

# Work-Related Skin Disease in the Plastics Industry

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*In a survey of a representative sample of workers taken at each of four different plastics manufacturers, 122 completed self-administered questionnaires were obtained. Twenty-six respondents (21.3%) met the case definition for having a work-related skin disorder during the preceding year. Sixteen (61.5%) cases indicated that their skin problems were present for 11 or more days, and 50% reported that their normal daily activities were at least somewhat affected. Risk of disease was elevated for workers who reported skin contact with formaldehyde (OR = 3.30; 95% CI = 1.02-10.69) or with polyvinylchlorides (PVCs) or their precursors (OR = 4.08; CI = 1.19-14.06), used barrier creams (OR = 4.51; CI = 1.22-16.68), were female (OR = 5.42; CI = 0.97-30.22), were 35 or younger (OR = 4.65; CI = 1.53-14.19), and for each use of hand cleaner at work (OR = 1.22; CI = 1.05-1.41). These findings should be considered when designing programs to reduce the incidence of skin disease among workers in the plastics industry. Am. J. Ind. Med. 31:545-550, 1997. © 1997 Wiley-Liss, Inc.*

**KEY WORDS:** occupational dermatitis; rashes; resins; canned hand cleaners; work-related skin disease; formaldehyde; polyvinyl chloride

## INTRODUCTION

Researchers have demonstrated that the production of plastics is one of the leading causes of occupational dermatitis [O'Malley et al., 1988]. Kanerva et al. [1988] determined that plastic materials are responsible for 27.7% of cases of allergic eczema; Tarvainen et al. [1993] found 26% of workers in the glass-fiber-reinforced plastics industry to be suffering from skin disorders from a variety of causes.

This study was undertaken to identify specific chemicals, job duties, protective equipment usages, individual and family medical conditions, and personal characteristics associated with increased likelihood of the development of work-related skin disorders. The results will be used to guide prevention efforts.

## MATERIALS AND METHODS

### Study Population

Employing an industrial index to identify businesses with a primary Standard Industrial Code (SIC) of 2821

(Plastics, Materials, and Nonvulcanizable Elastomers), we located 38 such work sites operating in Ohio as of January 1995. An introductory letter explaining the purpose of the research and requesting their participation in the project was mailed to each company's safety officer or plant engineer. For those that agreed to take part, a walk-through inspection and an opportunity to distribute questionnaires were scheduled.

Seven companies (18.4%) volunteered to take part in the study. At four of these worksites, an entire shift or entire workforce was interviewed, or the questionnaire was administered at regularly scheduled safety meetings, where virtually all attendees returned the survey. At the other three sites, workers were free to choose whether or not to complete the questionnaire. Stratified analysis revealed some significant differences between the self-selected group and the "captive" responders; therefore, the former was excluded from analysis.

Each of the four companies produced a consumable intermediate plastic in powder, liquid, or pellet form, made to the specifications of other manufacturers, who in turn used them in a wide array of products. Additionally, three of these companies produced their own final products, which included laminated tabletops, fiberglass insulation, and adhesives.

Workforces at these sites ranged in size from 23 to 175, with a total of 338. From these four sites, all 135

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(39.9%) workers who had the opportunity to do so (i.e., were present at the time of the site visit), returned questionnaires. One hundred twenty-two (90.4%) were completed sufficiently to permit evaluation of major risk factors for skin disease.

## The Questionnaire

The survey instrument was a questionnaire being developed by the Washington Department of Labor for the study of skin disease in the general work population [Kaufman and McCann, 1996], which was modified for evaluation of workers in the plastics industry. Information sought included demographics (age, race, ethnicity, sex, education); rash history (including reactions to jewelry, cosmetics, creams, perfumes, soaps/detergents, pets, hobbies or other jobs); personal and family history of asthma, hay fever, or hives; job description (e.g., title, length of service, average hours worked/week); personal protective equipment usage; and a detailed accounting of the use of, exposure to, and skin contact with 18 different chemicals commonly used in this industry's manufacturing process. Respondents who indicated that a substance had come into contact with their skin were asked to report each of the different ways this occurred. Choices included splashed, while mixing, as a mist, cleaning with the substance, pouring/squirting, leak in protective equipment, or while moving/handling. For those who reported that they had a skin problem during the past year, we sought information on the location, duration, severity, etiology, effect, and treatment course of the disorder.

## Case Definition

Disease status was self-determined, with no independent medical confirmation. An individual met the case definition by responding positively to the question, "During the past 12 months, have you had dermatitis, eczema, or any other red inflamed skin rash (not burns)?," and by answering yes to at least one of the following two questions: "Do you believe that any of the skin rashes or skin conditions that you have had in the past 12 months were caused by exposure to any chemicals, substances or other conditions while you were at work?" or "Do you believe that any of the skin rashes or skin conditions that you have had in the past 12 months were worsened by exposure to any chemicals, substances or other conditions while you were at work?," or by opting for the response "better" when asked: "During the past 12 months, did your skin rash get better, worse, or stay about the same during the time you were away from your job (e.g., on weekends, days off, vacation, medical leave, or job change)?"

## Statistical Analysis

Hand-cleaning practices with soap, detergent, canned hand cleaner, or water only, both at home and at work, were

measured ordinally. Workers were categorized as high exposure risk when they were involved directly in the production process (blender/polymer/kettle operators, extruders, or resin mixers); medium risk when they were peripherally involved in production (loaders; laboratory workers; towmotor operators; or research, design, production, or chemical engineers); and low risk when they were entirely removed from production work (clerical workers, administrators, or sales people). Aside from the multiple categories available for how skin contact occurred, all other independent variables were dichotomized (e.g., white/nonwhite, skin contact with formaldehyde/no skin contact with formaldehyde).

Crude odds ratios were calculated to identify risk factors for the development of skin disease. Those that were statistically significant ( $p < 0.05$ ), or that displayed a relatively large size of effect, along with pertinent interaction terms and potential confounders, were retained for logistic regression analysis. Differences in  $-2 \log$  likelihoods were examined to help determine the best model. Lastly, we applied the parameter estimates from the final model to calculate the probability of skin disease for various combinations of risk factors.

## RESULTS

Thirty-five (28.7%) of the 122 workers reported skin disease during the previous year; 26 (21.3%) attributed the skin disease to the workplace (i.e., met the case definition). For individual companies, the proportion of workers with work-related skin disease ranged from 9.1% to 24.3%. Ten (38.5%) of the cases indicated that their skin problems were present for more than 30 days of the preceding year, six (23.1%) reported they were present for 11–30 days, five (19.2%) for 6–10 days, and the other five (19.2%) for 1–5 days. Of the 24 who completed the question inquiring about how much their daily activities were adversely affected when their skin problem was at its most severe, 12 (50.0%) reported that they were at least somewhat affected and the other 12 indicated that they were not at all affected. Twenty-four (92.3%) included their hands and/or arms as a part of the body where the disease manifested, four (15.4%) included their face, and four (15.4%) included their trunk and/or much of their body. Having skin problems in the past due to jewelry, cosmetics, lotions, perfumes, soaps, or pets were not predictors of work-related skin disease during the past year.

Four (40%) of the 10 women and 63 (56.3%) of the 112 men in the study held high-exposure risk jobs. Workers 35 or less years of age were significantly more likely to have high-risk jobs than their older counterparts (OR = 3.40; CI = 1.49–7.89). For 11 (61.1%) of the 18 substances, moving/handling was the most frequently cited activity that resulted in skin contact with the substance.

**TABLE I.** Distribution and Odds Ratios for Personal Risk Factors among Plastics Industry Workers for Work-Related Skin Disease, Ohio, Jan.–April 1995

Risk factor	% With & without factor	# of cases	# Noncases	Odds ratio (& 95% C.I.)
Age 35 or Less	45.1	18	37	3.59 (1.31, 10.10)*
vs 36 or Older	54.9	8	59	1.00
White	85.2	24	80	2.40 (0.50, 22.86)
vs Non-White	14.8	2	16	1.00
Female	8.2	3	7	1.66 (0.26, 7.96)
vs Male	91.8	23	89	1.00
Hx of Asthma	9.8	3	9	1.26 (0.20, 5.60)
vs No Asthma	90.2	23	87	1.00
Hx of Hay Fever	23.0	8	20	1.69 (0.57, 4.89)
vs No Hay Fever	77.0	18	76	1.00
Hx of Hives	12.3	1	14	0.23 (0.01, 1.71)
vs No Hives	87.7	25	82	1.00
Family Hx Asthma	10.7	2	11	0.64 (0.07, 3.27)
vs No Fam/Asthma	89.3	24	85	1.00
Family Hx Hayfevr	20.5	5	20	0.90 (0.24, 2.90)
vs No Fam/Hayfevr	79.5	21	76	1.00
Family Hx Eczema	9.8	2	10	0.72 (0.07, 3.72)
vs No Fam/Eczema	90.2	24	86	1.00
Atopy	30.3	10	27	1.60 (0.59, 4.32)
vs No Atopy	69.7	16	69	1.00
Family Hx Atopy	31.1	7	31	0.77 (0.26, 2.21)
vs No Family Hx	68.9	19	65	1.00
LT 10 Yrs at Job	61.5	20	55	2.48 (0.86, 8.20)
vs 10+ Years	38.5	6	41	1.00
Some College	67.2	19	63	1.42 (0.50, 4.18)
vs No College	32.8	7	33	1.00
Dissatsfd w/Job	13.1	6	10	2.58 (0.68, 8.90)
vs Satisfied	86.9	20	86	1.00
High Risk Job	54.9	19	48	3.56 (0.72, 34.23)
vs Low Risk Job	16.4	2	18	1.00
Medium Risk Job	28.7	5	30	1.50 (0.22, 17.19)
vs Low Risk Job	16.4	2	18	1.00

\*Statistically significant at  $\alpha = .05$ , two-sided.

In addition to being  $\leq 35$  years of age, and reporting skin contact with alcohol, lubricants, and polyvinylchloride (PVC) or its precursors (Tables I, II), each use of canned hand cleaner (OR = 1.16; CI = 1.04–1.29) or detergent (OR = 1.09; CI = 1.00–1.19) at work was associated with significantly increased risk of skin disease, as was use of barrier creams (OR = 6.88, CI = 2.09, 23.04), Table III. Stratification by job longevity revealed that among persons who had worked at their company for <10 years, young workers were at elevated risk of skin disease (OR = 5.56; CI = 1.12–53.25).

Risk factors retained in the final multivariate model included female gender,  $\leq 35$  years of age, use of barrier creams, skin contact with formaldehyde or PVC or its precursors, and (each) use of canned hand cleaner during the

work day (Table IV). Figure 1 depicts the probability of skin disease for various subpopulations of plastics workers. Risk of disease ranged from 1.8% in the reference group (males with none of the other risk factors), to 97.2% for females with all risk factors, including use of hand cleaner at work once per day.

## DISCUSSION

### Disease Prevalence

The manner in which subjects were selected, and the high response rate should ensure that if our estimate of self-reported, work-related skin disease is inaccurate, it is because it underrepresents true prevalence. Company

**TABLE II.** Associations between Skin Contact with Various Chemicals and Likelihood of Work-related Skin Disease, Ohio, Jan.–April, 1995

Substance	% With & without exposure	# of cases	# Noncases	Crude odds ratio (& 95% C.I.)
Formaldehyde	28.7	9	26	1.43 (0.51, 3.93)
vs No Exposure	71.3	17	70	1.00
Pigments	54.1	18	48	2.25 (0.82, 6.29)
vs No Exposure	45.9	8	48	1.00
Alcohol	21.3	10	16	3.13 (1.08, 9.01)*
vs No Exposure	78.7	16	80	1.00
Perchloroethylene	3.3	1	3	1.24 (0.02, 16.19)
vs No Exposure	96.7	25	93	1.00
Polyethylene	41.0	14	36	1.94 (0.75, 5.10)
vs No Exposure	59.0	12	60	1.00
PVC or Precursors <sup>a</sup>	20.5	10	15	3.38 (1.16, 9.84)*
vs No Exposure	79.5	16	81	1.00
Acetone	23.0	8	20	1.69 (0.57, 4.89)
vs No Exposure	77.0	18	76	1.00
Toluene	5.7	2	5	1.52 (0.14, 9.95)
vs No Exposure	94.3	24	91	1.00
Naphtha	4.1	1	4	0.92 (0.02, 9.86)
vs No Exposure	95.9	25	92	1.00
Fiberglass	8.2	3	7	1.66 (0.26, 7.96)
vs No Exposure	91.8	23	89	1.00
Styrene	24.6	10	20	2.38 (0.85, 6.64)
vs No Exposure	75.4	16	76	1.00
Meth Eth Ketone	21.3	7	19	1.49 (0.49, 4.48)
vs No Exposure	78.7	19	77	1.00
Benzene	10.7	3	10	1.12 (0.18, 4.85)
vs No Exposure	89.3	23	86	1.00
Degreasers	26.2	11	21	2.62 (0.95, 7.21)
vs No Exposure	73.8	15	75	1.00
Thermoplastics	28.7	11	24	2.20 (0.81, 5.96)
vs No Exposure	71.3	15	72	1.00
Lubricants	28.7	13	22	3.36 (1.24, 9.16)*
vs No Exposure	71.3	13	74	1.00
Epoxy Resins	7.4	2	7	1.06 (0.10, 6.07)
vs No Exposure	92.6	24	89	1.00
Other Resins <sup>b</sup>	29.5	11	25	2.08 (0.77, 5.62)
vs No Exposure	70.5	15	71	1.00

\*Statistically significant at alpha = .05, two-sided.

<sup>a</sup>May include polyvinyl chloride, PVC homopolymer, vinyl acetate, or vinyl chloride.

<sup>b</sup>Other resins may include various synthetic resins, both thermosetting (e.g. urea-, melamine- or phenol-formaldehydes) and thermoplastic (e.g. vinyl chloride), and natural resins (e.g. gums).

participation in the study was strictly voluntary and those with the most problems may have chosen not to take part, despite assurances that the investigation was only research oriented and in no way of a regulatory nature. If the survey had included workers ill on the day of our site visit and those assigned to swing or night shifts, when adherence to safety and hygiene guidelines may be less stringent, the proportion with skin disease may well have been greater. Furthermore, anecdotal evidence from informal interviews

as well as reviews of OSHA 200 logs revealed that a number of seriously affected coworkers may have left their positions when their skin disorders persisted. Additionally, 32.7% of workers 35 or younger met the case definition, compared to only 11.9% of their older counterparts. Holness and Nethercott's [1995] finding that among the skin diseased, increasing age was inversely correlated with continued employment, appears to apply to our study population as well.

**TABLE III.** Distribution of Personal Protective Equipment Usages & Odds Ratios Associated with Work-related Skin Disease, Ohio, Jan.–April, 1995

Protective equipment	% Who used/ did not use	# of cases	Noncases	Odds ratio (95% CI)
Apron	24.6	10	20	2.38 (0.85, 6.64)
Did Not Use	75.4	16	76	1.00
Boots/Safety Shoes	87.7	25	82	4.27 (0.59, 187.59)
Did Not Use	12.3	1	14	1.00
Goggles/Safety Glasses	90.2	24	86	1.40 (0.27, 13.91)
Did Not Use	9.8	2	10	1.00
Faceshield	50.0	16	45	1.81 (0.69, 4.83)
Did Not Use	50.0	10	51	1.00
Respirator	50.0	15	46	1.48 (0.57, 3.89)
Did Not Use	50.0	11	50	1.00
Gloves	82.0	21	79	0.90 (0.28, 3.50)
Did Not Use	18.0	5	17	1.00
Smock	44.3	12	42	1.10 (0.42, 2.86)
Did Not Use	55.7	14	54	1.00
Overalls	32.8	13	27	2.56 (0.96, 6.81)
Did Not Use	67.2	13	69	1.00
Barrier Creams	14.8	10	8	6.88 (2.09, 23.04)*
Did Not Use	85.2	16	88	1.00

\*Statistically significant at alpha = .05, two-sided.

**TABLE IV.** Adjusted Odds Ratios and 95% Confidence Intervals from Final Multiple Logistic Regression Model Evaluating Predictors of Skin Disease, Ohio, Jan.–April, 1995

Risk factor	Odds ratio	95% Confidence interval
Female Gender	5.42	0.97, 30.22
Age 35 or Younger	4.65	1.53, 14.19
Use Barrier Cream During Job Performance	4.51	1.22, 16.68
Each Use of Canned Hand Cleaner at Work	1.22	1.05, 1.41
Skin Contact w/Formaldehyde at Work	3.30	1.02, 10.69
Skin Contact w/PVC or Its Constituents <sup>a</sup>	4.08	1.19, 14.06

<sup>a</sup>May include polyvinyl chloride, PVC homopolymer, vinyl acetate, or vinyl chloride.

### Risk Factors for Work-Related Skin Disease

Working at a high-exposure risk job initially appeared to be an important (though nonstatistically significant) risk factor for work-related skin problems: proportion diseased = 28.5% for high risk, 14.3% for medium risk, and 10% for low-exposure risk workers. However, with multivariate analysis, job exposure classification lost its explanatory power, as variation in likelihood of skin disease was captured by specific exposures to formaldehyde and PVCs and use of canned hand cleaner and barrier creams. It was not possible to attribute how much use of barrier creams and hand cleaners actually contributed to disease, as opposed to

these variables merely serving as proxies for jobs with greater exposure risks.

The magnitude of risk associated with using barrier creams and canned hand cleaner at work and skin contact with formaldehyde and polyvinyl chloride or its constituents may have been distorted by enhanced recall by the diseased workers. However, the lag time between exposure and completion of the questionnaire was equivalent for the diseased and nondiseased. Furthermore, these factors were not the rare exposures that can readily bias results when differential recall by cases and controls is present [Sackett, 1979] (e.g. 18 (14.8%) workers reported skin contact with PVC or its constituents, the rarest of these four risk factors). Nor was the disease outcome extremely serious, which would increase the likelihood of the afflicted searching for explanatory causes [Mausner and Kramer, 1985]. For these reasons, if there was any exposure misclassification, it was most likely nondifferential and, therefore, biased results toward the null.

Although young workers (35 or less) were much more likely to have high exposure risk jobs (OR = 3.40; CI = 1.49–7.80) than older workers, they continued to be at increased risk of disease after controlling for each of the exposures associated with such jobs. However, as mentioned earlier, this may partially or wholly be due to older workers seeking employment elsewhere when their skin problems persist.

The finding of elevated risk for females would seem to corroborate what other researchers have concluded regarding gender and various forms of skin disease [Lantinga et al., 1984; Meding and Swanbeck, 1990; Kavli and Forde, 1984; Kanerva et al., 1994]. Yet, it has also been demonstrated that

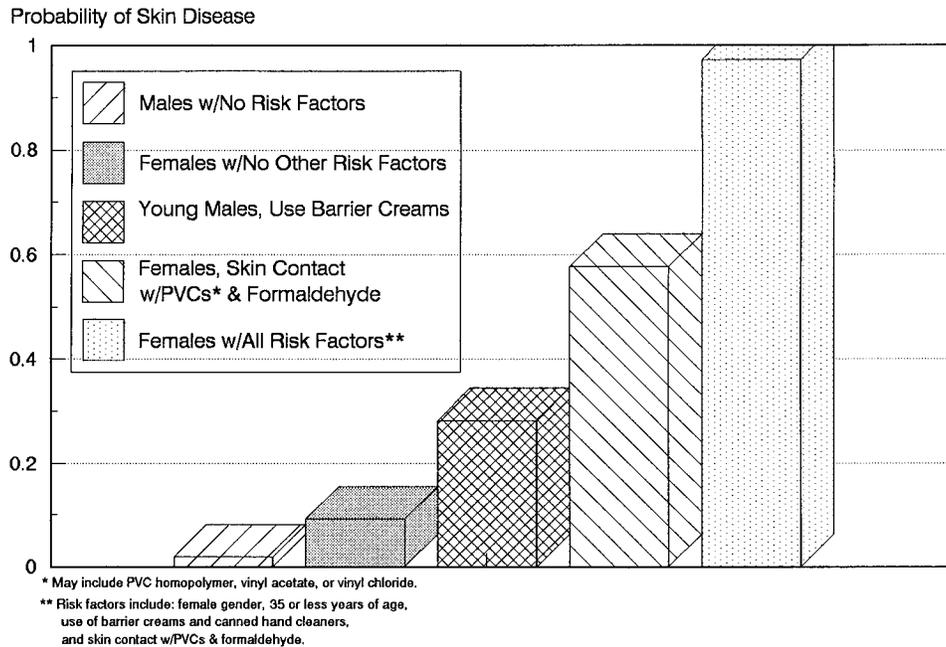


FIGURE 1. Probability of skin disease for various subpopulations of plastics workers.

females are more likely to seek medical attention [Verhaak, 1995; National Center for Health Statistics, 1981], which may occur because they are more aware of bodily changes or attach more significance to them. Since disease status was not medically confirmed in this study, it is not possible to distinguish the relative contributions of actual elevation of risk and increased likelihood of reporting it.

## CONCLUSION

Work-related skin disease appears to be a widespread and persistent problem that adversely affects the quality of life of plastic workers. Prevention programs should begin with efforts to minimize workers' skin contact with noxious substances, some of which, e.g., formaldehyde, may put the worker at increased risk of developing cancer. Use of canned hand cleaners and barrier creams should be examined to determine if they are associated with greater incidence of disease. An additional issue to address is whether males underreport skin disease and, if not, what factors explain elevated rates in females.

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