

Piercing and Metal Sensitivity: Extended Analysis of the North American Contact Dermatitis Group Data, 2007–2014

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Background: Body piercing provides a unique route of metal exposure.

Objective: The aim of this study was to update previous analyses using the North American Contact Dermatitis Group data comparing pierced and unpierced individuals.

Methods: This was a retrospective cross-sectional analysis of 17,912 patients patch tested by the North American Contact Dermatitis Group from 2007 to 2014 for demographics, positive reactions to metals (nickel, cobalt, chromium), and detailed analysis of nickel reactions by age, sex, and source of exposure.

Results: Piercing was significantly associated with female sex, being older than 18 years, and atopy ($P < 0.003$). Nickel sensitivity was associated with 1 or more piercing for men and women combined ($P < 0.0001$; relative risk [RR], 2.54; 95% confidence interval [CI], 2.35–2.75), although this association was stronger for men (RR, 2.21; 95% CI, 1.77–2.76) than women (RR, 1.47; 95% CI, 1.31–1.65). The frequency of positivity to nickel increased with number of piercings (14.3% for 1 piercing to 34.0% with ≥ 5 piercings). Piercing was not significantly associated with cobalt sensitivity alone ($P = 0.8992$) and was negatively associated with chromium sensitivity ($P < 0.0001$). Jewelry was the most common source of allergic reactions to nickel irrespective of sex or pierced status.

Conclusions: Nickel sensitivity was significantly associated with piercing in both men and women. Jewelry was the most common source.

Body piercing is an ancient cultural and aesthetic practice. Creating artificial holes in the skin allows introduction of foreign objects for personal decoration, individualization, or

integration with cultural norms. Piercing jewelry is often metal and provides a unique route of metal exposure. In 1967, Gaul¹ described some of the first cases of allergic contact dermatitis from nickel in earrings. Since then, multiple studies evaluating the association between piercing and nickel allergy have been conducted,^{2–18} but large-scale epidemiologic studies have been limited. In 2014, our group evaluated the association between nickel allergy and piercing in a partial data set ($n = 9393$)¹⁹; that report did not include a detailed analysis of nickel reactions by age (especially pediatric patients), sex, or exposure source. This study updates the previous investigation comparing the pierced versus unpierced population for demographic characteristics and positive patch test reactions to metals (nickel, cobalt, chromium), as well as provides a detailed analysis of nickel positivity by age, sex, and sources of exposure.

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METHODS

Database

This study was approved by the Minneapolis Veterans Affairs Medical Center's Human Studies Subcommittee. Methods for patch testing, grading of reactions, and data recording by the North American Contact Dermatitis Group (NACDG) have been

previously described.^{20–24} The screening allergen series consisted of 65 to 70 allergens (Chemotechnique Diagnostics AB [Malmö, Sweden] and allergEAZE SmartPractice [Calgary, Alberta, Canada]) applied using Finn Chambers (SmartPractice, Phoenix, AZ) on Scanpor tape (Norgesplaster Alphaform AS, Vennessla, Norway). There were 3 metals on the screening series: nickel (nickel sulfate hexahydrate, 2.5% petrolatum), cobalt (cobalt chloride, 1.0% petrolatum), and chromium (potassium dichromate, 0.25% petrolatum). Patient data recorded in the database included demographics (patient age, sex, and race), atopic history (hay fever, atopic dermatitis, asthma), location of dermatitis (3 sites maximum), number of piercings, strength of patch test reaction for each allergen, and allergen source. Only 1 source was entered per allergen; if multiple sources were present, the source that was most clinically relevant was recorded. Body site of piercing(s) and age at first piercing were not recorded. Data were verified before manually entered into the central database.

Study Population

All patients underwent patch testing with a member of the NACDG between January 1, 2007, and December 31, 2014. A total of 18,430 patients were patch tested during the study period, and only those with piercing data available were included. The pierced population was defined as having 1 or more piercings, whereas the unpierced population had no body piercings.

Study Design

The database was transferred from its original Access format (Access 2010; Microsoft Corp, Redmond, WA) to Excel (Excel 2010; Microsoft Corp). In keeping with previous studies, *metal sensitivity* was defined as a positive patch test reaction to the

specified metal (nickel, cobalt, chromium), regardless of clinical relevance; doubtful reactions not thought to be allergic and irritant reactions were excluded.¹⁹ A retrospective analysis of NACDG data was used to assess the association of metal sensitivity with pierced status and number of piercings. For metal sensitivity analyses, only patients tested to that metal were included (nickel, $n = 17,838$; cobalt, $n = 17,897$; chromium, $n = 17,904$). The relationship between nickel sensitivity and piercing was further evaluated by age and sex, as well as source.

Statistical Analysis

Counts and proportions were used to convey demographics and metal reaction positivity. The pierced and unpierced populations were compared using Pearson χ^2 or Fisher exact test (2 tailed) when appropriate. Relative risk (RR) and confidence intervals (CIs) were calculated using SAS software (SAS 9.2; SAS, Cary, NC). Association between number of piercings and metal sensitivity was evaluated using a generalized linear model, log-binomial regression with the number of piercings as a categorical predictor. A total of 47 comparisons were made; thus, a Bonferroni-corrected P value (<0.003) was used as the cutoff for statistical significance.

RESULTS

Study Population

Of the 18,430 patients patch tested by the NACDG during the study period, 17,912 had piercing data available. The pierced population (≥ 1 piercings) consisted of 11,047 patients, whereas the unpierced population (0 piercing) included 6,865 patients. The pierced population was further subdivided according to piercing number (Fig. 1).

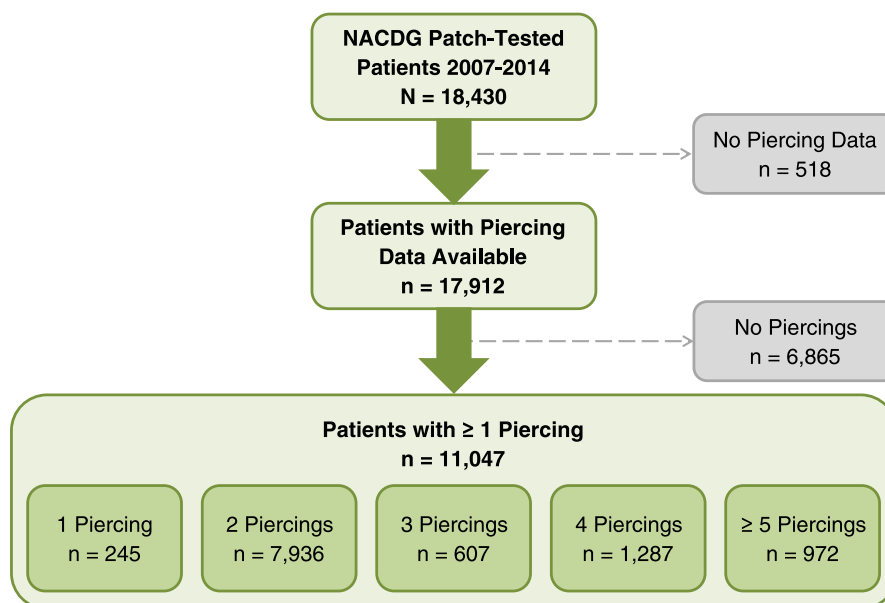


Figure 1. Study population.

Patient Demographics

Table 1 reports demographic data for the study population overall and compares the pierced and unpierced subgroups, including MOAHLFA (Male, Occupational, Atopy, Hand dermatitis, Leg dermatitis, Face dermatitis, Age > 40 years) characteristics.²⁵ Age older than 18 years was significantly associated with piercing. Piercing was associated with atopy (childhood atopic dermatitis, hay fever, and/or asthma), female sex, and nonwhite race.

Nickel

Of the 17,838 patients patch tested to nickel, 3334 (18.7%) had a positive patch test reaction. Piercing was significantly associated with nickel sensitivity (24.4% vs 9.6%, $P < 0.0001$), and a positive correlation between nickel positivity and piercing number was

observed (14.3% with 1 piercing to 34.0% with ≥ 5 piercings, $P < 0.0001$; Table 2). Piercing in both sexes was significantly associated with nickel sensitivity compared with their unpierced counterparts ($P < 0.0001$; Table 3), but this association was stronger in men (RR, 2.21; 95% CI, 1.77–2.76) than women (RR, 1.47; 95% CI, 1.31–1.65). Comparing the pediatric population (age ≤ 18 years) with the adult population (age > 18 years), the frequency of nickel sensitivity was higher for both pediatric sexes (male, 21.4% for pierced vs 16.6% for unpierced; female, 31.6% for pierced vs 28.8% for unpierced) than for adults (men, 16.3% for pierced vs 6.9% for unpierced; women, 24.4% for pierced vs 15.8% for unpierced). Table 3 conveys nickel positivity by age and sex. The most common sources of nickel allergic reactions varied by age and sex, but jewelry was the most common source overall (Table 4).

TABLE 1. Patient Demographics for Pierced and Unpierced Patients

Demographic	Overall, n (%)	Pierced, n (%)	Unpierced, n (%)	Pierced vs Unpierced	
	N = 17,912	N = 11,047	N = 6865	RR (95% CI)	P
Sex*					
Male†	5786 (32.3)	479 (4.3)	5307 (77.3)	0.10 (0.09–0.10)	<0.0001‡
Age, y§					
Average	49.0	46.7	51.1		
Adult (>18)	16,971 (94.9)	10,567 (95.7)	6404 (93.4)	1.85 (1.73–1.97)	<0.0001‡
≤5	58 (0.3)	14 (0.1)	44 (0.6)	0.39 (0.25–0.62)	<0.0001‡
6–12	278 (1.6)	89 (0.8)	189 (2.8)	0.52 (0.43–0.61)	<0.0001‡
13–18	585 (3.3)	367 (3.3)	218 (3.2)	1.02 (0.95–1.08)	0.5959
19–29	1943 (10.9)	1426 (12.9)	517 (7.5)	1.26 (1.22–1.30)	<0.0001‡
30–39	2635 (14.7)	1824 (16.5)	811 (11.8)	1.15 (1.11–1.18)	<0.0001‡
40–49	3415 (19.1)	2294 (20.8)	1121 (16.4)	1.11 (1.08–1.14)	<0.0001‡
50–59	4043 (22.6)	2530 (22.9)	1513 (22.1)	1.02 (0.99–1.05)	0.1856
≥60	4935 (27.6)	2493 (22.6)	2442 (35.6)	0.77 (0.74–0.79)	<0.0001‡
Race					
White	15,355 (86.4)	9366 (85.3)	5989 (88.2)	0.91 (0.88–0.94)	<0.0001‡
Atopy					
Hay fever¶	5368 (30.1)	3525 (40.0)	1843 (26.9)	1.09 (1.07–1.12)	<0.0001‡
Eczema‡#	4520 (25.4)	3079 (28.0)	1441 (21.1)	1.14 (1.12–1.17)	<0.0001‡
Asthma**	2836 (15.9)	1884 (17.1)	952 (13.9)	1.09 (1.06–1.13)	<0.0001‡
Any of the above††	8047 (45.0)	5277 (47.8)	2791 (40.7)	1.12 (1.09–1.14)	<0.0001‡
Sites‡‡					
Hand†	4460 (24.9)	2513 (22.8)	1947 (28.4)	0.89 (0.86–0.91)	<0.0001‡
Leg†	2025 (11.3)	1027 (9.3)	998 (14.5)	0.80 (0.77–0.84)	<0.0001‡
Face†	3886 (21.7)	2906 (26.3)	980 (14.3)	1.29 (1.26–1.32)	<0.0001‡
Occupational skin disease†§§	1826 (10.2)	897 (8.1)	929 (13.5)	0.78 (0.74–0.82)	<0.0001‡

*Sex for 1 pierced and 2 unpierced patients missing in the database, with denominators adjusted accordingly.

†MOAHLFA index.

‡Statistically significant value, $P < 0.003$, Bonferroni correction.

§Age for 10 pierced and 6 unpierced patients missing in the database, with denominators adjusted accordingly. Additional 4 unpierced patients' age incorrectly entered in the database, with denominators adjusted accordingly.

||Race for 62 pierced and 73 unpierced patients missing in the database, with denominators adjusted accordingly.

¶Hay fever status for 28 pierced and 24 unpierced patients missing in the database, with denominators adjusted accordingly.

#Eczema status for 50 pierced and 51 unpierced patients missing in the database, with denominators adjusted accordingly.

**Asthma status for 28 pierced and 17 unpierced patients missing in the database, with denominators adjusted accordingly.

††All atopic statuses for 7 pierced and 9 unpierced patients missing in the database, with denominators adjusted accordingly.

‡‡All sites for 8 pierced and 5 unpierced patients missing in the database, with denominators adjusted accordingly.

§§Refers to overall skin disease being occupationally related, not necessarily related to piercings or allergy. Occupationally related data for 25 pierced and 8 unpierced patients missing in the database, with denominators adjusted accordingly.

TABLE 2. Reactions to Metals by Number of Piercings

Metal Allergen	Pierced, n (%) [*]	Unpierced, n (%) [*]	RR (95% CI), <i>P</i>	No. Piercings				
				1	2	3	4	≥5
Nickel (n = 17,838) [†]	2677/10,986 (24.4)	657/6852 (9.6)	2.54 (2.35–2.75), <0.0001 [‡]	35/245 (14.3)	1821/7885 (23.1)	155/604 (25.7)	337/1285 (26.2)	329/967 (34.0)
Cobalt (n = 17,897) [§]	954/11,035 (8.6)	370/6862 (5.4)	1.60 (1.43–1.80), <0.0001 [‡]	19/245 (7.8)	647/7925 (8.2)	50/606 (8.3)	119/1287 (9.2)	119/972 (12.2)
Chromium (n = 17,904)	222/11,043 (2.0)	245/6861 (3.6)	0.56 (0.47–0.67), <0.0001 [‡]	8/245 (3.3)	158/7932 (2.0)	16/607 (2.6)	21/1287 (1.6)	19/972 (2.0)

*Denominator is the number of patients tested to metal in each category (unpierced, pierced, number of piercings).

[†]Seventy-four patients not tested to nickel, adjusted denominators appropriately.

[‡]Statistically significant value, *P* < 0.003, Bonferroni correction.

[§]Fifteen patients not tested to cobalt, adjusted denominators appropriately.

^{||}Eight patients not tested to chromium, adjusted denominators appropriately.

Cobalt

Of the 17,897 patients patch tested to cobalt, 1324 (7.4%) had a positive patch test reaction (Table 2). Cobalt sensitivity seemed to be statistically associated with piercing (*P* < 0.0001; RR, 1.60; 95% CI, 1.43–1.80), with a modestly positive correlation with piercing number (7.8% for 1 piercing to 12.2% for ≥5 piercings, *P* < 0.0001; Table 2). Stratified analysis revealed that nickel positivity was a confounder for the relationship of cobalt sensitivity and piercing (Table 5). Piercing was not statistically associated with cobalt sensitivity alone (*P* = 0.8992; RR, 0.99; 95% CI, 0.81–1.20; Table 5).

Chromium

In total, 17,904 patients were patch tested to chromium. Of these, 467 (2.6%) had a positive patch test reaction (Table 2). Chromium sensitivity was negatively correlated with piercing (*P* < 0.0001; RR, 0.56; 95% CI, 0.47–0.67), regardless of nickel or cobalt cosensitivity (Table 5).

DISCUSSION

This study has several key findings. First, nickel sensitivity was 2.5 times greater in pierced individuals than in those with no piercings (*P* < 0.0001). There was also a positive correlation between piercing number and nickel positivity. Second, piercing was not significantly associated with sensitivity to cobalt alone and was negatively associated with chromium sensitivity. Third, the frequency of nickel sensitivity was higher in women, but the correlation with piercing was stronger in men. Fourth, jewelry was the most common source of nickel allergic reactions irrespective of sex, age, or pierced status.

Nickel Sensitivity and Piercing

The association between nickel sensitivity and piercing reported herein is consistent with previous analyses of the partial NACDG piercing data set.¹⁹ Nickel sensitivity was 2.5 times greater in pierced individuals than in those with no piercings, and nickel sensitivity increased with the number of piercings. Other studies, conducted mostly in Europe, have found associations between nickel sensitivity and piercing^{2–18} but primarily evaluated smaller and/or subdivided populations, including men only,⁹ women only,^{3,4,14} adolescent/pediatric subjects,^{8,10,15,16,18} or fewer than 1000 subjects.^{3,4,6–11,13,14} This study provides the largest, most comprehensive population to date for evaluating the association between nickel sensitivity and piercing.

Cobalt and Chromium Sensitivity and Piercing

Initial crude analyses suggested a statistical association between body piercing and cobalt sensitivity (*P* < 0.0001; RR, 1.60; 95% CI, 1.43–1.80); however, stratified analysis revealed that nickel was a confounding variable; piercing was not associated with cobalt sensitivity alone (*P* = 0.8992; RR, 0.99; 95% CI, 0.81–1.20). Van

TABLE 3. Comparison of Nickel Sensitivity in Pierced Versus Unpierced, by Sex and Age

	Nickel Sensitivity		RR (95% CI)
	Pierced,* n (%)	Unpierced,† n (%)	P
Overall			
Male (n = 5779)	79/479 (16.5)	396/5300 (7.5)	2.21 (1.77–2.76), <0.0001‡
Female (n = 12,056)	2598/10,506 (24.7)	261/1550 (16.8)	1.47 (1.31–1.65), <0.0001‡
≤18 y			
Male (n = 333)	3/14 (21.4)	53/319 (16.6)	1.35 (0.39–4.68), 0.7126
Female (n = 585)	143/453 (31.6)	38/132 (28.8)	1.03 (0.94–1.13), 0.5432
19–29 y			
Male (n = 485)	20/80 (25.0)	60/405 (14.8)	1.69 (1.08–2.64), 0.0249
Female (n = 1452)	471/1340 (35.1)	27/112 (24.1)	1.46 (1.04–2.04), 0.0180
30–39 y			
Male (n = 783)	24/132 (18.2)	59/651 (9.1)	2.01 (1.30–3.10), 0.0019‡
Female (n = 1844)	480/1685 (28.5)	28/159 (17.6)	1.62 (1.15–2.28), 0.0033
40–49 y			
Male (n = 1014)	16/116 (13.8)	54/898 (6.0)	2.29 (1.36–3.87), 0.0019‡
Female (n = 2388)	561/2169 (25.9)	42/219 (19.2)	1.35 (1.02–1.79), 0.0300
50–59 y			
Male (n = 1264)	9/80 (11.3)	71/1184 (6.0)	1.88 (0.97–3.61), 0.0618
Female (n = 2747)	551/2422 (22.7)	57/325 (17.5)	1.30 (1.01–1.66), 0.0336
≥60 y			
Male (n = 1894)	7/57 (12.3)	99/1837 (5.4)	2.28 (1.11–4.68), 0.0258
Female (n = 3026)	390/2427 (16.1)	69/599 (11.5)	1.40 (1.10–1.77), 0.0054

*Of pierced patients allergic to nickel, age was missing for 2 patients in the database. Of all pierced patients, age was missing for 10 patients, and sex was not recorded for 1 pierced (non-nickel allergic) patient. Denominators reflect the number of pierced patients tested to nickel.

†Of unpierced patients allergic to nickel, no data were missing in the database. Of all unpierced patients, age was missing for 6 patients and incorrectly entered for 4 patients, and sex was not recorded for 2 unpierced (non-nickel allergic) patients. Denominators reflect the number of unpierced patients tested to nickel.

‡Statistically significant value, $P < 0.003$, Bonferroni correction.

Hoogstraten et al⁵ also found a significant association between cobalt allergy and piercing but did not account for nickel as a potential confounder. Our current findings are consistent with the previous partial NACDG piercing data set.¹⁹ We again observed a pattern of coreactivity of nickel and cobalt, which could stem from cobalt also being a component of jewelry items.^{26–28} Among individuals allergic to nickel, various coreactivities with cobalt have been reported: 48% of school-aged girls in the study by Larsson-Stymne and Widström,⁴ 27% of school-aged children in the study by Dotterud and Falk,⁸ 25% (414/1651) of the general NACDG patch test population,¹⁹ and 24% (814/3334) in the current study.

Chromium sensitivity was negatively correlated with piercing ($P < 0.0001$; RR, 0.56; 95% CI, 0.47–0.67), consistent with the previous study.¹⁹ It is likely that piercing jewelry may not present significant exposure to chromium, as a recent article by Bregnbak et al²⁹ revealed that none of 848 jewelry items tested (including piercing jewelry) released chromium more than 0.5 ppm (the threshold of the test). Considering these findings, piercings are an unlikely source of or risk factor for chromium sensitivity.

Association Between Nickel Sensitivity and Piercing, by Sex and Age

Pierced men and women both had higher frequencies of nickel sensitivity than unpierced comparison groups, but the association

with piercing was stronger in men (RR, 2.21) than in women (RR, 1.47). Associations between piercing, nickel allergy, and sex have previously been shown in men^{9,19,30} and women.^{4,5,8,12,13,15,19} Meijer et al⁹ demonstrated this in men in a population of 520 Swedish military men aged 18 to 24 years, and Ehrlich et al³⁰ demonstrated this in a North American population of men aged 18 to 43 years. Of note, in both all-male studies, composite metal sensitivity was reported (ie, nickel and cobalt) and not nickel sensitivity alone. Van Hoogstraten et al⁵ specifically reported nickel sensitivity, revealing significantly higher nickel positivity for pierced young men (≤35 years old).

For women, several studies report the association between nickel allergy and piercing. In our study, 95.7% of the pierced population was female, reflecting the social norm of piercing in North American women. Consequently, women encounter more potential exposures to nickel from piercings, resulting in larger populations for studies. Women are also more likely to encounter nickel from other sources including hair clips, bracelets, necklaces, and watches,¹⁹ which may explain why the frequency of nickel sensitivity in the unpierced female population (16.8%) was still higher than that of the pierced male population (16.5%).

For most age subgroups of both sexes, piercing was associated with a higher frequency of nickel sensitivity but attained significance only for men aged 30 to 39 and 40 to 49 years. This is likely

TABLE 4. Top 3 Nickel Sources in Pierced Versus Unpierced, by Sex and Age

	Pierced	Unpierced
Overall		
Male	Jewelry (27/79) Belts (18/79) Unspecified miscellaneous items (7/79)	Jewelry (80/396) Belts (59/396) Unspecified miscellaneous items (30/396)
Female	Jewelry (1720/2598) Unspecified miscellaneous items (193/2598) Food products (164/2598)	Jewelry (106/261) Food products (49/261) Unspecified miscellaneous items (39/261)
≤5 y		
Male	Jewelry* (1/1)	Unspecified miscellaneous items (3/8) Building materials (1/8) Shirts, pants, blouses, dresses, skirts (1/8)
Female	Jewelry (2/5) Unspecified miscellaneous items* (2/5)	Unspecified miscellaneous items (3/6) Food products (1/6) Jewelry (1/6)
6–12 y		
Male	Unspecified miscellaneous items* (1/1)	Belts (5/22) Shirts, pants, blouses, dresses, skirts (4/22) Unspecified clothing† (3/22) Food products† (3/22)
Female	Jewelry (17/37) Unspecified miscellaneous items (5/37) Food products (3/37)	Food products (4/16) Jewelry (4/16) Belts (2/16)
13–18 y		
Male	Unspecified miscellaneous items* (1/1)	Belts (10/23) Food products (4/23) Unspecified clothing (2/23)
Female	Jewelry (55/101) Food products (18/101) Belts (5/101)	Food products (6/16) Jewelry (6/16) Belts† (1/16) Unspecified clothing† (1/16) Shirts, pants, blouses, dresses, skirts† (1/16)

TABLE 4. (Continued)

	Pierced	Unpierced
19–29 y		
Male	Belts (7/20) Jewelry (2/20) Equipment, instruments, miscellaneous supplies† (1/20) Massage oils, aromatherapy† (1/20) Unspecified miscellaneous items† (1/20) Orthopedic implants, prostheses† (1/20) Solvents, oils, lubricants, fuels† (1/20)	Belts (13/60) Jewelry (13/60) Unspecified miscellaneous items (4/60)
Female	Jewelry (311/471) Unspecified miscellaneous items (31/471) Food products (30/471)	Food products (9/27) Jewelry (8/27) Unspecified miscellaneous items (3/27)
30–39 y		
Male	Jewelry (8/24) Belts (5/24) Food products† (1/24) Material handling machinery† (1/24) Unspecified miscellaneous items† (1/24) Shirts, pants, blouses, dresses, skirts† (1/24) Tools† (1/24) Vehicles† (1/24) Watches† (1/24)	Jewelry (14/59) Belts (12/59) Equipment, instruments, miscellaneous supplies (3/59)
Female	Jewelry (331/480) Unspecified miscellaneous items (29/480) Food products (28/480)	Jewelry (14/28) Unspecified miscellaneous items (7/28) Food products (5/28)
40–49 y		
Male	Jewelry (7/16) Belts (2/16) Vehicles (2/16)	Jewelry (12/54) Unspecified miscellaneous items (5/54) Belts† (4/54) Food products† (4/54)
Female	Jewelry (371/561) Unspecified miscellaneous items (45/561) Food products (28/561)	Jewelry (20/42) Unspecified miscellaneous items (10/42) Food products (6/42)
50–59 y		
Male	Jewelry (6/9) Belts (2/9) Unspecified miscellaneous items (1/9)	Jewelry (15/71) Belts (7/71) Food products (5/71)

(continued on next page)

TABLE 4. (Continued)

	Pierced	Unpierced
Female	Jewelry (363/551)	Jewelry (24/57)
	Unspecified miscellaneous items (42/551)	Unspecified miscellaneous items (10/57)
	Food products (40/551)	Food products (9/57)
≥60 y		
Male	Jewelry (3/7)	Jewelry (23/99)
	Belts (2/7)	Unspecified miscellaneous items (12/99)
	Metal, woodworking, and special material machinery† (1/7)	Belts (8/99)
	Unspecified miscellaneous items† (1/7)	
Female	Jewelry (269/390)	Jewelry (29/69)
	Unspecified miscellaneous items (37/390)	Food products (9/69)
	Food products (17/390)	Unspecified miscellaneous items (5/69)

Only specified sources are reported here. If "unknown" or "not applicable" was in the top 3 sources, these were excluded. For "Jewelry," source codes "930" and "931" were combined.

*Signifies less than 3 sources reported because of few positive nickel reactions.

†Reflects sources with equal prevalence, thus having more than 3 sources reported.

because these 2 groups comprised the largest male cohorts. Other age subgroups for men had much smaller numbers, especially in younger populations. For both pierced men and women, nickel sensitivity peaked in the 19- to 29-year age group and thereafter generally decreased with age.

Sources of Nickel Allergic Reactions

Overall, jewelry was the most common source of nickel dermatitis in both pierced and unpierced men and women. Nickel is commonly found in jewelry items, and multiple studies quantifying the release of nickel in jewelry have been conducted worldwide using

dimethylglyoxime (DMG) testing. The DMG test has a sensitivity of detecting nickel release of approximately 60%,³¹ so it may underestimate nickel release. In a study from Thailand of 551 jewelry items, 39.2% released nickel.³² In Israel, 382 (36.8%) of 1037 jewelry items were positive for nickel on DMG testing.³³ In Korea, high nickel-releasing jewelry accounted for 12.4% for branded jewelry and 70.8% for nonbranded jewelry.³⁴ To limit nickel exposure and hopefully reduce nickel sensitivity, some countries, such as those of the European Union under the European Union Nickel Directive (now included in the Registration, Evaluation, Authorization, and Restriction of Chemicals regulation), have implemented restrictions regarding acceptable nickel release of products intended for direct and prolonged contact with the skin (eg, jewelry). Following such regulations, significant reductions in the risk of nickel sensitivity after piercing have been reported.^{14,17,35}

In the younger cohort (<30 years old), jewelry was a common source of nickel allergic reactions, but clothing, unspecified miscellaneous items, and food products were also frequently implicated. In adult patients (>18 years old), belts were a common source of nickel contact dermatitis for men, but not for women. It is possible that men may wear belts more often than women. Irrespective of sex, a recent study by Hamann et al³⁶ supports belts as a relevant source of nickel exposure, with more than half of belts in the United States releasing nickel. Women are also more likely to be pierced and probably more likely to wear jewelry compared with men, and with only 1 source reported per allergen, only the most clinically relevant was recorded. For women, this would most likely include jewelry items.

Limitations

This study was limited by several factors. First, we did not examine the strength or clinical relevance of reactions. In addition, our test concentration of nickel was 2.5%, whereas many European studies tested 5%, making comparisons difficult. Second, piercing location(s) and age at first piercing were not collected. Thus, correlations of

TABLE 5. Positive Patch Test Reactions in Patients Tested for Nickel, Cobalt, and Chromium

	Overall, n (%)	Pierced, n (%)	Unpierced, n (%)	Pierced vs Unpierced	
Positive Reaction	N = 17,833	N = 10,984*	N = 6849†	RR (95% CI)	P
Any metal	4043 (22.7)	3050 (27.8)	993 (14.5)	1.92 (1.79–2.04)	<0.0001‡
Only 1 metal	3057 (17.1)	2316 (21.1)	741 (10.8)	1.95 (1.80–2.10)	<0.0001‡
Nickel	2436 (13.7)	1976 (18.0)	460 (6.7)	2.68 (2.43–2.95)	<0.0001‡
Cobalt	403 (2.3)	247 (2.2)	156 (2.3)	0.99 (0.81–1.20)	0.8992
Chromium	218 (1.2)	93 (0.8)	125 (1.8)	0.46 (0.36–0.61)	<0.0001‡
Two metals	913 (5.1)	685 (6.2)	228 (3.3)	1.87 (1.62–2.17)	<0.0001‡
Nickel and cobalt	741 (4.2)	607 (5.5)	134 (2.0)	2.82 (2.35–3.40)	<0.0001‡
Nickel and chromium	82 (0.5)	43 (0.4)	39 (0.6)	0.69 (0.45–1.06)	0.0876
Cobalt and chromium	90 (0.5)	35 (0.3)	55 (0.8)	0.40 (0.26–0.61)	<0.0001‡
All 3 metals	73 (0.4)	49 (0.4)	24 (0.4)	1.27 (0.78–2.07)	0.3304

*Sixty-three pierced patients were not tested to all 3 metals.

†Sixteen unpierced patients were not tested to all 3 metals.

‡Statistically significant value, $P < 0.003$, Bonferroni correction.

piercing site, age at first piercing, and metal sensitivity are not possible. Third, as a cross-sectional study, no causative relationships can be determined. Finally, patients not tested to each metal (nickel, $n = 74$; cobalt, $n = 15$; chromium, $n = 8$) were excluded from our analyses. These patients likely had previous patch test–positive reactions to these metals. Thus, the statistical associations from this study could underrepresent actual values.

SUMMARY/CONCLUSIONS

Consistent with the previous partial NACDG piercing data set report and other studies, this analysis confirmed a positive statistical association between nickel sensitivity and piercing. Nickel sensitivity increased with number of piercings. The association of piercing and nickel sensitivity was stronger in men than in women. The most common source of nickel dermatitis was jewelry, with other sources relevant in younger age groups and unpierced individuals. Allergy to other metals, including cobalt and chromium, was not positively associated with piercings.

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