An Epidemic of Dermatitis at a Large Construction Site

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During 6 months in 1986, an epidemic of dermatitis occurred among more than 5600 workers at a single large construction site in the United States. To identify its cause, we used the monthly nurses' log of visits to the medical facility to characterize the outbreak by person, place, and time. Follow-up studies included a survey of carpenters and skin testing of laboratory animals. Workers were more than twice as likely to visit the medical facility for a skin-related complaint in 1986 compared with 1985 (relative rate [RR] = 2.6, 95% confidence interval [CI] 2.2–3.2). Carpenters experienced the greatest increased risk (RR = 9.7, 95% CI 5.5–17.3). We found a strong association between dermatitis and handling of fire-retardant lumber and plywood. Carpenters working only with fire-retardant lumber had a rate of dermatitis 4 times that of carpenters who worked exclusively with untreated wood (RR = 3.6, 95% CI 1.5–8.6). Carpenters who occasionally worked with fire-retardant lumber and plywood were at moderate risk (RR = 2.18, 95% CI 0.7–6.7). Although laboratory tests showed that phosphate compounds could be leached with water from the fire-retardant wood, an extract of these phosphates did not irritate the skin of laboratory animals. We concluded the epidemic was a result of handling fire-retardant lumber but could not identify the specific chemical agent. In view of the observed association, construction workers should be advised to handle this material with caution, especially in high temperature and humidity.

Dermatitis is a condition common to the construction industry. More than 38 000 cases were reported to the United States Bureau of Labor Statistics[1] from 1973 through 1984, representing 37% of all reportable occupational illnesses in this industry. This situation probably arises from exposure to a variety of irritant and sensitizing agents and a general difficulty in maintaining hygienic conditions at construction sites. This rate of dermatitis may increase even further with the use of new chemicals and materials or unusual environmental conditions. Here we report an outbreak of dermatitis at one of the largest construction sites in the United States. Our investigation began when a worker requested assistance from the National Institute for Occupational Safety and Health in August 1986.[2]

At the site, located amid the coastal plains along the Gulf of Mexico, two nuclear power plants were under construction, employing more than 5600 workers. The requestor believed that dermatitis cases resulted from working near fire-retardant lumber and plywood. These materials had been used exclusively inside the power plant for scaffolding and other temporary structures since 1984. Untreated lumber and plywood were used outside the power plants. All lumber and plywood, treated and untreated, was stored near the carpentry building where it was cut to size by sawyers and delivered for use. The fire-retardant lumber (pine) was prepared off-site by mixing dicyandiamide, phosphoric acid, and formaldehyde in water and applying this mixture to the wood by a vacuum/pressure process.[3] The wood was then removed from the treatment tanks and kiln dried.

We visited the site and examined six workers with dermatitis. Pruritic, maculopapular lesions were noted on the arms of some workers. Other parts of the body affected included the shoulders and flank. Workers reported that their rashes began while at work and lasted from days to weeks. Most workers had not reported a rash in previous years. We initiated a study with four goals: (1) to characterize reported dermatitis cases by person, place, and time; (2) to determine if fire retardant materials were associated with the dermatitis; (3)

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to identify the specific agent responsible for the outbreak; and (4) to make recommendations to prevent further cases of dermatitis.

Materials and Methods

Characterization of the Outbreak

All workers employed by the general contractor were provided medical care at the on-site 24-hour clinic. A record of each visit was kept in a log that included the employee's badge number and trade, the nature of the problem, the date of the visit, the part of the body affected, and the unit and building where the employee worked. We considered each skin-related visit recorded from Jan 1, 1985 to Oct 19, 1986 that was not preceded by a similar visit within the past 30 days. Rates of skin-related visits/100 workers by month, year, and trade were calculated using the average number of workers employed each year. The frequency of cases by location and the distribution of the dermatitis by the part of body affected also were enumerated.

Carpenter Survey

A cross-sectional survey of carpenters at the construction site was conducted on Nov 19, 1986. Carpenters worked in small crews and built concrete forms outside of the power plants or scaffolding inside the power plants. Other carpenters were assigned to temporary facilities and built temporary structures, worked as sawyers, and, from time to time, helped build concrete forms and scaffolding. Scaffolding crews worked inside the power plants and handled fire-retardant material exclusively, whereas those making concrete forms worked only with untreated lumber and plywood. Carpenters assigned to temporary facilities handled treated lumber and plywood whenever they worked inside the power plants or, as sawyers, cut both types of lumber. Their exposure was less than that of the scaffolding crews but greater than that of carpenters building concrete forms.

A self-administered questionnaire was given to each carpenter at work on Nov 19. Information sought included demographics, work history, medical history of skin conditions and allergies, exposure to fire-retardant lumber, and use of protective clothing. The questionnaires were distributed by the foreman of each crew, completed at the beginning of each shift, placed in a sealed envelope, and returned to the investigative team by the crew foreman. The questionnaires were immediately reviewed for completeness. Carpenters reporting a red rash of the upper extremities (with or without pustules) that was accompanied by itching and/or burning and had an onset no earlier than Jan 1, 1986, were considered to have a possible contact dermatitis.

Approximately one third of the carpenters reporting a current skin condition that met this case definition and an equal number of carpenters reporting no current rash were randomly chosen and examined on Nov 20 by a physician (MO) blinded to the results of the questionnaire. We compared the results from the physical examination with the questionnaire case definition to determine the accuracy of the questionnaire in predicting the presence (and absence) of a possible contact dermatitis.

The Statistical Analysis System[4] for personal computers Version 6 was used for statistical analyses. Approximate 95% confidence intervals (CI) surrounding the relative rate (RR) point estimate were calculated according to the method of Greenland and Robins.[5] The Mantel-Haenszel procedure for dose-response[6] was used as a test of trend.

Toxicity Determination

Fire-retardant 2 × 4 lumber and plywood and untreated 2 × 4 lumber were collected from the site. Wood slivers were soaked in de-ionized water or an artificial sweat solution[7] for 12 hours in a ratio of 2 grams of wood to 20 mL of solvent to create six extracts. The total volume of each extract was approximately 100 mL. The six extracts, a de-ionized water blank, and an artificial sweat blank were then analyzed for total phosphate. After appropriate diluting, each sample was injected into a Dionex 2010i ion chromatograph equipped with an AGH/AS4 anion separator column system, micromembrane suppressor, and conducting detector. Anions were eluted with 3.0 mM $NaHCO_3$ eluent. Identity of phosphate was accepted as the peak having the same retention time as the lab standard under the same chromatographic conditions.

Given the extent of the outbreak, we believed the dermatitis was more likely to represent a cutaneous irritation rather than a cutaneous allergy. Thus human patch testing was not attempted.[8] Instead, the primary skin irritancy of four extracts (treated wood in water, treated wood in artificial sweat, untreated wood in de-ionized water, and untreated wood in artificial sweat) and two blanks (de-ionized water and artificial sweat) was evaluated. A small amount of the six undiluted test materials (0.5 mL) was applied to intact skin sites on six New Zealand White rabbits (3 males and 3 females) and allowed to remain in contact with the skin for 24 hours. The sites were scored for edema and erythema and checked for tissue damage at the end of the application period (24-hour reading) and 2 days later (72-hour reading) according to the method of Draize.[8] A primary irritancy index score was determined by averaging the edema and erythema skin reaction on each animal. Possible edema and erythema scores ranged from 0 (no reaction) to 4 (severe reaction).

Results

Between Feb 2 and Oct 19, 1986, there was a total of 445 visits from 407 workers to the medical facility for skin-related problems (Table 1). Only 122 visits were

TABLE 1
Skin-Related Visits to the Medical Facility at a Large Construction Site February 2–October 19, 1985 and 1986

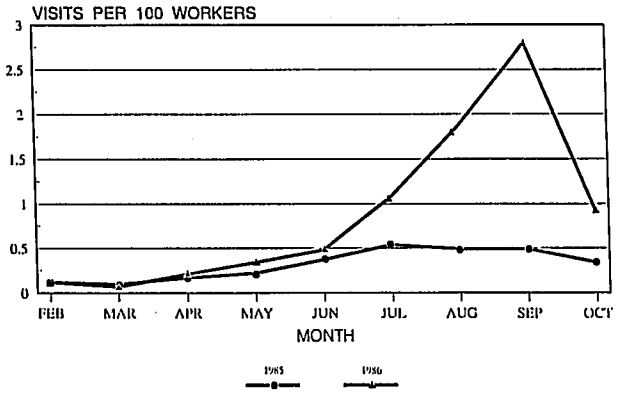
Trade	Year	N*	Visits	Rate/100 Workers	Rate Ratio	95% CI‡	
						Lower Bound	Upper Bound
Carpenters	1986	373	127	34.0	9.7	5.5	17.3
	1985	343	12	3.5			
Laborers	1986	651	67	10.3	2.6	1.6	1.4
	1985	459	18	3.9			
Electricians	1986	1506	66	4.4	1.9	1.3	3.0
	1985	1324	30	2.3			
Ironworkers	1986	475	35	7.4	3.5	1.9	6.4
	1985	662	14	2.1			
Pipefitters	1986	1926	85	4.4	2.8	1.6	4.8
	1985	1015	16	1.6			
Others	1986	720	65	9.0	0.8	0.5	1.2
	1985	276	32	11.6			
Total	1986	5651	445	7.9	2.6	2.2	3.2
	1985	4079	122	3.0			

* N = average number of full-time workers employed each year.
† RR = relative rate = (1986 visits/1986 average number of workers)/(1985 visits/1985 average number of workers).
‡ CI = confidence intervals.

made during the same time period the previous year (RR = 2.6; 95% CI: 2.2, 3.2). The number of visits per month for skin-related problems was similar in 1985 and 1986 from Feb through April (Figure). Beginning in May 1986, the relative number of visits per month between 1986 and 1985 began to increase, reaching a maximum in September 1986.

In 1986, carpenters had the highest rate of skin-related visits to the medical facility (34 cases per 100 carpenters), followed by laborers (10 cases per 100 laborers), and ironworkers (7 cases per 100 ironworkers) (Table 1). With the exception of the "others" category, all trades experienced a higher rate of visits to the medical facilities for skin-related problems in 1986 relative to 1985, and these increases were all statistically significant.

The proportion of affected workers being assigned to work inside either of the two power plants was 70% in 1986 compared to 63% in 1985, but this difference was not statistically significant ($\chi^2 = 2.03$, $P = 0.15$) (Table 2). The number of workers assigned to various areas at the construction site was not known, and these proportions should be interpreted with caution. The upper extremity was the principal part of the body affected during both years, representing 58% of the visits in 1985 and 62% in 1986 ($\chi^2 = 2.37$, $P = 0.12$).



All contract workers.

Figure. Visits to the medical facility for skin-related problems, 1985 and 1986.

Carpenter Survey

On Nov 19, 1986, of 338 carpenters 310 (92%) completed questionnaires. A total of 181 (54%) carpenters reported having had a skin condition, but only 99 (29%) met the case definition of possible contact dermatitis. Twenty-four (31%) carpenters reporting a current skin condition and 22 (9%) without a current skin condition were examined the following day (Table 3). Twelve of those examined met the questionnaire case definition for possible contact dermatitis. Eleven of those reporting a current skin condition had physical findings consistent with possible contact dermatitis. The questionnaire case definition was estimated to have a sensitivity of 82% and a specificity of 91%.

TABLE 2
Visits to the Medical Facility for Skin-related Problems by Work Area and the Part of Body Affected

Year	Work Area		Other	Total
	Power Plant 1	Power Plant 2		
1985	54	23	45	122
1986	167	144	134	445
	Part of Body Affected			
	Upper Extremity	Head & Shoulders		
1985	66	12	44	122
1986	275	19	151	445

Cases were not associated with race or a history of atopy. When carpenters were categorized by whether they worked with fire-retardant lumber, 47 could not be placed into a single category and were excluded. Carpenters working in scaffolding crews, having the greatest exposure to fire-retardant materials, were at greatest risk (RR = 3.6; 95% CI 1.5, 8.6) compared to carpenters working exclusively with concrete forms (Table 4). Foremen and temporary facility workers were at moderate risk (RR = 2.2; 95% CI 0.7, 6.7). The statistical test for trend was highly significant (χ^2 = 9.78, P = 0.001).

Toxicity Testing

Total phosphate concentrations for the extracts of the fire-retardant lumber ranged from 4.7 to 7.1 mg/g wood. The extracts from treated plywood had lower phosphate concentrations (4.1 and 5.1 mg/g wood in artificial sweat and water, respectively) than did the treated 2 × 4 lumber extracts (6.8 and 7.1 mg/g wood). Extractions of the untreated wood, the artificial sweat blank, and the water blank had no detectable phosphates.

The results of the 24-hour application of the test materials to the intact skin of test animals and the specific observations with regard to erythema and edema are summarized in Table 5. The primary irritancy index results (ranked from lowest to highest) were: water blank (0.0), untreated wood extract in artificial sweat (0.1), untreated wood in de-ionized water (0.2), treated wood in artificial sweat (0.4), artificial sweat blank (0.5), and the treated wood in de-ionized water (0.5). The slight variation and relatively low scores suggest that the irritant properties of the six samples were equivalent. There was no evidence of tissue damage.

TABLE 3
Sensitivity and Specificity of Questionnaire Case Definition for Possible Contact Dermatitis*

Questionnaire	Physician's Determination Possible Contact Dermatitis		Total
	Yes	No	
Possible contact dermatitis			
Yes	9	3	12
No	2	32	34
Total	11	35	46
Sensitivity	9/11 (81.8%)		
Specificity	32/35 (91.4%)		

* A questionnaire case of possible contact dermatitis was a self-reported red rash on the upper extremities which caused itching and/or burning that began no earlier than Jan 1, 1986.

Discussion

Our findings indicate that an outbreak of dermatitis occurred at this construction site and was confined to the 6-month period during the summer of 1986. Carpenters, the tradespeople most likely to handle fire-retardant lumber, experienced the greatest likelihood of skin-related visits to the medical facility in 1986. The demonstration of a dose-response relationship between handling fire-retardant materials and dermatitis suggests a causal association.

No specific agent was identified, nor is it conclusive that a causal role for the fire-retardant lumber existed. Perhaps the offending agent was elsewhere within the power plants. This could explain the dose-response trend for carpenters' handling fire-retardant materials. However, it would not explain why carpenters were at much greater risk than other employees working inside the power plants. An alternative explanation is that a physical irritation resulted from the rubbing of particulate sawdust against the skin of carpenters and that the dermatitis was not the result of a chemical effect. We think this unlikely since such a physical irritation would result in a high background rate of dermatitis rather than the well-defined epidemic observed. Also, the carpenters who handled treated lumber did not necessarily contact more sawdust than did other carpenters.

Assuming that the treated wood was responsible for the dermatitis, a possible explanation for the negative toxicity testing was that the wood extracts were not made from the fire-retardant lumber that caused the dermatitis. Treated lumber had been purchased from two suppliers. Because of a delay in delivery from supplier A, lumber from a new supplier (supplier B) was purchased and first arrived at the site on April 11, 1986. A second shipment was received on May 21, 1986.

TABLE 4
Possible Contact Dermatitis and Work with Fire Retardant Lumber in Carpenters, 1986*

	Exposure to Fire-Retardant Lumber			Totals
	0	1	2	
Possible contact dermatitis				
Yes	3	11	72	86
No	25	36	116	177
Relative rate	1.00	2.18	3.57	
95% CI	–	(0.7, 6.7)	(1.5, 8.6)	

* Exposure categories were defined as: 0 = carpenters who did not work with fire-retardant lumber. 1 = carpenters who occasionally worked with fire-retardant lumber. 2 = carpenters who worked exclusively with fire-retardant lumber.
Mantel-Haenszel test for dose-response χ^2 = 9.78, P = 0.001.

TABLE 5
Primary Skin Irritancy Scores in Rabbits for the Extracts of Fire-retardant and Untreated Woods

Extract	Average Erythema		Average Edema		PII*
	24 hr	72 hr	24 hr	72 hr	
Fire-retardant 2 × 4 lumber in water	0.67	0.17	0.17	0.00	0.5
Fire-retardant 2 × 4 lumber in sweat	0.50	0.00	0.33	0.00	0.4
Untreated 2 × 4 lumber in water	0.17	0.17	0.00	0.00	0.2
Untreated 2 × 4 lumber in sweat	0.17	0.00	0.00	0.00	0.1
De-ionized water	0.00	0.00	0.00	0.00	0.0
Artificial sweat	0.67	0.17	0.17	0.00	0.5

Scoring key for skin reactions for primary skin reactions in rabbits:

Erythema and eschar formation	Score
No reaction	0
Very slight erythema	1
Well-defined erythema	2
Moderate to severe erythema	3
Severe erythema to slight eschar formation	4
Edema formation	
No edema	0
Very slight edema	1
Well-defined edema	2
Moderate edema (raised approx 1 mm)	3
Severe edema (raised more than 1 mm and extending beyond the area of exposure)	4

* PII = primary irritation index. The averages were added together and divided by two to determine the PII.

Subsequent orders for treated lumber from supplier B were made on May 28, June 11, July 16, July 31, Aug 11, and Aug 26, 1986. The lumber used in the toxicity testing originated from supplier B and was received at the construction site sometime after Sep 1, 1986.

The raw ingredients of the fire-retardant treatment may have contained potential allergens, but the treated lumber did not contain free formaldehyde or dicyandiamide and human patch testing was not considered. The large number of affected workers suggested that the offending agent was more likely to have been an irritant than an allergen. Furthermore, human subject review board considerations prevented patch testing on unexposed and unaffected workers. Even if patch testing had been an available option, negative test results would have been uninformative for reasons similar to those described above.

The distribution of dermatitis cases by season showed that the epidemic was confined to the summer months, when temperatures were frequently in excess of 95°F, and humidity was often 80% or higher. Workers reported that temperatures inside the power plants could exceed outdoor temperatures by 20°F. With this in mind, it is interesting to note that phosphates from the treated lumber could be leached from the wood by both water and sweat. This suggests that an interaction between the hot and humid working conditions inside the power plants and contact with the treated lumber from supplier B might have resulted in the epidemic. One possible mechanism for this interaction was that carpenters, working in extreme heat, were sweating heavily. When the treated wood was held next to their skin for prolonged periods, an irritant may have leached from the wood onto their skin, causing the dermatitis. Workers inside the power plants routinely wore short-sleeved or sleeveless shirts and did not wear gloves. The protection afforded by long-sleeved shirts and gloves could not be evaluated during the survey.

To our knowledge this is the first reported epidemic of dermatitis associated with fire-retardant lumber. Reports of dermatitis have been associated with several types of woods and with certain fire retardants. Several woods are known to cause allergic contact dermatitis,[10] including teak, larch, and mahogany. Carpenters are known to be at risk from such allergens whenever handling these woods. It also has been reported that pine contains 2 allergenic constituents, γ-pinene and δ_3-carene, but that dermatitis resulting from exposure to pine is uncommon.[10] A commonly used fire-retardant applied to childrens' clothing (TRIS [2,3 dibromopropyl] phosphate) was removed from the market after it was found to cause dermatitis.[11] This material, the active ingredient in the fire-retardant lumber, and many other fire retardant chemicals are phosphate compounds.

We emphasize the usefulness of the medical logs kept by the medical facility. The two power plants were located on a 500-acre site and the workforce was larger than that of many towns. Without the data from the medical logs, a preliminary survey of the work force would have been required to understand the course of the outbreak and to identify that carpenters were most affected. This would have been a large and difficult task. It has been stated elsewhere,[12] and we concur, that the use of existing data sources for surveillance contributes substantially to the recognition and eventual control of occupational diseases.

Several recommendations were made during our investigation including: (1) the continued surveillance of construction workers for dermatitis, (2) that carpenters wear gloves and long-sleeve shirts with changes in clothing available, whenever practical, when handling treated lumber and plywood, and (3) that those sawing treated lumber wear dust masks to avoid exposure to wood dust. It also was stressed that the medical staff attempt to differentiate possible contact dermatitis from other forms of nonoccupationally related skin disease. This would decrease disease misclassification, help alert staff to outbreak situations, and aid in the identification of the causal agent.

Although the toxicity testing of the treated wood did not demonstrate that the wood was a skin irritant, it is uncertain how well the model system reproduced the conditions of workplace exposure. In view of the strong association between dermatitis and exposure to the treated wood, construction workers should be advised to handle this material with caution, especially in high temperature and humidity conditions.

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Vive la Foie!

In 1970, there were three hundred different drugs for the liver in France, accounting for nearly 5% of French drug consumption. A comparison between French and American drug consumption in 1976 showed that 12% of French drugs, compared to 5% of US drugs, were for the digestive system. The difference is even more striking when one realizes that French per capita drug consumption is greater overall than that in the United States.

In 1976, French hepatologists . . . (absolved) the liver of its responsibility for most diseases (except, of course, cirrhosis and hepatitis), and since then it has been unfashionable to talk about the "crise de foie". . . .

CREDOC found that between 1970 and 1980 the number of persons saying that they suffered from liver disease declined by a factor of four. The sale of drugs for the liver also . . . dropped dramatically: the 1982 study of prescriptions for the Office of Health Economics in London found a relative excess of gastrointestinal drugs for Italy but not for France.

From *Medicine and Culture: Varieties of Treatment in the United States, England, West Germany, and France* by L. Payer. New York: Henry Holt & Co.; 1988: 59.