

Sensitization to Rubber Accelerators in Northeastern Italy: The Triveneto Patch Test Database

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Background: Natural and synthetic rubbers containing rubber accelerators are well-known causes of occupational skin disease. Allergic contact dermatitis caused by rubber gloves is frequent and has almost exclusively been attributed to contact sensitization to accelerators.

Objective: This study aimed to evaluate the frequency of rubber accelerators sensitization in the population living in northeastern Italy, to find time trend and a correlation with occupations, and to investigate co-sensitization between rubber accelerators.

Methods: A population of 23,774 subjects was patch tested in 6 cities in northeastern Italy in the years 1996 to 2012 using carba mix 3%, thiuram mix 1%, benzothiazole (MBT) mix 1%, and isopropyl phenyl paraphenyldiamine diamine (IPPD) mix 0.6%.

Results: The overall frequency of carbamates, MBT, thiurams, and IPPD mix sensitization was 3.4%, 0.65%, 1.75%, and 0.83%, respectively. On a logistic regression analysis (control group: white-collar workers), we found a statistically significant association to carbamates (odds ratio [OR], 1.3; 95% confidence interval [CI], 1.03–1.7) and thiurams (OR, 1.6; 95% CI, 1.1–2.3) for health care workers. Thiuram sensitivity was also significantly associated with dermatitis in maids and restaurant workers (OR, 2.2; 95% CI, 1.4–3.6), hairdressers (OR, 3.6; 95% CI, 1.8–7.1), shop assistants (OR, 2.9; 95% CI, 1.2–6.8), construction workers (OR, 2.7; 95% CI, 1.7–4.1), mechanics (OR, 2.1; 95% CI, 1.3–3.4), and professional drivers (OR, 2.6; 95% CI, 1.2–5.9).

Conclusions: In conclusion, our results demonstrated that rubber accelerators have an important role in allergic contact dermatitis in the northeast of Italy and their sensitization is associated significantly with occupations that wear gloves or use chemical substances. Between rubber accelerators tested, carbamates sensitization is prevalent and increasing during considered years.

Natural and synthetic rubbers containing rubber accelerators are well-known causes of occupational skin disease.¹ Allergic contact dermatitis caused by rubber gloves is frequent, and has almost exclusively been attributed to contact sensitization to accelerators.² Rubber accelerators are added during the manufacturing process to speed up rubber vulcanization, but residual amounts remain in the gloves and are released during use, potentially leading to type IV sensitization.¹ Chemicals including carbamates, thiurams, and benzothiazoles (MBT) are commonly used as vulcanizing agents. In addition, antioxidants that prevent

rubber deterioration, such as black rubber mix chemicals IPPD (*N*-isopropyl-*N'*-phenyl-*p*-phenylenediamine), may be included in rubber processing.^{1,3} All these allergens are commonly tested in European baseline series, except for carbamates, because some authors^{4,5} suggested a cross-reaction with thiurams^{4–9} and false-positive reactions.

The aims of this study were as follows:

- to evaluate the frequency of sensitization to rubber accelerators, including carbamates, in a population patch tested for suspected allergic contact dermatitis living in northeastern Italy from 1996 and 2012;
- to find associations with occupations;
- to analyze whether there is a temporal trend in the frequency of sensitization in the considered time span;
- to investigate co-sensitization between different rubber accelerators.

METHODS

Patient Characteristics

A total of 24,052 patients (aged >15 years) with symptoms and/or signs of suspected allergic contact dermatitis were patch tested

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from 1996 to 2012 in 8 departments of Occupational Medicine or Dermatology in northeastern Italy (Trieste, Pordenone and 3 clinics from Padua—Bolzano, Trento, and Rovigo—participated in the study only from 1998 to 2004).

Through a standardized questionnaire, we collected individual characteristics, occupational history, and a personal and family history of atopy (asthma and/or allergic rhinoconjunctivitis with at least one positive prick test reaction to relevant aeroallergens.¹⁰) A total of 23,774 patients were included in the final sample, after exclusion of 278 patients primarily because of lack of relevant data (personal characteristics, incomplete patch testing).

All subjects were categorized by professional group, collapsing related occupational groups into a larger one (eg, nurses, physicians, and other hospital workers were collapsed into “health care workers” category). A similar collapse was arranged for body sites category (eg, fingers, palms, and dorsal hands were collapsed into “hands”).

Occupational-related analysis was performed on 20,849 subjects, discarding 2925 because of incomplete or inaccurate collection of subject's professional history.

Current occupation of patients was used as a proxy of exposure: we did not take into account historical occupational anamnesis because sensitization is often acquired after a short exposure.¹¹ Subjects were classified by occupational group and statistical analyses were performed taking into account potential confounding effect of age and sex.

No ethical approval was required: all subjects were patients who underwent patch testing for diagnostic purposes and gave informed consent.

Patch Test

Patients were patch tested with the European baseline series¹² with carba mix 3% in pet (*N,N* diphenylguanidine 1%, zinc diethyldithiocarbamate 1%, zinc dibutylthiocarbamate 1%), thiuram mix 1% in pet (Tetramethylthiuram monosulfide [TMTM] 0.25%, Tetramethylthiuram disulfide [TMTD] 0.25%, tetraethylthiuram disulfide [TETD] 0.25%, Dipentamethylenethiuram disulfide [PTD] 0.25%), MBT mix 2% in pet (*N*-Cyclohexylbenzothiazyl-sulfenamide [CBS] 0.5%, Dibenzothiazyl disulfide [MBTS]) 0.5%, Morpholinyl-mercaptobenzothiazole [MOR] 0.5%, 2-mercaptobenzothiazole [MBT] 0.5%) and IPPD mix or “black rubber” 0.6% in pet (*N*-isopropyl-*N'*-phenyl paraphenylenediamine 0.1%, *N*-cyclohexyl-*N'*-phenyl paraphenylenediamine 0.25%, *N*, *N'*-diphenylparaphenylenediamine 0.25%), using Finn Chambers on Scanpor (Epitest Ltd, Tuusula, Finland) and allergens from FIRMA (Firenze, Italy).

Patches were applied on the upper back and removed 48 hours later. Application sites were examined on removal and 24/48 hours after removal, according to International Contact Dermatitis Research Group guidelines.¹³

In the second examination, +, ++, and +++ grade reactions were considered as positive, whereas dubious reactions were considered as negative.

Statistical Analysis

We performed analysis of data using statistical software STATA v. 13.1 (Stata Corp, LP, College Station, TX). $K \times k$ contingency tables were used to cross tabulate categorical data, and χ^2 tests were performed.

Multivariate logistic regression analysis has been used to evaluate the associations between occupations, patch test results, patients' age (quintiles: ≤ 25 , 26–34, 35–45, 46–58, and ≥ 59 years) and year of patch testing (3-year span subgroups: 1996–1998, 1999–2001, 2002–2004, 2005–2007, 2008–2010, after 2010).

We studied the different incidence rates of rubber accelerator sensitization during the study in the different cities in northeastern Italy.

Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated from the coefficients and the standard errors of logistic regression output. Logistic analysis was conducted to evaluate the role of professions and main confounding factors, sex and age, in sensitization, with white-collar workers as the reference group. Trend tests across ordered groups were performed using Cuzick test for trend. Patients with missing data were excluded from the analysis. A *P* value of less than 0.05 was used to denote statistical significance.

RESULTS

The study sample included 16,056 (67.5%) women and 7718 (32.5%) men. The mean age of the population was 43.1 ± 17 years, without any significant difference by sex. The overall frequency of carbamates, MBT, thiurams, and IPPD mix sensitization was 3.4% (2.6% of women and 5.2% of men, $P = 0.006$), 0.65% (0.9% of men and 0.6% of women, $P = 0.01$), 1.75% (1.8% of men and 1.7% of women), and 0.83% (0.9% of women and 0.8% of men), respectively.

In Figure 1, the comparison of prevalence of sensitization between different rubber accelerators in years considered is reported. We observed a downtrend for carbamates sensitization from 1996 to 2006, with a prevalence of sensitization ranging between 5% and 2.3%. In years 2010 to 2012, sensitization increased to 4.8%. The skin sensitivity was lower and more stable for the other accelerators: ranging between 2% and 2.4% for thiurams, 1% and 1.5% for IPPD mix, and 1% and 0.3% for MBT mix.

Table 1 reports body sites involvement in subjects sensitized to considered rubber accelerators. The most frequent body site involved was the hands for thiurams (60%; OR, 2.45; 95% CI, 2.0–3.1) and MBT mix (54%; OR, 1.8; 95% CI, 1.2–2.6). Leg dermatitis was more frequent in those sensitized to carbamates (11.6%; OR, 1.8; 95% CI, 1.4–2.3), whereas face dermatitis was not related to any considered rubber accelerators.

Table 2 shows the distribution of profession. We considered 20,849 patients of which 14,130 (67.8%) were women and 6719 (32.2%) were men, excluding the remaining patients because of incomplete or inaccurate information about job's category. On a logistic regression analysis (control group: white-collar workers), we found a statistically significant association to carbamates (OR, 1.3; 95% CI, 1.03–1.7) and thiurams (OR, 1.6; 95% CI, 1.1–2.3) for health care workers. Thiuram sensitivity was also significantly

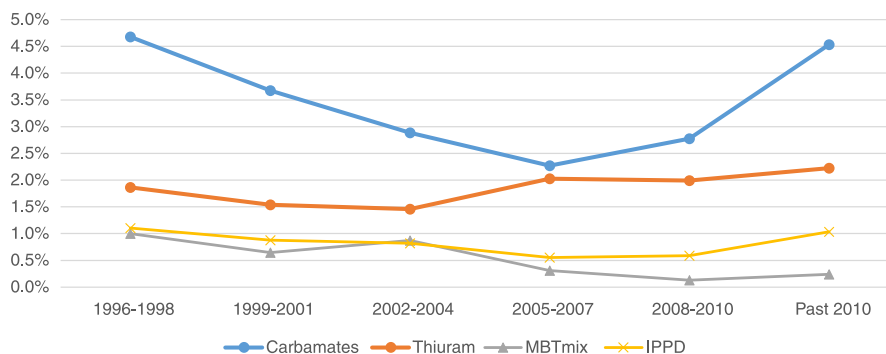


Figure 1. Rubber accelerator sensitization trend in considered years.

associated with dermatitis in maids and restaurant workers (OR, 2.2; 95% CI, 1.4–3.6), hairdressers (OR, 3.6; 95% CI, 1.8–7.1), shop assistants (OR, 2.9; 95% CI, 1.2–6.8), construction workers (OR, 2.7; 95% CI, 1.7–4.1), mechanics (OR, 2.1; 95% CI, 1.3–3.4), and professional drivers (OR, 2.6; 95% CI, 1.2–5.9). MBT mix sensitivity is related to paper production workers (OR, 5.9; 95% CI, 1.4–25.7) and to farmers (OR, 4.0; 95% CI, 1.5–10.5). IPPD mix sensitivity is associated with hairdressers (OR, 2.8; 95% CI, 1.1–7.2) and chemical industry workers (OR, 4.0; 95% CI, 1.5–10.2).

Men presented higher risk to be sensitized to carbamates (OR, 2.1; 95% CI, 1.7–2.4).

Table 3 shows the cross-reaction between the 4 considered accelerators. The results confirm a strong association between carbamates and thiurams (OR, 17.5; 95% CI, 13.6–21.5) and between mercaptobenzothiazole and thiurams (OR, 13.7; 95% CI, 8.8–21.3). To note, most patients sensitized to carbamates (621 cases; 82.91%) were negative to thiurams.

DISCUSSION

Our study investigated rubber accelerator sensitivity in the largest database of patch tests in northeastern of Italy, finding an increased rate of sensitization from 2008 to 2012 for carbamates and thiurams reaching values of 4.5% and 2.1%, respectively. In accordance with the literature, a lower prevalence of sensitization for IPPD mix (1.0%) and MBT mix (0.3%)¹ was found.

Thiurams are comparatively cheap and well-established rubber vulcanizing agents. Worldwide, thiurams have been considered to be the most common rubber contact allergen chemicals causing

type IV hypersensitivity reactions.^{1,2} However, in our study, we found a higher prevalence of sensitization to carbamates with values more than double in the last years considered. Recently, a similar result was confirmed by Warburton et al¹⁴ in a study about rubber allergens in Europe. The increase in carbamate sensitivity could be related to the decrease in the use of MBT and thiurams in the manufactured gloves and an increase of carbamates, to maintain good elasticity of gloves.^{1,5}

Some authors in previous years considered it redundant to test carbamates and thiurams because they cross-react^{7–9,15}; moreover, irritant reactions and false-positive rates have been reported for carbamates,¹⁶ which were excluded from the European Standard Series. In a Swedish study, Hansson et al⁴ showed that every positive reaction to dithiocarbamate was accompanied by a positive reaction to the corresponding thiurams, except for 1 patient. To note, the Hansson study reported data from 24 patients sensitized to rubber accelerators and the authors themselves stated that results needed to be confirmed in larger studies.

In our study, sensitization to carbamates is increasing through the years. Our findings are in accord with results obtained in some American and European centers that report a high relevance of carba mix sensitization ranging between 1.6% and 4% in Europe and the United States^{3,17} and reaching 15% in Thailand in association with occupational contact dermatitis in nurses.¹⁸

In 2003, Geier et al⁵ reported that sensitization to carbamates in patients with suspected occupational contact dermatitis related to rubber gloves in Europe (Information Network of Department of Dermatology 1995–2001) was 3.5% with a stable trend in considered

TABLE 1. Sensitization to Rubber Accelerators in Different Body Sites

Body Sites	Carbamates Mix 3% Pet			Thiurams Mix 1% Pet			MBT Mix 2% Pet			PPD Mix 0.6% Pet		
	Pos.	%	OR (95% CI)	Pos.	%	OR (95% CI)	Pos.	%	OR (95% CI)	Pos.	%	OR (95% CI)
Hand	250	37.8	0.96 (0.8–1.1)	215	60.4	2.45 (2.0–3.1)	61	54.0	1.8 (1.2–2.6)	59	34.7	0.8 (0.6–1.2)
Leg	77	11.6	1.8 (1.4–2.3)	11	3.1	0.43 (0.2–0.8)	10	8.9	1.4 (0.7–2.7)	15	8.8	1.3 (0.8–2.25)
Face	96	13.7	0.78 (0.6–1.0)	59	16.6	0.92 (0.7–1.2)	13	11.5	0.6 (0.4–1.1)	39	22.9	1.4 (0.96–2.0)
Other	244	36.9	1.0 (0.8–1.2)	72	20.2	0.4 (0.3–0.6)	30	26.6	0.6 (0.4–0.9)	57	33.5	0.8 (0.6–1.2)

Association between body sites and studied haptens is reported as OR and 95% CI. In bold are reported significant results.

TABLE 2. Association Between Rubber Accelerators, Occupations, Sex, and Age Evaluated Using Multiple Regression Analysis

Occupation	Total n	Carbamates Positive, n (%), OR (95% CI)	Thiurams Positive, n (%), OR (95% CI)	MBT Mix Positive, n (%), OR (95% CI)	IPPD Mix Positive, n (%), OR (95% CI)
White-collar workers	5137	174 (3.4), —	58 (1.3), —	30 (0.6), —	35 (0.7), —
Health care workers	2487	103 (4.1), 1.3 (1.03–1.7)*	45 (1.8), 1.6 (1.1–2.3)*	6 (0.2), 0.4 (0.2–1.05)	25 (1.0), 1.5 (0.9–2.4)
Maids and restaurant workers	955	27 (2.8), 0.8 (0.5–1.2)	24 (2.5), 2.2 (1.4–3.6)**	3 (0.3), 0.5 (0.2–1.8)	9 (0.9), 1.4 (0.7–2.9)
Barbers, hairdressers	270	7 (2.6), 0.95 (0.4–2.1)	10 (3.7), 3.6 (1.8–7.1)***	1 (0.4), 0.7 (0.1–5.0)	5 (1.9), 2.8 (1.1–7.2)*
Shop assistants	175	2 (1.1), 0.4 (0.1–1.5)	6 (3.4), 2.9 (1.2–6.8)*	0 (0.0), —	0 (0.0), —
Farmers and fishers	204	6 (2.9), 0.7 (0.3–1.6)	4 (2.0), 1.6 (0.6–4.5)	5 (2.5), 4.0 (1.5–10.5)**	2 (1.0), 1.4 (0.3–5.9)
Construction workers	1099	52 (4.7), 1.1 (0.8–1.6)	34 (3.1), 2.7 (1.7–4.1)	9 (0.8), 1.3 (0.6–2.7)	12 (1.1), 1.6 (0.8–3.1)
Mechanics	1086	40 (3.7), 0.8 (0.6–1.2)	26 (2.4), 2.1 (1.3–3.4)**	17 (1.6), 2.4 (1.3–4.4)**	6 (0.6), 0.8 (0.3–2.0)
Woodworkers	333	13 (3.9), 1.0 (0.5–1.7)	5 (1.5), 1.3 (0.5–3.3)	6 (1.8), 2.9 (1.2–7.0)	1 (0.3), 0.4 (0.1–3.2)
Textile and leather workers	515	19 (3.7), 1.1 (0.7–1.8)	4 (0.8), 0.7 (0.2–1.9)	3 (0.6), 1.0 (0.3–3.3)	7 (1.4), 2.0 (0.9–4.5)
Chemical industry workers	190	7 (3.7), 0.9 (0.4–2.0)	2 (1.1), 0.9 (0.2–3.8)	3 (1.6), 2.5 (0.7–8.2)	5 (2.6), 4.0 (1.5–10.2)**
Paper production workers	53	1 (1.9), 0.4 (0.1–3.2)	1 (1.9), 1.7 (0.2–12.2)	2 (3.8), 5.9 (1.4–25.7)**	0 (0.0), —
Professional drivers	230	12 (5.2), 1.1 (0.6–2.0)	7 (3.0), 2.6 (1.2–5.9)*	3 (1.3), 1.9 (0.6–6.3)	1 (0.4), 0.6 (0.1–4.7)
Domestic workers	280	12 (4.3), 1.5 (0.8–2.7)	6 (2.1), 1.8 (0.8–4.1)	5 (1.8), 3.5 (1.3–9.1)**	3 (1.1), 1.5 (0.5–4.9)
Household workers	2832	78 (2.8), 1.0 (0.7–1.3)	54 (1.9), 1.3 (0.9–2.0)	22 (0.8), 1.7 (0.9–3.1)	23 (0.8), 1.0 (0.6–1.9)
Retired	3258	136 (4.2), 1.0 (0.7–1.4)	58 (1.8), 1.0 (0.6–1.6)	16 (0.5), 1.0 (0.4–2.1)	38 (1.2), 1.4 (0.8–2.6)
Unemployed	375	11 (2.9), 0.8 (0.5–1.6)	4 (1.1), 0.9 (0.3–2.6)	3 (0.8), 1.4 (0.4–4.5)	1 (0.3), 0.4 (0.1–2.9)
Other occupations	545	22 (4.0), 1.1 (0.7–1.7)	12 (2.2), 2.1 (1.1–3.9)	1 (0.2), 0.3 (0.04–2.1)	1 (0.2), 0.3 (0.04–2.0)
Individual characteristics					
Males	6719	2.1 (1.7–2.4)	1.0 (0.8–1.3)	1.5 (0.99–2.2)	0.9 (0.7–1.3)
Age	—	1.0 (1.0–1.0)	1.01 (1.005–1.02)*	1.0 (1.0–1.0)	1.01 (0.99–1.02)

Reference category for occupation: white-collar workers.

Statistically significant results are highlighted in bold.

* $P < 0.01$.** $P < 0.001$.*** $P < 0.0001$.

years. This sensitization was lower compared to that of thiurams which reached 15.1% of patch test positivity in this selected group.⁵

More recent papers that studied patch test positivity using the European data base from 2002 to 2010 obtained a lower prevalence of thiuram sensitization (OR, 4.23; 95% CI, 3.69–4.87) whereas no data were available for carbamates, because it was not present in standard series.⁶

The changing trend in patch test reactions to rubber accelerators was pointed out by Cao et al,³ with thiurams positive only when in a combination of carbamates, thiurams, and diphenylguanidine, particularly in the health care setting. Our results confirm this finding with an increased role for carbamate sensitization compared to thiurams.

The temporal trend we observed in northeastern Italy, with a decreased trend in sensitization in the years 1996 to 1998 to 2005 to 2007, and a progressive increase in more recent years could confirm the increased use of carbamates as rubber accelerators in preference to thiurams in more recent years.^{17,19} Moreover, Bergendorff et al,²⁰ analyzing the chemical changes in rubber allergens during vulcanization, reported that thiuram disulfides rarely appear in the final rubber, although they may have been used as additives. Instead, thiurams are often converted to dithiocarbamates or to product formed by addition to mercaptobenzothiazole structures, if these have been used together with thiurams as accelerators.²⁰ Also, Brehler et al in 2002,¹⁹ analyzing the composition of rubber gloves,

did not find thiurams but only carbamates. These aspects can explain why in our 786 patients sensitized to carbamates, 621 (82.91%) were negative to thiurams.

Analyzing the sites of dermatitis involved in people sensitized to rubber accelerators, the prevalent body site involved was the hands for thiurams and MBT mix, and leg for carbamates, probably due to the wearing of rubber shoes and gloves and boots during work or leisure time.

As regards the rubber accelerator sensitization in professional groups, we found a statistically significant increased risk in health care workers for carbamates (OR, 1.3; 95% CI, 1.03–1.7) and thiurams (OR, 1.6; 95% CI, 1.1–2.3), whereas the sensitization for IPPD and MBT mix in health care workers remains relatively rare, corresponding to the literature.^{1,3} Health care workers use rubber gloves for many

TABLE 3. Co-sensitization to Rubber Accelerators, OR (95% CI)

Haptens	Carbamates +	Thiurams +	MBT Mix +
Carbamates +	—	—	—
Thiurams +	17.1 (13.6–21.5)	—	—
MBT mix+	7.7 (5.0–11.7)	13.7 (8.8–21.3)	—
IPPD mix+	2.7 (1.6–4.6)	5.7 (3.4–9.6)	4.6 (1.9–11.4)

hours every day and this repeated contact can induce sensitization and skin symptoms.

Thiuram sensitization is significantly associated with other occupations, such as maids and restaurant workers, barbers and hairdressers, and construction workers and mechanics who are using different kinds of rubber gloves during their activity. The association with professional drivers can be related to the fact that these workers do also short mechanical work on their vehicle.

IPPD mix and MBT mix sensitization are more common in workers involved in industrial black rubber use as Warburton et al¹ reported. MBT mix sensitization is significantly higher in mechanics, paper production workers, woodworkers, farmers and fishers, and domestic workers who can use black rubber during work activities. On the other hand, IPPD mix sensitization is significantly higher in chemical industry workers, hairdressers, and barbers, due to the contact with para-amino chemical agents, present in permanent hair, eyelash, and eyebrow dyes.

Cross-reactivity between rubber accelerators is well known, particularly the cross-reactivity between carbamates and thiurams, due to the fact they are a redox pair, which means that during oxidation of a dithiocarbamate, the corresponding thiuram disulfide is formed.⁴ Thus, there is a redox equilibrium between the dithiocarbamate and the corresponding thiuram disulfide. Moreover, 82.91% of our patients were sensitized only to carbamates and not to thiurams; for that reason, we stress the need to test carbamates in standard series to avoid missing important and relevant sensitization due to the presence of carbamates in rubber gloves and also in other products. Carba mix 3% was tested in pet and contained *N,N*-diphenylguanidine 1%, zinc diethyldithiocarbamate 1%, zinc dibutyldithiocarbamate 1%. To avoid the reported irritant reaction and to better know the relevant sensitization it might be useful to test the 3 haptens alone instead of the mix.²¹

CONCLUSIONS

In conclusion, our results demonstrated that rubber accelerators have an important role in allergic contact dermatitis in the northeast of Italy and their sensitization is associated significantly with occupations that wear gloves or use chemical substances. Between rubber accelerators tested, carbamate sensitization is prevalent and increasing during considered years. Moreover, carbamates are nowadays the most used rubber accelerators, because producers have reduced thiurams and MBT due to their sensitizing potentials.

For that reason, we believe there is a need to test carbamates, using individual haptens, to detect in an exhaustive way rubber sensitization related to gloves.

REFERENCES

1. Warburton KL, Urwin R, Carder M, et al. UK rates of occupational skin disease attributed to rubber accelerators, 1996–2012. *Contact Dermatitis* 2015;72:305–311.
2. Geier J, Lessmann H, Mahler V, et al. Occupational contact allergy caused by rubber gloves—nothing has changed. *Contact Dermatitis* 2012;67:149–156.
3. Cao LY, Taylor JS, Sood A, et al. Allergic contact dermatitis to synthetic rubber gloves: changing trends in patch test reactions to accelerators. *Arch Dermatol* 2010;146:1001–1007.
4. Hansson C, Pontén A, Svedman C, et al. Reaction profile in patch testing with allergens formed during vulcanization of rubber. *Contact Dermatitis* 2014;70:300–308.
5. Geier J, Lessmann H, Uter W, et al. Occupational rubber glove allergy: results of the Information Network of Departments of Dermatology (IVDK), 1995–2001. *Contact Dermatitis* 2003;48:39–44.
6. Pesonen M, Jolanki R, Larese Filon F, et al. Patch test results of the European baseline series among patients with occupational contact dermatitis across Europe—analyses of the European Surveillance System on Contact Allergy network, 2002–2010. *Contact Dermatitis* 2015;72:154–163.
7. Logan RA, White IR. Carbamix is redundant in the patch test series. *Contact Dermatitis* 1988;18:303–304.
8. Knudsen BB, Menné T. Contact allergy and exposure patterns to thiurams and carbamates in consecutive patients. *Contact Dermatitis* 1996;35:97–99.
9. Holness DL, Nethercott JR. Results of patch testing with a special series of rubber allergens. *Contact Dermatitis* 1997;36:207–211.
10. Prodi A, Rui F, Fortina AB, et al. Occupational sensitization to epoxy resins in Northeastern Italy (1996–2010). *Int J Occup Environ Health* 2015;21(1):82–87.
11. Geier J, Krauthelm A, Uter W, et al. Occupational contact allergy in the building trade in Germany: influence of preventive measures and changing exposure. *Int Arch Occup Environ Health* 2011;84:403–411.
12. Bruze M, Andersen KE, Goossens A, et al. Recommendation to include fragrance mix 2 and hydroxyisohexyl 3-cyclohexene carboxaldehyde (Lyrall) in the European baseline patch test series. *Contact Dermatitis* 2008;58:129–133.
13. Wilkinson D, Fregert S, Magnusson M, et al. Terminology of contact dermatitis. *Acta Derm Venereol* 1970;50:287–292.
14. Warburton KL, Bauer A, Chowdhury MM, et al. ESSCA results with the baseline series, 2009–2012: rubber allergens. *Contact Dermatitis* 2015;73:305–312.
15. Andersen KE, Burrows D, Cronin E, et al. Recommended changes to standard series. *Contact Dermatitis* 1988;19(5):389–390.
16. Bruynzeel DP, Andersen KE, Camarasa JG, et al. The European standard series. European Environmental and Contact Dermatitis Research Group (EECDRG). *Contact Dermatitis* 1995;33(3):145–148.
17. Britton JER, Wilkinson SM, English JSC, et al. The British standard series of contact dermatitis allergens: validation in clinical practice and value for clinical governance. *Br J Dermatol* 2003;148:259–264.
18. Boonchai W, Thanomkitti K, Kasemsarn P. Occupational contact dermatitis in tertiary university hospital: a 5-year retrospective study. *J Med Assoc Thai* 2014;97(11):1182–1188.
19. Brehler R, Rütter A, Kütting B. Allergenicity of natural rubber latex gloves. *Contact Dermatitis* 2002;46(2):65–71.
20. Bergendorff O, Persson C, Ludtke A, et al. Chemical changes in rubber allergens during vulcanization. *Contact Dermatitis* 2007;57:152–157.
21. Warshaw EM, Raju S, DeKoven JG, et al. Positive patch test reactions to carba mix and iodopropynyl butylcarbamate: data from the North American Contact Dermatitis Group, 1998–2008. *Dermatitis* 2013;24(5):241–245.