

Respiratory Function and Immunological Status in Workers Employed in a Latex Glove Manufacturing Plant

Eugenija Zuskin, MD, PhD,¹ Jadranka Mustajbegovic, MD, PhD,² Bozica Kanceljak, MD, PhD,²
E. Neil Schachter, MD,^{3*} Jelena Macan, MD,² and Antun Budak, MD, PhD³

A study was performed in 17 female workers employed in a latex glove manufacturing plant. The mean age of these workers was 42 years and the mean duration of their employment was 19 years. The employees were primarily nonsmokers or light smokers. The presence of chronic respiratory symptoms and acute work-related symptoms was recorded for these workers. Ventilatory capacity was measured during the morning work shift by recording maximum expiratory flow-volume curves from which forced vital capacity (FVC), 1-second forced expiratory volume (FEV₁) and maximum expiratory flow at 50%, and the last 25% of the vital capacity (FEF₅₀, FEF₇₅) were measured. A control group of 17 nonexposed women workers was also studied. The prevalence of chronic respiratory symptoms was greater among latex workers than among control confectionery packer workers, varying from 5.9% (vs. 0% in controls) for occupational asthma to 58.8% (vs. 0% in controls) for dyspnea grades 3 or 4. There was also a high prevalence of acute work-related symptoms in this industry, in particular, eye irritation (76.5%), dryness of the nose (70.6%), throat burning (70.6%), dryness of the throat (64.7%), and cough (58.8%). Among exposed workers, measured ventilatory capacity data were significantly lower than among controls, particularly FEF₇₅ (75.1% ± 10.5%). One of the 17 studied workers (5.9%) had a positive skin reaction to latex and had symptoms compatible with occupational asthma. Our data suggest that in addition to occupational asthma, the manufacture of latex gloves is associated with frequent, nonspecific respiratory findings. Am. J. Ind. Med. 33:175–181, 1998. © 1998 Wiley-Liss, Inc.

KEY WORDS: latex workers; respiratory symptoms; lung function

INTRODUCTION: INVESTIGATING LATEX SENSITIVITY

The study of respiratory disease due to latex has focused on allergy to this agent. Repeated exposures to latex may

lead to the development of latex sensitivity [Spanner et al., 1989; Levy et al., 1992; Slater et al., 1990, 1992a,b,c; Hunt et al., 1995]. Allergy to latex is a typical example of a type I immunologically mediated, immediate hypersensitivity reaction [Kujala et al., 1995]. Clinical manifestations of hypersensitivity reactions to latex include eczema, contact urticaria, and respiratory symptoms such as occupational asthma and occupational rhinitis [Baur and Jager, 1990; Moneret-Vautrin et al., 1994]. Most studies of this allergy involve health care workers and patients undergoing surgical procedures or internal examinations associated with the use of natural rubber products [Carrillo et al., 1986; Turjanmaa, 1987; Turjanmaa et al., 1990; Bubak et al., 1992; Lagier et al., 1992; Vandenplas et al., 1995a,b; Kaczmarek et al., 1996]. Liss et al. [1997] reported that in 12.1% of studied health care workers, sensitization to latex accompanied by work-related symptoms such as eye irritation, hives, and

¹Andrija Stampar School of Public Health, Zagreb Croatia

²Institute for Medical Research and Occupational Medicine, Zagreb, Croatia

³Mount Sinai School of Medicine, New York, New York

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*Correspondence to: Dr. E. Neil Schachter, Box 1232, Mount Sinai School of Medicine, One Gustave L. Levy Place, New York, NY 10029-6574

wheezing or whistling in the chest were found. Occupational allergy to latex due to the use of disposable gloves has been described in up to 30% of health care workers [Jones et al., 1994]. Recently, Kujala et al. [1997] reported a clear association between natural rubber latex sensitization and a decrease in the work ability index among health care workers.

Some authors report a positive association between atopic status and the risk of latex sensitivity [Turjanmaa, 1987; Wrangsjo et al., 1988; Turjanmaa et al., 1990]. The reported prevalence of latex-associated disease may be very different depending on the study and the setting; prevalences varying from 1% to as high as 80% in exposed individuals have been described [Turjanmaa, 1987; Turjanmaa et al., 1990; Levy et al., 1992; Kelly et al., 1993; Kurup et al., 1993; Reijula et al., 1994].

The present study was undertaken to investigate latex sensitivity and its consequences in a group of workers occupationally exposed to latex during the manufacture of latex gloves.

MATERIALS AND METHODS

Workplace Environment

Discovered in the last century, natural rubber (latex) is one of industry's most important vegetable materials. Natural latex is a milky substance that serves as the source of natural rubber. It is produced by plants and trees of the *sapodilla* family. Most commercially used natural latex comes from hevea tree plantations of tropical Africa and Asia [Levy et al., 1995]. Natural rubber particles are surrounded by a thin phospholipoprotein coat, which is a mixture of several agents: long-chain polymers of cis-1,4-poly-isopropene (33%), resin (2%), protein and other organic substances (1.8%), and water (65%).

We studied workers employed in a rubber manufacturing plant that prepared latex solution from the original rubber material collected from rubber trees. During the latex manufacturing process, many chemicals were added to the latex, such as vulcanizers, accelerators, stabilizers, and antioxidants. The latex solution is kept in a large open vat into which the molds are submerged. Since this is performed in a large nonventilated room, workers are exposed to a high concentration of latex aerosol released into the air during the mixing of the latex. Subsequently, the latex gloves are dried in the same workroom. During the drying process, latex particles are also released into the work environment. Next, the latex gloves are treated with cornstarch or talc, used as the powdering agent. Workers' exposure to latex may occur from the inhalation of latex aerosols released from the latex solution, or during the drying process. Exposure may also occur from the

inhalation of latex-contaminated powder particles, which are aerosolized during the powdering of the gloves.

Subjects

This study included 17 female workers representing all the workers employed in a small, latex glove manufacturing plant in Zagreb, Croatia. Over the past 5 years, 11 workers left the latex plant as a result of recent economic dislocations. None of these workers left for health-related reasons. The mean age of 17 workers was 42 years (range: 33–51 years), their mean height was 160 cm (range: 155–166 cm), and the mean duration of their employment was 19 years (range: 8–28 years). The workers were mostly nonsmokers (13; 76.5%). The four identified smokers (23.5%) smoked 10 cigarettes or fewer daily. Because of the minimal nature of the smoking, the group of 17 workers was combined for the evaluation of respiratory and allergic effects. In addition, a group of 17 nonexposed female workers employed in the packing of food products was studied as a control for the prevalence of chronic respiratory symptoms and ventilatory capacity. The age, height, smoking habits, and duration of employment were matched in the exposed and in the control groups. As in the worker group, 4/17 (23.5%) of the controls were light smokers. The controls were selected from 106 packers in a confectionery plant who worked in a separate building unexposed to dusts, fumes, or chemicals. Medical records and questionnaires performed in these controls were reviewed in order to match latex workers with controls. Workers in both plants (latex and control) were given complete examinations every year, which included pulmonary function testing and symptoms questionnaires.

Respiratory Symptoms

Chronic respiratory symptoms were recorded using the Medical Research Council (UK) questionnaire on respiratory symptoms [1960] with additional questions on occupational asthma [WHO, 1986; Maestrelli et al., 1992; Godnic-Cvar, 1995]. In all workers a detailed occupational history as well as questions about their smoking habit were recorded. The following definitions were used:

- chronic cough or phlegm: cough and/or phlegm for a minimum of 3 months a year
- chronic bronchitis: cough and phlegm for a minimum of 3 months a year and for not less than 2 successive years
- dyspnea grades: 3—shortness of breath when walking with other people at an ordinary pace on level ground; grade 4—shortness of breath when walking at their own pace on level ground
- occupational asthma: recurring attacks of dyspnea, chest tightness and pulmonary function impairment

of the obstructive type diagnosed by physical examination and spirometric measurements during exposure to dust at or following work (decrease of $FEV_1 > 15\%$) and confirmed by medical records.

Nasal catarrh, sinusitis, and hoarseness were confirmed by asking questions such as: Have you ever had nasal catarrh and for how long? Have you ever had sinusitis and for how long? Have you ever had hoarseness and for how long? All positive answers were confirmed by review of the worker's industrial medical records.

Acute symptoms that developed during the work shift were also recorded in all latex workers. These symptoms consisted of cough, dyspnea, irritation and dryness of the throat; itching, secretion, dryness, or bleeding of the nose; eye irritation and headache. Workers were also asked about skin changes noted in relation to their work with latex gloves. Control workers were not questioned about acute symptoms, but prevalences in our previously studied 806 unexposed workers (Zuskin et al., 1996) were very low (cough: 2.5%; dyspnea: 1.1%; irritation or dryness of the throat: 3.4%).

Ventilatory Capacity

Ventilatory capacity measurements in exposed and in control workers were performed concurrently by recording maximum expiratory flow-volume (MEFV) curves using a pneumotach-spirometer, the Mijnhardt Vicatest P2A (AE Bunnik, the Netherlands). The forced vital capacity (FVC), 1-second forced expiratory volume (FEV_1), and maximum flow rates at 50% and the last 25% of the vital capacity (FEF_{50} , FEF_{75}) were determined on the MEFV curves. Measurements were performed on the first working day (Monday) of the work week during the morning work shift. The spirometer was calibrated on a daily basis. Lung function testing was performed according to the recommendations of Quanjer et al. [1993]. At least three MEFV curves were recorded for each subject, and the best of three technically satisfactory MEFV curves was used in analysis of the parameters. We used the curve with the greatest value for $FVC + FEV_1$ [Quanjer, 1993]. The measured ventilatory capacity values were also compared to the predicted values of Quanjer [1983].

Immunological Studies

Skin-prick tests were performed in all exposed workers with aqueous extracts of latex and extracts obtained from latex gloves. Testing was performed with three types of latex allergen: one prepared from the natural rubber material obtained before processing (latex 1, e.g., before adding any chemicals) and the second (latex 2) from latex gloves collected in the workroom. These allergens were prepared in

a concentration of 0.02% at the Institute of Immunology in Zagreb, by the method of Sheldon et al. [1957]. The third allergen (latex 3) was a standardized aqueous extract of latex (prepared after being processed by the addition of chemicals) (2 mg/ml) prepared by Epipharm Allergic Service Ges. m.b.H. (Linz, Austria). In addition, workers were also skin-prick tested with histamine base (1 mg/ml) a standard irritant, and buffer solution as a control. Skin testing also included specific allergens: house dust, *Dermatophagoides pteronyssinus* and mixed molds. Skin-prick testing was performed according to the recommendations of Kjellman et al. [1988] using a lancet with a 1 mm tip. Skin reactions were evaluated after 20 minutes. A test was considered positive if the diameter of the observed wheal was 3 mm greater than that of the buffer solution.

The total serum IgE level was determined by an enzyme-immunoassay, IgE quick T-test (Epignost Ges. m.b.H.). Levels of IgE below 100 IU/L were considered normal.

Environmental Measurements

The dust concentrations in the work environment were measured by a two stage Hexhlet apparatus (Casella, London, UK), which collects total and respirable dust particles. Dust samples were collected over an entire 8-hour work shift in the areas where workers were working. In addition, the ambient temperature was measured by psychrometer "Asmanu," relative humidity by digital hydrothermometer, and air flow by apparatus "Testoterm" type 491. At least three measurements for each parameter were performed at workplaces where workers were examined.

Statistical Analysis

The results of ventilatory capacity measurements were analyzed using the paired t-test to compare the worker's baseline lung function with that of the control (matched by sex, age, and height). The chi-square test and, when appropriate, Fisher's exact test were used for testing differences in prevalence data of respiratory symptoms between groups; $p < 0.05$ was considered significantly different.

RESULTS

Respiratory Symptoms

The prevalence of chronic respiratory symptoms is presented in Table I for the 17 latex and the 17 control workers. In the latex workers, the highest symptom prevalences were recorded for dyspnea (10; 58.8%), followed by chronic cough (7; 41.2%) and hoarseness (7; 41.2%). Chronic cough, dyspnea, nasal catarrh, sinusitis, and hoarseness were all significantly more prevalent among

TABLE I. Prevalence of Chronic Respiratory Symptoms in Latex and Control Workers (Croatia 1996)

Group	Mean age (yr)	Mean height (cm)	Mean employment (yrs)	Chronic cough	Chronic phlegm	Chronic bronchitis	Dyspnea grade 3 or 4	Occupational asthma	Nasal catarrh	Sinusitis	Hoarseness
Latex N = 17	42 ± 8	160 ± 4	19 ± 6	7 41.2%	2 11.8%	2 11.8%	10 58.8%	1 5.9%	5 29.4%	5 29.4%	7 41.2%
P value				<0.05	NS	NS	<0.01	NS	<0.05	<0.05	<0.01
Control N = 17	40 ± 6	161 ± 5	18 ± 7	0	0	0	0	0	0	0	0

NS = difference statistically not significant ($p > 0.05$).

TABLE II. Ventilatory Capacity in 17 Latex Workers and 17 Control Workers (Croatia 1996)*

Mean age (yr) X ± SD	Mean height (cm) X ± SD	Mean employment (yrs) X ± SD	FVC			FEV ₁			FEF ₅₀			FEF ₇₅		
			Workers L	Control L	% ^a	Workers L	Control L	% ^a	Workers L/s	Control L/s	% ^a	Workers L/s	Control L/s	% ^a
42 ± 8	160 ± 4	19 ± 6	3.07 ± 0.12	3.41 ± 0.06	90.0	2.25 ± 0.22	2.81 ± 0.10	80.0	3.30 ± 0.25	4.20 ± 0.03	78.5	1.57 ± 0.09	2.09 ± 0.02	75.1
			workers-control P < 0.05			workers-control P < 0.05			workers-control P < 0.05			workers-control P < 0.001		

*Ventilatory capacity data are presented as mean ± SE.

^aMeasured values of workers as percentage of control.

latex workers than among controls. Other symptoms were also more frequent, but the difference did not reach statistical significance. In one of the 17 latex workers (5.9%) (a nonsmoker), symptoms of occupational asthma were elicited. This worker had no record of respiratory disease prior to employment in this industry.

A high prevalence of acute symptoms during the work shift was recorded in the 17 latex workers, including eye irritation (13; 76.5%), dryness of the nose (12; 70.6%), burning of the throat (12; 70.6%), dryness of the throat (11; 64.7%), cough (10; 58.8%), dyspnea (8; 47.1%), bleeding of the nose (8; 47.1%), and headache (7; 41.2%).

Ventilatory Capacity

Ventilatory capacity in the 17 latex and the 17 control workers is presented in Table II. Significantly lower values were found for FVC, FEV₁, FEF₅₀ ($p < 0.05$) and FEF₇₅ ($p < 0.001$) for the latex workers than for controls. Analysis of individual data of ventilatory capacity among the 17 latex workers demonstrated that values lower than 80% of predicted were found for FEV₁ in one worker (5.9%), for FEF₅₀ in 5 (29.4%), and for FEF₇₅ in 9 (52.9%). Among the 17 latex workers, there was one worker (a nonsmoker), with occupational asthma and positive skin-prick tests to latex 1 and 2 allergens. This worker had an FEV₁ that was 78.3% of predicted, an FEF₅₀ that was 51.2% of predicted, and an FEF₇₅ that was 44.5% of predicted. These abnormalities

were more pronounced than those of the other studied latex workers.

Immunological Study

Skin-prick testing demonstrated that only one worker among the 17 tested latex workers (5.9%) had an immediate positive skin-prick reaction to latex 1 and latex 2. This worker also demonstrated an elevated total serum IgE level (175 kU/L) and complained of symptoms compatible with occupational asthma. She noted that her acute respiratory symptoms were particularly pronounced during the work shift. All tested workers had positive skin reactions to histamine solution. None of the workers reacted with positive skin prick tests to house dust, *Dermatophagoides pteronyssinus* and buffer. No worker had a positive skin-prick reaction to the latex 3 antigen. None of the other 16 latex workers had increased total serum IgE level.

Environmental Measurements

The major dust to which these workers were exposed was talc. The mean measured dust concentration was 7.7 mg/m³ for total dust and 1.9 mg/m³ for respirable fraction. The concentrations were higher than recommended by the Croatian regulations (total dust: 1.5 mg/m³, respirable fraction: 0.5 mg/m³). The measured microclimatic factors, such as relative humidity (38%) and maximal air flow (0.01

m/s) in the workroom were within recommended Croatian standards (relative humidity <75%; maximum air flow 0.3 m/s). The measured environmental temperature was 25°C, which was higher than recommended by Croatian regulations (17°C–22°C).

DISCUSSION

Our study demonstrates that work in a rubber latex manufacturing plant is associated with an excess of respiratory symptoms and lung function abnormalities. In a majority of the studied workers, these chronic respiratory symptoms were not related to specific allergy to latex. Our study thus suggests that in addition to causing specific sensitivity, the manufacture of latex products is associated with frequent nonspecific respiratory irritation.

Among our 17 studied latex workers, only one had occupational asthma (5.9%) with an increased total IgE serum level. This prevalence is similar to that described by Tarlo et al. [1990], who reported occupational asthma caused by latex in 6% of workers employed in surgical glove manufacturing plant. Occupational asthma due to latex was found in 2.5% hospital employees by Vandenplast et al. [1995a]. It has been demonstrated that water soluble protein allergens from latex gloves may act as aeroallergens causing rhinitis and asthma [Jaeger et al., 1992; Lagier et al., 1990; Seaton et al., 1988]. Jaeger et al. [1993] reported that the powders of latex gloves are potent aeroallergens that can cause severe immediate-type allergic reactions of the upper and lower respiratory tract, particularly rhinitis and asthma. Marcos et al. [1991] suggested that latex present in rubber gloves acts as inhalant allergen producing occupational asthma in exposed subjects, probably by means of an IgE-mediated mechanism.

Chronic upper respiratory symptoms were common in the studied latex workers. Five (29.4%) complained of nasal catarrh and sinusitis. Seven (41.2%) complained of hoarseness. Kanny et al. [1992] also reported a case of rhinitis and asthmalike symptoms in a female cook who used rubber gloves at work. Similarly, Marcos et al. [1991] described asthma and rhinitis in a nurse associated with the use of latex surgical gloves. Allmers et al. [1986] studying health care workers demonstrated that the first symptoms of an immediate-type sensitization to latex (urticaria and allergic symptoms of the lower respiratory tract) were noticed after an average of 5 years.

A large number of our workers complained of acute symptoms that developed during the work shift. This was particularly pronounced for eye irritation (76.5%), dryness of the nose (70.6%), and burning sensation of the throat (70.6%). These findings are similar to those of Sussman et al. [1991] and Jaeger et al. [1992], who described that latex in the air elicited allergic rhinitic symptoms and conjuncti-

tis. Rhinitis and conjunctivitis due to the airborne antigen from latex gloves also have been described by Baur and Jaeger [1992]. A large number of our studied latex workers complained of headache (7; 41.2%).

Latex allergy is frequently confirmed by skin testing. Hadjiliadis et al. [1996] described a positive association between the size of a specific latex skin test response and the severity of latex-induced symptoms. Among our workers, only one demonstrated positive skin-prick reactions to latex 1 and latex 2 antigens associated with increased total serum IgE level. Bubak et al. [1992] reported that out of 34 health care workers with respiratory symptoms and positive skin tests to latex, 54.3% had increased latex-specific IgE antibodies. Serum IgE antibody to latex was found in 93% of health care workers sensitized by exposure to latex gloves [Sussman et al., 1991]. In a study by Jaeger et al. [1993], 82% of patients with respiratory symptoms and positive skin tests to latex had specific IgE antibodies to natural latex.

The ventilatory capacity data among our studied workers demonstrated significantly reduced measurements as compared with predicted. Tarlo et al. [1990] described acute spirometric changes during the work shift associated with a fall of 15% or greater in FEV₁ accompanied by symptoms of occupational asthma in workers employed in a latex surgical glove manufacturing plant. Methacholine challenge in these workers indicated airway hyperresponsiveness. Pisati et al. [1994] reported that nebulization of nonpowdered latex glove extract induced immediate bronchoconstriction. The authors suggested that airborne powder from latex gloves can be an occupational hazard. Latex, adsorbed onto cornstarch powder in latex gloves and then aerosolized when the gloves are handled, is felt to be the causative agent of the respiratory events described.

In our study, nonspecific respiratory symptoms and lung function changes were associated with exposure to latex particles in a glove manufacturing plant. Only one of the studied workers suffered from specific latex allergy and occupational asthma. For the remaining workers, a majority of whom exhibited chronic respiratory symptoms, nonspecific airway inflammation due to latex dust was the probable cause of these findings.

Primary prevention of latex-induced illnesses requires a reduction of the overall dust exposure. The importance of reducing nonspecific irritants in this workplace is emphasized by the high prevalence of symptoms and lung function abnormalities associated with latex exposure. Because of the potentially serious consequences of latex allergy, efforts also must be directed at reducing the potential for sensitization. Reducing the amount of cornstarch powder used in this process can reduce airborne respirable latex irritants and allergens presumably reducing both specific and nonspecific airway irritation. The protein and allergen content of latex

gloves can be lowered by washing them during the manufacturing process. Prevention of sensitization, however, may necessitate total avoidance of exposure to latex. Medical surveillance as well as specific immunologic testing may be needed to identify those workers at special risk for latex allergy.

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