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INVESTIGATIVE REPORT

Validation of Self-testing as a Method to Estimate the Prevalence of Nickel Allergy

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The aim of this study was to investigate the validity of self-patch testing for nickel allergy, in order to determine a cost-effective method for surveillance of the prevalence of nickel allergy. Population-based study including patch testing is the most reliable method to study the prevalence of allergy, but it is expensive and has logistical problems. A total of 191 dermatology patients referred to patch testing were provided with a self-test package with written instructions. The self-test was applied on the arm by the patient, on the same day that the regular patch test was applied on the back. The patient evaluated the self-test before patch test reading at the clinic. Patch test at the dermatology clinic detected 46/191 (24%) nickel-positive individuals. The sensitivity of the self-test was 72% (95% confidence interval (CI) 57–84), the specificity 91% (95% CI 85–95), and the proportion of agreement 86% (95% CI 81–91). Thus, in the population studied, the validity of self-testing for nickel allergy was adequate. ***Key words: contact allergy; epidemiology; patch test; self-test; sensitivity; specificity.***

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Contact allergy is common. Population-based studies show that the prevalence of contact allergy is approximately 20% among adult Scandinavians (1–4). Among adolescents in Denmark, Mortz et al. (5) found that the prevalence of contact allergy was 15%. The most prevalent allergens are nickel, fragrances and preservatives. Nickel allergy is more common in women than in menin all previous studies. Most studies on nickel allergy are made in western Europe and in Scandinavia. The prevalences mentioned (1) are from a rewiew of population-based data past decades. Allergic contact dermatitis is recognized as a public health problem and prevention is of importance (6). Legislation may be effective in preventing contact allergy, and the European Nickel Directive (7) came into full force in 2001. The directive limits permissible nickel release from items in prolonged contact with the skin, e.g. jewellery, watches, buttons and zips (8).

Continuous epidemiological surveillance is necessary to determine the prevalence of contact allergy and to evaluate interventions. Thus, reliable and inexpensive epidemiological tools are required. Genuine population studies including patch tests are difficult to perform for logistical reasons. Data from patch tests at the clinic are sometimes used to estimate the prevalence of contact allergy. However, such data comprise a selected material and are not representative of the general population. Regarding nickel allergy in the general population, it was found in a previous study that 56% of subjects with nickel allergy had no self-reported symptoms of dermatitis (9).

For epidemiological surveillance of common skin diseases in the general population, questionnaires may be useful, provided that the questions are validated. Questions about self-reported nickel allergy have been validated in a few studies (9–12). The validity of self-reported nickel allergy was low in all the studies, having a positive predictive value of 31–58%. Consequently, the questions overestimate the true prevalence. To investigate the prevalence of nickel allergy other methods are necessary.

A self-test kit, Nixema® (Mekos Laboratories ApS, Hillerød, Denmark), has recently been introduced on the Swedish market for detection of contact allergy to nickel and fragrance allergy. Self-testing might be a useful method to investigate the prevalence of contact allergy in the general population, but the method has to be validated and evaluated.

The aim of the present study was to compare results from self-patch testing, performed and read by the patient, with results from patch testing using an established method, performed and read by the dermatologist.

METHODS

Study population

The study was performed at three dermatology departments, Örebro University Hospital, Karolinska University Hospital Solna and Skåne University Hospital. Patients were included consecutively from the clinics when referred to patch testing as part of the clinical investigation. Inclusion criteria were:

Table I. *Characteristics of the participants (*n = *191)*

Characteristics	
Örebro/Solna/Skåne, *n*	94/27/70
Women, *n* (%)	132/191 (69)
Mean age, years (range)	44 (18–65)
History of atopic dermatitis, *n* (%)	82/185 (44)
Reasons for patch test[a], *n* (%)	
Hand eczema	76/191 (40)
Facial eczema	39/191 (20)
Eczema on lower legs	9/191 (5)
Other eczema	60/191 (31)
Other reason	28/191 (15)

[a]Multiple alternatives possible.

age 18–65 years; and able to read and understand Swedish. Exclusion criteria were: previous patch test; systemic treatment with corticosteroids; antihistamine or other immunosuppressive treatment; exposure to ultraviolet (UV) light or topical treatment with corticosteroids on the test area during the past 14 days; pregnancy; and dermatitis on the test area. In total, 191 patients participated, 69% women, and the mean age was 44 years (Table I). Patient's history of atopic dermatitis was obtained from their medical records.

Patch testing

The patients were referred to patch testing as part of an investigation of eczema. They were tested with nickel sulphate 5% pet. and fragrance mix 8% pet. (cinnamic alcohol, cinnamic aldehyde, hydroxycitronellal, amylcinnamaldehyde, geraniol, eugenol, isoeugenol, and oakmoss absolute, all 1%) included in the Swedish baseline series provided by Chemotechnique Diagnostics, Vellinge, Sweden. Allergens were applied on Finn chambers® on Scanpor® tape (Epitest Ltd Oy, Tuusula, Finland) or on IQ Ultra® Chambers (Chemotechnique Diagnostics) and fixed to the patient's back with adhesive tape, Fixomull® or Scanpor®. Patch tests were applied for 2 days on the back, and readings were performed on day (D)3–4 and D7. The readings were performed by different dermatologists as a part of routine clinical investigations. Morphological evaluation was performed according to international standard, International Contact Dermatitis Research Group (ICDRG) (13). For the analysis of data, +, ++, and +++ readings were pooled as positive patch tests. Positive patch testing to nickel sulphate D3 and/or positive patch testing on D7 are referred to as positive by the "gold standard".

Self-testing

Patients included in the present study received a self-test package on the same day as the patch test was applied on the back. The self-test used in the study, Nixema® (Mekos Laboratories ApS, Hillerød, Denmark), was purchased at the hospital pharmacy. The self-test is a medical plaster that incorporates two allergen patches with nickel sulphate, 0.16 mg/patch, and fragrance mix, 0.35 mg/patch, respectively. The fragrance mix contains the same substances as the patch test used on the back. The technique and test substances in Nixema® self-test are identical to those used in Mekostest® (former TRUE test) (Mekos Laboratories ApS, Hillerød, Denmark) (14, 15).

The Nixema® test package contained detailed written standard instructions from the supplier as to how to apply the test on the upper arm and how to evaluate the result. The patients applied the self-test on the upper arm on the same day as the patch test was applied on the back. The self-reading was carried out by the patient on D3–4, before the appointment at the clinic. The patient evaluated by scoring positive or negative on a recording sheet, which was delivered to the investigator in a sealed envelope that was not opened until analysis. The dermatologist then read the patch test on both the back and the arm.

Statistical analysis

The data were analysed using SPSS version 15 (SPSS Inc., Chicago, IL, USA).

Sensitivity, specificity, negative/positive predictive values and proportion of agreement were calculated using the patch test results on the back, read by the dermatologist as "gold standard". These proportions were supplemented with 95% confidence intervals (95% CI) using binominal distribution and calculated with STATA version 10 software (College Station, TX, USA). A χ^2 test was used for comparison of proportions. The study was approved by the ethics committee of Uppsala, Sweden (2009/059).

RESULTS

Nickel allergy

Patch test as "gold standard" detected 24% nickel-positive individuals (Örebro 24%, Solna 19%, Skåne 26%). Forty-one women and five men were positive to nickel in the patch test. In addition, three doubtful (IR or +?) reactions were found. Self-test results read by the patients compared with the established patch test method read by dermatologists are shown in Table II. Forty-six individuals evaluated the self-test as positive for nickel and 33 of those were regarded as positive by the "gold standard". Another 13 individuals evaluated the self-test as negative for nickel, even though it was positive by the "gold standard". Patch test results read by the dermatologist at D3–4, at D7, and the conclusion from both occasions ("gold standard") are presented in Table II. The result after one reading at D3–4 on the

Table II. *Self-test results read by the patient in relation to patch test results read by the dermatologist*

			Nickel patch test (dermatologist's reading, back), *n*					
			Reading D3–4		Reading D7		"Gold standard"[a]	
		Total, *n*	Positive[b]	Negative	Positive[b]	Negative	Positive[b]	Negative
Self-test (patient's reading, arm)	Positive	46	30	16	31	15	33	13
	Negative	145	9	136	12	133	13	132

[a]"Gold standard" is the conclusion from patch test reading by dermatologist on days 3 or 4 (D3–4) and day 7 (D7) combined.
[b]Reactions classed as +, ++, or +++ are all regarded as positive.

Table III. *Calculated validity of the self-test in relation to dermatologist's reading D 3–4 and "gold standard"*

	Reading D3–4		"Gold standard"[a]	
	% (95% CI)	*n*	% (95% CI)	*n*
Sensitivity	77 (61–89)	30/39	72 (57–84)	33/46
Specificity	89 (83–94)	136/152	91 (85–95)	132/145
Positive predictive value	65 (50–79)	30/46	72 (57–84)	33/46
Negative predictive value	94 (89–97)	136/145	91 (85–95)	132/145
Proportion of agreement	87 (81–91)	166/191	86 (81–91)	165/191

[a]"Gold standard" is the conclusion from patch test reading by dermatologist on D3–4 and D7.
CI: confidence interval.

back gave 39 nickel-positive individuals. Consequently, 15% of the reactions would have been missed with reading only at D3–4.

The calculated sensitivity, specificity, and positive and negative predictive values for the self-test are shown in Table III. The sensitivity for the self-test was 72%, when compared with "gold standard" patch test method. The proportion of agreement was 86%. However, the validity of the self-test was higher when compared with patch test reading at D3–4 only, yielding a sensitivity of 77%.

When comparing the patients' reading of the self-test with the dermatologists' reading of the self-test on the arm on the same day (D3–4), somewhat better agreement was found (Table IV). The sensitivity was 89% and the positive predictive value was 76%. However, the highest agreement was found when comparing the dermatologists' reading of the self-test on the arm with the reading of patch test on the back on the same day (D3–4). Both the sensitivity and the positive predictive value were then 84% and the proportion of agreement was 94% (Table V).

Thirteen individuals reported nickel allergy from self-test, but were nickel negative according to the "gold standard" patch test. Among the false-positives, 54% had a history of atopic dermatitis vs. 43% among the totals.

Fragrance allergy

The self-test for fragrance allergy gave 7 positive individuals, whereas the "gold standard" patch test gave 9 positive reactions. Due to the low number of fragrance-positive individuals, we did not perform any further analysis on fragrance allergy.

Table IV. *Self-test result regarding nickel allergy read by the patient in relation to the dermatologist's reading of the same test (on the arm) D3–4*

		Dermatologist's reading D3–4, arm, *n*		
		Positive[a]	Negative	Total
Self-test, patient's reading, arm	Positive	34	11	45
	Negative	4	136	140

[a]Reactions classed as +, ++, or +++ are all regarded as positive.

Table V. *Nickel patch test results read by the dermatologist. Comparison between patch test (self-test applied by the patient) on the arm and standardized patch test on the back*

		Dermatologist's reading D3–4, back, *n*		
		Positive[a]	Negative	Total
Dermatologist's reading D3–4, arm	Positive[a]	32	6	38
	Negative	6	141	147

[a]Reactions classed as +, ++, or +++ are all regarded as positive.

Drop-outs

In total, 243 patients were included, 52 (21%) of the patients did not complete the study. Seventeen of those did not successfully apply the self-test, six changed their minds, five did not attend the second reading, and another eight forgot the envelope with the result. For the remaining 16 individuals, no reason was given. The proportion of men/women was similar among the drop-outs and the participants, and the mean age was 40 vs. 44 years for drop-outs and participants, respectively.

DISCUSSION

The present study has validated a tool for epidemiological surveillance of nickel allergy. It is of importance to follow the prevalence of contact allergy in the general population. However, all the available methods have limitations.

Standardized patch testing with readings performed by a dermatologist on D3–4 and D7 is the most reliable method to investigate the occurrence of contact allergy and has, in the present study, been used as the "gold standard". However, population-based studies that include patch tests are expensive and have logistical problems, since each individual has to visit the dermatology department several times. Thus, in most population-based studies including patch testing, only one reading is performed. When studying the prevalence of nickel allergy with only one reading performed on D3, 10–15% of the positive patch test reactions to nickel may be missed because of delayed reactions (16). Results from the present study were similar, and showed that 15% (7/46) of positive patch test reactions would have been missed with only one reading. A study by Thyssen et al. (17) found that, with one reading performed on D2, 18–30% of positive patch test reactions to nickel sulphate may be missed. Uter et al. (18) compared patch test results for nickel at D2 and D3, and found that 26.6% of the positive reactions appeared at D3 only, while 3.6% of weak reactions at D2 were not considered allergic at D3.

Most studies on the occurrence of contact allergy are based on clinical data from patients at dermatology clinics (19–21). Obviously, people referred to a dermatology department constitute a selected group of patients

with skin symptoms, such as eczema, and cannot be considered representative of the general population.

Another approach for epidemiological surveillance is the CE-DUR method, which is discussed in studies from Germany and Denmark (22, 23). This method makes assumptions in order to estimate the 10-year prevalence of contact allergy, using national patch test sales information as well as clinical data. In the German study (22), the authors concluded that the morbidity data concerning contact allergy were in good accordance with data from population-based epidemiological studies. However, regarding nickel sensitization, the 9-year prevalence was 2.3% and 5.5% in different models, which is considerably lower than in studies in the general population (3, 24). In Denmark the 10-year prevalence of contact allergy measured by CE-DUR was slightly lower than the previous prevalence estimates from population-based studies in Denmark (23).

The use of questionnaires is another method for epidemiological studies. However, estimating the prevalence of contact allergy from self-reports seems to be difficult. Previous studies have shown low validity in predicting nickel allergy, with positive predictive values of 31% (12), 54% (11, 25) and 59% (9). Thus, questions about self-reported nickel allergy are not useful in epidemiological studies as they strongly overestimate the true prevalence.

The present study investigates whether self-testing might be a method sensitive enough to follow the prevalence of nickel allergy. The use of a self-test for surveillance of contact allergy would be beneficial and convenient for the investigator as well as for the test persons. It would be cost-effective to distribute the test and instructions by post and receive the answer without the study subjects needing to arrange appointments, transportation and take time off work. To the best of our knowledge the only previous report concerning contact allergy and self-testing is a conference presentation (26). That study found a proportion of agreement for nickel and fragrance mix together of 89.5% and a sensitivity of 97.5%. In the present study the sensitivity regarding nickel allergy was 72% and the proportion of agreement was 86% when comparing the self-test for nickel with the "gold standard" patch test. However, most validations concerning contact allergy include only one reading, and when the self-test results were compared with the results read by a dermatologist on D3–4 in this study, the sensitivity was 77%.

In the present study, there were 13 false-positive answers regarding nickel allergy using the self-test and 13 false-negative estimations. A limitation of the self-test is that only one reading is performed, which explains some of the false-negative answers. Table IV shows the discrepancies between the patients' and the dermatologists' reading. Our assumption is that these discrepancies were mainly due to the interpretation of irritant or doubtful reactions as positives by the patient. The proportion of patients with a history of atopic dermatitis was higher among the false-positives than among the group as a whole, which might contribute to more irritant reactions and, consequently, false-positive evaluations.

The skin of the back is more responsive than that of the arms and thighs, and only the upper back is recommended for routine diagnostic patch testing (27, 28). For practical reasons, however, a self-test has to be applied on the arm. Table V illustrates the discrepancies in relation to the test areas in the present study. Comparison of the results from the two test areas shows that the number of false-positives was the same as the number of false-negatives, and the test area was accordingly not of great importance in this study.

The study was performed at three different dermatology departments, and, consequently, different dermatologists performed the patch test readings. This might have influenced the results, but to minimize the risk, all patch tests were read by specialists in dermatology. In total, 243 individuals were included in this study, but the proportion of drop-outs was high, at 21%. Some patients had problems applying the self-test. More clearly written instructions would probably improve the participation rate.

All methods available for estimation of the occurrence of nickel allergy have limitations, practical, economic, or regarding validity. Awareness of these limitations is important when evaluating results from epidemiological studies. In the present study self-testing appears to be a reasonable alternative method for estimation of the prevalence of nickel allergy. However, the positive predictive value is critically dependent on the population chosen and the prevalence of disease within that population. This means that the positive predictive value may not be transferable from the patient population in the present study to the general population. Further testing in the general population will be needed to determine the usefulness of self-testing as an epidemiological tool to follow the prevalence of nickel allergy.

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The authors declare no conflict of interest.

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