

Incidence of latex sensitization among latex glove users

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Background: Although there are several reports of the prevalence of latex sensitization among health care workers, the incidence of sensitization is unknown.

Objective: The objective of this study was to estimate the incidence of sensitization among latex glove users at a hospital in Hamilton, Ontario, Canada.

Methods: Workers with negative results to the skin test at baseline were followed prospectively over 1 year, some wearing powdered gloves and others using powder-free gloves. They were reevaluated in 1995 with a questionnaire and skin prick test (SPT) sensitivity to latex reagents, three common inhalants, and six foods. A conversion was defined as a (new) latex SPT with wheal diameter at least 4 mm greater than saline control. Glove extracts were assayed for antigenic protein, and air samples were obtained to estimate exposure to airborne latex protein.

Results: During powdered glove use, personal exposures ranged from 5 to 616 ng/m³, whereas during powder-free glove use, all but two results for air samples were below the limit of detection (about 0.1 ng/m³). During the study period, the protein concentration in the powdered gloves, initially mean 557 µg/gm of sample, declined at a rate of 295 µg/gm per year ($p < 0.0001$). Of the 1075 SPT-negative participants at baseline, 479 were working in eligible wards, and of these, 435 (91%) participated in follow-up, 227 using powder-free gloves and 208 using powdered gloves. We identified four conversions, two (1.0%) in the powdered glove group and two

(0.9%) in the powder-free group. The two participants using powdered gloves were the only converters who were symptomatic. The significance of skin test conversions identified in the powder-free group, both asymptomatic patients, is unclear. The limitations of the study are discussed, including the limited power, the declines in latex protein concentrations, and the possibility of information (observer) bias. **Conclusion:** To our knowledge, this represents the first reported estimate (about 1%) of incidence of sensitization in hospital personnel using latex gloves. (*J Allergy Clin Immunol* 1998;101:171-8.)

Key words: Latex gloves, sensitization, powdered gloves, powder-free gloves, latex protein concentrations, prospective study, skin testing, airborne exposure

Natural rubber latex (NRL) allergy has become an important occupational health concern in recent years, particularly among health care workers (HCWs).¹⁻⁵ The major source of workplace exposure has been powdered latex glove use by HCWs. Workers involved in glove manufacturing may also be affected.⁶ Type I (IgE-mediated) NRL allergy symptoms include urticaria, angioedema, rhinitis, conjunctivitis, bronchospasm, and anaphylaxis.

Surveys of HCWs have demonstrated that the prevalence of sensitization to latex ranged from 2.9% in Finland⁷ to 4.7% in Belgium⁸ among hospital employees as a group and from 7% among operating room staff in Finland⁷ to 9% to 10% among operating room nurses in France⁹ and surgeons, anesthesiologists, and radiologists in Canada.¹⁰ Recently, Grzybowski et al.¹¹ found that 8.9% of 741 registered nurses in Michigan had positive test results for anti-latex IgE antibodies, which may be less sensitive than skin testing. Vandenplas et al.⁸ documented 2.5% of HCWs to have latex-induced occupational asthma confirmed with specific inhalation challenge.

Sensitization of HCWs may involve high costs, both in terms of day-to-day risks at work as well as potentially fatal anaphylactic shock. Disability from latex sensitivity is an increasing problem caused by latex product substitution, personnel reassignments, and workers compensation claims. Turjanmaa and Lahti¹² found, as did we,¹³

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Abbreviations used

HCW:	Health care worker
NRL:	Natural rubber latex
SPT:	Skin prick test

that individuals already sensitized to latex reacted less to an extract taken from a low-protein glove than to an extract from a regular glove. In addition, Vandenplas et al.¹⁴ suggested that gloves with a lower protein content could be useful in reducing the risk of asthmatic reactions in subjects with latex-induced asthma. It is not known, however, if use of low-protein gloves will reduce the incidence of latex sensitization. Although the need for such a study has been noted,^{5, 15} we are not aware that a prospective study has been published.

During 1992 and 1993, a number of HCWs at a hospital with two sites in Hamilton, Ontario, Canada, developed allergic symptoms that were associated with exposure to NRL. This provided an opportunity to undertake the current investigation to test the hypothesis that high protein levels in latex gloves are related to the incidence of sensitization.

Overall design

The study design had two main components. The first phase was a cross-sectional investigation in which 1351 HCWs who used latex gloves at the two sites at Hamilton hospital were screened in 1994 to determine the baseline prevalence of sensitivity to NRL. We recently reported the findings of the baseline survey.¹⁶ The prevalence of latex sensitization was 12.1% among participants, which was in the upper range of previous reports. There were significant associations with atopic status, positive skin test results to certain foods, work-related symptoms, and departmental use of gloves per HCW.

The second phase involved following the cohort prospectively over 1 year. At one of the sites, some departments continued to use the same powdered moderate- to high-protein latex gloves as in the past, whereas at the other site, powder-free latex gloves were introduced. We then performed repeat testing in 1995 to identify newly sensitized individuals. The objectives of the present study were to determine (1) the incidence rate at which individuals with initially negative skin test results within this group became newly sensitized to NRL and (2) the association, if any, between the rate of sensitization and exposure, as reflected by the latex protein of the gloves worn and airborne latex protein.

METHODS

Eligible population

Baseline. The details of the baseline study were reported previously.¹⁶ All 2062 employees at both sites who used latex gloves on a regular basis (at least one to two times per week) were invited to participate in the baseline screening in April through May 1994. The assessment included administration of a questionnaire and latex skin testing. Informed signed consent

was obtained from all participants, and the study protocol received approval from the institutional review board of the hospitals.

Glove use over the year. During the year after the 1994 assessment, glove use was as follows. At site G, HCWs on the wards used powder-free gloves whereas those in the operating rooms used powdered gloves. At site H, the situation was reversed. Those on the wards used powdered gloves and those in the operating rooms used powder-free gloves. As shown in the Results section below, the powder-free gloves contained very low levels of protein, whereas the powdered gloves contained much higher levels.

Follow-up. Follow-up testing was conducted in April and May 1995 and consisted of the same modalities (i.e., a questionnaire and latex skin testing). A negative-result latex SPT at baseline was defined as any individual with a 0 or 1 mm wheal to all latex reagents (i.e., none greater than 1 mm) in 1994. We also defined a priori that any skin test with a 2 or 3 mm wheal in 1994 would be considered equivocal and not included in the conversion data. Those who initially did not participate in retesting were contacted by the Employee Health Department to encourage participation. Two workers in the Labor and Delivery Unit at site H assigned to wear powdered gloves became symptomatic in October 1994, 6 months into the study. They were retested at that time and both were identified as having latex conversions. These two HCWs switched to nonlatex gloves, and coworkers on the ward changed to powder-free gloves (see Results section).

Skin test definitions at follow-up

A positive SPT was defined as a wheal diameter at least 4 mm greater than that caused by the saline control in a subject who had negative results to the latex skin test the previous year. Atopy was defined as two or more SPTs with results positive to common inhalant aeroallergens (ragweed, dust mite, or timothy grass). A latex skin test conversion was defined as a subject whose status went from negative (as defined above) to positive at follow-up testing, that is, development of a 4 mm or greater wheal (versus saline) to any latex reagent was considered a new positive skin test result and a conversion.

Questionnaire

The questionnaire, which was adapted from those used previously,^{17, 18} was, with minor exceptions, identical to that used for the 1994 baseline evaluation¹⁶ and was administered by four trained interviewers. The questionnaire obtained information on occupational history including job title, department, number of pairs of gloves and number of hours of glove use (over 3 days before the interview), years using latex gloves, types of glove worn during the past year, and exposure to chemical irritants at work. We also asked about smoking, past medical history, and allergies.

Latex skin test reagents

Skin testing was done with dilutions of commercially available ammoniated latex (Bencard Laboratory, Mississauga, Ontario, Canada). In vitro analyses of Bencard latex were done by Western blotting technique and contained all relevant proteins (7 to 10 mg/ml).¹⁹ Skin test dilutions to 1:10, 1:100, 1:1000, 1:10,000, 1:100,000, and 1:1,000,000 of the stock latex extracts were prepared with saline diluent. In patients with suggestive histories of latex allergy (identified by questionnaire), skin tests were done beginning with the lowest dilution and progressing through increasing concentrations until a definite positive-

TABLE I. Results of personal and area air sampling for latex, according to hospital, season, and glove type, Hamilton Hospitals Latex Study, 1994-1995

	Powdered gloves (ng/m ³)		Powder-free gloves (ng/m ³)	
	Summer	Winter	Summer	Winter
Personal samples				
Hospital H	Ward	Ward	OR	OR
	5	40		
	9	87	*	*
	19	388		
	37	616		
Hospital G	OR	OR	Ward	Ward
	7	133	7 samples (*)	5 samples (*)
Area samples				
Hospital H	Ward	Ward	OR	OR
	4	20	0.1	*
	6	24	0.4	*
Hospital G	OR	OR	Ward	Ward
	5	29	4 samples (*)	*
	19	33		*

OR, operating room.

*Below limit of detection.

results skin test was obtained. In patients with no symptoms suggestive of latex allergy, skin testing was done with all latex dilutions at one time. Another skin test reagent was extracted from noncompounded ammoniated latex as previously described (reconstituted to 1 mg/ml).¹³

Glove extracts used for skin testing were prepared as reported previously.²⁰ Two grams of the palmar surface of latex rubber gloves used in the study (examination and surgical powdered gloves and examination and surgical powder-free gloves) were cut into 2 cm squares and submerged in 10 ml saline, agitated for 30 seconds to ensure all parts were wetted, and left for 15 minutes. The latex extracts were prepared in polypropylene tubes and containers. The final latex glove extracts were refrigerated and stored in 5 ml aliquots. The solution was labeled for date, glove brand, and glove lot number. The extract was assayed for antigenic protein with the use of an indirect ELISA technique.²¹ Variability in the potency of the skin test materials was minimized by use of the same lots of gloves for skin testing at baseline and follow-up. Extracts were prepared for use in 1994, and additional gloves from the same lot were frozen. Fresh extracts were prepared from the frozen gloves for the repeat testing in 1995. The Bencard reagent was purchased separately for each year. The ammoniated latex protein was prepared fresh for each year from the same lot of lyophilized latex protein.

Food and inhalant skin test extracts

Commercially available food and inhalant extracts were used for skin testing. Food extracts (Bencard Laboratory) included avocado, banana, kiwi, potato (all 1:10 dilution), and chestnut and cow's milk (1:20 dilution). Inhalant extracts included ragweed, timothy grass, and dust mite (Bencard Laboratory). Histamine (1:1000) (Bencard Laboratory) and physiologic saline served as positive and negative controls, respectively. New skin test reagents were purchased each year.

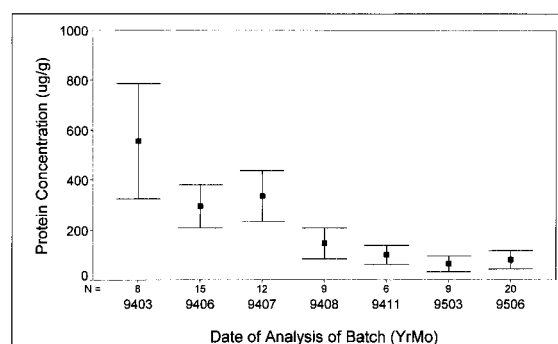


FIG. 1. Protein concentrations in powdered surgical gloves according to batch analysis date (squares represent mean, bars represent $\pm$ SEM).

Skin test method

The SPT was performed by trained registered nurses. They were not aware of the glove types worn by individual subjects, and as noted above, both powdered and powder-free gloves were in use at both hospitals. The same pair of nurses remained at each site throughout the skin testing procedure. Both forearms were wiped clean with alcohol. Skin test sites were clearly marked, a drop of extract was placed on the skin, and this was pricked with commercially available skin test lancets (Hollister Stier Laboratory, Etobicoke, Ontario). Skin tests were read at 15 minutes, and all positive test results were measured. All positive skin test wheal and flare responses were outlined with black pen and transferred to paper with the use of transparent tape for a permanent record.

Exposure assessment

Direct exposure. To provide estimates regarding the range of airborne latex concentrations, a limited number of area and personal air samples were obtained in both hospitals to characterize locations of frequent and low or no glove use. These were conducted on two occasions (winter and summer) to reflect different ventilation conditions. We present the results from sampling at locations for both powdered and powder-free gloves obtained during the 1-year prospective time interval.

Air sampling method. Air samples assayed for airborne latex protein were collected by drawing air through Teflon (polytetrafluoroethylene) filters at a flow rate of 3.5 or 4.0 L/min for personal samples and 180 L/min for area samples.

Analytical method. The immunoassay for latex aeroallergens has been previously described.^{22,23} Briefly, the latex allergens were extracted with buffer and quantified by inhibition immunoassay with the use of a concentrated latex glove extract adsorbed onto plastic microtiter plates and latex-specific IgE antibodies pooled from five latex-sensitive persons. The results were expressed as latex-allergenic protein per cubic meter of air. The lower analytical limit of detection of this method is approximately 2 ng or 40 ng/ml, allowing detection of 0.1 ng/m³ in 20 m³ of air.

Indirect exposure measures. The following were declared in advance to be latex exposure metrics of interest: hospital; departmental use of gloves (obtained from hospital purchasing records over the previous year); job title; years since subject started using latex gloves; number of gloves per day averaged over the 3 days before the interview; number of hours per day wearing gloves; and exposure to chemical irritants at work.

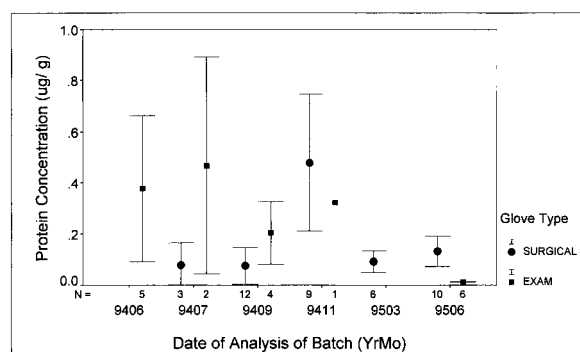


FIG. 2. Protein concentrations in surgical (circles) and examination (squares) powder-free gloves, according to batch analysis date (squares and circles represent mean, bars represent $\pm$ SEM).

Latex protein content of gloves over time. Samples of gloves from consecutive lots used during the follow-up period were forwarded to the Guthrie Research Institute from the hospital as received. They were shipped in groups when several lots had accumulated and were assayed when received. For the purposes of analyses, glove protein concentrations less than the limit of detection were taken to be one half of the limit (e.g., $< 0.2 \mu\text{g/gm}$ taken as $0.1 \mu\text{g/gm}$). Variability of the latex ELISA was found to be less than 25%.²²

Statistical analyses

Estimates of sample size requirements for the powder-free and powdered glove groups were calculated before the baseline study, assuming an alpha level of 0.05 and 80% power. Although we were uncertain what the incidence rate of latex sensitization would be, on the basis of the approximate 10% latex sensitization prevalence observed in HCWs, we calculated sample sizes required for possible incidence rates among those HCWs using powdered gloves ranging from 0.5% to 5.0% and among those using powder-free gloves ranging from 0.01% to 0.5%. For example, given a 2.0% incidence rate in the powdered glove group, the sample size required in each group was 489, 551, or 989 if the incidence rate in the powder-free glove group was 0.01%, 0.1%, or 0.5%, respectively. On the basis of our knowledge that more than 2000 HCWs were initially eligible at baseline,¹⁶ we anticipated during the design stage that there would be approximately 500 participants per group at follow-up.

We compared categorical variables with chi-square tests or Fisher's exact test (two-tailed) as appropriate. We examined the change in protein concentration in gloves as a function of time by using linear regression models. The distribution of protein concentrations in each glove brand was examined to determine whether log-transformed data were closer than the untransformed data to a normal distribution, although the arithmetic and geometric means did not differ markedly. We computed the relative risk of conversion between glove groups adjusted for potentially confounding variables by using logistic regression. We used the SAS (Cary, N.C.), SPSS (Chicago, Ill.), and SYSTAT (Chicago, Ill.) statistical programs. A probability value of less than 0.05 was considered to be statistically significant.

RESULTS

Exposure

Air sampling results. The results of personal and area air samples for latex protein during use of powdered and

TABLE II. Distribution of participants in follow-up study according to hospital site, Hamilton Hospitals Latex Study, Ontario, 1995

	Site G	Site H	Total
SPT negative at baseline	580	495	1075
Excluding those in nonparticipatory depts in 1994	544	403	947
Excluding wards that did not participate during the year	316	275	591
Excluding those who floated, were transferred, or were absent during the year (leaving those eligible to participate)	243	236	479
Participated in follow-up testing	225	210	435

powder-free gloves are displayed in Table I. For the powdered gloves, the personal exposures ranged from 5 to 83 ng/m^3 in the summer and 40 to 616 ng/m^3 in the winter. The samples obtained at background locations where gloves were not in use showed nondetectable levels. During powder-free glove use, all but two results for air samples were below the limit of detection ($< 0.1 \text{ ng/m}^3$, and these two results were $< 1 \text{ ng/m}^3$).

Glove protein concentrations over time. The mean protein concentrations expressed as micrograms per gram of sample, according to the assay batch dates, are shown in Fig. 1 (for powdered surgical gloves) and Fig. 2 (for powder-free gloves). There were too few samples of the powdered examination gloves for a meaningful regression model. The latex content of the powdered surgical gloves declined (Fig. 1) at a rate of 295.6 $\mu\text{g/gm}$ per year, and this was highly statistically significant ($p < 0.0001$) whether untransformed or log-transformed. The decline was thus more than an order of magnitude over the time period under study; the regression model explained approximately 40% of the variation. There were very small changes over time in the powder-free gloves (Fig. 2). The protein content was less than 1% of that in the powdered gloves studied.

Participants in follow-up testing

Of the 1075 participants with negative results to the skin test at baseline testing in 1994, 947 were working at the time of the 1994 assessment in departments that were included in the prospective study (Table II). After excluding those working in wards that became ineligible for the study during the year of follow-up and those who floated between wards, were transferred, or were absent for more than 6 months during the year, there were 479 subjects with negative results to the SPTs at baseline who could have participated (Table II). Of these, 435 (91%) participated in the follow-up testing. These 435 HCWs were similar to the other 640 with negative skin test results who were not eligible for (or did not participate in) the follow-up with respect to sex, hospital, atopic status, and distribution of job titles, although they were more likely to be current or ex-smokers and less likely to be younger than 30 years old (data not shown).

However, neither smoking status nor age were significantly related to latex skin test status in our baseline study.¹⁶

Characteristics of powdered and powder-free glove users

There were 227 participants retested who had been using powder-free gloves (40 from the operating room at site H and 187 from the wards at site G) and 208 participants who had been using powdered gloves (36 from the operating room at site G and 172 from the wards at site H). The two glove groups were similar with respect to age, sex, atopic status, years of glove use, and smoking status (Table III). Among those using the powder-free gloves, the proportion of laboratory workers was smaller and the proportion of other occupations, including housekeepers, was greater than among those using the powdered gloves.

Skin test conversions

We identified four conversions or incident cases of latex skin test positivity: two (1.0%) of 208 in the powdered glove group and two (0.9%) of 227 in the low-protein group. This yielded a crude odds ratio (OR) for the powdered versus powder-free glove groups of 1.1 (95% CI, 0.2 to 7.7). In logistic regression models, the addition of sex ($p > 0.2$), smoking status ($p > 0.4$), or age (in four strata; $p > 0.7$) was not significant, and these did not result in a material change in the OR. The addition of atopic status in 1995 to the model was significant ($p < 0.001$; OR 26) though based on the small number of cases. The addition of atopy did not result in a change in the risk estimate for glove type (OR 1.04).

The characteristics of the subjects with skin test conversions are tabulated in Table IV. Three were female, including two nurses and a ward clerk, and one was a male lab worker. The two converters using powdered gloves worked in the labor and delivery unit; one was a nurse, the other a ward clerk. These were the only converters who were symptomatic. One reported burning and itching eyes, itchy tongue, and respiratory symptoms, and the other reported sneezing, runny and stuffy nose, and persistent cough. Both of these converters from the labor and delivery unit were nonatopic and did not react to foods at baseline but at retesting in October 1994 were found to be atopic, and one reacted to a single food (avocado). One of the converters from the powder-free group had skin test results for the common inhalants ranging from 3 to 17 mm (Table V).

Skin test results

Table V displays the skin test results observed for the converters. One of the converters in the powder-free glove group reacted only to ammoniated latex (Guthrie, Inc.) but not to the Bencard latex reagent, and one converter in the powdered glove group also reacted only to one latex reagent (powdered examination glove extract) but not to Bencard. The other two converters reacted to the full-strength Bencard reagent.

TABLE III. Characteristics of participants at follow-up by glove usage group, Hamilton Hospitals Latex Study, Ontario, 1995

Characteristic examined	Glove type used		P Value
	Powdered	Powder-free	
Age			
Younger than 40 (%)	81 (39.3)	107 (47.6)	> 0.2
40 to 49 (%)	75 (36.4)	72 (32.0)	
50 and older (%)	50 (24.3)	46 (20.4)	
Total*	206	225	
Sex, no. F (%)	192 (92.3)	212 (93.4)	> 0.6
Atopic status			
Atopic (%)	9 (4.3)	9 (4.0)	
Not Atopic (%)	199 (95.7)	218 (96.0)	> 0.8
Total	208	227	
Smoking status			
Current (%)	53 (25.9)	59 (26.0)	> 0.9
Ex (%)	57 (27.8)	64 (28.2)	
Never (%)	95 (46.3)	104 (45.8)	
Total	205	226	
Occupation			
Nurses and physicians (%)	120 (58.0)	148 (65.2)	< 0.001
Therapist and technician (%)	25 (12.7)	24 (10.6)	
Lab worker (%)	2 (1.0)	21 (9.3)	
Others (%)	60 (29.0)	34 (15.0)	> 0.5
Total	207	227	
Years since first use of latex gloves at work (mean $\pm$ SD)	12.3 $\pm$ 8.0	4.6 $\pm$ 7.6	> 0.5
Total	188	210	

*Data for some characteristics not available for all subjects.

DISCUSSION

We observed a skin test conversion rate among HCWs using powdered gloves of approximately 1% over the year of follow-up, which was in the middle of the range that we had estimated during the design of the study. Although unexpected, the conversion rate in the group using powdered gloves was only slightly greater than that among those using powder-free gloves. However, we documented marked differences in exposure as assessed by both the protein levels measured in the gloves and the results obtained from air sampling. The concentrations of latex aeroallergens measured during use of powdered gloves were comparable to those reported previously.^{23, 24} Although the incidence of newly sensitized workers was relatively low, it should be emphasized that both of the converters identified in the powdered glove group were symptomatic, but those in the powder-free glove group were not.

Interpretation of conversions

The clinical significance of the skin test conversions, especially in the absence of symptoms, is not known. Whether these represent subjects who might have devel-

TABLE IV. Characteristics of skin test converters, Hamilton Hospitals Latex Study, Ontario, 1995

	Converter			
	122/Site G	778/Site G	1541/Site H	1629/Site H
Case No./Hospital site	122/Site G	778/Site G	1541/Site H	1629/Site H
Date of follow-up testing	April/May 95	April/May 95	October 94	October 94
Sex/age	M/47	F/31	F/28	F/42
Latex glove group	Powder-free	Powder-free	Powdered	Powdered
Smoking in 1994	Ex	Never	Never	Never
Latex reaction BL/FU	Neg/Pos	Neg/Pos	Neg/Pos	Neg/Pos
Atopy BL/FU	Neg/Neg	Neg/Neg	Neg/Pos	Neg/Pos
Food sensitivity BL/FU	Neg/Neg	Neg/Neg	Neg/Neg	Neg/Pos
Ward	Lab	CCU	L&D	L&D
Job title	Lab worker	Nurse	Nurse	Ward Clerk
Hours/wk	38	38	20	38
Year first wore latex gloves (ever/at current hospital)	1988/1988	1986/1990	NK/1990	NK/1978
Gloves per day (average over 3 days before survey): Total/	94: 2/2/0	94: 23/23/0	94: 5.7/5.7/0	94: 4/4/0
Latex/Vinyl	95: 0/0/0	95: 1.3/1.3/0	95: ?	95: ?
Time gloves worn per day (hrs, 3 days before survey)	94: 0.5-2 95: 0-0.5	2-3 0.5-2	0.5-2 ?	0.5-2 ?

BL, baseline; FU, follow-up; L&D, labor and delivery; NK, not known.

oped work-related asthma with further exposure is not clear, but latex challenges were not performed. In particular, the skin test conversions identified among the asymptomatic workers using powder-free gloves are difficult to interpret. However, it should be noted that one of these patients reacted only to the ammoniated latex reagent and not to the glove extract or to the Bencard reagent. This is unusual and possibly suggests sensitization to other components. In one of these (case 778), results of Western blot and Ala-stat (Diagnostic Products Corp., Los Angeles, Calif.) studies performed at baseline in 1994 and at follow-up in 1995 were both negative (data not shown). Moreover, since one cannot state definitively when the conversions to the sensitized state occurred, it is possible that these (as well as any of the other) conversions reflected a delayed manifestation of sensitization associated with previous glove use that was underway at the time of baseline testing. Alternatively, these conversions may have occurred from exposure to residual latex dust in adjacent crawl spaces that remained from powdered latex gloves that had been used previously. These conversions may also represent a reaction to an altered protein or another chemical constituent of the glove.

Both of the converters using powdered gloves tested as atopic at follow-up; one reacted to full-strength Bencard reagent and the other reacted only to the powdered examination glove extract. This latter finding is unusual and may represent a reaction to nonprotein material or to protein modified during manufacturing, but this speculation has not been verified by immunoblotting. Of interest, one of the converters working in a powdered glove environment was a ward clerk. While an initial impression might be that this job should involve little exposure to latex, Vandenplas et al.²⁵ recently reported a case of occupational asthma caused by latex

in an administrative hospital employee (medical secretary in an emergency room) who never used latex gloves, thought to be caused by indirect exposure to airborne latex.

Cluster of converters in the labor and delivery unit

Both converters using powdered gloves were identified when the workers in the labor and delivery unit became symptomatic halfway through the 1-year follow-up period, which led to the request for early retesting for this group. Whether there was unusual glove use or other circumstances in this department is unknown. The data regarding glove purchases indicated that this department used more examination (bulk) than sterile gloves and that an index of glove use per HCW during the year before the study (1178) was in the middle of the range across departments, which ranged from 0 to 3335. We previously observed in our baseline investigation that latex SPT results status was associated with an index of sterile glove use per HCW by department but not with bulk glove use.¹⁶ Of interest, although Grzybowski et al.¹¹ did not find significant differences in anti-IgE latex positivity in their study of nurses, the prevalence was highest among labor and delivery nurses (13.6%) and lowest among operating room nurses (6.4%).

Limitations

The power of this prospective phase was limited by the number of participants, which was only about half of that expected. This occurred in part because many hospital wards where baseline negative-results SPT participants were working did not participate in the prospective phase of the study or the HCWs did not remain in an eligible location throughout the year because of hospital restructuring that was underway. In addition, the sub-

TABLE V. Results of skin testing among converters (in mm), Hamilton Hospitals Latex Study, Ontario, 1994-1995

Skin test reagent	Case No.			
	122	778	1541	1629
Glove group	Powder-free	Powder-free	Powdered	Powdered
Saline/histamine	0/4	0/3	0/4	0/4
Glove brand A/B/C/D	0/0/0/0	0/2/0/0	4/0/0/0	0/0/0/0
Ammoniated latex	4	3	0	2
Bencard full	0	5	0	4
Bencard 1:10	0	0	0	4
Bencard 1:100	0	0	0	2
Bencard 1:1000	0	0	0	2
Bencard 1:10,000	0	0	0	2
Bencard 1:100,000	0	0	0	0
Bencard 1:1,000,000	0	0	0	2
*Banana/avocado/potato/chestnut	0/0/0/0	0/0/0/0	0/0/0/2	2/4/2/0
Ragweed/dust mite/timothy grass	0/0/0	3/3/17	4/4/2	4/4/4

*All test results to kiwi and milk were negative.

stantial declines in protein levels in the powdered latex gloves that we documented during the study period may have reduced the number of conversions that occurred and suggests that the glove manufacturers had already responded to concerns about latex, even in products not considered to be low protein. The small declines observed in the powder-free gloves are very unlikely to be clinically significant.

The participation rate at follow-up was greater than 90% among those eligible, and thus selection bias was unlikely. Moreover, these participants at follow-up testing did not differ from those identified at baseline as having negative results to the skin test but who were not eligible for (or did not participate in) the prospective component with respect to a number of characteristics, including atopic status, that are strongly associated with latex sensitivity and were thus a potential confounder. Although there were differences between the follow-up participants and other subjects with negative results to the skin test in the distribution of smoking status and age, these factors were not associated with latex skin test status at baseline. Among the participants at follow-up, those using powdered gloves resembled those using low-protein powder-free gloves for all of these characteristics.

However, information bias may have been present. The definition of a skin test converter was determined before analysis of the data and was based on objective findings (skin test measurement). Although the nurses performing the skin tests were trained in skin testing, they were divided among the two locations and thus may not have been blinded to exposure group in general. On the other hand, both types of gloves were in use at both sites. Thus it was possible that the skin test procedures and interpretation differed between sites, resulting in observer bias. This was strongly suggested by the difference in the number of "equivocal" skin test readings (latex minus saline skin test

differences of 2 to 3 mm), which was not a primary outcome of interest. There were 22 such skin test results in the powder-free glove group compared with two in the powdered glove group.

The observed low incidence could also be related to the nature of the study design. Although prospective and therefore better than many workplace studies that have been cross-sectional in design, many of the workers we studied had been working with latex for years. Thus this was not an inception cohort. Because the incidence of occupational asthma and sensitization is thought to be greatest during the first 1 to 2 years of exposure,²⁶ those who became symptomatic or were at risk for sensitization may have left the workforce, leaving survivors who are more "resistant" (the healthy worker survivor effect). That is, this represented a survivor population that might be expected to display a lower latex sensitization rate. The 1-year follow-up period may also contribute to the results. A naive patient population, larger sample size, and longer follow-up period would have been more ideal and may have produced different results.

Food tests

We and others have previously demonstrated food cross-reactivity, with a strong association between latex SPT results status and skin test reactions to certain foods.^{16, 27, 28} This can make interpretation of skin tests difficult. However, given that only one of the converters had a positive test reaction to foods, cross-reactions to foods are unlikely to explain the findings.

On the other hand, the interesting observation that the two symptomatic converters using powdered gloves changed status from nonatopic to atopic (and one of these also changed food skin test results status) raised the possibility that the subjects had heightened skin test reactivity or dermatographism. However, the wheal diameter for saline for these two subjects was recorded as 0 mm, which argues against this. Both of these individ-

uals were subsequently accommodated in an environment in which coworkers used powder-free gloves, consistent with the diagnosis of latex allergy and with other reports.

We are not aware that any other prospective study has estimated the incidence of sensitization to latex. Newman Taylor²⁶ recently noted that such studies are few, with the "exception of enzyme studies and current studies of laboratory animals, flour and acid anhydride workers," no other investigation has estimated the incidence of sensitization and asthma in relation to measured exposure.

In conclusion, in this prospective study of latex sensitization, we observed a conversion rate for latex sensitization of approximately 1%. The incidence rate was not significantly related to glove type used, which was an unexpected finding. This may have resulted from observer bias between sites, limited study power, reactions to altered proteins or other materials in the low-protein gloves, other factors, or combination of these factors. Converters using powdered gloves were the only symptomatic ones. Importantly, we have also documented a sharp decline in latex protein concentrations in powdered latex gloves over the study period, which may have reduced the sensitization rate in this group. These results should not be interpreted to suggest that low-protein powder-free gloves have no effect on reducing latex sensitization. Additional studies involving larger populations for longer periods of follow-up are required. We would recommend that low-protein powder-free gloves be used.

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