

Body Piercing and Metal Allergic Contact Sensitivity: North American Contact Dermatitis Group Data From 2007 to 2010

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Objective: This study aimed to examine the association between piercing and patch test sensitivity to metals (nickel, cobalt, and chromium) in North America.

Methods: A retrospective analysis of 9334 patients tested by the North American Contact Dermatitis Group from 2007 to 2010 was conducted.

Results: Nickel sensitivity was statistically associated with at least 1 piercing (risk ratio [RR], 2.52; 95% confidence interval [CI], 2.26–2.81; $P < 0.0001$) and nickel sensitivity rates increased with the number of piercings (16% for 1 piercing to 32% for ≥ 5 piercings). Prevalence of nickel sensitivity was higher in females (23.2%) than in males (7.1%), but the association with piercing was stronger in males (RR, 2.38; 95% CI, 1.72–3.30; $P < 0.0001$) than in females (RR, 1.30; CI, 1.13–1.49; $P = 0.0002$). Crude analysis indicated that cobalt sensitivity was statistically associated with piercing (RR, 1.63; 95% CI, 1.40–1.91; $P < 0.0001$); however, stratified analysis showed that this relationship was confounded by nickel. After adjusting for nickel sensitivity, the adjusted risk ratio for piercing and cobalt was 0.78 (not significant). Chromium sensitivity was negatively associated with piercing (RR, 0.60; 95% CI, 0.48–0.75; $P < 0.0001$).

Conclusions: Piercing was statistically associated with sensitivity to nickel. This relationship was dose dependent and stronger in males. Cobalt sensitivity was not associated with piercing when adjusted for nickel. Chromium sensitivity was negatively associated with piercing.

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As a group, metals are among the most common contact allergens detected by patch testing in both adults and children.¹ Of these metals, nickel has been the most widely studied.² A recent review of published research found that the median nickel allergy prevalence in a general European population was 8.6% (range, 0.7%–27.8%) and this rate was higher in patients with dermatitis.³ In North America, nickel is the most common contact allergen detected in patients undergoing patch testing (15.5%–19.5%).^{4–6} Nickel allergy is considerably higher in females compared with males.³ This difference has been largely attributed to females' higher prevalence of piercings⁶ because nickel-containing jewelry, especially earrings, has long been proposed as a route for nickel sensitization.^{7–13}

A comprehensive literature search found 14 studies evaluating the association of metal allergy and piercings (Table 1),^{10–12,14–24} 11 studies from Europe, 2 studies from the United States, and 1 study from Asia. Six studies were limited to children, adolescents, or college students; 2 studies included males only^{21,24} and 1 studied females only.¹¹ Seven studies evaluated the number of piercings. All reported nickel sensitivity with only a few reporting cobalt or chromium sensitivity ($n = 6$ and 3, respectively). One early US

TABLE 1. Studies Evaluating Metal Sensitivity and Piercing

Study	Population	Metals Tested	No. Piercings Evaluated	Main Findings
Europe Fors et al ¹⁴ (Sweden) 2012	4376 adolescents (573 adolescents pierced)	Nickel	Yes	-Multiple piercings increased risk for nickel sensitivity by almost 50% compared with single piercing -Nickel-releasing orthodontics >1 y before piercing significantly decreased nickel positivity
Van Hoogstraten et al ¹⁷ (Europe) 1991	2176 patients referred for patch testing in 9 European clinics	Nickel, cobalt, chromium	No	-Females: (35 y and younger) strong association between pierced ears and nickel sensitivity (37.9% vs 4.8% in $P < 0.0001$); for those older than 35 y, 20.5% vs 10.0% ($P < 0.0005$) -Males: (35 y and younger) piercing was significantly associated with nickel sensitivity (21.6% vs 2.7%, $P < 0.0001$); no association in older than 35 y -Cobalt sensitivity was associated with piercing in young females (10.4% vs 3.6%, $P < 0.05$); no association in older women or men -Dental braces preceding ear piercing significantly reduced nickel sensitivity (in females, 25.0% vs 39.3%, $P < 0.006$; in males, 7.7% vs 22.5%, n.s.)
Smith-Sivertsen et al ¹⁸ (Norway) 1999	1767 adults in 2 cities (882 adults with pierced ears; >85% of women vs <8% of men)	Nickel	Yes	-Women with pierced ears significantly associated with nickel sensitivity (32.1% vs 8.5%; RR, 3.3; 95% CI, 2.01–5.43) >3 piercings increased risk for nickel sensitivity 4-fold -In men, no statistical association of nickel sensitivity with either piercing or number of piercings
Mortz et al ¹⁹ (Denmark) 2002	1146 schoolchildren aged 12–16 y (731 with pierced ears)	Nickel	No	-Girls: nickel positivity significantly associated with ear piercing (15.9% vs 3.6%; OR, 5.12; 95% CI, 1.82–14.44; $P < 0.002$) -Boys: nickel allergy not associated with piercing (OR, 0.88; 95% CI, 0.24–3.23; $P = 0.841$)
Larsson-Stymne and Widström ¹² (Sweden) 1985	960 schoolgirls (687 schoolgirls with pierced ears)	Nickel Cobalt	Yes	-Nickel positivity significantly associated with piercing (13% vs 1%; $P < 0.001$) -Rate increased with number of piercings (19% with >2 piercings vs 11% with 1 piercing; $P < 0.05$)
Kerosuo et al ²⁰ (Finland) 1996	700 adolescents (411 with pierced earlobes)	Nickel	Yes	-Nickel sensitivity associated with piercing (31% vs 2%; OR, 4.8; 95% CI, 1.6–14.6; $P < 0.001$); correlation stronger in girls than in boys but statistics not reported -Nickel positivity of 36% in >1 piercing per lobe vs 27% for 1 piercing per lobe

McDonagh et al ²¹ (United Kingdom) 1992	612 patients referred for patch testing	Nickel	No	-Highly significant ($P < 0.001$) increase in frequency of nickel allergy in females with pierced ears over those without piercings.
Nielsen and Menné ¹³ (Denmark) 1993	567 subjects aged 15–69 y (pierced earlobes: 12% of men, 67% of women)	Nickel	No	-Nickel sensitivity associated with piercing (14.8% vs 1.8%, $P < 0.0001$) -Adjusted for age and sex, 4-fold risk (OR, 4.47; 95% CI, 1.54–13.0)
Meijer et al ²² (Sweden) 1995	520 men (152 men with pierced earlobes)	Nickel, cobalt	No	-Positive nickel and/or cobalt patch test in 7.9% of pierced vs 2.7% unpierced young men ($P < 0.05$)
Dotterud and Falk ²³ (Norway) 1994	424 schoolchildren aged 7–12 y (89 schoolchildren with pierced ears)	Nickel, cobalt, chromium	Yes	-Nickel sensitivity associated with piercing in girls (30.8% vs 16.2%, $P < 0.05$); no difference in boys -Nickel positivity >3 holes (80%; RR, 31.26) in earlobes than those with 2 (27.7%; RR, 2.99), 1 (15.8%; RR, 1.47), or 0 (11.3%; RR, 1.00; $P < 0.0001$)
Mattila et al ²⁴ (Finland) 2001	284 university students (182 university students with pierced skin)	Nickel	Yes	-Nickel sensitivity associated with piercing: univariate analysis: OR, 12.4; 95% CI, 5.6–27.4; in multiple regression: adjusted OR, 3.6; 95% CI, 1.2–10.8; $P < 0.05$ -Females: 41.9% vs 14.3% ($P < 0.001$) -Males: not significant -No association of number of piercing sites with nickel sensitivity in females
Asia Nakada et al ¹¹ (Japan) 1997	337 adults (107 adults with pierced earlobes)	18 different metals	No	-Nickel and gold sensitivity associated with piercing 38.3% vs 25.6% (5% nickel; $P < 0.05$); 37.9% vs 23.3% (2% nickel; $P < 0.01$); 34.6% vs 0.7% (gold; $P < 0.001$) -Negative association with manganese; no association with cobalt or chromium
North America Prystowsky et al ¹⁵ (United States) 1979	1158 paid participants from general population	Nickel	No	-Nickel sensitivity associated with ear piercing in women (RR, 4.6) and men (RR, 33.0); significance tests not performed
Ehrlich et al ²⁵ (United States) 2001	118 men (68 men with piercing)	Nickel, cobalt, palladium, gold	Yes	-Metal sensitivity associated with piercing (14.6% with >1 piercing, 11.1% with 1 piercing, and 4% with no piercings; $P = 0.04$)
Current study (United States, Canada) 2014	9393 patients referred for patch testing	Nickel, cobalt, chromium	Yes	-Nickel sensitivity associated with piercing (RR, 2.52; 95% CI, 2.26–2.81; $P < 0.0001$) -Association stronger in males than females -Sensitivity rates increased with number of piercings -Cobalt sensitivity not associated with piercing when adjusted for nickel -Chromium sensitivity negatively associated with piercing (RR, 0.60; 95% CI, 0.48–0.75; $P < 0.0001$)

study found that nickel allergy correlated with a history of pierced ears, earlobe dermatitis, and jewelry rash in a representative sample of the general population.¹⁵ The other US study evaluated nickel, cobalt, gold, and palladium sensitivity in 118 men; 11 patients had at least 1 positive metal reaction and the reactions were higher in men with more than 1 (14.6%) piercing as compared with 1 (11.1%) piercing or no piercings (4%).²⁴

Although these studies substantiate the association between nickel allergy and piercing, the data are conflicting about this association in males and have primarily focused on nickel. To date, there have been no large epidemiologic analyses of these issues in North America. Studies suggest that metal sensitization may lead to serious consequences. These include future occupational dermatitis, systemic contact dermatitis (from ingested metal in food), and potential implications for implanted metal devices.²⁵ The latter is especially a hot topic in the orthopedic, cardiothoracic, and vascular fields. Because of the increased prevalence of body piercing^{26–29} and potential significant health implications from metal sensitivity,³⁰ the North American Contact Dermatitis Group (NACDG) began collecting information on piercings in patch tested patients in 2007. This study evaluates the association between body piercing and sensitivity to nickel, cobalt, and chromium.

METHODS

NACDG Database

Between January 1, 2007, and December 31, 2010, a total of 9393 patients with dermatitis were patch tested using the NACDG

standard series of 65 to 70 allergens, which included 3 metals: nickel (nickel sulfate, 2.5% petrolatum), cobalt (cobalt chloride, 1.0% petrolatum), and chromium (potassium dichromate, 0.25% petrolatum). Methods for patch testing, coding, as well as determining the final diagnoses and relevance of reactions have been previously described.⁴ Briefly, the information collected on patients included demographic information (age, sex, and race), number of piercings, occupation, site(s) of dermatitis, and final diagnoses. Occupational relatedness was determined in accordance with the NACDG criteria.^{5,31}

Study Design

The Minneapolis Veterans Affairs Medical Center Human Studies Subcommittee provided institutional review board approval for this retrospective analysis of deidentified data. For this study, only those individuals with piercing information were included. This group was then divided into those with at least 1 piercing or those with no piercings; the pierced group was further subdivided by the numbers of piercings (Fig. 1).

This study defined *metal sensitivity* as a positive patch test reaction to the specified metal, regardless of clinical relevance; doubtful reactions not thought to be allergic in nature as well as irritant reactions were excluded. Association of metal sensitivity and piercing was examined by sex (male vs female), age (20-year increments), piercing number, occupational relatedness (yes vs no), and coreactivity with other metals.

For the analyses of allergens, only patients tested for that allergen were included (nickel, n = 9334; cobalt, n = 9378; and chromium,

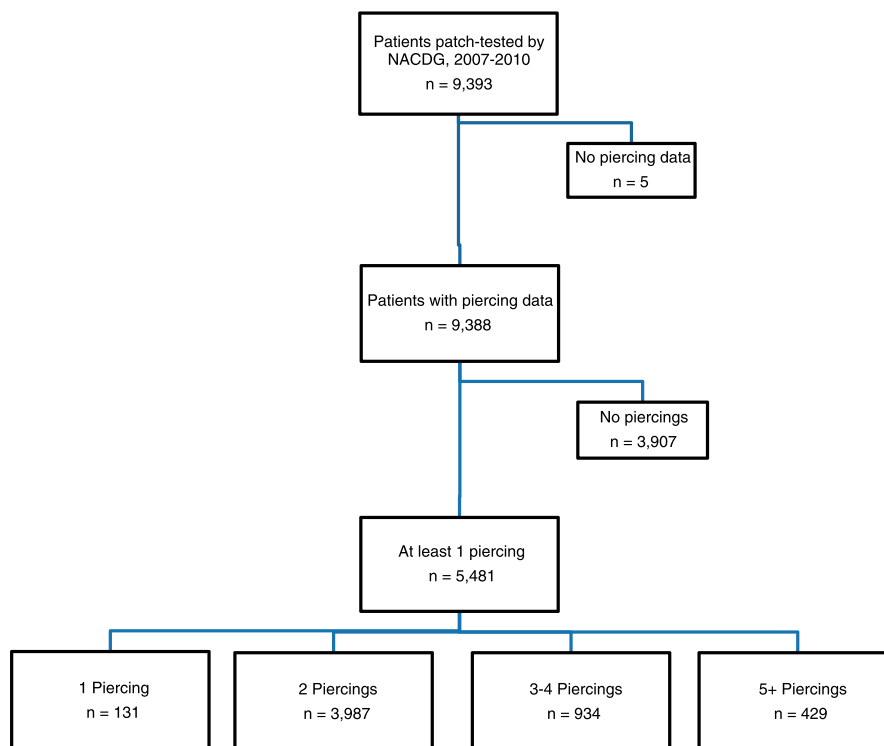


Figure 1.

TABLE 2. Demographics of Unpierced and Pierced Patients Referred for Patch Testing

Demographic Data	Overall (n = 9388)	Pierced (n = 5481)	Unpierced (n = 3907)
Sex			
Male,* n (%)	3189 (34.0)	243 (4.4)	2946 (75.4)
Age,† y			
Average	48.43	46.26	51.96
Range	0–98	2–98	0–95
>40,* n (%)	2898 (30.9)	1681 (30.7)	1217 (31.2)
Race, n (%)			
White	8190 (87.2)	4708 (85.9)	3482 (89.1)
Black	411 (4.4)	285 (5.2)	126 (3.2)
Asian	401 (4.3)	241 (4.4)	160 (4.1)
Hispanic	197 (2.1)	120 (2.2)	77 (2.0)
Other	189 (2.0)	127 (2.3)	62 (1.6)
Atopy, n (%)			
Eczema*‡	2071 (22.1)	1348 (24.6)	723 (18.5)
Asthma‡	1413 (15.1)	902 (16.5)	511 (13.1)
Hay fever§	2812 (30.0)	1739 (31.7)	1073 (27.5)
Site, n (%)			
Hand*	2392 (25.5)	1261 (23.0)	1131 (28.9)
Leg*	1027 (10.9)	500 (9.1)	527 (13.5)
Face*	1920 (20.5)	1387 (25.3)	533 (13.6)
Occupation related,* n (%)	1024 (10.9)	501 (9.1)	523 (13.4)

*MOAHLFA index.

†Age not specified for 6 patients (2 unpierced and 4 pierced patients); denominators were adjusted accordingly.

‡Eczema/asthma status not indicated for 2 patients (unpierced); denominators were adjusted accordingly.

§Hay fever status not indicated for 4 patients (3 unpierced and 1 pierced patients); denominators were adjusted accordingly.

||Total of any of up to 3 sites listed.

n = 9382). Coreactivity and comparisons between allergen sensitivities were examined using only patients who were tested for all 3 metals (n = 9329).

Analytic Methods

Counts and proportions were determined for demographic and allergen-related data (Excel 2010; Microsoft Corporation, Redmond, WA). The data from pierced patients were compared with those from patients with no piercings using Pearson or Mantel-Haenszel

χ^2 tests as well as Fisher exact test (2 tailed) when appropriate (SAS 9.2; SAS, Cary, NC). To account for multiple comparisons (n = 45), the Bonferroni correction³² was used and a P value of <0.001 was considered significant.

RESULTS

Demographics

Piercing data was available for 9388 of the 9393 patch tested patients; those with 2 piercings were the largest group (42.5%), followed by no piercings (41.6%; Fig. 1). Demographic information including MOAHLFA index³³ from the overall study data set as well as from the unpierced and the pierced groups is presented in Table 2. Most patients were women (66%), white (87%), and aged 40 years or younger (69%). Most of the women were pierced (84.4%), whereas only 7.6% of men were pierced.

Nickel

Nine thousand three hundred thirty-four patients were patch tested to nickel. Of these, 17.7% (1651 patients) had a positive reaction. Nickel sensitivity was statistically associated with at least 1 piercing (RR, 2.52; 95% confidence interval [CI], 2.26–2.81; $P < 0.0001$) and nickel sensitivity rates increased with the number of piercings (16.0% for 1 piercing to 32.4% for ≥ 5 piercings; Table 3). The prevalence of nickel sensitivity was higher in females (23.2%) than in males (7.1%), but the association with piercing was stronger in males (RR, 2.38; 95% CI, 1.72–3.30; $P < 0.0001$) than in females (RR, 1.30; CI, 1.13–1.49; $P = 0.0002$; Table 4). Nickel sensitivity was more common in younger individuals and decreased with age in both sexes (Table 4).

Cobalt

Nine thousand three hundred seventy-eight patients were patch tested to cobalt. Overall, 7.3% (685 patients) had a positive reaction to cobalt. Crude data showed that cobalt sensitivity was statistically associated with piercing (RR, 1.63; 95% CI, 1.40–1.91; $P < 0.0001$) and that sensitivity rate modestly increased with the number of piercings (7.6%–11.7%; Table 3). However, stratified analysis showed that the relationship between cobalt and piercing was confounded by nickel (Table 6). After adjusting for nickel

TABLE 3. Positive Reactions to Metals by Number of Piercings

Metal	No. Piercings					
	Unpierced	>1 Piercings	1	2	3–4	>5
Nickel (n = 9334)*	9.4% (365/3894)	23.6% (1286/5440)	16.0% (21/131)	22.6% (893/3951)	25.0% (234/932)	32.4% (138/426)
Cobalt (n = 9378)†	5.3% (208/3904)	8.7% (477/5474)	7.6% (10/131)	8.2% (328/3980)	9.5% (89/934)	11.7% (50/429)
Chromium (n = 9382)‡	4.3% (166/3903)	2.6% (140/5479)	3.8% (5/131)	2.6% (103/3985)	2.5% (23/934)	2.1% (9/429)

*Fifty-four patients were not tested for nickel; denominators were adjusted accordingly.

†Ten patients were not tested for cobalt; denominators were adjusted accordingly.

‡Six patients were not tested for chromium; denominators were adjusted accordingly.

TABLE 4. Positive Nickel Reactions by Sex and Age

	Pierced, %	Unpierced, %	RR	95 % CI	P
Overall					
Male (n = 3182)	15.2	6.4	2.38	1.72–3.30	<0.0001
Female (n = 6152)	24.0	18.5	1.30	1.13–1.49	0.0002
<20 y					
Male (n = 177)	30.0	16.2	1.86	0.68–5.08	not significant
Female (n = 330)	32.5	40.2	0.81	0.59–1.11	not significant
20–39 y					
Male (n = 684)	21.1	8.8	2.40	1.54–3.73	0.0001
Female (n = 1692)	29.2	18.6	1.57	1.13–2.18	0.0037
40–59 y					
Male (n = 1312)	8.7	5.5	1.60	0.82–3.11	not significant
Female (n = 2725)	24.1	19.7	1.23	0.98–1.53	not significant
>60 y					
Male (n = 1012)	6.3	4.5	1.38	0.20–9.41	not significant
Female (n = 1445)	14.8	12.4	1.19	0.87–1.63	not significant

sensitivity, the adjusted Mantel-Haenszel risk ratio for piercing and cobalt was 0.78 (0.66–0.92; $P = 0.0038$ —not significant after adjusting for multiple comparisons). Cobalt sensitivity was more prevalent in females (8.6%) than in males (4.8%) and generally decreased with age. Strength of association with piercing was not statistically significant when the 2 sexes were compared overall or by age group (data not shown).

Chromium

Nine thousand three hundred eighty-two patients were patch tested to chromium. Overall, 3.26% (306 patients) had a positive reaction to chromium. Chromium sensitivity was negatively associated with piercing (RR, 0.60; 95% CI, 0.48–0.75; $P < 0.0001$) and sensitivity rates decreased with increasing number of piercings (3.8%–2.1%; Table 3). Sensitivity to chromium was higher in males (4.7%) than in females (2.2%). The negative association with piercing was not statistically significant when sexes were compared overall and by age group (data not shown).

Positive Reactions in Patients Tested for All Metals

Nine thousand three hundred twenty-nine patients were tested for all 3 metals; 3891 (41.7%) patients were unpierced and 5438 (58.3%) patients had at least 1 piercing. Overall, 2069 (22.2%) patients had a positive reaction to at least 1 metal; pierced individuals were 1.84 times more likely to have a reaction to any metal as compared with patients with no piercings (95% CI, 1.69–2.01; $P < 0.0001$; Table 5). Of the patients who had a positive reaction to any metal, 1550 (74.9%) reacted to only 1 metal; sensitivity to nickel alone was strongly associated with piercing (RR, 2.69; 95% CI, 2.25–3.07; $P < 0.0001$), sensitivity to cobalt alone was not statistically associated with piercing, and sensitivity to chromium alone was negatively associated with piercing (RR, 0.45; 95% CI, 0.33–0.62; $P < 0.0001$; Table 5).

Four hundred seventy-eight patients reacted to only 2 metals. The risk for sensitivity to any 2 metals was associated with piercing (RR, 1.82; 95% CI, 1.50–2.21; $P < 0.0001$), driven largely by those allergic to both nickel and cobalt (RR, 2.62; 95% CI, 2.05–3.34; $P < 0.0001$; Table 5); chromium/nickel or chromium/cobalt paired

TABLE 5. Positive Reactions in Patients Tested for All 3 Metals

Positive Reaction	Overall (n = 9329), n (%)	Pierced (n = 5438), n (%)	Unpierced (n = 3891), n (%)	Pierced vs Unpierced	
				RR (95% CI)	P
Any metal	2069 (22.2)	1492 (27.4)	577 (14.8)	1.84 (1.69–2.01)	<0.0001
Only 1 metal	1550 (16.6)	1120 (20.6)	430 (11.1)	1.86 (1.68–2.07)	<0.0001
Nickel	1180 (12.7)	932 (17.1)	248 (6.4)	2.69 (2.35–3.07)	<0.0001
Cobalt	212 (2.3)	127 (2.3)	85 (2.2)	1.07 (0.81–1.40)	NS
Chromium	158 (1.7)	61 (1.1)	97 (2.5)	0.45 (0.33–0.62)	<0.0001
Two metals	478 (5.1)	43 (6.3)	135 (3.5)	1.82 (1.50–2.21)	<0.0001
Nickel and cobalt	373 (4.0)	293 (5.4)	80 (2.1)	2.62 (2.05–3.34)	<0.0001
Nickel and chromium	55 (0.6)	30 (0.6)	25 (0.6)	0.86 (0.51–1.46)	NS
Cobalt and chromium	50 (0.5)	20 (0.4)	30 (0.8)	0.48 (0.27–0.84)	NS
All 3 metals	41 (0.4)	29 (0.5)	12 (0.3)	1.73 (0.88–3.38)	NS

TABLE 6. Metal Coreactivity by Piercing Status

Metal	Pierced	Unpierced	RR	95% CI	P
Nickel positive					
	n = 1284	n = 365			
Cobalt	22.8%	21.9%	1.04	0.84–1.30	not significant
Chromium	2.3%	6.9%	0.06	0.03–0.09	<0.0001
Cobalt positive					
	n = 469	n = 207			
Nickel	62.5%	38.7%	1.62	1.34–1.95	<0.0001
Chromium	4.3%	14.5%	0.29	0.17–0.51	<0.0001
Chromium positive					
	n = 140	n = 164			
Nickel	14.3%	15.2%	1.41	0.87–2.27	not significant
Cobalt	21.4%	18.3%	0.78	0.46–1.31	not significant
Nickel negative					
	n = 4154	n = 3526			
Cobalt	1.95%	3.60%	0.54	0.41–0.71	<0.0001
Chromium	3.54%	2.77%	1.07	0.83–1.35	not significant
Cobalt negative					
	n = 4969	n = 3684			
Nickel	19.36%	7.41%	2.61	2.30–2.97	<0.0001
Chromium	1.83%	3.31%	0.55	0.42–0.72	<0.0001
Chromium negative					
	n = 5298	n = 3727			
Nickel	23.12%	8.80%	2.62	2.34–2.95	<0.0001
Cobalt	7.93%	4.43%	1.79	1.50–2.13	<0.0001

sensitivities were not statistically associated with piercing. Only 41 patients reacted to all 3 metals; sensitivity to all 3 metals was not associated with piercing (Table 5).

Occupational Relatedness

Of the 1651 positive nickel reactions, 69 (4.2%) were deemed related to occupation; occupation association was higher for cobalt (6.3%) and chromium (18.0%). Table 7 lists these characteristics by piercing status. For all 3 metals, occupational relatedness of the metal reactions was lower in pierced individuals than in unpierced individuals.

DISCUSSION

There are several important findings of this study. First, nickel allergy was statistically associated with piercing. Individuals with nickel sensitivity were 2.5 times more likely to have at least 1 piercing. Furthermore, this association was dose dependent; higher rates of nickel allergy were associated with greater piercing number. Second, although the overall sensitivity of nickel allergy was higher in females, the relationship between nickel allergy and piercing was stronger in males (RR, 2.38) than in females (RR, 1.30). Third, although crude analysis showed that cobalt sensitivity was associated with piercing, stratified analyses found that this association was caused by the confounding effect of

nickel. Fourth, there was a negative association of chromium sensitivity with piercing.

Nickel Allergy/Piercing

Consistent with previous reported studies,^{10–12,14–24} we found that nickel sensitization is associated with piercing. Our risk for nickel sensitization is lower than the previous studies. Kerosuo et al¹⁹ found that, in 700 adolescents, the odds of nickel sensitization was 4.8 in pierced adolescents as compared with unpierced adolescents (95% CI, 1.6–14.6). Mattila et al²³ found that, in 284 university students, the odds of nickel sensitization was 12.4 (95% CI, 5.6–27.4). This difference could be explained by a younger population in these 2 studies as compared with our study. A study by Smith-Sivertsen et al¹⁷ involving 1767 adults reported a similar rate to ours (RR, 3.3; 95% CI, 1.01–5.43).

Nickel Allergy Relationship With the Number of Piercings

We also found that the relationship between nickel allergy and piercing was dose dependent, a finding consistent with several studies.^{11,14,17,19,22,24} Only 1 study found no significant association between the number of piercings and nickel sensitivity; that Finnish study evaluated 284 university students and compared 1 to 2 piercings vs 3 or more piercings.²³ With a large study population, we expanded the stratification by piercing level and further substantiated this dose-dependent relationship. Our study did not collect data on body piercing location. Although it is possible that there may be some predilection for sensitization in certain body sites (eg, nasal ala, tongue, umbilicus, genitalia), this has not been studied, to our knowledge.

Nickel Allergy/Piercing Association by Age

The prevalence of nickel allergy and frequency of piercing are higher in younger populations and often trend together.^{12,17,20} We found that, in addition to these trends, the association of nickel sensitivity and piercing was highest in young adults (20–39 years). Van Hoogstraten et al¹⁶ also found a stronger association in young women (younger than 35 years) compared with older women.

TABLE 7. Occupational Relatedness of Positive Metal Patch Test Reactions by Piercing Status

		Occupational Related, n (%)	
		Yes	No
Nickel sensitive (n = 1651)	Pierced (n = 1286)	36 (2.8)	1250 (97.2)
	Unpierced (n = 365)	33 (9.0)	332 (91.0)
Cobalt sensitive (n = 685)	Pierced (n = 477)	17 (3.6)	460 (96.4)
	Unpierced (n = 208)	26 (12.5)	182 (87.5)
Chromium sensitive (n = 306)	Pierced (n = 140)	10 (7.1)	130 (92.9)
	Unpierced (n = 166)	45 (27.1)	121 (72.9)

Nickel Allergy/Piercing Association by Sex

Although 2 previous studies of men only^{21,24} found an association of nickel allergy and piercing and 1 study¹⁶ found a similar correlation in young males, others have found no statistically significant association of piercing and nickel allergy in males.^{17,18,20,22,23} In contrast, we found that the association between nickel allergy and piercing was stronger in males (RR, 2.38) than in females (RR, 1.30). This could be caused by several factors. First, some studies that reported no significant association in males actually showed a positive trend but had low statistical power.^{17,22} Although males do tend to pierce at an older age than females,^{19,23,28} the data are conflicting on whether this is protective for developing metal sensitivity and several studies have found no statistically significant association between age of first piercing and nickel sensitization.^{19,23} Although men wear some metal jewelry (eg, watches, chains), their frequency of jewelry use is likely much less than women; consequently, males' risk for being sensitized to nickel from a source other than piercing is lower, which could explain a stronger association with piercing and nickel sensitivity. Because unpierced women are still very likely to wear clip earrings, necklaces, bracelets, watches, and metal-containing hair ornaments, their nonpierced rate of nickel sensitization would be expected to be higher than in men. This is indeed what we found. Interestingly, in Nigeria, where men wear costume jewelry at equal rates to women, there was no difference in nickel allergy prevalence between the sexes.³⁴

Other studies have sought to determine the effect of piercing and exposure to orthodontic metals on nickel sensitization. Fors et al¹⁴ found that the risk for nickel sensitivity almost halved when orthodontic appliance treatments preceded exposure to piercing, postulated to be caused by oral tolerance. This is similar to previous studies that showed a reduced frequency of nickel sensitivity in pierced individuals when nickel-containing orthodontic appliances preceded piercing by a certain length of time.^{17–19} Our study did not evaluate timing of piercing or exposure to dental orthopedic devices.

Cosensitivity and Association of Chromium and Cobalt With Piercing

Several studies evaluated the association of piercing with metals other than nickel. Nakada et al¹⁰ found a positive association with gold sensitivity in 337 adults. Ehrlich et al²⁴ found an association with allergy to metal in general (nickel, gold, cobalt, palladium) but did not report significant associations for specific metals. Meijer et al²¹ found an association with nickel and/or cobalt sensitivity but did not report data separately for cobalt. Of the other studies that examined piercing and cobalt sensitivity,^{10,16,22} only the study by Van Hoogstraten et al¹⁶ found an association with piercing and cobalt sensitivity and it was only significant in young females who also had the highest rates of nickel sensitivity.

Many studies have documented the cosensitivity of cobalt and nickel.^{2,35–40} This relationship is multifactorial and not well

understood.⁴¹ The high frequency of cosensitivity is often attributed to concurrent exposure to the 2 metals, with sensitization from consumer products including jewelry asserted to be the most common cause of cobalt allergy.¹ Although jewelry can be a source of cobalt contact dermatitis,⁴² the recent development of a cobalt spot test⁴³ has enabled easier testing for cobalt release from consumer products; subsequent analysis of cobalt release from inexpensive jewelry in Denmark, Thailand, and China found that relatively few jewelry items actually release cobalt.^{44,45} A similar study in Korea showed higher rates of cobalt release in certain metal items (eg, belts, 28.6%; hairpins, 14.3%) but found that only 1.0% of earrings had a positive cobalt spot test.⁴⁶ A recent study from Germany, however, found that 43.6% of 87 earrings and piercing jewelry (especially piercing posts) had at least 1 part releasing cobalt.⁴⁷ Although crude analyses identified an association of cobalt sensitization and piercing, when stratified by nickel sensitivity, this association was no longer statistically significant. Further analyses determined that nickel is a confounder for the relationship between cobalt and piercing.

Two previous studies have evaluated chromium sensitivity and piercing and found no statistical association.^{11,23} Our study actually found a negative association. It is unclear whether chromium positivity is protective (unlikely) or whether these groups represent distinct populations with different exposures and risk factors. Chromium is not commonly found in jewelry.²

Unlike Europe, North America has no regulation of nickel content in jewelry. In response to the increasing prevalence of nickel allergy in the general population, government regulations on nickel release from consumer products were initiated in Denmark in the early 1990s, followed by the European Union Nickel Directive in 1994.⁴⁸ Subsequent European studies suggest that these attempts to limit nickel exposure have been successful in decreasing nickel allergy in young females.^{46,49–56} It is unclear what affects these European regulations have had in North America. Detection of nickel sensitivity in North American patch test patients has continued to increase during the last 3 decades.^{57,58} A recent study about nickel content in earrings from the United States (San Francisco) found that 30.7% release excessive nickel.⁵⁹

Study Limitations

There are several limitations to this study. First, the data are descriptive and cannot determine causal relationships. Second, the patients included in the database represent a referral population to tertiary contact dermatitis clinics; it is unlikely that they are representative of dermatology patients, let alone generalizable to the general North American population. Third, direct comparisons between studies may be limited owing to differences in the concentrations of nickel and different metal preparations used for patch testing in European studies. Fourth, we excluded patients who were not tested to metals in these analyses (nickel, *n* = 54; cobalt, *n* = 10; and chromium, *n* = 6); these patients may have not been tested because of previous strong positive patch test reactions.

Exclusion of these patients yields a conservative analysis, and therefore, associations may be stronger than what was found herein. Finally, we were limited to the variables collected in the database.

CONCLUSIONS

This study evaluated the correlation between body piercing and metal sensitivity in a large cohort of patients patch tested in North America. Our results support the conclusions of previous studies that metal allergy and nickel sensitivity are positively associated with body piercing and that this relationship is dose dependent. This relationship was stronger in men than in women as well as in younger individuals. The positive association of piercing with cobalt sensitivity was negated when stratified by nickel sensitivity, and nickel sensitivity was shown to be a confounding variable in relationship. Chromium was negatively associated with piercing.

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