

Latex Allergy in the Prehospital Setting

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Abbreviations:

NRL = natural rubber latex
SA = South Australia
SAAS = South Australian Ambulance Service
SAAS FTO = South Australian Ambulance Service full time ambulance officers
SJSA VO = St. John Ambulance South Australia volunteers
SJWA VO = St. John Ambulance Western Australia District volunteers

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Abstract

Introduction: Latex allergy first was recognized early in the 20th Century, but was not a matter of concern until the last decade of that Century. The reported incidence of latex allergy in different occupations varies considerably. It has been documented in dental workers, operating theater staff, anesthetists, and laboratory technicians. However, little data specifically related to those involved in patient care in the emergency prehospital setting are available.

Methods: A questionnaire was distributed to a sample of both volunteer and salaried first responders from St. John Ambulance Australia in South Australia and Western Australia, and the South Australian Ambulance Service. The first responders were surveyed to: (1) determine the incidence of latex allergy; (2) consider possible factors associated with its development; (3) compare characteristics of the surveyed groups; and (4) reinforce the development of an educational program.

The study tool had predetermined statistical qualities. Data were collated and processed using standard statistical procedures. Surveys were collected anonymously. **Results:** Of the 2,716 forms distributed, 1,099 were returned, resulting in an overall response rate of 40.5%. Atopy was identified in 14.9% of participants, hand dermatitis in 9.4%, and latex allergy in 6.4%. In the group of full-time ambulance officers, there was a significantly higher incidence of hand dermatitis and latex allergy. There also was a significant relationship between latex allergies and both dermatitis and glove usage (as measured by frequency and duration).

Conclusion: In a group of first responders assessed by an anonymous, voluntary questionnaire, the subset of full-time, salaried ambulance officers was identified as having a higher incidence of hand dermatitis and latex allergy than their volunteer co-workers. These results require further assessment to substantiate the frequency of latex allergy and determine the predisposing factors. All personnel must learn about hand care. Non-powdered, natural rubber latex gloves should be supported for general use in this setting.

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Introduction

The St. John Ambulance in South Australia (984,377 km²; population 1,493,074)¹ and Western Australia (2,525,000 km²; population 1,883,869) provide a unique corps of trained, uniformed, and coordinated volunteers to deliver first aid in a large portion of the Australian land mass. Training progresses from basic first aid, including defibrillation, to more advanced skills. In 2002, 9,242 uniformed St. John volunteers provided 640,659 hours of public duty, 63,304 hours of transport and other duties, and treated 106,355 persons nation-wide.²

The South Australian Ambulance Service (SAAS) provides the sole ambulance road transport service across the entire state of South Australia. In rural areas, it requires volunteer support and may utilize St. John volunteers.

The first case of an immediate type reaction to natural rubber latex (NRL) was described in 1927, and was caused by a rubber dental prosthesis.³ In 1979, Nutter recognized NRL as a cause of contact urticaria.⁴ The introduc-

tion of Universal Precautions⁵—now Standard Precautions⁶—coincided with a rapid increase in the number of reported reactions, and in 1991, the Food and Drug Administration published a bulletin outlining the risks of anaphylaxis with NRL items.⁷ Multiple studies examined the occupational prevalence of the latex allergy^{8–12} using a variety of tools for assessment,¹³ but few have considered the prehospital emergency medicine setting.¹⁴

The prehospital environment allows frequent exposure to body fluids of all forms, often in potentially injurious surroundings. Suitable gloves are mandatory. Based on the data regarding the incidence of latex allergy in first responders, should the St. John Ambulance use nitrile gloves in place of NRL gloves.¹⁵

Methods

Approval

The proposed study was approved by the Research Ethics Committee of St. John Ambulance Australia and the Executive Committee of the SAAS. Financial support was provided by The Priority in Australia of The Order of St. John.

Subjects

The subjects represented four groups: (1) 927 volunteer members of St. John Ambulance SA (SJSA VO); (2) 240 volunteer members of St. John Ambulance WA District (SJWA VO); (3) 1,091 volunteers from the SA Ambulance Service (SAAS VO); and (4) 458 full-time ambulance officers from the SAAS (SAAS FTO). There were 2,716 individuals available for assessment, and responses were submitted anonymously.

Instrumentation and Assessment

A validated questionnaire with known predictive qualities was adapted to assess the prevalence of latex allergy in the surveyed group.⁹ The data collected included: (1) demographic data and information on present first responder activity and use of protective gloves; (2) data relating to hand care, tasking, and domestic activity that could be used to assess NRL exposure; (3) data recording clinical features of atopy, dermatitis, and latex allergy; and (4) details of action taken by the respondent with respect to the reported symptoms.

Atopy was considered present if the respondent gave positive answers to any two or more questions on a history of asthma, allergic rhinitis, or atopic dermatitis. Glove dermatitis was established on the basis of the reporting of ≥ 2 long-term symptoms of itching, redness, or rash (excluding hives). Latex allergy was established based on the following: (1) the sudden onset (within 30 minutes of wearing gloves) of hand urticaria with or without the occurrence of allergic rhino-conjunctivitis; (2) lower respiratory tract symptoms such as coughing, wheezing, or chest tightness; (3) generalized cutaneous itching or urticaria; or (4) upper airway edema, hypotension, dizziness, or collapsing.

Statistical Analysis

The data were collated and the results were processed using chi-square (χ^2) tests for the equality of proportions and homogeneity. Results shown as non-significant are at the $p = 0.05$ level. Processing was carried out using the R Statistical Language.¹⁶

Results

Responses were received from 1,099 of the 2,716 surveyed members, a response rate of 40.5%. This rate varied between groups as follows: (1) SAAS FTO = 38.4%; (2) SAAS VO = 28.8%; (3) SJSA = VO 51%; and (4) SJWA VO = 58.3%.

As a group, the volunteers represented a broader age range and, on average, were older than the full-time staff. There were significant differences in the distribution of ages between all four groups ($p < 0.001$). As a group, the volunteers consisted of a significantly greater proportion of staff > 50 years of age ($p < 0.001$). The volunteers from WA had a significantly lower proportion of personnel > 50 years than did the SA volunteers ($p < 0.05$) (Figure 1). One respondent declined to disclose his/her age or sex.

In all volunteer groups, females were more common than males, but in the full-time capacity, this sex ratio was reversed. The proportion of females in the SJSA VOs (54%) was significantly lower than in the other two volunteer groups (62% average, $p < 0.05$). However, in the SAAS FTOs group, males significantly predominated (71%, $p < 0.001$). Eight declined to state their sex (Figure 2). Two hundred (43%) SJSA VOs spent > 10 years acting as a first responder. The distributions of service years for the SAAS volunteers and the SJWA volunteers were not significantly different. Compared to these groups, the SAAS FTOs had a higher average number of years of service, with the SJSA volunteers having the highest average in years of service ($p < 0.001$).

It was predicted that most (92%) of the salaried staff would record duty > 200 hours per annum. Nevertheless, 31% of the SAAS volunteers contributed > 200 hours, significantly ($p < 0.001$) more than either of the other St. John groups where, on the average, 16% contributed > 200 hours.

Latex gloves were used widely, with an affirmative response on 1,054 questionnaires (96%). Full-time, ambulance officers reported using these gloves invariably (100%). Of the SAAS volunteers and SJWA volunteers, 97% used gloves significantly more than the SJSA volunteers (93%), ($p < 0.01$). The use of vinyl gloves was reported by 17/921 volunteers and nitrile gloves were used by one respondent.

The SAAS full-time, ambulance officers were the most likely to use non-powdered gloves (84%) significantly more frequently ($p < 0.001$) than the SAAS VOs and SJWA VOs (44%), who in turn used non-powdered gloves significantly more often than the SJSA VOs (19%, $p < 0.001$). Ninety-four percent of respondents donned gloves < 10 times/day and 78% of those occasions were for < 20 minutes.

A total of 547 respondents indicated that they wore gloves as required by another employer—many of the NRL gloves were used by 424 respondents in the medical, paramedical, and nursing areas. Of the 176 SAAS FTOs, 69 were required to wear protective gloves in places other than in their principal employment. In this situation, NRL gloves were preponderant (60/69) and powdered gloves were more common (36/69). In their alternative employment, the duration and frequency of glove usage was similar to that of their first responder role (78% used gloves < 10 times/day, and 71% of these events were for < 20 minutes).

Over two-thirds of the survey group wore gloves in household settings. A major NRL component in the gloves used in this setting could be identified in 50% of the responses.

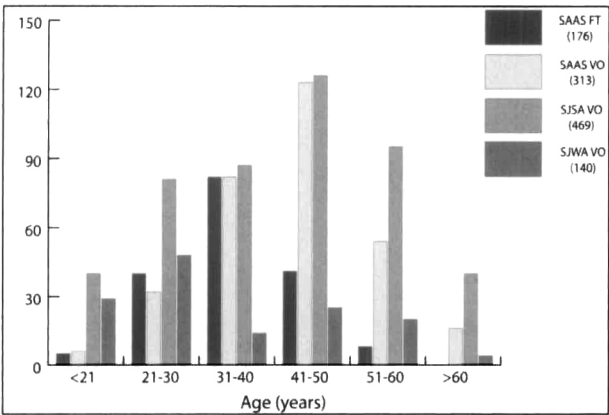


Figure 1—Age distribution of respondents by grouping (SAAS FT = South Australian Ambulance Service full-time; SAAS VO = South Australian Ambulance Service volunteer; SJSA VO = St. John Ambulance SA volunteer; SJWA = St. John Ambulance WA District volunteer)

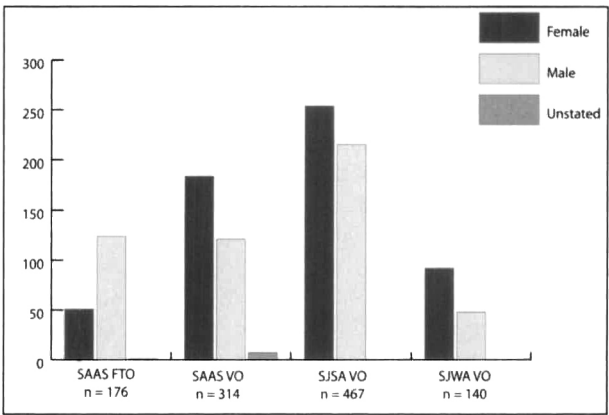


Figure 2—Gender ratio of respondents by grouping (SAAS FT = South Australian Ambulance Service full-time; SAAS VO = South Australian Ambulance Service volunteer; SJSA VO = St. John Ambulance SA volunteer; SJWA = St. John Ambulance WA District volunteer)

	SAAS FTO	SAAS VO	SJSA VO	SJWA VO	Overall VO
n = 1,099	n = 176	n = 314	n = 469	n = 140	n = 923
Atopy	18 (10.2%)	34 (10.8%)	78 (16.6%)	34 (24.3%)	15.8%
Dermatitis	30 (17.1%)	24 (7.6%)	34 (7.2%)	15 (10.7%)	7.9%
Latex allergy	25 (14.2%)	17 (5.4%)	16 (3.4%)	12 (8.6%)	4.9%

Table 1—Reported clinical entities by subsets (SAAS FT = South Australian Ambulance Service full-time; SAAS VO = South Australian Ambulance Service volunteer; SJSA VO = St. John Ambulance SA volunteer; SJWA = St. John Ambulance WA District volunteer)

Hand washing after glove usage was routine (as indicated by the “always” response) for 41% of SAAS FTOs, but only for 26% of the SAAS and SJWA volunteers and for 6% of the SJSA volunteers. These percentages are significantly different statistically ($p < 0.001$). Hand washing after glove usage never was practiced in 3% of SAAS FTOs, 8% of SAAS volunteers, 2% of SJWA volunteers, and 31% of SJSA volunteers (significantly more than the others, $p < 0.001$).

Atopy, hand dermatitis, and latex allergy were considered present within the entire respondent group in 14.9%, 9.4%, and 6.4% respectively. The breakdown by subsets is presented in Table 1.

Between groups, the incidence of atopy ranged between groups from 10.2–24.3%. These differences are statistically significant ($p < 0.001$). However, although the incidence of atopy for the volunteers as a group was higher (15.8%), it is not significantly different statistically from that of the FTOs (10.2%). There was no statistically significant difference between the two SAAS groups, or between the two St. John groups. The difference between the SAAS groups (10.6%) and St. John groups (18.4%) was significant ($p < 0.001$).

The full-time first responders demonstrated a higher ($p < 0.001$) incidence of dermatitis (17.1%) than did the three

volunteer groups (average 7.9%). There was not a statistically significant difference between the incidence of dermatitis for the three volunteer groups.

Seventy individuals (6.4%) were considered allergic to latex. The FTOs showed a higher latex allergy rate (14.2%) than did the VO (4.9%) ($p < 0.001$). Among the volunteers, the latex allergy rate was significantly higher for SJWA than for SJSA or SAAS ($p < 0.05$). There were no differences between the sexes.

The percentages of respondents with both dermatitis and latex allergy were: (1) SAAS FTOs, 10.2%; (2) SAAS VOs, 3.5%; (3) SJSA, 2.8%; and (4) SJWA, 5.0%. There was no difference between the three volunteer groups (average 3.4%). However the rate for the SAAS FTOs was greater than for the VOs ($p < 0.001$).

The relationship between the dermatitis and latex allergy rates within each group (Table 1) is presented in Figure 3. The data relating full-time/volunteer status, sex, and latex allergy status are in Table 2.

Responders were assessed with regards to duration of service, number of glove changes per duty, and duration of glove wearing in each episode. The results are presented in Tables 3, 4, and 5. The percentages in these tables refer to

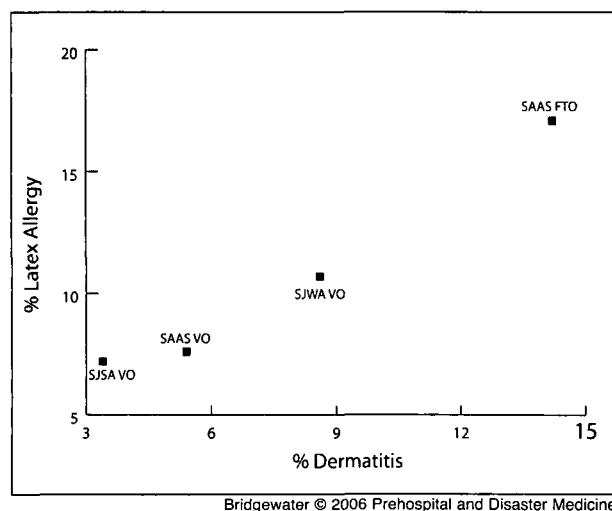


Figure 3—Dermatitis/latex allergy relationship by grouping (SAAS FT = South Australian Ambulance Service full-time; SAAS VO = South Australian Ambulance Service volunteer; SJSA VO = St. John Ambulance SA volunteer; SJWA = St. John Ambulance WA District volunteer)

the number of latex allergy sufferers as a percentage of all respondents classified in the same cell. The data in Table 3 suggest that the rate of latex allergy does not increase in proportion to increasing service years.

Considering all first responders as a single group, Table 4 illustrates that a significant increasing trend occurred in the rate of latex allergies with an increasing frequency of glove changes per time period ($p < 0.001$). While this trend was not statistically significant in either the FTO or the combined volunteer groups by themselves (possibly because of the sample sizes involved), the responders with >5 glove changes per time period demonstrated a higher latex allergy rate than did those with fewer changes.

Table 5 demonstrates a significant increasing trend in latex allergies with increasing duration of each glove exposure. This trend is statistically significant ($p < 0.001$) for all first responders combined, and marginally significant ($p < 0.06$) for the FTO and volunteer groups separately.

Hand symptoms of some form (itching, redness, hives, or other rash) with long-term exposure to NRL were reported in 658 individuals (59.9%).

A total of 188 workers recorded problems extending >5 years, and in some cases, these symptoms persisted for >10 years. Seventy-eight workers (71% of all respondents) consulted with a medical practitioner (general practitioner 50; allergist/immunologist 11; dermatologist 17) and 16 (1.5%) underwent skin testing. A total of 65 respondents (5.9%) reported changing the type of gloves they used, and 26 (2.4%) used inner gloves. Ninety-eight respondents (8.9%) reported using some variety of hand creams. Fifteen (1.4%) resorted to oral medication.

Discussion

Knowledge of the prevalence of the latex allergy in a particular category of worker provides some indication of the exposure of that group to NRL. A base comparison of this knowledge with future studies and a logical, persuasive factor for

implementing work environment and practice changes, is essential. A thorough questionnaire will not identify all NRL-allergic individuals and may falsely identify others.¹⁷ The work reported by Safadi *et al* employed a questionnaire, skin prick, patch testing, and a serum NRL-specific IgE assay.¹⁴ Using a questionnaire will provide some indicators of value, and is less expensive than a comprehensive screening program.¹⁸ While a questionnaire may be associated with under-reporting, Verna states "Despite non-specificity, validated questionnaires constitute the most useful means to implement health surveillance and prevention of latex-related diseases among healthcare workers".¹⁹

The overall response rate of 40.5% (varying between subsets 28.8%–58.3%) can be compared with 64% in a survey of similar size ($n = 1,628$) of active-duty, dental officers in the US Army.⁸

Age Distribution

St. John in South Australia and the SASS have a striking number of volunteers who donate >300 hours of service each year. These highly committed volunteers tend to be older, well-educated, and have the time and inclination to be involved.²⁰ The ability of this group to adapt to new practices can be questioned, but the associated enthusiasm and higher education standard would be supportive of change. The age distribution from the SJWA volunteers, with $>50\%$ at <30 years of age, may be more amenable to practice change and be trained in an environment that is more latex-safe.^{21,22}

Sex Ratio

Within this survey, there is a greater proportion of latex sensitive females than males among both the volunteers and the SAAS FTOs. The females in the FTOs group had a higher latex allergy rate, albeit not significant. While not a feature of this report, the higher incidence of latex allergy in females usually has been explained on an occupational basis rather than on a gender-related predisposition.

Potential Exposure to NRL

In this study, duration of service, duty hours, number of glove changes, and duration of glove wearing were analyzed. The rural-based SAAS volunteers tended to wear gloves less frequently, but for a longer period of time than did their full-time colleagues who primarily were based at larger depots in a metropolitan area. The report by Bollinger *et al* noted that there was no relationship between duration of service and latex allergy.¹⁸ Previous and current employment practices are relevant. South Australian Ambulance Service personnel previously have used powdered latex gloves. Nearly half of respondents in this series reported having to use protective gloves in other employment, most commonly in the nursing profession. Natural Rubber Latex gloves were the type of glove most frequently noted.

Individuals experiencing problems associated with glove exposure may choose to resign and seek employment in other areas.

Glove Usage and Dermatitis

Full-time staff wore protective NRL gloves. Volunteers were less assiduous but all achieved $>93.4\%$ compliance in their role

SAAS FTOs				
	Latex Allergic	Not Latex Allergic	Not Available	Total
Males	15 (12.1%*)	109	--	124
Females	9 (17.6%)	42	--	51
Not Available	1	--	--	1
Total	25 (14.2%)	151	--	176
All VOs				
	Latex Allergic	Not Latex Allergic	Not Available	Total
Males	12 (3.1%)	374	--	386
Females	33 (6.1%)	497	7	537
Total	475 (4.9%)	871	7	923

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Table 2—Status, sex, and latex allergy (SAAS FTO = South Australian Ambulance Service full-time officer; VO = volunteer) *Percentages given are percentages of the corresponding row total

Service Years:	<5	5-10	11-20	>20
FTO (25/175)	9/43 (20.9%)	7/77 (9.1%)	8/37 (21.6%)	1/18 (5.6%)
VO (45/923)	16/364 (4.4%)	11/240 (4.6%)	14/180 (7.8%)	4/134 (3.0%)

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Table 3—Latex allergy by service years (FTO = full-time officer; VO = volunteer)

Glove changes per period	<5	5-10	11-20	>20
FTO (25/175)	6/57 (10.5%)	15/95 (15.8%)	3/20 (15.0%)	1/3 (33.3%)
VO (45/923)	34/758 (4.5%)	9/122 (7.4%)	0/11 (0.0%)	2/6 (33.3%)
All	40/815 (4.9%)	24/217 (11.1%)	3/31 (9.7%)	3/9 (33.3%)

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Table 4—Latex allergy by frequency of glove usage (FTO = full-time officer; VO = volunteer)

Duration of Exposure (minutes)	<5	5-10	11-20	>20
FTO (25/175)	0/0	1/21 (4.8%)	11/90 (12.2%)	13/64 (20.3%)
VO (44*/923)	5/139 (3.6%)	17/383 (4.4%)	8/222 (3.6%)	14/157 (8.9%)
All	5/139 (3.6%)	18/404 (4.5%)	19/312 (6.1%)	27/221 (21.2%)

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Table 5—Latex allergy by duration of each glove exposure (FTO = full-time officer; VO = volunteer)

*Information from one latex allergic volunteer on this item is missing

as first responders. This probably reflects the emphasis on the importance of applying the principle of standard precautions. Hand dermatitis was recognized in 9.4% of all respondents, and in 17% of SAAS FTOs. This is lower than the occurrence of hand dermatitis reported for other healthcare workers.⁹ This survey demonstrates that dermatitis and latex allergy rates are positively correlated—the higher the dermatitis rate in a group, the higher the latex allergy rate. This reinforces the emphasis needed on hand care when using protective gloves. The lower incidence of hand dermatitis in volunteers may reflect the relatively short exposure time of these first responders when compared to full-time personnel and other healthcare workers such as dental staff and operating theater personnel.

Type of Glove

A total of 645 respondents indicated that they used powdered gloves, but there was a notable difference in the type of gloves used by subsets. While SAAS FTOs previously had used powdered latex gloves, this survey was conducted at a time when non-powdered gloves routinely were provided to these members. This change had occurred only a few months before the study. Such a change reduces the aeroallergen levels,²³⁻²⁵ latex-specific IgE antibody levels in sensitized staff members, and the clinical prevalence of latex allergy.^{24,26} Reducing latex exposure is associated with fewer socioeconomic consequences than is removal from exposure and should be considered a safe alterna-

tive.²⁷ St. John Ambulance Australia now has a policy that all NRL gloves should be non-powdered.

Keeping in mind the volunteer component of the survey, 547 respondents were required to use protective gloves in other employment (most often nursing) and latex gloves figured prominently in the type of glove reported. This may influence the lack of a relationship between years of service recognized and latex allergies.

Hand Washing

Some of the first responders reported "always" washing their hands after wearing gloves, and some indicated that it was "never" practiced. While this pattern was common in all groups, 30.7% of SJSA VOs recorded never washing after wearing gloves. Correct hand washing is important for reducing the risk of infection, but also must be conducted pre- and post-contact in order to minimize the incidence of hand dermatitis. Incomplete hand washing/drying, the use of soaps, hand cleansers, sanitizers, and glove powder may be contributing factors in the development of irritant dermatitis. This disrupts the skin barrier and may predispose to the development of latex allergy. Appropriate hand care should be encouraged in all first responder groups.

Atopy

The overall atopy incidence of 14.9% is low in comparison with that usually reported in Australia (30%),²⁸ and contrasts with Safadi's cohort of US first responders with an atopy rate of 37%.¹⁴ This may be explained by the possibility that individuals with significant asthma or eczema may not volunteer as first responders.

Latex Allergy

The latex allergy was recognized in 6.4% of the overall respondents, but the subsets showed marked variation—a low of 3.4% in SJSA VOs and a high of 14.2% in the FTOs. There was no indication that these individuals were aware of their possible hypersensitive state and supervisors of all three groups were unaware of specific members having latex allergy at the time.

Action Taken

Diagnosing latex allergy may be delayed when the affected person does not seek diagnostic help and when the physician does not consider the diagnosis. While 60% of respondents reported symptoms related to wearing gloves, only 11% of these sought medical advice (35% of these respondents saw physicians with expertise in diagnosing latex allergy). This reluctance to seek medical advice suggests a lack of understanding of the condition and its potential danger. Similar findings have been reported in dental personnel.⁹

Volunteerism

It is noted that 83% of the persons surveyed for this study were volunteers. In many situations, their presence was critical to the

provision of an ambulance service in rural and remote areas. Their response to directives and requests could be markedly different from that of a career-minded profession like the soldier/dentist in the US Army.⁸ The manager who needs to deal with both volunteer and full-time staff, and wishes to implement practice changes in regard to NRL glove use, must recognize this critical difference between volunteers and salaried staff and, if necessary, use differing implementation strategies.

Workplace Control

For emergency service providers, like defense force personnel,²⁹ the workplace is undefined and uncontrollable. Natural rubber latex usage is wide-spread in the community and first responders can expect to encounter it knowingly or unknowingly at any time. In this survey, a large number of respondents knowingly were exposed to NRL in other employment settings and in the domestic setting.

Limitations

This study used a voluntary, anonymous questionnaire. The voluntary aspect may have been acceptable to the ethos of a group largely made up of volunteers, but it did not ensure the high response rate necessary to provide comprehensive and convincing data. The concept of anonymity may have preserved elements of privacy, but deprived the individual and the organization of the benefit of specific data obtained.

Conclusions

Full-time officers had a higher incidence of latex allergy than did their volunteer colleagues. There was a linear relationship between latex allergy and dermatitis between subgroups and a correlation between the duration and frequency of glove usage with latex allergy for all first responders.

Volunteer officers more often were female, older, had longer service records, used powdered latex gloves more often, and washed their hands less consistently. The effect of the SAAS introducing non-powdered gloves should be assessed at a later date. Ongoing education on this topic, as well as hand care, is vital. The latter particularly relates to St. John Ambulance volunteers in South Australia.

In an era of emerging corporate responsibility, mandatory participation in an identified process to detect latex allergy should be preferred, and respondents should have confidence in the manner in which information will be managed.

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References

1. Anonymous: South Australia at a glance: Australia Bureau of Statistics; 2000. Report No.: ABS Catalogue No. 1306.4.
2. Fiori L: *Annual Report of the Priory in Australia of the Order of St John*. Canberra: Priory in Australia of the Order of St John; 2002–2003.
3. Stern G: Ueberempfindlichkeit gegen kautschuk als ursache von urticaria und quinckeschem oedem. *Klin Wochenschr* 1927;6:1096–1099.
4. Nutter AF: Contact urticaria to rubber. *Br J Dermatol* 1979;101(5):597–598.
5. US Centers for Disease Control and Prevention (CDC): Recommendations for prevention of HIV transmission in health-care settings. *MMWR* 1987;36(Supplement 2):1–18.
6. Garner J, Hierholzer W, McCormick R, et al: Guideline for isolation precautions in hospitals: Part 1: Evolution of isolation practices (Special Communication). *Am J Infect Control* 1996;24(1):24–31.
7. Anonymous: Allergic reactions to latex-containing items. *FDA Medical Bulletin* 1991;21(7):1–2.
8. Berky ZT, Luciano WJ, James WD: Latex glove allergy: A survey of the US Army Dental Corps. *JAMA* 1992;268(19):2695–2697.
9. Katelaris CH, Widmer RP, Lazarus RM: Prevalence of latex allergy in a dental school. *Med J Austr* 1996;164(12):711–714.
10. Liss GM, Sussman GL, Deal K, et al: Latex allergy: Epidemiological study of 1,351 hospital workers. *Occup Environ Med* 1997;54(5):335–342.
11. Sinha A, Harrison PV: Latex glove allergy among hospital employees: A study in the north-west of England. *Occupational Medicine* 1998;48(6):405–410.
12. Watts DN, Jacobs RR, Forrester B, Bartolucci A: An evaluation of the prevalence of latex sensitivity among atopic and non-atopic intensive care workers. *Am J Ind Med* 1998;34(4):359–363.
13. Warshaw E: Latex allergy. *J Am Acad Dermatol* 1998;39(1):1–24.
14. Safadi GS, Corey EC, Taylor JS, et al: Latex hypersensitivity in emergency medical service providers. *Ann Allergy Asthma Immunol* 1996;77(1):39–42.
15. Langdon-Orr C, Neyle D: *Choice of Gloves for Use by Emergency Medical Service Personnel, in Particular, First Aiders of the Operations Branch of St. John Ambulance Australia: A Discussion Paper and Literature Review*. Canberra, Australia: St. John Ambulance Australia, 1996.
16. R Development Core Team: *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing, 2004.
17. Brown RH, Schauble JF, Hamilton RG: Prevalence of latex allergy among anesthesiologists: Identification of sensitized but asymptomatic individuals. [see comment]. *Anesthesiology* 1998;89(2):292–299.
18. Bollinger ME, Mudd K, Keible LA, et al: A hospital-based screening program for natural rubber latex allergy. *Ann Allergy Asthma Immunol* 2002;88(6):560–567.
19. Verna N, Di Giampaolo L, Renzetti A, et al: Prevalence and risk factors for latex-related diseases among healthcare workers in an Italian general hospital. *Ann Clin Lab Sci* 2003;33(2):184–191.
20. Warburton J, Oppenheimer M, (ed.): *Volunteering: Noble Gesture or the Logic of Necessity? Volunteers and Volunteering*. Sydney: The Federation Press; 2000.
21. Cohen DE, Scheman A, Stewart L, et al: American Academy of Dermatology's position paper on latex allergy. *J Am Acad Dermatol* 1998;39(1):98–106.
22. New South Wales Health Department: Policy framework and guidelines for the prevention and management of latex allergy in NSW Public Health Services. NSW Health Department 2000; File 97/1580-2(Circular 2000/99).
23. Swanson MC, Bubak ME, Hunt LW, et al: Quantification of occupational latex aeroallergens in a medical center. *J Allergy Clin Immunol* 1994;94(3 Pt 1):445–451.
24. Allmers H, Brehler R, Chen Z, et al: Reduction of latex aeroallergens and latex-specific IgE antibodies in sensitized workers after removal of powdered natural rubber latex gloves in a hospital. *J Allergy Clin Immunol* 1998;102(5):841–846.
25. Hunt LW, Fransway AF, Reed CE, et al: An epidemic of occupational allergy to latex involving health care workers. *J Occup Environ Med* 1995;37(10):1204–1209.
26. Saary MJ, Kanani A, Alghadeer H, et al: Changes in rates of natural rubber latex sensitivity among dental school students and staff members after changes in latex gloves. *J Allergy Clin Immunol* 2002;109(1):131–135.
27. Vandenplas O, Jamart J, Delwiche JP, et al: Occupational asthma caused by natural rubber latex: Outcome according to cessation or reduction of exposure. *J Allergy Clin Immunol* 2002;109(1):125–130.
28. Ponsonby AL, Dwyer T, Kemp A, et al: The use of mutually exclusive categories for atopic sensitization: A contrasting effect for family size on house dust mite sensitization compared with ryegrass sensitization. *Pediatr Allergy Immunol* 2003;14(2):81–90.
29. Bridgewater F, Trudgen K: The nature of latex allergy and its implications for the Australian Defence Force. *ADF Health* 2004;5:78–84.