

Skin Disorders Among Construction Workers Following Hurricane Katrina and Hurricane Rita

An Outbreak Investigation in New Orleans, Louisiana

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Objectives: To determine the extent and scope of the outbreak of skin eruptions, to identify the causes of the acute skin diseases, to identify risk factors for the conditions, and to reduce the dermatologic morbidity among workers repairing buildings damaged by Hurricane Katrina and Hurricane Rita.

Design: Retrospective cohort study.

Setting: Military base in New Orleans, Louisiana.

Participants: Civilian construction workers living and working at a New Orleans military base between August 30, 2005, and October 3, 2005. Living conditions were mainly wooden huts and tents with limited sanitation facilities.

Main Outcome Measures: Survey of risk factors, physical examination, skin biopsy specimens, and environmental investigation of the occupational and domiciliary exposures.

Results: Of 136 workers, 58 reported rash, yielding an attack rate of 42.6%. The following 4 clinical entities were

diagnosed among 41 workers who had a physical examination (some had >1 diagnosis): 27 (65.9%) having papular urticaria, 8 (19.5%) having bacterial folliculitis, 6 (14.6%) having fiberglass dermatitis, and 2 (4.9%) having brachioradial photodermatitis. All diagnoses except brachioradial photodermatitis were confirmed by histopathologic examination. After adjusting for race/ethnicity and occupation, sleeping in previously flooded huts was statistically significantly (adjusted odds ratio, 20.4; 95% confidence interval, 5.9-70.2) associated with developing papular urticaria, the most common cause of rash in this cluster.

Conclusions: We identified 4 distinct clinical entities, although most workers were diagnosed as having papular urticaria. Huts previously flooded as a result of the hurricanes and used for sleeping may have harbored mites, a likely source of papular urticaria. To reduce the morbidity of hurricane-related skin diseases, we suggest avoiding flooded areas, fumigating with an acaricide, and wearing protective clothing.

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OUTBREAKS OF DERMATOLOGIC diseases occur frequently after hurricanes and flooding^{1,2}; however, few of these outbreaks have been systematically investigated.^{3,4} The causes of dermatologic problems after recent hurricanes in the United States have included staphylococcal infections, tinea corporis, and arthropod bites.⁵ Hurricane

matologic conditions (ie, skin or wound infections and rashes).^{2,5}

On September 30, 2005, members of the Centers for Disease Control and Prevention Greater New Orleans Public Health Support Epidemiology and Surveillance team were

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Katrina made landfall on August 29, 2005, and Hurricane Rita on September 24, 2005. Syndromic surveillance in New Orleans, Louisiana, following these hurricanes indicated that 22% of diseases treated were der-

approached by officials from a New Orleans hospital to assist in the investigation of an outbreak of dermatologic disease among construction workers. The objectives of the investigation were to determine the extent and scope of the outbreak, to identify the causes of the acute skin diseases, to identify risk factors for the conditions, and to reduce the dermatologic morbidity among these workers.

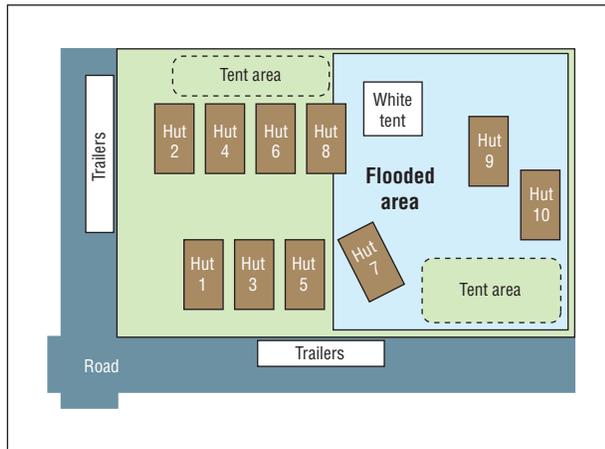


Figure 1. Construction worker encampment.

Table 1. Demographic Characteristics of Workers With Self-Reported Rash

Characteristic	No. (%) of Workers		P Value
	Self-reported Rash (n = 58)	No Rash (n = 78)	
Age, median, y	34	42	<.01 ^a
Male sex	58 (100.0)	78 (100.0)	
Race/ethnicity			
White	22 (37.9)	46 (58.9)	.02 ^b
Native American	24 (41.4)	10 (12.8)	<.001
Black	8 (13.8)	12 (15.4)	.79
Mexican/Hispanic	4 (6.9)	8 (10.3)	.49
Other	0	2 (2.6)	.22

^aWilcoxon rank sum test.

^b χ^2 Test.

METHODS

EPIDEMIOLOGICAL INVESTIGATION

The construction workers were living and working together at a military base in northern Plaquemines Parish, Louisiana. Living quarters consisted of an encampment on the base that had 11 screened-in wooden huts raised above the ground, several personal tents on the ground, trailers, and limited sanitation facilities (Figure 1). Work duties mainly entailed repairing roofs of buildings on the base damaged by the recent hurricanes. Base authorities and the construction company's supervisory staff became concerned when several workers were unable to participate in routine work activities because of the severity of their rashes.

We defined a case as any worker living or working at the encampment who had a self-reported rash with onset from August 30, 2005, the date of entry into the camp, to October 3, 2005, the date of our investigation. All employees living in the encampment were interviewed using a standardized questionnaire. The questionnaire asked about typical risk factors for acute skin diseases such as poor personal hygiene, occupational exposures to fiberglass and other building materials, sleeping location and conditions, exposure to animals and arthropods, and preexisting medical conditions. Respondents were asked to identify their primary sleeping location during the week before rash onset on a map of the encampment (Figure 1).

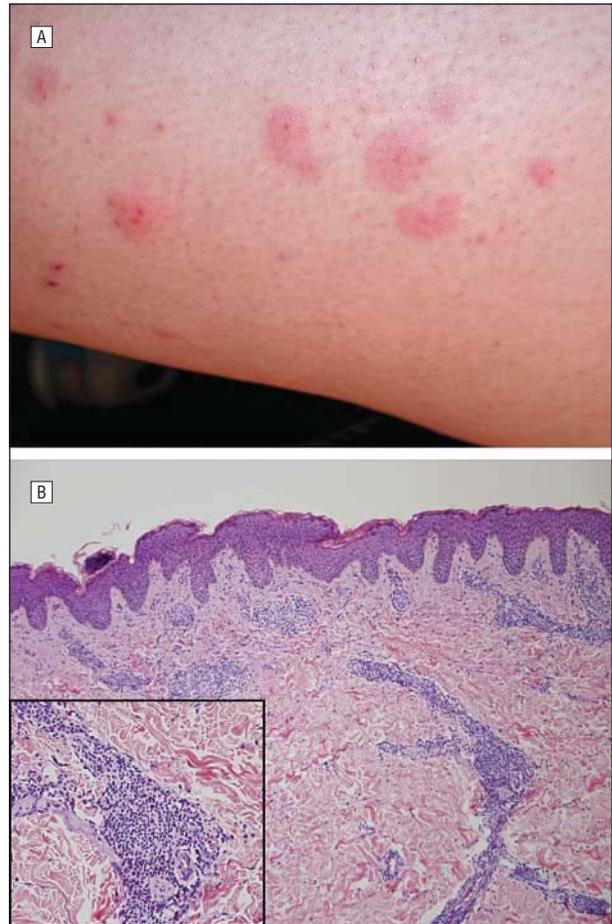


Figure 2. Papular urticaria. A, Representative case. B, Histopathologic biopsy specimen finding of papular urticaria (hematoxylin-eosin, original magnification $\times 20$). Inset, Magnified histopathologic biopsy specimen shows superficial and deep inflammatory infiltrate with numerous eosinophils (hematoxylin-eosin, original magnification $\times 40$).

Univariate and bivariate analyses were performed to determine risk factors associated with the development of specific dermatologic conditions. Multivariate logistic regression models were constructed using all variables statistically significant on univariate analysis; the comparison group was the rest of the cohort. In addition, we assessed collinearity using condition indexes. Data were analyzed using Epi Info (Centers for Disease Control and Prevention, Atlanta, Georgia) and SAS 9.0 (SAS Institute, Cary, North Carolina).

DERMATOLOGIC AND HISTOPATHOLOGIC EXAMINATION

All patients with self-reported rash were offered an on-site physical examination by a board-certified dermatologist (S.A.N.). Skin biopsy specimens of representative cases were obtained and sent to Ochsner Medical Center (New Orleans) and to Walter Reed Army Medical Center (Washington, DC) for histopathologic examination.

ENVIRONMENTAL INVESTIGATION

All wooden huts and several tents were evaluated for weather and flood damage. Soil and leaf litter around the wooden huts were collected for desiccation and microscopic examination for arthropods of clinical significance. A work site evaluation was

conducted by a team from the National Institute for Occupational Safety and Health (NIOSH). The NIOSH investigators collected air and roofing samples for composition analysis.

RESULTS

All 136 employees living in the encampment on October 3, 2005, were interviewed. All were male, with a median age of 39 years (age range, 18-64 years). Half of the workers identified themselves as being of white race/ethnicity and a quarter as Native American (**Table 1**). Of 136 employees, 58 reported rash or pruritus, yielding a crude attack rate of 42.6%. Forty-one of 58 individuals (70.7%) were examined, and the following 4 distinct clinical entities were diagnosed (some had >1 diagnosis): 27 (65.9%) having papular urticaria (**Figure 2**), 8 (19.5%) having bacterial folliculitis (**Figure 3**), 6 (14.6%) having fiberglass dermatitis (**Figure 4**), and 2 (4.9%) having brachioradial photo-dermatitis. Ten workers had more than 1 condition (**Figure 5**).

Twenty-nine of 58 workers (50.0%) with self-reported rash slept in huts 7 through 10 (Figure 1), statistically significantly more than those who slept in the other huts (relative risk [RR], 3.7; 95% confidence interval [CI], 2.6-5.2). Of those workers sleeping in huts 7 through 10, 68.9% were identified as Native American. Most (79.3%) of the workers with a self-reported rash identified their occupation as roofer, whereas the remaining 20.7% held various occupations such as carpenters, forklift operators, and insulators. In addition, 84.5% of this group reported showering daily, and 34.5% used insect repellent daily. Insects reported at the encampment by the workers included flies, gnats, mosquitoes, and fleas; however, only 6 of those with self-reported rash associated their skin lesions with mosquito bites. The military base was treated with aerial spraying of an insecticide after Hurricane Katrina, and insect monitoring was maintained by military leadership.^{3,6}

INVESTIGATIONS OF SPECIFIC DERMATOLOGIC CONDITIONS

Papular Urticaria

Of 41 workers examined, 27 (65.9%) were diagnosed as having papular urticaria (Figure 2A). The diagnosis of papular urticaria was made in the field by the board-certified dermatologist (S.A.N.) based on clinical findings of multiple edematous erythematous papules, often with a minute central punctum or hemorrhage, and was confirmed by histopathologic presence of eosinophilic infiltrate in the superficial and deep dermis (Figure 2B). Workers having papular urticaria had a dense rash, particularly on their upper and lower extremities and chest, and more than one-third of cases had between 50 and 200 papules.

Of the workers having papular urticaria, all were male, and the median age was 26 years, which was statistically significantly younger than the rest of the workers ($P < .01$). Seventy percent of those with papular urticaria were Na-



Figure 3. Representative case of bacterial folliculitis.

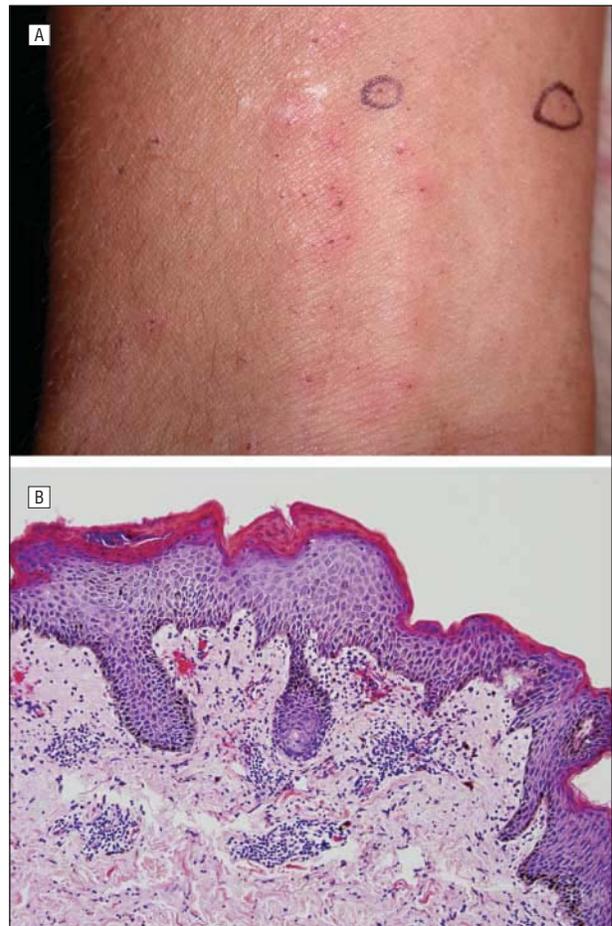


Figure 4. Fiberglass dermatitis. A, Representative case. B, Magnification of biopsy specimen shows superficial perivascular chronic inflammatory infiltrate with overlying spongiosis, mild irregular acanthosis, and parakeratosis (hematoxylin-eosin, original magnification $\times 40$).

ive American, and Native American race/ethnicity was statistically significantly associated with the development of papular urticaria (RR, 7.1; 95% CI, 3.4-14.8) (**Table 2**). Ninety-three percent described their occupation as roofer, which was also statistically significantly associated with the development of papular urticaria (RR, 7.3; 95% CI, 1.8-29.4). Having slept in huts 7

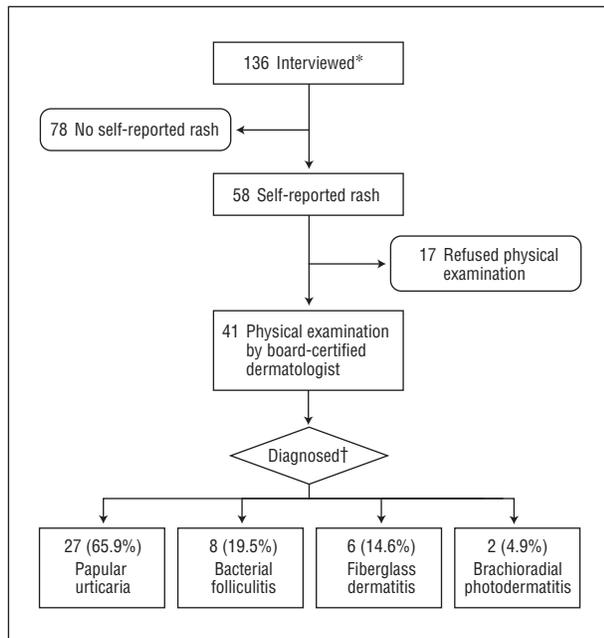


Figure 5. Flowchart of workers identified. *Excluding 53 workers who departed from the base the day before the interview. †Some workers were diagnosed as having multiple clinical entities.

through 10 was statistically significantly associated with the development of papular urticaria (RR, 16.8; 95% CI, 6.3-45.1) compared with all other sleep locations. After adjusting for the effects of sleeping location, Native American race/ethnicity, and occupation as roofer, only sleeping in huts 7 through 10 remained statistically significantly associated with the development of papular urticaria (adjusted OR, 20.4; 95% CI, 5.9-70.2). We found no evidence of collinearity between the variables in our regression model using condition indexes. All workers sleeping in huts 7 through 10 relocated to other sleep locations; the use of repellent and the fumigation of huts were recommended.

Bacterial Folliculitis

Eight workers (median age, 27 years) were diagnosed clinically as having bacterial folliculitis (Figure 3). Half of these workers were Native American, 7 were roofers, and 3 had slept in huts 7 through 10. Compared with those without rash, none of the risk factors (race/ethnicity, occupation, or sleeping in huts 7-10) were statistically significant in the development of folliculitis. Histopathologic examination showed folliculitis. If clinically indicated, patients were treated with oral antibiotics.

Fiberglass Dermatitis

Six workers (median age, 28 years) were diagnosed as having fiberglass dermatitis (Figure 4A). This diagnosis was made among those workers who manifested poorly demarcated diffuse erythema with urticarial, sandpapery, or morbilliform texture, predominantly on the volar aspects of the forearms, with intense pruritus that began within 4 hours of exposure of handling fiberglass.

Table 2. Risk Factors for the Development of Papular Urticaria Among Workers

Risk Factor	No. (%) of Workers		Relative Risk (95% Confidence Interval)
	Papular Urticaria (n=27)	No Papular Urticaria (n=109)	
Native American race/ethnicity	19 (70.4)	15 (13.8)	7.1 (3.4-14.8)
Roofer	25 (92.6)	61 (55.9)	7.3 (1.8-29.4)
Living in wooden huts 7-10	21 (77.8)	9 (8.3)	16.8 (6.3-45.1)
Shower daily	23 (85.2)	91 (83.5)	1.0 (0.4-2.9)
Repellent use daily	11 (40.7)	53 (48.6)	0.8 (0.4-1.5)

Four of 6 were Native American, all were roofers, and 3 had slept in huts 7 through 10. Only Native American race/ethnicity (RR, 6.0; 95% CI, 1.2-31.3) was statistically significant on univariate analysis. We obtained punch biopsy specimens from 2 patients with suspected fiberglass dermatitis, both of which had a histopathologic appearance consistent with fiberglass irritation (Figure 4B). Treatment with topical corticosteroids was prescribed to those with fiberglass dermatitis; the use of personal protective measures was stressed as well.

Brachioradial Photodermatitis

Two workers (median age, 44 years) were diagnosed as having brachioradial photodermatitis.⁷ One was Native American and the other of white race/ethnicity, 1 was a roofer, and 1 had slept in huts 7 through 10. Because of the small sample size, none of these risk factors could be analyzed.

ENVIRONMENTAL AND SITE INVESTIGATION

Although the interiors of huts 7 through 10 and the surrounding grounds were dry at the time of the investigation, the environmental investigation revealed that these huts had sustained flooding during Hurricane Katrina as evidenced by a remaining waterline (Figure 1). Shower and laundry facilities were available on-site, although the main shower trailer at the time of the investigation was out of order. The soil and leaf litter samples collected from around the huts were processed using a Berlese funnel but did not yield any arthropod species.

The work site evaluation by NIOSH included air and material sampling. Three personal breathing zone air samples were collected over approximately 4 hours during which old rooftops were removed. The roofing materials contained fiberglass, and 1 of the air samples detected a fiberglass concentration of 0.01 fiber/cm³, which is below the NIOSH recommended exposure limit of 3 fibers/cm³. Therefore, this exposure was not clinically or occupationally important, but it confirmed the presence of fiberglass at the work site. All other air samples were below the analytical detection limit. Two bulk samples of roofing material were tested for asbestos; none were detected in either sample.

In this posthurricane outbreak investigation, we identified the following 4 clinical entities: papular urticaria, bacterial folliculitis, fiberglass dermatitis, and brachioradial photodermatitis. Although most of the workers were diagnosed as having papular urticaria, this outbreak demonstrates the importance of a multidisciplinary team suited to evaluate skin disease in a setting with environmental and occupational exposures. The delineation of the different dermatologic entities allowed us to implement appropriate treatment and preventive measures, as well as to allay fears of epidemic skin disease.

Various skin diseases have been associated with hurricanes. Infestations with mites may occur when there is a disturbance to the ecosystem such as flooding. This causes displacement of rodents or birds, leaving mites to seek alternate hosts such as humans.⁸ Infectious causes such as *Vibrio vulnificus*^{5,9} and leptospirosis¹⁰ should be considered in ill patients with open wounds that were exposed to posthurricane floodwaters. *Vibrio vulnificus* is common in the warm waters (>20°C) of the Gulf of Mexico,¹¹⁻¹³ and several wound-associated cases were documented after Hurricane Katrina.⁹ Leptospirosis wound infections occur when persons are exposed to freshwater or mud contaminated by the urine of animals infected with leptospire. Floodwaters have been associated with outbreaks of leptospirosis.^{10,14} Other dermatologic conditions associated with occupational and chemical exposures in postflooding cleanup activities have been documented.^{2,4}

We found that workers with a self-reported rash were 4 times more likely to be sleeping in huts that had sustained flooding at the time of rash onset. Similarly, those with papular urticaria were 20 times more likely to be sleeping in the previously flooded huts. One or 2 days before this investigation, the workers living in huts 7 through 10 relocated to tents. A follow-up with the safety officer 2 weeks after the investigation revealed that workers' rashes were improving and that huts 7 through 10 remained unoccupied. Therefore, the arthropod bites were clearly associated with the flooded huts. Papular urticaria is a reaction caused by bites from mosquitoes, fleas, bedbugs, and various species of mites.⁸ We suspect that the source may have been mites whose natural hosts such as rodents or birds may have been displaced by the flooding in these huts. Mosquitoes were less likely the source because of spraying that occurred at the base and because the bites resolved once the workers relocated out of the contaminated huts. Likewise, bedbugs and fleas were never seen by the workers with self-reported rashes in the huts, and they used the same bedding without further experiencing bites. No specific arthropod could be identified from the environmental sampling. Receding floodwaters, the return of arthropods to their natural habitat and hosts, and nocturnal behavior of the offending arthropod could explain our inability to identify the causative organism.

Construction workers living and working at this military base came from all parts of the United States, including several Native American reservations. Initial re-

ports suggested that the skin problems were primarily in Native American workers. Our investigation found that Native American race/ethnicity was associated with the risk of papular urticaria on univariate analysis; however, this finding did not persist on multivariate analysis. The workers racially/ethnically self-segregated in the encampment (eg, 68.9% of the Native Americans slept in huts 7-10), which may have led to confounding among these variables. Once we controlled for these variables, only sleeping in huts 7 through 10 remained a statistically significant risk factor. Most of the cases were in Native Americans, and racial/ethnic self-segregation into specific sleeping huts may have played a role in this focal environmental exposure.

Our investigation has several limitations. Before our investigation, 53 employees had left the compound as part of normal work rotations. These workers were primarily Mexican and Mexican American, and they had lived in tents in the encampment area since August 30, 2005. None had reported rashes, and we did not have access to their contact information. Therefore, inclusion of this group would have most likely biased our results toward the null. The few workers with bacterial folliculitis, fiberglass dermatitis, and brachioradial photodermatitis prevented adequate analysis of risk factors for these conditions.

CONCLUSIONS

A multidisciplinary team, including epidemiologists (R.N., A.L.C., E.L., and L.H.G.), a dermatologist, and an entomologist, were able to discern 4 separate clinical entities among cases originally reported as a rash cluster and to provide appropriate clinical and preventive recommendations. A suspected mite infestation of flooded housing units is the most plausible hypothesis, although we were unable to identify the arthropod source. Our immediate recommendations to the construction company and to the military leadership were to relocate all workers sleeping in huts 7 through 10 to other sleep quarters, to improve the accessible laundry services for workers' clothes, to encourage workers to shower daily and to use insect repellent, and to enforce Occupational Safety and Health Administration guidelines when removing fiberglass roofing, including wearing long-sleeved shirts and gloves.¹⁵

People working and living in posthurricane environments where flooding has occurred may be at an increased risk of exposure to arthropods. To reduce dermatologic morbidity, we suggest avoiding flooded areas, fumigating with an acaricide, wearing protective clothing, and using arthropod repellent.

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Lederman, Gould, and Norton. *Analysis and interpretation of data*: Noe, Cohen, Lederman, Gould, Alsdurf, Vranken, Ratard, and Mott. *Drafting of the manuscript*: Noe, Lederman, Gould, and Norton. *Critical revision of the manuscript for important intellectual content*: Noe, Cohen, Gould, Alsdurf, Vranken, Ratard, Morgan, Norton, and Mott. *Statistical analysis*: Cohen, Gould, and Alsdurf. *Administrative, technical, and material support*: Noe, Lederman, Gould, Alsdurf, and Ratard. *Study supervision*: Morgan, Norton, and Mott.

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