements were ND. All elemental concentrations were below the relevant occupational exposure criteria.

Discussion and Conclusions

Airborne exposures to respirable particulate and silica, total particulate, and elements were below all applicable exposure criteria for the fire fighters working out of the Jackson Barracks temporary staging area. The results of the environmental survey do not warrant changes to apparatus transport activities as observed during the NIOSH site visit on October 19, 2005. However, should fire fighter activities differ from those observed by NIOSH, the department should reassess the exposures to ensure they remain below applicable exposure criteria.

During the environmental survey, fire fighters were observed covering their nose and mouth with paper towels to minimize exposures. Respiratory protection is not required if exposures remain as monitored during our site visit. Should the NOFD allow voluntary use of respirators for protection against nuisance dust, fire fighters should use NIOSH-approved N-95 filtering facepiece respirators. Paper towels do not provide respiratory protection because they do not adequately filter small particles and do not seal with the face. Voluntary use of respirators must be addressed in the NOFD's respiratory protection program, and should follow the OSHA regulations (29 U.S. Code of Federal Regulations 1910.134).

Recommendations

Results of environmental sampling conducted on October 19, 2005, indicated that monitored exposures did not exceed any applicable exposure limit for fire fighters stationed at Jackson Barracks. The following

recommendations are offered to further reduce the fire fighters' exposures while working in flood-affected areas:

1. Keep the doors and windows of vehicles closed and use the air conditioning system in the recirculation mode.

2. Maintain longer distances between vehicles when conducting inspection/assessment trips, when response time is not a factor. This will allow some dust from previous vehicles to settle.

3. Perform preventive maintenance on vehicles, including changing the filter on air conditioning systems, ensuring proper door seals, and replacing broken glass.

4. Allow the voluntary use of respiratory protection, using NIOSH-approved N-95 filtering facepiece respirators for protection against nuisance dust, in accordance with OSHA regulations.

5. Clean the inside and outside of the vehicles regularly to minimize exposure to dust. The outside of vehicles should be cleaned using standard washing techniques, i.e., soap and water or rinse with water. Inside the vehicles, a damp cloth or a vacuum equipped with a high-efficiency particulate air (HEPA) filter should be used to remove dust. Compressed air should not be used to remove dust from inside or outside the vehicle.

References

33. NIOSH [2003]. NIOSH manual of analytical methods. 4th ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

34. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

35. ACGIH [2005]. 2005 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

36. CFR [2003]. 29 CFR 1910.1000. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Table 1
Analytical Limits for Elements (Metals and Minerals)
October 19, 2005

New Orleans Fire Department
HETA #2006-0023-3003

	LOD (µg/sample)	LOQ (µg/sample)	MDC (mg/m^3)	MQC (mg/m^3)
Aluminum	2	7	0.005	0.02
Antimony	0.9	3	0.002	0.007
Arsenic	2	8	0.005	0.02
Beryllium	0.05	0.2	0.0001	0.0005
Calcium	5	20	0.01	0.05
Cadmium	0.2	0.8	0.0005	0.002
Cobalt	0.9	3	0.002	0.007
Chromium	0.6	2	0.001	0.005
Copper	0.1	0.5	0.0002	0.001
Iron	4	10	0.01	0.02
Lithium	0.1	0.3	0.0002	0.0007
Magnesium	1	5	0.002	0.01
Manganese	0.09	0.3	0.0002	0.0007
Molybdenum	0.3	1	0.0007	0.002
Nickel	0.5	2	0.001	0.005
Lead	1	4	0.002	0.01
Phosphorus	3	10	0.007	0.02
Platinum	7	20	0.02	0.05
Selenium	6	20	0.01	0.05
Silver	0.2	0.6	0.0005	0.001
Sodium	3	9	0.007	0.02
Tellurium	3	9	0.007	0.02
Thallium	3	10	0.007	0.02
Tin	2	7	0.005	0.02
Titanium	0.2	0.6	0.0005	0.001
Vanadium	0.2	0.7	0.0005	0.002
Yttrium	0.05	0.2	0.0001	0.0005
Zinc	0.3	1	0.0007	0.002
Zirconium	0.2	0.5	0.0005	0.001

LOD = limit of detection mg = milligram m^3 = cubic meter
LOQ = limit of quantitation µg = microgram L = liter
MDC = minimum detectable concentration MQC = minimum quantifiable concentration

The limits of detection (LOD) describe the amount of substance below which it cannot be detected in the sample. The limits of quantitation (LOQ) describe an amount of substance above the LOD, but not enough to quantify accurately. The LOD and LOQ are values determined by the analytical procedure used to analyze the samples, and are not dependent on sample volumes. Minimum detectable concentrations (MDCs) are determined by dividing the LODs by air sample volumes for the given set of samples. Minimum quantifiable concentrations (MQCs) are determined by dividing the LOQs by air sample volumes for the given set of samples, and reflect a concentration above the MDC but not enough to quantify accurately. MDC and MQC values are based on a sample volume of 419 liters.

Table 2
Occupational Exposure Limits for Elements Quantified in Environmental Survey
October 19, 2005

New Orleans Fire Department
HETA #2006-0023-3003

	NIOSH Recommended Exposure Limit[a]	OSHA Permissible Exposure Limit[a]	ACGIH Threshold Limit Value[a,b]
Aluminum	10	15	10
Arsenic	[c,d]	0.01	0.01
Calcium carbonate	10	15	10
Iron oxide	5	10	5
Magnesium oxide	N/A	15	10
Manganese	1	[c]	0.2
Molybdenum	N/A	15	10
Sodium	N/A	N/A	N/A
Tin oxide	2	2	2
Titanium dioxide	[d]	15	10
Zinc oxide	5	15	2

[a] Evaluation criteria reported as mg/m^3.

[b] Based on the 2005 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents published by the American Conference of Governmental Industrial Hygienists (ACGIH®).

N/A, not applicable, indicates that no evaluation criterion exists.

[c] Occupational exposure limit is only available as a ceiling limit value, not applicable for the type of sampling conducted during this evaluation.

[d] Potential occupational carcinogen, non-quantitative exposure limit labeled "lowest feasible concentration."

Table 3
Concentrations of Elements in PBZ Air Samples
October 19, 2005

New Orleans Fire Department
HETA #2006-0023-3003

	Range	Mean
Aluminum	trace (between 0.005 and 0.02)–0.084	0.050
Arsenic	ND (less than 0.005)–0.0026	0.0020
Calcium	trace (between 0.01 and 0.05)–0.080	0.050
Iron	trace (between 0.01 and 0.02)–0.067	0.042
Magnesium	trace (between 0.002 and 0.01)–0.020	0.012
Manganese	ND (less than 0.0002 and 0.0007)–0.0012	0.00045
Sodium	trace (between 0.007 and 0.02)–0.052	0.026
Titanium	trace (between 0.0005 and 0.001)–0.0029	0.0018
Zinc	ND (less than 0.0007)–0.0032	0.00098

Trace is defined as a concentration between the minimum detectable concentration and the minimum quantifiable concentration.

ND, non-detectable, is defined as less than the minimum detectable concentration.

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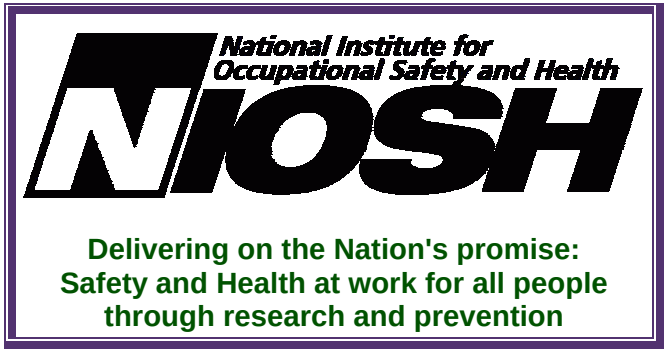

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