

Original article

Latex-induced occupational asthma: time trend in incidence and relationship with hospital glove policies

Background: Natural rubber latex (NRL) has become as a major cause of occupational asthma (OA) in workers using NRL gloves. Few population-based studies have assessed the impact of changes in the patterns of glove usage on the incidence of NRL-induced OA.

Objective: To characterize the time trends in incident cases of NRL-induced OA in Belgium and examine whether incidence rates were related to the types of gloves used in hospitals.

Methods: Incident cases of NRL-induced OA were identified through a retrospective review of all claims submitted to the Workers' Compensation Board up to December 2004. Based on the results of diagnostic procedures, the diagnosis of NRL-induced OA was categorized as definite, probable, unlikely, or indeterminate. The patterns of glove usage were characterized through a questionnaire survey of Belgian hospitals.

Results: A total of 298 claims for NRL-induced OA were identified, including 127 subjects with definite OA and 68 with probable OA. Categorized by the year of asthma onset, the incident cases of definite and probable NRL-induced OA markedly decreased from 1999 onwards. The use of powdered NRL gloves fell from 80.9% in 1989 to 17.9% in 2004. Powdered NRL gloves were predominantly substituted with NRL-free gloves, especially in the case of non-sterile procedures.

Conclusion: These national compensation-based data confirm that a persistent decline in the incidence of NRL-induced OA has occurred since late 1990s. This downward trend has temporally been associated with a decreasing usage of powdered NRL, further supporting a beneficial role of changes in glove policies.

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Key words: asthma; latex; occupational disease; prevention.

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Accepted for publication 20 May 2008

During the 1990s, natural rubber latex (NRL) emerged as a major cause of occupational asthma (OA) in workers using NRL gloves, especially in healthcare workers (HCWs) (1, 2). Several surveys of HCWs have suggested that the use of NRL gloves with a lower content in powder and/or protein is associated with a reduced incidence of NRL allergy (3), although these studies yielded variable levels of evidence (4). A few observational studies investigated the impact of changes in glove policies on the incidence of NRL-related diseases through the analysis of compensation statistics (5–8). The analysis of compensation-based data from Ontario (5) and Germany (6–8) indicated that switching from powdered NRL gloves to powder-free NRL gloves has been temporally associated with a decline in the annual number of claims allowed for NRL-induced OA, although these data might have been affected by changes in the diagnostic criteria.

The aims of this study were:

- (1) to characterize the time trends in incident cases of NRL-induced OA using standard diagnostic criteria; and
- (2) to examine whether the incidence rates are related to the types of gloves used in healthcare facilities.

Therefore, all claims for NRL-induced OA submitted to the national Workers' Compensation Board (WCB) up to 2004 were reviewed in order to date the onset of NRL-induced asthma and ascertain the diagnosis. The pattern of glove usage was assessed through a questionnaire survey of Belgian hospitals.

Methods

Identification of NRL-induced asthma

Incident cases of NRL-induced OA were identified through a retrospective review of all claims for OA notified to the Belgian WCB (Fonds des Maladies Professionnelles – Fonds voor de Beroepsziekten) up to December 2004. In Belgium, NRL-induced OA has

Abbreviations: HCW, Healthcare worker; NRL, Natural rubber latex; OA, Occupational asthma; WCB, Workers' Compensation Board.

been compensated by the WCB since 1992. However, workers who had developed the disease prior to 1992 were still permitted to fill a claim in subsequent years, since there is no legal restriction as to the delay between the onset of the symptoms or the end of workplace exposure and the submission of a claim to the WCB.

The WCB medical records were reviewed to extract the information pertaining to the demographic, occupational, and clinical characteristics of the claimants. In Belgium, workers submitting a claim for OA are evaluated by the WCB's medical experts using the following standard procedures:

- (1) gathering medical and occupational history;
- (2) immunological testing for common allergens and occupational agents where appropriate; and
- (3) assessment of spirometry and nonspecific bronchial hyper-responsiveness to histamine (9).

With respect to claimants exposed to NRL, skin-prick tests with a commercial NRL extract since 1994 (Stallergènes, Waterloo, Belgium) and measurements of NRL-specific IgE antibodies (CAP Pharmacia, Uppsala, Sweden) are completed. The WCB's medical experts may refer claimants to specialized centers in order to perform specific inhalation challenges with NRL gloves. Medical experts of the WCB are allowed to refer claimants to specialized centers for performing specific inhalation challenges with NRL gloves according to a previously described method (10).

For the purpose of this study, the diagnosis of NRL-induced OA was categorized as:

- (1) *definite* when the causal role of NRL was supported by a positive inhalation challenge with NRL gloves, work-related changes on serial peak flow readings, or changes in the level of non-specific bronchial hyper-responsiveness in relation to work exposure (11); and
- (2) *probable* when IgE-mediated sensitization to NRL ascertained by skin-prick testing or specific IgE antibodies measurement was associated with either a clinical history suggestive of OA or functional evidence of asthma [i.e. $\geq 15\%$ post-bronchodilator improvement in forced expiratory volume in one second (FEV₁) or a concentration of histamine causing a 20% fall in FEV₁ (PC₂₀) of 8 mg/ml or less].

The criteria used for defining probable NRL-induced OA were based on previously published data showing that high predictive values for a positive inhalation challenge with NRL are obtained when IgE-mediated sensitization to NRL is associated with either a suggestive clinical history (76%) (12) or the presence of nonspecific bronchial hyper-responsiveness (84%) (13).

Incidence rates were estimated by only taking into account the claims that were assigned a definite or a probable diagnosis of NRL-induced OA among HCWs. Incident cases were categorized based upon the year when the work-related asthma symptoms first appeared in order to avoid any bias resulting from a better notification of cases over recent years. The number of non-administrative hospital employees expressed as full-time equivalents was obtained from the Federal Public Service of Health (<http://www.health.fgov.be>). These numbers increased steadily from 91 582 full-time equivalents in 1991 to 106 479 in 2003.

Survey of hospital glove policies

A questionnaire survey of glove policies was conducted among Belgian hospitals ($n = 300$) identified through the directory of the Belgian Hospital Association (<http://www.hospitals.be>). The questionnaire aimed at collecting information on the type(s) of non-sterile and sterile gloves used in each institution (i.e. powdered

NRL, powder-free NRL, or NRL-free) and the moment when the glove policies were changed, if applicable. WCB hygienists sent the questionnaire to occupational physicians in charge of the hospital personnel or to health and safety representatives, and their participation to the survey was stimulated by repeated phone and personal contacts.

The data collected through the questionnaire survey were used to construct *usage indices* for every type of glove in each healthcare institution over the years. These indices were calculated by assuming that 90% of gloves used in hospitals were non-sterile gloves and 10% were sterile (14). Each type of non-sterile and sterile glove was given an arbitrary 'coefficient' value of 100% when all the gloves in the hospital were of that type; 50% when two types of gloves were used; 33% when the three different types of gloves were used; and 0% when the type of gloves under consideration was not used in the hospital. The resulting indices were expressed as a percentage of total gloves used in each institution. National usage indices were then derived for each type of glove by averaging the individual indices for non-sterile and sterile gloves of the surveyed hospitals.

Analysis of results

Data are presented as median with 25th and 75th percentiles for numerical variables. Comparisons were made using Wilcoxon rank sum test for numerical variables and either chi-square or Fisher exact tests for categorical variables with all the tests being two-tailed. The level of statistical significance was set at $P < 0.05$.

Results

Incident cases of NRL-induced asthma

A total of 298 claims for NRL-induced OA were identified up to December 31, 2004. Based on chart review, the diagnosis of NRL-induced OA was categorized as definite in 127 (42.6%) of the claimants and probable in 68 (22.8%). Among claimants with definite NRL-induced OA, the diagnosis was documented through specific inhalation challenges in 118 (92.9%) subjects, peak expiratory flow records in three subjects (2.4%), both procedures in five (3.9%), and serial assessments of nonspecific airway hyper-responsiveness alone in one worker (0.8%). All these subjects also demonstrated positive allergic tests to NRL. Among those classified as having probable NRL-induced OA with all of them showing IgE sensitization to NRL, the diagnosis was further supported by a clinical history suggestive of OA in 25 (36.8%) subjects, functional evidence of asthma in 9 (13.2%), or both features in 34 (50.0%). The diagnosis of NRL-induced OA was reasonably excluded based on the results of specific inhalation challenges or peak flow monitoring in 51 (17.1%) of 298 claimants and remained indeterminate because of insufficient data in 52 (17.4%) claimants. The demographic, occupational, and clinical characteristics of the 195 subjects with definite or probable NRL-induced OA are summarized in Table 1. The majority of these subjects (165 of 195; 84.5%) worked in healthcare environments. The onset of work-related asthma symptoms could be

Table 1. Demographic and clinical characteristics of claimants with definite or probable NRL-induced asthma (*n* = 195)

Characteristic	<i>n</i>	(%)
Age(years)	36.0	(30–40)*
Female	173	(88.7)
HCWs	165	(84.5)
Nurses/assistant nurses	144	(73.9)
Hospital housekeeping staff	10	(5.1)
Physicians	3	(1.5)
Technologists	2	(1.0)
Dental staff	2	(1.0)
Catering staff	2	(1.0)
Miscellaneous	2	(1.0)
Non-healthcare workers 30 (15.5%)	30	(15.5)
Chemical/pharmaceutical workers	15	(7.7)
Cleaners	6	(3.1)
Food workers	5	(2.7)
Hairdressers	2	(1.0)
Miscellaneous	2	(1.0)
Time intervals between:		
Work exposure and onset of NRL allergy(months)*	60	(12–120)*
Work exposure and onset of OA(months)*	84	(36–144)*
Onset of OA and claim to WCB(months)*	24	(9–60)*
Associated NRL-related symptoms:		
Rhinitis	165	(84.6)
Urticaria	161	(82.6)
Anaphylactic reaction	82	(42.1)
Hand eczema	63	(32.3)
Atopy†	131	(67.2)
Pre-existing asthma	31	(15.9)
Current/ex-smokers	20/26	(10.3/13.3)
Histamine PC ₂₀ ≤ 8 mg/mL or ≥ 15% post-bronchodilator improvement in FEV ₁ (assessed in 175 claimants)	148	(75.9)

Data are presented as absolute numbers with percentages within parentheses unless otherwise specified; NRL, natural rubber latex; OA, occupational asthma; WCB, Workers' Compensation Board; FEV₁, forced expiratory volume in one second; PC₂₀, concentration of histamine causing a 20% fall in FEV₁; HCW, healthcare workers.

*Median with 25th and 75th percentiles between parentheses.

†Atopy defined as a positive skin-prick test response to at least one of five common inhalant allergens.

dated in 191 patients, including 162 HCWs. Work-related asthma (alone or associated with other NRL-related disorders) was the inaugural symptom in 74 (37.9%) of the claimants. The median time elapsed between the onset of work-related asthma and the submission of a claim to the WCB was 24 (25th–75th percentiles; 9–60 months). This time interval decreased over the years: 81 (42–129 months) for those cases with symptom onset prior to 1992; 36 (9–63 months) in those for whom the onset of symptoms occurred between 1993 and 1995; 24 (8–36 months) during the 1996–1998 period; and 7 (4–12 months) thereafter.

Categorized according to the year of asthma onset, the annual number of HCWs with definite or probable NRL-induced OA, started to increase in 1988, peaked in 1998, and declined sharply thereafter (Fig. 1). The time pattern of incident cases of NRL-induced OA by the year of

asthma onset was similar in non-HCWs and in HCWs. However, the annual numbers of NRL-induced OA in non-HCWs were too low (ranging from zero to five per year) to conduct a separate analysis on these workers. The time-related changes in estimated annual incidence rates of NRL-induced OA among Belgian HCWs were similar to those provided through the examination of the absolute numbers of incident cases: the incidence of work-related asthma symptoms increased from 10.9 per 100 000 full-time equivalents in 1991 to a maximum of 19.7 in 1998, and then declined steadily to reach 3.8 cases per 100 000 full-time equivalents in 2003 and 2004 (Fig. 1).

Survey of glove policies

The questionnaire was completed by 88 (29.3%) of the 300 target hospitals. These participants represented 41.2% of all registered hospital beds and 44.7% of non-administrative workers employed in Belgian hospitals according to the 2003 census. Participation to the survey was higher among university-affiliated institutions (16 of 25) as compared to non-affiliated hospitals (71 of 275) (*P* < 0.001); and among hospitals from where at least one claim had been notified to the WCB (37 of 83) as compared to hospitals without claims (51 of 217) (*P* = 0.007).

The earliest change in hospital glove policy was reported to have occurred in 1990. The changes in the national indices of glove usage over time are illustrated in Fig. 1 and are summarized according to hospital characteristics in Table 2. The overall usage index of powdered NRL-gloves declined gradually from 80.9% in 1989 to 17.9% in 2004. Figure 1 shows that the decline in incident cases of NRL-induced OA, categorized by the onset of work-related asthma, paralleled the decreasing usage of powdered NRL gloves. The decrease in NRL-powdered gloves usage was more pronounced for non-sterile (from 80.5% to 14.4%) than for sterile procedures (from 84.6% to 48.9%). Over the same period, the overall usage indices increased from 16.9% to 61.7% for NRL-free gloves and from 2.2% to 20.4% for powder-free NRL gloves. Overall changes in glove policies were quite similar according to the characteristics of the surveyed hospitals, with the notable exception that university hospitals had more frequently switched to NRL-free gloves for both non-sterile (88.9%) and sterile applications (22.9%), as compared with non-university hospitals (61.9% and 12.9%, respectively) (Table 2).

Discussion

These national compensation-based data show that the incidence of NRL-induced OA among HCWs has declined markedly since late 1990s. These findings further support the previously published compensation statistics

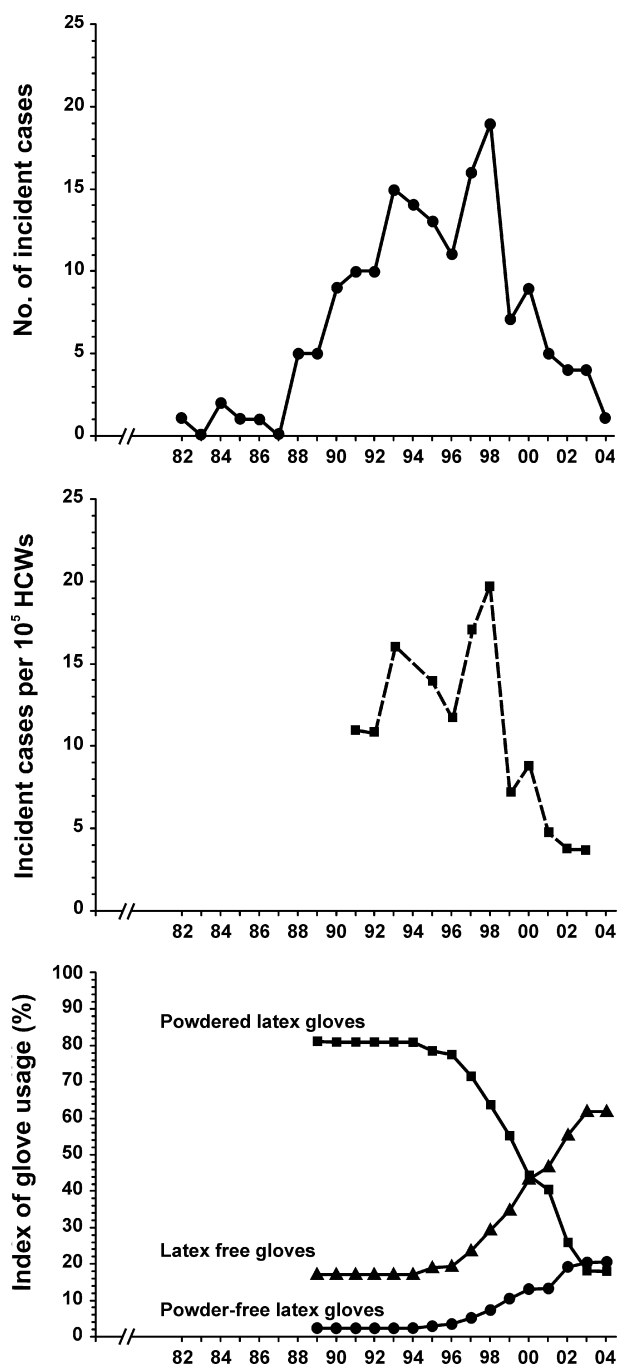


Figure 1. Upper panel: Annual numbers of definite and probable cases of NRL-induced occupational asthma in HCWs categorized by the year of the onset of work-related asthma symptoms. Middle panel: Incidence rates of NRL-induced OA expressed as the number of incident cases per 10⁵ full-time equivalents of non-administrative employees in Belgian hospitals. Lower panel: Usage indices (expressed as % of total glove usage) of the different types of gloves in surveyed Belgian hospitals (■ = powdered latex gloves; ▲ = latex free gloves; ● = powder-free latex gloves). HCWs, healthcare workers; NRL, natural rubber latex; OA, occupational asthma.

from Ontario (5) and Germany (6–8) although, in our study, the process of case ascertainment was based on uniform and objective criteria. In addition, incident cases were analyzed according to the year of symptom onset rather than to the year of claim submission in order to minimize the effects of the increasing awareness of NRL allergy among HCWs and the medical community. It is unlikely that the observed decline in incidence since 1999 resulted from new NRL-induced OA cases that would still not have been notified to the WCB in December 2004. Therefore, the median time elapsed between the onset of symptoms and the notification to the WCB was 24 months, and this interval has decreased in recent years.

Potential limitations might have affected these data derived from an occupational disease register. Medico-legal statistics may suffer from under-reporting since some categories of workers are not covered by legal compensation schemes and eligible workers may not notify their occupational disease due to fears for adverse financial outcomes. In Belgium, self-employed workers, including most physicians and dentists, are not entitled to compensation and are likely to be under-represented in the medico-legal statistics on NRL allergy. Those workers who qualify for compensation are entitled to receive several types of financial awards, which are better than those obtained from the national health insurance. Although potential biases may have led to underestimate the true incidence of NRL-induced OA, it is unlikely that they may account for the observed time trends in incident cases.

The observed decline in incident cases of NRL-induced OA occurred concomitantly with a marked reduction in the use of powdered NRL gloves in healthcare facilities (Fig. 1) and a conversion to NRL-free gloves or powder-free NRL gloves. In Ontario, the number of claims allowed for NRL-induced OA by the year of symptom onset started to decline in 1995, although information on the nature and timing of preventive interventions was available only for the two largest hospitals (5). In Germany, the annual numbers of claims submitted for NRL-induced urticaria and OA to the statutory accident insurance started to decline in 1999 after implementation of a regulation-enforced switch to powder-free NRL gloves in 1997–1998 (6–8). The questionnaire survey of Belgian hospitals also documented a marked reduction in the use of powdered NRL gloves from 80.9% in 1989 to 17.9% in 2004. Noticeably, these changes in glove policies were implemented in the absence of a structured prevention program or regulations pertaining to glove policy. The overall pattern of change in glove usage was similar to that reported from Germany with two noticeable differences. In Belgium, powdered NRL gloves were switched mainly to NRL-free gloves, especially for non-sterile applications, whereas powder-free NRL gloves were used predominantly for sterile procedures. The reliability of data on glove use gathered through the questionnaire survey may be criticized on the ground of

Table 2. Glove policies according to hospital characteristics

	Powdered NRL Gloves		NRL-free Gloves		Powder-free NRL Gloves	
	1989	2004	1989	2004	1989	2004
<i>Sterile and nonsterile gloves</i>						
All participating hospitals (<i>n</i> = 88)	80.9	17.9	16.9	61.7	2.2	20.4
University hospitals (<i>n</i> = 16)	87.4	7.1	12.0	82.3	0.6	10.6
Non-university hospitals (<i>n</i> = 72)	79.4	18.9	18.0	57.7	2.6	23.4
Hospitals with ≥ 1 claim to WCB (<i>n</i> = 35)	80.4	16.4	17.8	63.3	1.8	20.2
Hospitals without claims to WCB (<i>n</i> = 53)	81.2	16.9	16.3	61.5	2.4	21.6
<i>Nonsterile gloves</i>						
All participating hospitals (<i>n</i> = 88)	80.5	14.4	18.3	66.9	1.2	18.7
University hospitals (<i>n</i> = 16)	86.7	2.2	13.3	88.9	0	8.9
Non-university hospitals (<i>n</i> = 72)	79.1	17.2	19.4	61.9	1.5	20.9
Hospitals with ≥ 1 claim to WCB (<i>n</i> = 35)	79.8	12.6	19.2	68.7	1.0	18.7
Hospitals without claims to WCB (<i>n</i> = 53)	80.9	15.7	17.7	65.6	1.4	18.7
<i>Sterile gloves</i>						
All participating hospitals (<i>n</i> = 88)	84.6	48.9	4.5	15.0	10.9	36.1
University hospitals (<i>n</i> = 16)	93.8	51.0	0	22.9	6.2	26.1
Non-university hospitals (<i>n</i> = 72)	82.3	47.6	5.6	12.9	12.1	39.5
Hospitals with ≥ 1 claim to WCB (<i>n</i> = 35)	85.8	50.5	4.9	15.2	9.3	34.3
Hospitals without claims to WCB (<i>n</i> = 53)	83.7	47.7	4.2	14.8	12.1	37.5

NRL, natural rubber latex; WCB, Workers' Compensation Board. See *Methods* section for a detailed description of glove usage indices.

participation biases. Thus, higher response rates from university-affiliated hospitals and from hospitals where cases of NRL-induced OA have occurred may have led to overestimate and/or antedate the changes in glove policies. However, the downward trend in the use of powdered NRL gloves did not differ according to hospital characteristics among participating institutions (Table 2).

The temporal association between the downtrend in incident cases of NRL-induced OA and the reduction in the use of powdered NRL gloves supports a cause and effect relationship. However, the role of an overall reduction in the allergen content of NRL gloves resulting from improvements in manufacturing processes cannot be determined from these data. Thus, there is some published evidence that the protein and allergen content of NRL gloves has declined in the mid to late 1990s (8, 15, 16). Serial surveys of medical gloves marketed in Finland have shown that the proportion of NRL gloves (either powdered or non-powdered) containing a high level of allergens decreased from 28% in 1995 and to 6% in 2001 (17). Properly designed intervention studies would have been required to determine the respective

contribution of changes gloves usage compared to an overall reduction in allergen content and to identify the most cost-effective preventive strategy.

In conclusion, these national compensation-based data further confirm that a persistent decrease in the incidence of NRL-induced OA has occurred concomitantly with a marked reduction in the use of powdered NRL gloves in healthcare facilities. This temporal association supports a beneficial contribution from changes in glove policies in preventing the development of NRL allergy.

Acknowledgments

The authors wish to thank Arlette Fagnot, Sonia Deroo, and Jean-Paul Noel for their assistance in retrieving the medical records, and Jean-Paul Hennuy (Federal Public Service of Health) for providing statistics on Belgian healthcare workers. The authors are grateful to the industrial hygienists of the Belgian WCB (Fonds voor de Beroepsziekten – Fonds des Maladies Professionnelles) who carried out the questionnaire survey and to Denyse Gautrin and Heberto Ghezso for their help in analyzing the data.

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