

Patch test results in schoolchildren

Results from the Information Network of Departments of Dermatology (IVDK) and the German Contact Dermatitis Research Group (DKG)*

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Our aim was to explore the current spectrum of contact allergens in schoolchildren, as a basis for diagnosis and prevention of allergic contact dermatitis. Results of patch tests in children 6–15 years old, performed in the years 1990–1995 by 22 centres of the German Contact Dermatitis Research Group and filed by the Information Network of Departments of Dermatology, were analysed and evaluated retrospectively, including epidemiologic data. Children with positive tests (62 out of 156 boys and 108 out of 260 girls tested) had a higher frequency of allergic contact dermatitis and a lower frequency of atopic dermatitis than patch test negative ones. 16 distinct allergens elicited positive reactions in $\geq 1\%$ of the children tested. Reactions to nickel sulfate occurred in 15.9% of all children tested, but in 25.0% of girls 14/15 years old, and in only 4.5% of boys 6–13 years old. Double-sensitizations with cobalt salts, potassium dichromate and palladium were seen. Mercury compounds were found in 2nd place (thimerosal: all children: 11.3%; 6–13 years old: 14.3%; 14/15 years old: 8.0%), followed by fragrance allergens. We conclude that contact allergy in children is related to their sex and age. Prophylaxis against nickel, mercury, and fragrance allergy needs to be improved. A shortened standard series may be sufficient for testing children.

Key words: contact allergy; children; epidemiology; patch tests; nickel; thimerosal; mercury; fragrance. © Munksgaard, 1997.

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Although contact allergy is not the most frequent cause of dermatitis in childhood, recent studies (1–5) unambiguously indicate that it must be considered as a relevant factor for the development of eczema in children as well. Proof of contact allergy usually requires patch testing. To use this tool ad-

equately, it is helpful to know which children are at risk of developing contact allergy, and which allergens are encountered most often. Identification of the latter is also necessary to compile an optimal patch test series and to plan preventive measures for children. In order to answer these questions, we have analysed the results of patch tests done in schoolchildren 6–15 years of age.

*22 Departments of dermatology contributed data to this study as members of the IVDK and DKG:

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Patients and Methods

Our retrospective analysis was based on the files of the Information Network of Departments of Dermatology (IVDK) in Germany, which records results of patch tests done by its members, all of which belong to the German Contact Dermatitis Research Group (DKG) (6–8). All patch tests recorded by 22 centres in the years 1990–1995 were included, which had been performed in children 6–15 years old for diagnostic purposes according to DKG guidelines (9). Finn Chambers had been

used throughout, and the standard allergens evaluated in this study had been purchased from Hermal, Reinbek, Germany; for those 16 allergens yielding allergic reactions most often, concentrations are shown in Table 1. Additional allergens had been tested in many cases according to the individual requirements, and due to particular circumstances the standard series had not been used in each case. Depending on the centre, test chambers had been attached for 1 or 2 days; only readings on day (D) 3 were evaluated for this study, based on generally accepted criteria (9, 10). In the following, readings classified as +, ++ or +++ are summarily named allergic or positive (pos.), in contrast to all other readings (–, ?+ or IR) that are summarized as non-positive (non-pos.). Complementary data that had been filed and were used for our study included the indication for patch testing, history of atopic dermatitis, final clinical

diagnosis, and localization of eczema. In addition to the overall analysis, separate analyses were done for girls and boys, for young prepubertal children (6–13 years old) and older ones (14/15 years old), and for children reactive to nickel or defined groups of allergens. For most statistical evaluations the χ^2 -test was used. Correlations of reactions to mercury compounds were tested with the McNemar test, and patch-test-positive children were compared to patch-test-negative ones by use of Fisher's exact test. $p \leq 0.01$ was considered statistically significant.

Results

Data of 22 centres were available (see title page). Patch tests had been done in 416 children (156 boys, 260 girls); 223 of them were 6–13 years old (101 boys, 122 girls), and 193 were 14/15 years old

Table 1. Numbers of tests done with each allergen in separate subgroups of children and (*in italics*) % of positive reactions

Allergen Konzentration/Vehicle	Age: 6–15 (years)			Age: 6–13 (years)			Age: 14/15 (years)		
	total	boys	girls	total	boys	girls	total	boys	girls
nickel sulfate 5.0% pet.	383 <i>15.9</i>	142 <i>5.6</i>	241 <i>22.0</i>	198 <i>12.1</i>	89 <i>4.5</i>	109 <i>18.3</i>	185 <i>20.0</i>	53 <i>7.5</i>	132 <i>25.0</i>
thimerosal 0.05% or 0.1% pet.	371 <i>11.3</i>	137 <i>13.1</i>	234 <i>10.3</i>	196 <i>14.3</i>	86 <i>15.1</i>	110 <i>13.6</i>	175 <i>8.0</i>	51 <i>9.8</i>	124 <i>7.3</i>
benzoyl peroxide 1.0% pet.	79 <i>8.9</i>	38 <i>13.2</i>	41 <i>4.9</i>	40 <i>10.0</i>	22 <i>13.6</i>	18 <i>5.6</i>	39 <i>7.7</i>	16 <i>12.5</i>	23 <i>4.3</i>
fragrance mix 8.0% pet.	380 <i>8.2</i>	139 <i>11.5</i>	241 <i>6.2</i>	196 <i>8.7</i>	86 <i>11.6</i>	110 <i>6.4</i>	184 <i>7.6</i>	53 <i>11.3</i>	131 <i>6.1</i>
cobalt sulfate 2.5% pet.	107 <i>7.5</i>	43 <i>4.7</i>	64 <i>9.4</i>	49 <i>6.1</i>	23 <i>0.0</i>	26 <i>11.5</i>	58 <i>8.6</i>	20 <i>10.0</i>	38 <i>7.9</i>
amalgam 5.0% pet.	55 <i>7.3</i>	22 <i>9.1</i>	33 <i>6.1</i>	31 <i>12.9</i>	15 <i>13.3</i>	16 <i>12.5</i>	24 <i>0.0</i>	7 <i>0.0</i>	17 <i>0.0</i>
mercury ammonium chloride 1.0% pet.	372 <i>6.5</i>	141 <i>8.5</i>	231 <i>5.2</i>	196 <i>7.7</i>	88 <i>9.1</i>	108 <i>6.5</i>	176 <i>5.1</i>	53 <i>7.5</i>	123 <i>4.1</i>
phenylmercuric acetate 0.05% pet. or 100 ppm aq.	149 <i>5.4</i>	52 <i>0.0</i>	97 <i>8.2</i>	79 <i>6.3</i>	27 <i>0.0</i>	52 <i>9.6</i>	70 <i>4.3</i>	25 <i>0.0</i>	45 <i>6.7</i>
Amerchol L-101 50.0% pet.	100 <i>5.0</i>	31 <i>9.7</i>	69 <i>2.9</i>	49 <i>6.1</i>	16 <i>12.5</i>	33 <i>3.0</i>	51 <i>3.9</i>	15 <i>6.7</i>	36 <i>2.8</i>
cobalt chloride 1.0% pet.	382 <i>3.9</i>	142 <i>2.8</i>	240 <i>4.6</i>	199 <i>3.0</i>	89 <i>1.1</i>	110 <i>4.5</i>	183 <i>4.9</i>	53 <i>5.7</i>	130 <i>4.6</i>
potassium dichromate 0.5% pet.	387 <i>2.6</i>	142 <i>2.1</i>	245 <i>2.9</i>	200 <i>3.5</i>	89 <i>3.4</i>	111 <i>3.6</i>	187 <i>1.6</i>	53 <i>0.0</i>	134 <i>2.2</i>
colophony 20.0% pet.	382 <i>2.4</i>	139 <i>3.6</i>	243 <i>1.6</i>	196 <i>2.0</i>	86 <i>2.3</i>	110 <i>1.8</i>	186 <i>2.7</i>	53 <i>5.7</i>	126 <i>1.5</i>
balsam of Peru 25.0% pet.	384 <i>1.8</i>	139 <i>0.7</i>	245 <i>2.4</i>	197 <i>0.5</i>	86 <i>0.0</i>	111 <i>0.9</i>	187 <i>3.2</i>	53 <i>1.9</i>	134 <i>3.7</i>
wool wax alcohols 30.0% pet.	373 <i>1.6</i>	139 <i>1.4</i>	234 <i>1.7</i>	194 <i>2.1</i>	86 <i>1.2</i>	108 <i>2.8</i>	179 <i>1.1</i>	53 <i>1.9</i>	126 <i>0.8</i>
Kathon CG 100.0 ppm aq.	375 <i>1.1</i>	135 <i>1.5</i>	240 <i>0.8</i>	194 <i>1.5</i>	84 <i>2.4</i>	110 <i>0.9</i>	181 <i>0.6</i>	51 <i>0.0</i>	130 <i>0.8</i>
formaldehyde 1.0% aq.	383 <i>1.0</i>	139 <i>1.4</i>	244 <i>0.8</i>	197 <i>1.0</i>	86 <i>2.3</i>	111 <i>0.0</i>	186 <i>1.1</i>	53 <i>0.0</i>	133 <i>1.5</i>

(55 boys, 138 girls) (Table 2). Test chambers had been attached for 1 day in 191 patients (45.9%), and for 2 days in 225 patients (54.1%). With respect to the data evaluated by us, significant differences related to test centres or to the time of allergen exposure were not apparent.

The characteristics of all children tested are shown in Table 2. 137 (52.7%) of the girls and 88 (56.4%) of the boys had been tested in order to exclude allergic contact dermatitis, because contact allergy had been considered as a possible reason for their eczema, although not in the first place; in 69 (26.5%) of the girls and in 35 (22.4%) of the boys testing was done to confirm a suspected contact allergy. The remaining 87 (20.9%) children had been tested for various different or unspecified reasons. Out of all children tested, a history of atopic dermatitis was positive in 172 (41.3%), negative in 184 (44.2%), uncertain in 37 (8.9%) and not recorded for the remaining 23 (5.5%) ones. With patch testing being finished, a final diagnosis of atopic dermatitis was made in 105 (25.2%) of all children; allergic contact dermatitis was diagnosed in 103 cases (24.8%), and other diagnoses were made in the remaining 208 cases (50%). Hand eczema was present in 73 (17.5%) of test patients, whereas head and/or neck were affected in 96 (23.1%).

It is noteworthy that, with regard to the patient characteristics mentioned above, some differences occurred for distinct groups of children (Table 2). The percentage of boys among children 6–13 years old was markedly higher than within the group 14/15 years old (45.3% versus 28.5%), and a history of

atopic dermatitis as well as a final diagnosis of atopic dermatitis (which was established after testing) had been recorded more often for younger children than for older ones ($p < 0.01$). Although hand eczema was noted more often in older children than in younger ones (20.7% versus 14.8%), this difference was not statistically significant.

Out of the 416 children tested, 170 had responded with at least 1 positive reaction; 62 (36.5%) were boys and 108 (63.5%) were girls. Children with positive reactions had been tested more often to confirm allergic contact dermatitis than children with negative reactions only (32.4% versus 19.9%; $p < 0.01$), and among them allergic contact dermatitis was finally diagnosed in a higher percentage of cases, too (45.3% versus 10.6%; $p < 0.001$), whereas atopic dermatitis was more common within the patch-test-negative group (30.1% versus 18.2%; $p < 0.01$). Within the group of patch-test-positive children, eczema was localized on the hands in 36 cases (21.2%) and on head and/or neck in 40 cases (23.5%). Differences between patch-test-positive and negative children with regard to sex or to the localization of eczema were not significant.

Table 1 gives a list of those 16 allergens that yielded positive reactions in at least 4 of the 416 children tested; that is in $\geq 1\%$ of the study population. For each allergen, the total number of tests done is shown, as well as the number of tests done in subgroups of children defined by sex and age, and the percentage of positive reactions obtained within these subgroups. The leading allergen was nickel sulfate, followed by thimerosal and fra-

Table 2. Characteristics of all children tested

	Age 6–15 (years)			Age 6–13 (years)			Age 14/15 (years)		
	total	boys	girls	total	boys	girls	total	boys	girls
no. of patients tested	416	156	260	223	101	122	193	55	138
	100%	100%	100%	100%	100%	100%	100%	100%	100%
reason for testing: exclusion of allergic contact dermatitis	225	88	137	127	55	72	98	33	65
	54.1%	56.4%	52.7%	57.0%	54.5%	59.0%	50.8%	60.0%	47.1%
reason for testing: confirmation of allergic contact dermatitis	104	35	69	61	25	36	43	10	33
	25.0%	22.4%	26.5%	27.4%	24.8%	29.5%	22.3%	18.2%	23.9%
history: atopic dermatitis stated	172	70	102	106	49	57	66	21	45
	41.3%	44.9%	39.2%	47.5%	48.5%	46.7%	34.2%	38.2%	32.6
final diagnosis: atopic dermatitis	105	45	60	69	32	37	36	13	23
	25.2	28.8%	23.1%	30.9%	31.7%	30.3%	18.7%	23.6%	16.7%
final diagnosis: allergic contact dermatitis	103	31	72	53	17	36	50	14	36
	24.8%	19.9%	27.7%	23.8%	16.8%	29.5%	25.9%	25.5%	26.1%
localization of eczema: hands	73	26	47	33	13	20	40	13	27
	17.5%	16.7%	18.1%	14.8%	12.9%	16.4%	20.7%	23.6%	19.6%
localization of eczema: head/neck	96	32	64	55	22	33	41	10	31
	23.1%	20.5%	24.6%	24.7%	21.8%	27.0%	21.2%	18.2%	22.5%

The table shows absolute numbers of children and % of patients tested (number of patients tested = 100% in each column).

grance mix, yielding 15.9%, 11.3% and 8.2% positive reactions in all children tested.

Since in addition to thimerosal several other mercury containing compounds had elicited considerable numbers of allergic reactions, a "mercury"-group of patients was defined, consisting of those children who had responded with at least 1 positive reaction to thimerosal, ammoniated mercury, phenylmercuric acetate, amalgam, mercury chloride, Mercurochrome or phenylmercuric borate. Analogous to the "mercury"-group, a "fragrance"-group was defined, comprising only children with at least 1 positive patch test to fragrance mix, colophony, or balsam of Peru.

Nickel-positive children ("nickel"-group; $n=61$) are compared to the "mercury"-group ($n=59$) and "fragrance"-group ($n=38$) in Table 3, which is based on absolute numbers of reactive children, irrespective of the numbers of tests done in girls and boys of both age groups. It is clear from this that nickel allergy was in 86.9% a problem of girls ($n=53$), and particularly of older children than younger ones (60.7% versus 39.3%). In contrast, the preponderance of girls was only marginal

(57.6%) within the "mercury"-group, in which 66.1% of the children were younger than 14 years and only 33.9% were aged 14/15, so that the age distribution was reverse to that of the "nickel"-group ($p \leq 0.01$). Nearly identical numbers of girls and boys ($n=18$ and $n=20$) fell into the "fragrance"-group, irrespective of their age. A history of atopic dermatitis was most frequently (35.6%) found in the "mercury"-group, whereas allergic contact dermatitis was diagnosed most often in the "nickel"-group (60.7%). Some more characteristics are shown in Table 3.

Nickel allergy may be associated with allergy to other metals. In 49 children, patch tests had been done with both, nickel sulfate and palladium chloride. 9 of them were positive for nickel, and 1 child with a +++ reaction to nickel was also positive (++) for palladium (Table 4). Some more nickel-sensitive children had been tested with cobalt salts ($n=59$) or potassium dichromate ($n=59$), resulting in 11 and 5 positive reactions respectively (Table 4).

This double sensitization to metals in nickel-sensitive children was compared to double sensitiza-

Table 3. Characteristics of patients positive for nickel sulfate ("nickel"-group), to at least 1 of the 7 mercury-containing compounds thimerosal/mercury ammonium chloride/phenylmercuric acetate/amalgam/mercury chloride/mercurochrome/phenylmercuric borate ("mercury"-group), or to at least 1 of the 3 fragrance-associated allergens balsam of peru/colophony/fragrance mix ("fragrance"-group)

	"Nickel"-group $n=61$ (100%)	"Mercury"-group $n=59$ (100%)	"Fragrance"-group $n=38$ (100%)
no. of boys 6-13 years old	4 6.6% [4.0%]	18 30.5% [17.8%]	10 26.3% [9.9%]
no. of girls 6-13 years old	20 32.8% [16.4%]	21 35.6% [17.2%]	9 23.7% [7.4%]
no. of boys 14/15 years old	4 6.6% [7.3%]	7 11.9% [12.7%]	8 21.1% [14.5%]
no. of girls 14/15 years old	33 54.1% [23.9%]	13 22.0% [9.4%]	11 28.9% [8.0%]
reason for testing: exclusion of allergic contact dermatitis	27 44.3%	28 47.5%	22 57.9%
reason for testing: confirmation of allergic contact dermatitis	22 36.1%	20 33.9%	13 34.2%
history: atopic dermatitis stated	14 23.0%	21 35.6%	10 26.3%
final diagnosis: atopic dermatitis	3 4.9%	12 20.3%	3 7.9%
final diagnosis: allergic contact dermatitis	37 60.7%	25 42.4%	19 50.0%
localization of eczema: hands	14 23.0%	13 22.0%	7 18.4%
localization of eczema: head/neck	15 24.6%	12 20.3%	8 21.1%

The table shows the absolute numbers of children and % of the total number n of patients in each subgroup ($n=100\%$ in each column). In addition [in square brackets], the % of positive children is given in relation to the number of tested children belonging to the corresponding subgroup of sex and age (see Table 2 for n).

Table 4. Double-sensitization of nickel-sensitive children (age 6–15 years) and young adults (age 16–30 years) who were also tested with palladium chloride, a cobalt salt (sulfate or chloride), or potassium dichromate

	Share of nickel-sensitive patients with positive reactions to					
	Palladium chloride		Cobalt sulfate or chloride		Potassium dichromate	
	age 6–15 (years)	age 16–30 (years)	age 6–15 (years)	age 16–30 (years)	age 6–15 (years)	age 16–30 (years)
Ni +, ++ or +++	1/9 (11.1%)	158/554 (28.5%)	11/59 (18.6%)	523/2518 (20.8%)	5/59 (8.5%)	138/2517 (5.5%)
Ni +	0/5 (0.0%)	34/265 (12.8%)	4/35 (11.4%)	135/1101 (12.3%)	3/35 (8.6%)	56/1100 (5.1%)
Ni ++	0/3 (0.0%)	76/216 (35.2%)	6/20 (30.0%)	241/1050 (23.0%)	2/20 (10.0%)	48/1050 (4.6%)
Ni +++	1/1 (100%)	48/73 (65.8%)	1/4 (25.0%)	147/367 (40.1%)	0/4 (0.0%)	34/367 (9.3%)

Parallel tests were carried out in children (age 6–15) years and young adults (age 16–30) with nickel sulfate and palladium chloride in 49 and 2145 cases, with nickel sulfate and cobalt salts in 376 and 9536 cases, and with nickel sulfate and potassium dichromate in 375 and 9518 cases respectively. For those double-tested patients out of both age groups who responded with +, ++ or +++ reactions to nickel sulfate, the table shows the share and % of patients who were also sensitive (+, ++ or +++) to palladium chloride, cobalt salt (sulfate or chloride), or potassium dichromate.

Table 5. Reactivity of children who were tested with two different mercury compounds

	Thimerosal pos.	Thimerosal non-pos.	Mercury ammonium chloride pos.	Mercury ammonium chloride non-pos.
mercury ammonium chloride pos.	11	13		
mercury ammonium chloride non-pos.	31	308		
phenylmercury acetate pos.	6	2	5	3
phenylmercury acetate non-pos.	16	119	7	128

Children tested with thimerosal and mercury ammonium chloride: $n=363$.

Children tested with thimerosal and phenylmercuric acetate: $n=143$.

Children tested with mercury ammonium chloride and phenylmercuric acetate: $n=143$.

pos.: +, ++ or +++ reaction. non-pos.: -, ?+ or IR reaction.

tion in nickel-sensitive young adults (16–30 years) who had been tested during the same period of time by the same centres with identical methods (Table 4). With 158 (28.5%) palladium-sensitive patients in a total of 554 adults with nickel allergy, palladium-sensitivity was more common in this adult group than among our nickel-sensitive children (Table 4). Furthermore, the rate of palladium-sensitivity in adults showed a significant increase parallel to an increasing strength of the nickel reactions from + to ++ and from ++ to +++ ($p \leq 0.001$). Major differences between the sensitization of nickel-responsive children and young adults to cobalt salts and potassium dichromate were not apparent. Cobalt sensitivity in nickel-responsive young adults was also correlated to the strength of their nickel reactions ($p \leq 0.001$).

7 distinct mercury-containing compounds had been recorded that had elicited positive reactions. With 3 of them (thimerosal, mercury ammonium chloride and phenylmercuric acetate), sufficient numbers of parallel tests had been done within the same children to analyse cross-reactivities between 2 different compounds (Table 5). It can be derived from the data shown in Table 5 that thimerosal

produced significantly more positive reactions than mercury ammonium chloride ($p=0.01$) and phenylmercuric acetate ($p=0.001$). Mercury ammonium chloride yielded some additional positive reactions in patients non-positive with thimerosal and elicited more positive reactions than phenylmercuric acetate. Only 1 patient was exclusively reactive to phenylmercuric acetate, but to no other mercury compound.

Positive reactions to wool wax alcohols, Amerchol L-101, kathon CG, and benzoyl peroxide occurred in a higher percentage of the younger children than in older ones, whereas no such difference was found for formaldehyde (Table 1). Relatively more boys were found to be positive for benzoyl peroxide and amerchol L-101 than girls (13.2% versus 4.9% and 9.7% versus 2.9% respectively, Table 1). However, these 2 allergens had been tested in comparatively low numbers of children only.

Discussion

Consistent with recently published studies (1–5, 11, 12), our findings demonstrate the existence of con-

tact allergy related to eczema in children. Patch testing undoubtedly is a helpful diagnostic tool not only for adults, but for children, too. This holds also true for children with atopic dermatitis.

Furthermore, our detailed analysis reveals some peculiarities with regard to the children who were patch tested for diagnostic purposes. The fact, e.g., that corresponding to previous studies (1, 3, 12-15) the majority of our patients, as in studies with adults (16), were females is not a matter of course; it is noteworthy because, at this age, sex-related occupational or environmental influences should not be of relevance. It is also an open question whether the change of disparities between data obtained from girls and boys occurring at puberty might be related to hormonal effects.

Although by far more girls than boys had been tested, the absolute number of girls reacting positively to mercury compounds or fragrance allergens were only slightly higher than the corresponding numbers of sensitive boys (Table 3). Interestingly, corresponding data to these findings were also published by others (1, 3, 4). Since there is no evidence so far that girls' skin is less irritable than boys' skin, this argues against the hypothesis that a major share of the reactions to mercury or fragrance compounds could in fact be irritant reactions rather than allergic ones. Consequently, one has to ask why a higher percentage of the boys tested reacted positively to mercury and fragrance allergens than of the girls tested. In any case, sex-related differences in epicutaneous testing of children need to be taken into account by future studies.

Compared to all children tested, the % of children tested to confirm a suspected contact allergy was higher among those children responding with at least 1 positive patch test reaction than among the patch-test-negative ones (32.4% versus 19.9%). This difference indicates that the clinical assessment is useful to select children appropriately for patch testing. Vice versa, positive patch test results were apparently taken into account for the final diagnosis, because allergic contact dermatitis was diagnosed in 45.3% of all patch-test-positive children, and in even 60.7% of nickel-positive children, but in only 10.6% of children with negative tests.

It is debatable whether atopy is really more common in younger children selected for patch testing than in older ones; possibly atopy is only associated more uncritically with eczema in younger children. Patch testing is not useful to establish a diagnosis of atopic dermatitis, and documentation of specific investigations for atopic eczema was not included in the files available for our study. Not too much significance should be attached either to

the surprisingly low percentage of atopic dermatitis within the "nickel"-group as compared to the "mercury"-group, unless this is confirmed by future studies. One reason may be that mercury-reactive children were mostly younger ones, whereas nickel sensitivity was mainly seen in girls aged 14/15. Based on the absolute numbers of positive reactions within the 3 distinct allergen groups (Table 3), a relation between these groups of allergens and the localization of eczema on head/neck or hands was not obvious.

Nickel sulfate was the top-ranking allergen that yielded the highest number of positive reactions. Similar observations were made previously (2, 4, 5, 11, 12-15, 17-20), and the high frequency of nickel sensitivity among our teenage girls (age 14/15) is consistent with an acquisition of nickel allergy by wearing costume jewellery. The necessity for better prophylaxis is clear.

Synchronous contact allergy to 2 distinct metals may result from 2 unrelated processes of sensitization following separate or coupled exposures to both antigens during life. If so, it should occur more often in adults than in children, because the chance to acquire a double sensitization via this mechanism increases with time and age. Alternatively, double sensitization to 2 distinct metals may be due to a given antigen-similarity of both metals in question; in this case exposure to 1 allergen would automatically elicit allergy towards both metals, and no time-related increase of double sensitization within the group of patients reactive to such an allergen is to be expected. Our data seem to indicate that, compared to young adults, nickel-sensitive children may be less frequently sensitized to palladium chloride, whereas sensitization to cobalt chloride or sulfate and potassium dichromate may occur with similar frequency among nickel-sensitive children and adults. If this impression can be confirmed by larger numbers of tests in future studies, it could in fact indicate different mechanisms of sensitization towards palladium and cobalt or chromate. The finding that strong reactions to nickel significantly correlate with an increased frequency of cobalt sensitivity confirms earlier observations (21), but for palladium such a correlation has not previously been published.

Mercury compounds were reported to be major allergens in children before (1-4, 11, 14, 18, 22). Since we found a lower percentage of mercury-sensitive children in the older age group than in the younger group, sensitization may be due to mercury-containing medical preparations applied to young children. Sources of mercury allergens are well-known (23, 24), and a broad variety of pharmaceutical preparations used in

Germany (25) contains mercury compounds, mainly as preservatives. Since the median of birth years of our mercury-positive children was 1982, mercury-preserved vaccines had presumably been given to them. In contrast, if dental fillings with amalgam were a relevant source of mercury allergens, older children should be affected more often by mercury allergy than younger ones. Our data shown in Table 5 reveal that thimerosal is adequate for testing, and that in doubtful cases mercury ammonium chloride may be tested additionally.

Fragrance allergens (fragrance mix, colophony, balsam of Peru) were identified as sensitizers for younger as well as for older children. Interestingly, the absolute numbers of boys and girls reacting to these allergens were merely equal, although many more girls had been tested. Bearing in mind that in most cases it is impossible to pinpoint the causative product, the results shown in Tables 1, 3, as well as similar findings by others (3, 5, 12, 15), support a general recommendation not to use fragrant compounds for children.

Sensitization to Kathon CG, wool wax alcohols and Amerchol L-101 may have been acquired through the application of skin care products or creams containing these ingredients (2). Since more younger children than older ones were affected, this could have happened during early childhood. The possibility of such a sensitization should therefore be considered when an eczema develops in spite of adequate skin care. Possibly the rather high percentage of boys reactive to benzoyl peroxide and Amerchol L-101 is due to some selection bias, because these 2 allergens had been tested in considerably less cases than the other allergens. Their irritant potential may also play a role.

In contrast to some earlier studies (1, 2, 11–13, 15, 19), neomycin, shoe allergens, benzocaine, and rubber compounds were not detected as common allergens by us. One reason may be that, for technical reasons, we confined our analysis to readings on D 3; thus some allergic reactions to allergens causing delayed responses (e.g., neomycin) (26, 27) were probably missed. Regional differences in the distribution of these previously reported allergens and differences in methods of investigation offer additional explanations.

Irritant reactions were not recorded in relevant numbers. Therefore, we share the opinion of many other authors (2, 3, 5, 11, 15, 28) that for children the same patch test methods can be used as for adults. However, for screening purposes in children, we suggest a shortened standard series comprising nickel, cobalt, dichromate, thimerosal, fragrance allergens, wool wax alcohols and Ka-

thon CG. For other geographical regions local experience should also be taken into account.

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