

Particulate masks and non-powdered gloves reduce latex allergen inhaled by healthcare workers

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Summary

Background Although allergy to latex is a well-characterized phenomenon, some hospitals continue to provide staff with powdered latex gloves as an option to low- or non-powdered gloves.

Objective We aimed to measure the extent to which inhalation of latex particles could be reduced by the use of protective masks or by replacing powdered latex gloves with non-powdered latex gloves.

Methods Twenty healthcare workers in a hospital setting wore nasal air samplers (NAS) and Institute of Occupational Medicine (IOM) samplers for four 20-min periods. Subjects wore powdered gloves, non-powdered gloves and no gloves during three sampling periods, and in the fourth, subjects applied an aerosol barrier face-mask or a particulate face-mask (N95) while wearing powdered gloves. All samples were stained for particles bearing Hev b 5 allergen by the Halogen assay.

Results All subjects inhaled Hev b 5 bearing particles in all sampling periods. IOM samplers collected particles at 70% of the rate of NAS. The number of particles inhaled while wearing powdered gloves was 23.8-fold higher than when not wearing gloves and 9.7-fold higher than when wearing non-powdered latex gloves ($P < 0.0001$). Wearing an aerosol barrier mask did not significantly reduce the number of particles inhaled ($P = 0.108$), while use of particulate masks significantly reduced the number of particles inhaled by 17.4-fold ($P = 0.003$).

Conclusions Use of non-powdered gloves is the most effective method of reducing occupational aeroallergen exposure to latex arising from gloves. However, secondary protection using particulate masks is a valid alternative, and may be helpful for preventing respiratory sensitization.

Keywords allergen, exposure, Hev b 5, intervention, IOM, latex, mask, nasal air sampler

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Introduction

IgE-mediated hypersensitivity to natural rubber latex remains a serious occupational health problem in healthcare workers, especially since the adoption of universal exposure precautions in the mid-1980s [1]. Exposure to latex allergens adsorbed to powder from latex gloves can cause urticaria, rhinoconjunctivitis, airborne contact dermatitis, asthma or even life-threatening anaphylaxis in sensitized people. Hev b 5, a major latex allergen, has been identified as an important sensitizing antigen among healthcare workers [2–5].

Currently the only form of treatment available is allergen avoidance and symptomatic relief with no safe, effective specific immunotherapy for this condition. Despite recommendations to avoid powdered latex gloves [6], both for personal and patient health, some healthcare workers are still provided with powdered latex gloves by their employer. While it is recognized that use of non-powdered gloves can substantially reduce concentrations of latex allergen in the air [7] and latex-specific IgE

antibodies in workers [8], it is unknown how this intervention influences the amount of inhaled allergenic particles during typical hospital duties and medical procedures.

Personal protective equipment has been used to reduce inhalation of allergenic particles. HEPA-laminar flow helmets have been shown to prevent nearly all allergen from approaching the face [9]. However, such a measure is too cumbersome to be applied during medical procedures. The effect of simple face masks on reducing inhalation of particles bearing latex allergen is not known. Two types of face masks are used in hospital settings: aerosol barrier masks and particulate masks. The former are widely available and are principally used to protect surgical patients from aerosols generated by healthcare workers. Particulate masks, on the other hand, are designed to protect healthcare workers from inhaling infectious material (such as mycobacteria) emanating from patients or biological specimens. These are available in specialized settings within healthcare environments. We hypothesized that these particulate masks may be more effective than the aerosol masks in reducing inhalation of particles bearing latex allergen.

The aim of this study was to measure the extent to which inhalation of particles carrying Hev b 5 was reduced by the use of protective masks or by replacing powdered gloves with

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non-powdered latex gloves. The study was conducted among healthcare workers performing various duties in a bronchoscopy suite.

Materials and methods

Latex exposure of staff at a bronchoscopy suite in a hospital was examined using nasal air samplers [10] and Institute of Occupational Medicine (IOM) filter samplers [11]. The nasal air samplers are small devices that fit snugly into each nostril and collect inhaled particles by impacting them onto an internal collection plate covered with an adhesive strip. IOM filter samplers consist of a small battery-operated pump (model PCXR4, SKC Limited, Blandford Forum, Dorset, UK) drawing a constant flow of air at 2.0 L/min through a 0.8- μ m membrane filter (Millipore, Lane Cove, NSW, Australia) held within an IOM sampling head (SKC Limited). The sampling head was worn on the lapel within the breathing zone, while the pump was worn on the belt. The samplers were used in accordance with the occupational standards AS2985-1987 and AS3640-1989. Thus, the nasal air samplers permit the detection of inhaled particles, while the IOM collects particles at the lapel. By using both techniques we were able to examine the effect of wearing masks, while controlling for variation in local ambient exposure to allergenic particles.

Twenty healthcare workers wore a pair of nasal air samplers and an IOM sampler (rate of 2 L air/min) simultaneously for 4 $\times$ 20 min sampling periods. These periods consisted of:

- Resting quietly in the tea room or office, without wearing gloves.
- Performing duties such as bronchoscopies, cleaning of equipment or tending to patients while wearing powdered latex gloves ('Ambi-Tex', Ansell, Victoria, Australia).
- Performing similar duties while wearing non-powdered latex gloves ('Flexi', Mediflex, Islandia, NY, USA).
- Performing similar duties while wearing the powdered latex gloves and either a particulate-filtering mask (N95 Particulate Respirator, Kimberly Clark Corp, North Ryde, New South Wales, Australia) or aerosol barrier mask (Tecnol® PCM 2000 0.1 μ m fluid shield, Kimberly Clark Corp). Ten subjects wore the particulate mask and 10 subjects wore the aerosol barrier mask.

All other equipment used by the healthcare workers during the experiments was labelled latex-free and ventilation within the suite was constant throughout the rooms.

Nasal air samples, which consisted of particles collected onto adhesive (Inhalix, Sydney, Australia), were laminated onto 0.45 μ m Polyvinylidene difluoride (PVDF) membrane. IOM sampler filters (1.0 μ m PVDF) were laminated with the same adhesive. All samples were then processed using the Halogen immunoassay (Inhalix, Sydney, Australia).

The protocol for the Halogen assay, detailed elsewhere [12], was optimized for the detection of particles bearing Hev b 5 and reduced to a 1-day protocol. Briefly, laminated samples were wetted, then incubated for 30 min in borate buffer pH 8.2 to extract the allergen from the particles onto the membrane, followed by blocking in 5% skim milk in phosphate buffered saline/0.05% Tween 20 for 45 min. Samples were incubated with a monoclonal ('6F6', 1 μ g/mL) directed against Hev b 5 [13] (CRC for Asthma, Sydney, Australia) diluted 1 in 2000 for 2 h,

followed by 1.5 h in biotinylated anti-mouse IgG (1 in 500, Sigma, St Louis, MO, USA) then 1.5 h in Streptavidin alkaline phosphatase conjugate (1 in 1000, Sigma). Samples were then washed three times in PBST between each incubation step. Samples were then developed with BCIP/NBT (Sigma) for 15 min. A control isotype antibody confirmed specificity of the primary antibody. Positive detection of allergen was determined by a 'halo' of stain around a particle. Entire samples were counted.

The study was approved by the Central Sydney Area Health Service Ethics Review Committee (RPA Zone) and written consent was obtained from all participants.

Statistical analysis

Counts were log₁₀ transformed to normalize the data. Comparison between all four sampling conditions for nasal air samplers and IOM filters was by repeated measures analysis of variance using Analyse-It for Microsoft Excel software (Analyse-It Software Ltd, Leeds, UK). Pair-wise comparisons between the conditions were tested by paired *t*-tests (Analyse-It). The correlation between nasal air samplers and IOM filter samples was examined using intraclass correlation coefficients [14], for the three conditions, excluding when masks were worn.

Results

All subjects inhaled Hev b 5 bearing particles in every condition. Particle counts ranged from 3 to 5278 on the nasal air samplers and 3 to 5018 on the IOM filters.

Overall, significant differences were detected between the four sampling conditions for both NAS and IOM ($P < 0.0001$). Both NAS and IOM samples demonstrated substantially higher latex particle counts during periods in which powdered gloves were used, compared with periods when no gloves or non-powdered gloves were used (Fig. 1 and Table 1). There was no significant difference in particle counts between the no gloves and the non-powdered gloves conditions although there was a trend towards higher counts when wearing the gloves (Table 1).

As expected, IOM sampling detected similar particle numbers when powdered gloves were worn with or without a mask ($P = 0.49$, Fig. 1). The effectiveness of the mask was assessed by examining the ratio of NAS to IOM filter counts with and

Table 1. Fold differences of Hev b 5 carrying particles collected by healthcare workers by nasal air sampling and IOM filter sampling in a hospital bronchoscopy suite. Twenty subjects each wore powdered gloves, non-powdered gloves or no gloves. Significance was detected by paired sample *t*-tests

Fold difference (95% CI)	No gloves	Non-powdered gloves	Powdered gloves
No gloves	–	2.47* (0.92–6.65)*	2.38* (11.5–49.6)*
Non-powdered gloves	1.31† (0.53–3.23)†	–	9.66* (4.11–22.7)*
Powdered gloves	12.3† (6.71–22.5)†	9.41† (4.29–20.7)†	–

*NAS samples. †IOM samples.

without wearing a mask. The use of this ratio adjusted for variation in the ambient exposure to latex. The analyses showed that wearing an aerosol barrier mask did not significantly reduce the number of particles inhaled ($P=0.108$); however, wearing particulate masks significantly reduced the number of particles inhaled by 17.4-fold (95% CI 3.4 to 88.5, $P=0.003$, Fig. 2). Of the 10 subjects who wore particulate masks, there was no significant difference in the amount inhaled while wearing powdered gloves with a particulate mask compared with not wearing gloves or wearing non-powdered gloves (all $P > 0.05$).

By combining all sampling conditions except when masks were worn, the intraclass correlation coefficient between NAS and IOM sampler was 0.82 (Fig. 3). The average ratio of NAS to IOM sampler counts across these samples was 1.43.

Discussion

We have demonstrated that, in a hospital setting, substantial reductions in the number of latex allergenic particles that are inhaled can be achieved through use of either non-powdered gloves or by wearing breathing masks.

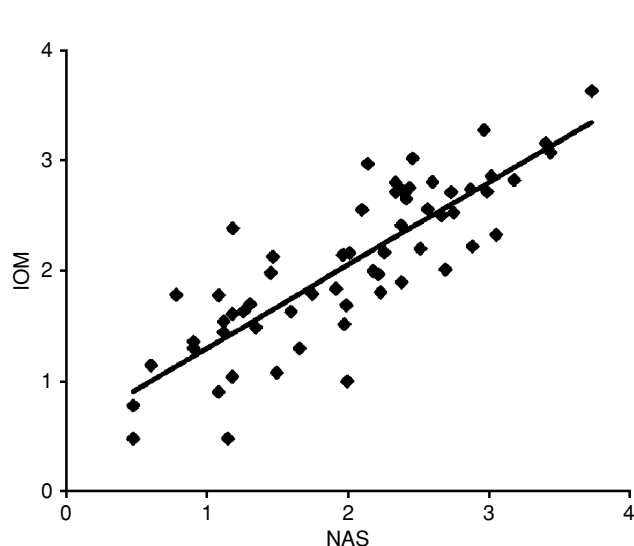


Fig. 1. Numbers of particles bearing Hev b 5 collected by (a) nasal air sampling and (b) IOM filter sampling for each subject ($n=20$) over 20-min sampling periods, for the three glove conditions. Geometric means and 95% confidence intervals of the mean are shown for each condition.

Such observations regarding the reduced levels of airborne latex allergen, following the replacement of powdered gloves with non-powdered gloves, has been shown previously by static air (area) sampling and by personal air sampling [6,15], identifying the allergen using pooled IgE reactive to crude latex or by counting numbers of corn starch particles [16]. We have shown that exposure to the major latex allergen, Hev b 5, is decreased substantially by the use of non-powdered gloves. We have also shown that the inhaled dose follows the pattern of exposure determined by sampling at the lapel.

It is noteworthy that allergenic particles were sampled and inhaled while subjects were not wearing gloves. This indicates that all staff in healthcare settings, such as theatres and endoscopy suites, are probably exposed to low, background levels of latex particles, independent of their choice of gloves worn. Low and persistent levels of latex allergen are sufficient to induce sensitization and latex-specific allergic symptoms, including asthma [17]. It is also possible that the allergenic particles are carried on clothing and gowns and may be transferred between people, as has been shown for other allergenic particulates [18]. In addition, particles are likely to accumulate in settled dust and be redispersed into the air with disturbance. Thus a personal choice to reduce airborne latex allergen by use of non-powdered

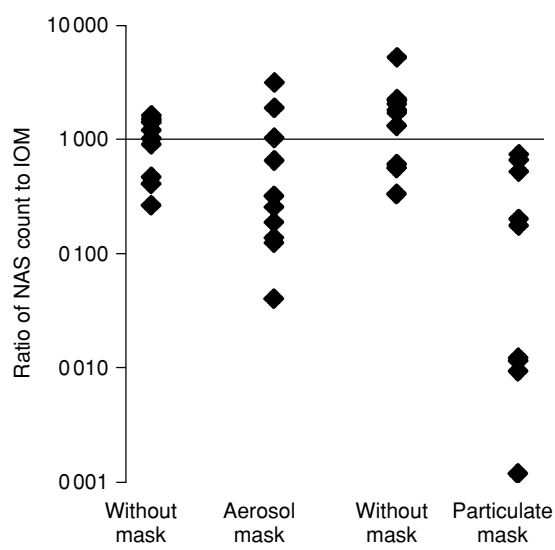


Fig. 3. Nasal air sampling counts compared with IOM filter sampling counts of Hev b 5 bearing particles collected ($n=20$) under three conditions: (a) while wearing powdered latex gloves; (b) while wearing non-powdered latex gloves; and (c) not wearing gloves.

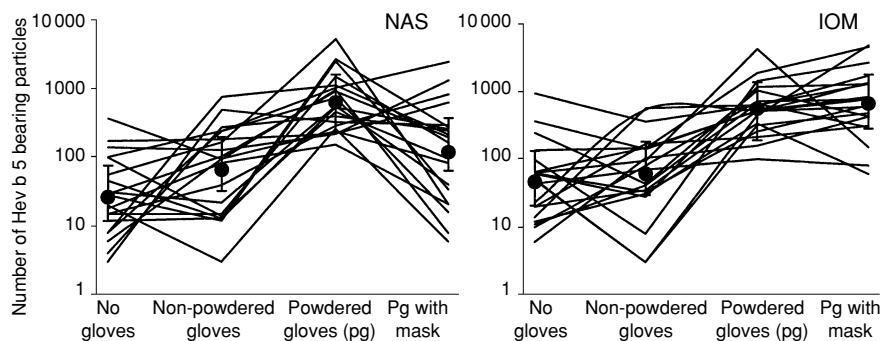


Fig. 2. Comparison of effect of aerosol barrier masks and particulate masks on the number of inhaled particles bearing Hev b 5. (a) Ratio of nasal air sampling (NAS) count to IOM count showing paired groups without mask ($n=10$ each) and either aerosol barrier mask ($n=10$) or particulate mask ($n=10$).

gloves will not remove the entire source of exposure if co-workers choose to wear powdered gloves.

Our hypothesis that the particulate masks would offer more effective protection than the aerosol barrier masks was supported. These results provide evidence that healthcare workers who are allergic to latex allergen and need to wear gloves can reduce their exposure by wearing non-powdered gloves or alternatively by wearing a particulate mask when wearing powdered gloves. This may be a simple and useful alternative to workers who prefer the ease of donning powdered gloves but are sensitized to the allergen adsorbed to the powder, and may be particularly relevant for the prevention of occupational asthma.

In some cases, more particles were inhaled while wearing a mask than when not, suggesting that the seal of the mask must determine the effectiveness. While staff were aware of the correct application and fit of the masks and applied them before donning gloves, clearly particles were still inhaled. Alternatively, the results may be indicative that people tend to inhale faster or deeper when wearing the perceived breathing obstruction. In either case, it is likely that this observation holds for other types of particulates and possibly aerosols [19], and therefore in avoidance of allergen or potentially infectious aerosols, the emphasis on the mask fit is important.

Compared with nasal air sampling, IOM samplers under-sampled by approximately 30%. This percentage difference between nasal air samplers and IOM samplers was found with the collection of *Alternaria* spores [20]. The design of the IOM sampling head was to collect 'the same measured dust concentration and aerodynamic size distribution as that inspired by the wearer, regardless of dust source, location and wind condition' [11]. Given a ratio that nears 1, and given the collection efficiencies and nature of the two samplers, the amounts detected by sampling are likely to be close to actual amounts of particles inhaled under these circumstances.

In this study, we tested the samples examining only one of 11 known latex allergens. As a major latex allergen, Hev b 5 is present in many of the powdered latex gloves that have been examined [2,21] and few, if any, of the observed particles that resembled corn starch did not have an associated allergen-staining halo. This suggests that choice of counting particles bearing Hev b 5 was a valid measure of latex-bearing particles.

In conclusion, the use of non-powdered gloves is the most effective method of reducing occupational exposure to airborne latex allergen arising from gloves. However, secondary protection using particulate masks is also effective, and may be helpful for preventing latex-induced symptoms and respiratory sensitization.

Acknowledgements

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