

ORIGINAL ARTICLE

Excessive nickel release from earrings purchased from independent shops and street markets – a field study from Warsaw and London

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Abstract

Background Nickel allergy is frequent and cause morbidity and increased health care costs.**Objective** The aim of this study was to determine the proportion of inexpensive earrings randomly purchased from stores and street markets in two capitals that gave positive dimethylglyoxime (DMG) test reactions and to determine whether the degree of nickel release was related to shop category.**Methods** Random inexpensive metallic earrings were purchased from stores and vendors in London and Warsaw. A qualitative investigation of nickel release by using the DMG test was performed.**Results** DMG testing revealed that respectively 15.1% ($n = 205$) and 18.4% ($n = 206$) of earrings purchased in London and Warsaw released nickel as indicated by positive test outcomes. Stratification by store category showed that DMG test-positive jewellery were mainly purchased from street markets and from stores that were not part of national or international chains.**Conclusions** Despite the EU Nickel Directive having resulted in decreasing prevalence of nickel allergy, a large proportion of inexpensive earrings still release nickel in concentrations that may result in nickel allergy and dermatitis. Authorities should prioritize information campaigns and random inspections as a legislation that is not followed is of limited value.

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Ethical approval

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Introduction

Nickel allergy may develop following repeated or prolonged skin contact with metallic items that release nickel (e.g. jewellery, watches, spectacle frames, hair clasps, mobile phones, coins and work tools).^{1–3} Genetic predisposition exists but environmental nickel exposure is pivotal for the development of nickel allergy.⁴ When a sensitized subject is re-exposed to nickel ions in concentrations that exceed the individual's threshold level for reactivity, allergic nickel dermatitis is elicited. The dermatitis reaction may involve any body area but is most frequently located on the hands and head as these locations are typically in contact with nickel-releasing items. Double-blind placebo-controlled studies have shown that nickel-allergic individuals, but not healthy individuals, may develop hand dermatitis when repeatedly exposed to nickel in low concentrations (10 ppm) on the hands,⁵ or when orally exposed to nickel.⁶ Nickel in medical devices such as endoprosthesis or coronary stents might be a risk factor of dermatitis and instent restenosis since, the majority of these medical devices are made from Nitinol and stainless steel, respectively.^{7–9} Thus, nickel allergy is not just a trivial problem of intolerance to non-precious metal but a chronic condition that increases the risk of morbidity and may lead to sick leave and job change.

Following World War II, the prevalence of nickel allergy increased together with the increasing use of nickel in consumer items.¹⁰ Significant causative exposures changed over the decades from stocking suspenders (1930–60s)¹¹ and jean buttons (1970s)¹² to jewellery, and especially earrings for pierced ears (1980s).^{13,14} In response to the increasing nickel problem, Northern European

countries introduced nickel regulations aimed at the reduction of nickel exposure and prevention of nickel allergy.^{15,16} The EU Nickel Directive, a legislation based on the Danish and Swedish nickel regulations, was adopted by the European Commission and Parliament in 1994 (Table 1).¹⁷ Entry into force of the EU Nickel Directive was linked to the publication of the three reference test methods for control of compliance with the regulation, European Standards developed by CEN. The Nickel Directive entered into force in July 2000, and full force in 2001.

This study investigated the proportion of inexpensive earrings randomly purchased from stores and vendors in Warsaw and London that release nickel in amounts that can elicit nickel dermatitis. This was performed to estimate the magnitude of the nickel problem and to see whether the degree of nickel release from inexpensive earrings randomly purchased from stores and street markets in two capitals was related to shop category. We only investigated nickel release from earrings despite many other types of nickel exposure regulated by the Nickel Directive exist. Earrings were chosen not only because studies recently have been conducted on these items allowing for comparison but also because ear-piercing and thereby the use of earrings is a strong risk factor for nickel allergy.

Materials and methods

Purchase

In January 2010, inexpensive earrings were purchased by J.P.T. in Warsaw and London. Prior to shopping, study terms were decided

Table 1 The EU Nickel Directive and reference methods^{17,30,35–37}

		CEN standard
Part 1	<p><i>Original requirement</i> (before 2005): Nickel was prohibited in post assemblies which were inserted into pierced ears and other pierced parts of the human body during epithelialization of the wound, unless they were homogeneous and the nickel concentration was <0.05%.</p> <p><i>New requirement</i> (from 2005): Nickel release from all items inserted into pierced parts of the body (not only during epithelialization after piercing) should be <0.2 µg/cm²/week.</p>	<p>EN 1810 (Flame atomic absorption spectrometry. Nickel content is expressed as mass of nickel to total mass).</p> <p>EN 1811 (Items under investigation are placed in artificial sweat for 1 week and the concentration of dissolved nickel in the solution is determined by atomic absorption spectrometry (or other methodology) and expressed in µg/cm²/week).</p>
Part 2	Nickel may not be used in products intended to come into direct and prolonged contact with the skin such as earrings, necklaces, bracelets, chains, anklets, finger rings, spectacle frames, wrist-watch cases, watch straps, zippers, buttons and mobile phones if nickel release from the parts coming into direct and prolonged contact with the skin is >0.5 µg/cm ² /week.	EN 1811
Part 3	Nickel is prohibited in products such as those listed under point 2 if they have a coating and if they do not fulfil the requirement under point 2 for a period of at least 2 years of normal use of the product.	<p>EN 12472 (Method for simulation of wear and corrosion for the detection of nickel release from coated items. The item under investigation is exposed to a corrosive atmosphere and then placed in a container together with abrasive chips, water and a wetting agent. The container is rotated to smooth the surface and abrade the coating. Finally, the item is subjected to the EN 1811).</p>

by participating authors. It was agreed that around 200 earrings should be purchased in each city, preferably 10 items from each store, and that only 30–40 earrings should be purchased from street markets. In the event that we could not find 10 earrings in one store, it was acceptable to buy more than 10 earrings from stores that were visited subsequently. We aimed at buying earrings from a broad variety of stores and focused on earrings targeting girls and young women. We did not buy duplicates or return to the same store for further purchase. We only bought earrings with metallic perforating piercing posts and avoided buying clip on earrings.

We spent approximately 1100 € (range 1–10 €) buying 205 earrings in London and 700 € (range 1–12 €) buying 206 earrings in Warsaw. In London, we purchased earrings from 23 stores: 11 chain clothing stores in Oxford Street, 2 chain accessory stores in Westfield Shopping Centre and Oxford Street, respectively, 1 drug store in Oxford Street, 3 market stalls (one in Covent Garden and two at the Saturday morning Church Street market), 1 freestanding jewellery booth in the underground station at Westminster, 1 local artist in Covent Garden, 4 accessory and clothing stores located in Soho, East London and the Paddington areas. In Warsaw, we purchased earrings from 20 stores: eight chain clothing stores, three chain accessory stores and two freestanding jewellery booths located in two different shopping centres (Złote Tarasy and Warszawa Wilenska Shopping Centre), three street market stalls in the shopping area next to the 10th Anniversary Stadium (Stadion Dziesięciolecia) in Praga, one combined clothing and accessory store in Praga, one small local shop selling jewellery and art from local artists in the Praga area, and finally, two accessory

stores located in the underground terrain near the central railway station.

Nickel testing

Testing for nickel release was performed by J.P.T using the dimethylglyoxime (DMG) nickel spot test at the laboratory at Gentofte Hospital. It was prepared by a hospital pharmacy in the Capital Region of Copenhagen. The test solutions were 1% DMG in alcohol and 10% ammonium hydroxide in water. Spots in all individual parts of the earring that came into direct and prolonged skin contact were examined. The test was administered by placing two drops of each solution in succession on a white cotton-wool-tipped applicator that was rubbed for up to 20 s against the test object. A positive reaction was indicated by pink coloration of the applicator, whereas a negative reaction was registered when no colour change was observed. Doubtful reactions, defined as very weak pink reactions or discoloration possibly masking a pink colour, were retested and if the reaction remained doubtful it was considered negative. The detection limit of the DMG test has been estimated to be close to 0.5 µg/cm²/week, and thus a clinically relevant and useful screening test.^{18,19}

Results

Test outcome

DMG testing revealed that respectively, 15.1% and 18.4% of earrings purchased in London and Warsaw released nickel as indicated by positive test outcomes (Table 2). Stratification by store category showed that DMG test-positive jewellery were mainly

Table 2 The proportion of earrings that gave positive dimethylglyoxime (DMG) test reactions stratified by store category and city of purchase in studies performed in different countries and at different times

Study year	City	Type of store and DMG test-positive earrings, % (no. pos./no. tested)				Total
		Clothing (chain)	Accessory (chain)	Other*	Market	
<i>Present study</i>						
2010	London, UK	4.3 (4/93)	0 (0/21)	25.0 (15/60)	38.7 (12/31)	15.1 (31/205)
2010	Warsaw, Poland	3.8 (3/78)	2.5 (1/40)	39.7 (23/58)	36.7 (11/30)	18.4 (38/206)
<i>Results from other studies performed in EU member states</i>						
1999	Stockholm, Sweden† ²¹	0 (0/11)	0 (0/15)	11.1 (2/18)	–	4.5 (2/44)
2002–2003	Stockholm, Sweden‡ ²²	0 (0/18)	0 (0/10)	0 (0/33)	–	0 (0/61)
2010	Stockholm, Sweden‡ ²⁰	0 (0/11)	0 (0/57)	8.6 (3/35)	25.0 (1/4)	3.7 (4/107)
2009	Copenhagen, Denmark ³	4.8 (4/84)	0 (0/36)	31.0 (9/29)	57.1 (12/21)	14.7 (25/170)
<i>Results from studies performed outside of Europe</i>						
2007	San Francisco, USA ²⁷	8.3 (8/97)	26.6 (25/94)	42.9 (12/28)	69.0 (40/58)	30.7 (85/277)
2009	Chengdu and Beijing, China ²⁶	–	–	–	–	31.5 (99/314)
2009	Bangkok, Phuket, Hatyai, Thailand ²⁶	–	–	–	–	29.2 (71/243)

*Defined as stores that seem to have independent ownership and not take part in a chain. These could be accessory or clothing stores, freestanding booths in underground stations or shopping centres, drug stores and local artists.

†Before the EU Nickel Directive came into force.

‡After the EU Nickel Directive came into full force.

–, not tested.

purchased from street markets (36.7% in Warsaw and 38.7% in London) and from stores that seemed to have independent ownership and were not part of national or international chains, e.g. local accessory or clothing stores, freestanding booths in underground stations or malls, drug stores and local artists (39.7% in Warsaw and 25.0% in London). Positive DMG test results were much less frequent in earrings purchased from chain accessory or clothing stores. The proportion of piercing posts (the metallic part that perforates the ear) that gave positive DMG test reactions was 17.5% in earrings from Warsaw and 9.3% in earrings from London. The proportion of pendants (the decorative part hanging from the post or ring) that gave positive DMG test was 5.2% from earrings purchased in Warsaw and 15.0% from earrings purchased in London.

Observations

We found identical earrings on two occasions in different clothing chain stores in London and Warsaw (all DMG test negative). This may indicate that large earring producers cover the European market. Furthermore, we asked salespeople and vendors in smaller individually owned stores and market booths where they had purchased the earrings. Most of their earrings in both London and Warsaw were imported from Thailand, China, the Philippines, Indonesia and India. According to a Turkish sales person from the Church Street Market in London, individuals from an Asian background contacted him and other salespersons from time to time to sell jewellery that they had personally imported from Asian countries. Such vendors will typically cover their travel expenses for visiting family and friends in their former home countries by selling jewellery in their new home country. A salesperson from the underground area at 'Westminster' tube station spontaneously said that his products were nickel free and that authorities had once checked his jewellery for nickel release and found the levels acceptable. He said that authorities typically visit new stores or booths soon after they open (we found two DMG test-positive jewellery from this vendor).

Discussion

About one sixth of inexpensive earrings randomly purchased in Warsaw and London released nickel when analysed with the DMG nickel spot test (Table 2); a test that becomes positive in the presence of nickel in sufficient amounts to elicit nickel dermatitis in nickel-allergic individuals.^{18,19} No difference in the overall proportion of DMG test-positive earrings could be detected between a new (Poland has been an EU member since 2004) and an old (England has been an EU member since 1973) EU member state. However, a difference in the proportion of positive DMG test outcomes was observed when pendants and piercing posts were analysed separately, which could be a random finding. DMG-test positive earrings were mainly purchased from street markets and from stores with independent ownership (e.g. local accessory or clothing stores, freestanding booths in underground stations or

malls, drug stores, and stores displaying art and jewellery from local artists). This finding was in line with results from a recent DMG test study from Copenhagen (Table 2).³

Data from three previous DMG test studies performed in Stockholm, Sweden also supported our finding (Table 2).^{20–22} These studies were designed to investigate nickel release from metal parts in many different consumer items, e.g. several types of jewellery, belts, hair slides, spectacle frames, clothes, watches and buttons sold over the counter, before and 2 and 10 years after the EU Nickel Directive came into force. The proportion of DMG test-positive consumer items decreased significantly from 25% in 1999 to 8% in 2002–2003 and 9% in 2010.^{20–22} In the survey 2010, 61% of 43 items from street markets were DMG test positive. This remarkable decrease after 1999 is suggested to be a result, at least partly, of a national campaign in 1999, launched by the Swedish health authorities.²³ Information about nickel allergy was distributed to manufacturers, importers and retailers, authorities responsible for control, the general public, consumers, school nurses and media. Different channels were used, e.g. campaign postcards distributed in places where young people meet, an informative video for public service TV and information packs distributed to all local government's environmental health offices. To the best of our knowledge, no similar nationwide campaign has been launched concerning the EU Nickel Directive in any other country. It is suggested that it would greatly support compliance with the directive, and protect public health, if similar activities were introduced and possibly repeated in other countries.

In the fall of 2006, Spiewak and Pietowska tried to assess the level of adherence to the EU Nickel Directive by contacting relevant Polish authorities.²⁴ They were telephoned by an assistant pretending to be a consumer concerned about nickel allergy and safety of costume jewellery. She asked how she could examine if jewellery sold in shops complied with the EU Nickel Directive. None of the answering officers could offer her sufficient information or advice. In the second part of the survey, official letters were sent to the above-mentioned authorities, asking the following questions: (i) Which authority is responsible for monitoring jewellery for its conformity with EU Nickel Directive?; (ii) Are re-sellers obliged to produce any proof of the conformity?; (iii) Which authority is issuing such confirmations of conformity?; (iv) To which authority should a concerned client turn to in case of suspicion that the purchased jewellery releases more nickel than allowed?; and (v) Are there any sanctions for the sellers in case of trading items that do not comply with the regulations? The authors have never received any response to these letters.²⁴

The high frequency of DMG test-positive earrings from street markets and individual stores is disturbing. Individuals who buy earrings (and other jewellery) from such places are unlikely to be aware of the nickel allergy problem and may typically work in manual jobs with a high prevalence of hand dermatitis. In the UK, occupational relevance of nickel allergy was present in 22.8% of 368 nickel-allergic dermatitis patients.²⁵ The most common

occupations were retail clerks, hairdressers, domestic cleaners, metal workers and caterers.²⁵ To better protect European consumers, random control visits should be paid more often by authorities to these two categories of stores (individual independent shops and street markets) and information campaigns should be directed at subgroups of people visiting these. A recent DMG test study from China and Thailand showed that mass market earrings on sale frequently released high amounts of nickel (all earrings purchased in this study were inexpensive and mainly bought in markets targeting local head buyers and local tourists).²⁶ Such earrings are likely to end up in street markets and single shops in Europe and the US. Although we only purchased earrings, DMG test results from other jewellery and accessories that can be acquired from such stores are likely to parallel our findings. We only found a few DMG test-positive earrings from national and international chain stores in London and Warsaw (Table 2). The low proportion is likely to be a positive effect of the EU Nickel Directive as the proportion of DMG test-positive earrings sold from national chain stores in San Francisco was relatively high in a recent study (8.3–26.6%) (Table 2).²⁷ However, as national and international chain stores hold the largest share of the earring market in Europe and elsewhere, even a small proportion of DMG test-positive earrings may cause nickel dermatitis (and allergy) in a large group of people. Therefore, large resellers should make an effort to limit nickel release from their products.

The DMG test is an inexpensive and rapid test method that detects when $>0.5 \mu\text{g nickel/cm}^2/\text{week}$ is released.^{18,19} The Danish nickel regulation recommended the DMG test as a method to identify objects that were not in compliance with the regulation.¹⁶ Furthermore, the European Committee for Standardization (CEN) developed the CR 12471 screening procedure based on the DMG test.²⁸ The CR 12471 recommends that DMG testing is preceded by pre-treatment of items with artificial sweat and heat, to affect any protective layer. The DMG test was recently validated against the EN 1811 (the reference test method to show compliance with the Nickel Directive concerning nickel release) by analysing a sample of 96 metallic components from earrings purchased in San Francisco (Table 1).^{29,30} The sensitivity of the DMG test was 59.3% and that the specificity 97.5%.²⁹ Thus, the proportion of earrings that release $>0.5 \mu\text{g nickel/cm}^2/\text{week}$ may be even higher than we estimated in this study.

According to the current version of EN 1811 reference method (Table 1), the amount of nickel release determined by chemical analysis may be multiplied by an adjustment factor of 0.1 before its interpretation of compliance with the EU Nickel Directive.³⁰ This adjustment factor was introduced to compensate for difficulties when calculating complicated area sizes (e.g. of chains), and for the lack of experience. However, the current adjustment factor may greatly alter the interpretation of test data. Thus, a metallic item that releases $4.9 \mu\text{g nickel/cm}^2/\text{week}$ when analysed with the EN 1811 reference method will comply with the EU Nickel Directive if it is multiplied by 0.1 (as $0.49 \mu\text{g nickel/cm}^2/\text{week}$ is below

the limit). A draft revision of EN 1811 is currently in CEN voting procedure and the adjustment factor may hopefully be replaced by a more narrow release range (e.g. $0.28\text{--}0.88 \mu\text{g nickel/cm}^2/\text{week}$) as this is expected to better protect European consumers. Although we found that a high proportion of inexpensive earrings released too much nickel,^{18,19} these earrings may still comply with EU Nickel Directive. However, we submit that this is unlikely, and our findings suggest that authorities preferably should inform different parties, and make more inspection visits to detect selling of consumer items that release too much nickel, especially in the category of individually owned stores and street markets, similar to activities launched in Sweden.²³ Finally, it should be mentioned that a high proportion of piercing posts released $>0.5 \mu\text{g nickel/cm}^2/\text{week}$ as assessed by the DMG test. According to the EU Nickel Directive (Table 1), the release limit for piercing posts is only $0.2 \mu\text{g nickel/cm}^2/\text{week}$ and it is therefore possible that an even greater proportion released more nickel than allowed by the EU Nickel Directive.

The EU Nickel Directive has been into force for 10 years. An effect has been suggested from significant decreasing prevalence of nickel allergy in Danish and German female dermatitis patients under the age of 30 years.^{31,32} Furthermore, the prevalence of nickel allergy was 15.6% in adult Danish women from the general population ear-pierced before the Danish nickel regulation was introduced but only 6.9% in women ear-pierced after its introduction.³³ There is currently no nickel regulation in the US. In recent years, the prevalence of nickel allergy has increased significantly among North American dermatitis patients and especially in young age groups.³⁴ These data clearly suggest that the epidemiology of nickel allergy has evolved differently in the EU and the US.

Taken together, this study showed that DMG test-positive inexpensive earrings were most frequently purchased from street markets and stores that seemed to have independent ownership and were not part of national or international chains. Authorities should prioritize information and random inspections as a legislation that is not followed is of limited value. This study indirectly suggests that low-income groups and young people, who are likely to shop in street markets, are at greater risk of excessive nickel exposure.

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References

- 1 Lidén C, Røndell E, Skare L *et al*. Nickel release from tools on the Swedish market. *Contact Dermatitis* 1998; **39**: 127–131.
- 2 Thyssen JP, Johansen JD, Zachariae C *et al*. The outcome of dimethylglyoxime testing in a sample of cell phones in Denmark. *Contact Dermatitis* 2008; **59**: 38–42.
- 3 Thyssen JP, Menné T, Johansen JD. Nickel release from inexpensive jewelry and hair clasps purchased in an EU country – Are consumers

- sufficiently protected from nickel exposure? *Sci Total Environ* 2009; **407**: 5315–5318.
- 4 Bryld LE, Hindsberger C, Kyvik KO *et al.* Genetic factors in nickel allergy evaluated in a population-based female twin sample. *J Invest Dermatol* 2004; **123**: 1025–1029.
 - 5 Nielsen NH, Menné T, Kristiansen J *et al.* Effects of repeated skin exposure to low nickel concentrations: a model for allergic contact dermatitis to nickel on the hands. *Br J Dermatol* 1999; **141**: 676–682.
 - 6 Jensen CS, Menné T, Lisby S *et al.* Experimental systemic contact dermatitis from nickel: a dose-response study. *Contact Dermatitis* 2003; **49**: 124–132.
 - 7 Hillen U, Haude M, Erbel R *et al.* Evaluation of metal allergies in patients with coronary stents. *Contact Dermatitis* 2002; **47**: 353–356.
 - 8 Köster R, Vieluf D, Kiehn M *et al.* Nickel and molybdenum contact allergies in patients with coronary in-stent restenosis. *Lancet* 2000; **356**: 1895–1897.
 - 9 Gimenez-Arnau A, Riambau V, Serra-Baldrich E *et al.* Metal-induced generalized pruriginous dermatitis and endovascular surgery. *Contact Dermatitis* 2000; **43**: 35–40.
 - 10 Marcussen PV. Variations in the incidence of contact hypersensitivities. *Trans St Johns Hosp Dermatol Soc* 1962; **48**: 40–48.
 - 11 Calnan CD. Nickel dermatitis. *Br J Dermatol* 1956; **68**: 229–236.
 - 12 Brandrup F, Larsen FS. Nickel dermatitis provoked by buttons in blue jeans. *Contact Dermatitis* 1979; **5**: 148–150.
 - 13 Boss A, Menné T. Nickel sensitization from ear piercing. *Contact Dermatitis* 1982; **8**: 211–213.
 - 14 Fischer T, Fregert S, Gruvberger B *et al.* Nickel release from ear piercing kits and earrings. *Contact Dermatitis* 1984; **10**: 39–41.
 - 15 Lidén C. Nickel in jewellery and associated products. *Contact Dermatitis* 1992; **26**: 73–75.
 - 16 Menné T, Rasmussen K. Regulation of nickel exposure in Denmark. *Contact Dermatitis* 1990; **23**: 57–58.
 - 17 The Commission of the European Communities. European Parliament and Council Directive 94/27/EC of 30 June 1994 amending for the 12th time Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of dangerous substances and preparations. *OJ* 1994; **L188**: 1–2.
 - 18 Menné T, Andersen KE, Kaaber K *et al.* Evaluation of the dimethylglyoxime stick test for the detection of nickel. *Derm Beruf Umwelt* 1987; **35**: 128–130.
 - 19 Menné T, Brandrup F, Thestrup-Pedersen K *et al.* Patch test reactivity to nickel alloys. *Contact Dermatitis* 1987; **16**: 255–259.
 - 20 Biesterbos J, Yazar K, Lidén C. Nickel on the Swedish market: follow-up ten years after entry into force of the Nickel Directive. *Contact Dermatitis* 2010; **63**: 333–339.
 - 21 Lidén C, Johnsson S. Nickel on the Swedish market before the Nickel Directive. *Contact Dermatitis* 2001; **44**: 7–12.
 - 22 Lidén C, Norberg K. Nickel on the Swedish market. Follow-up after implementation of the Nickel Directive. *Contact Dermatitis* 2005; **52**: 29–35.
 - 23 Swedish National Institute of Public Health. To prevent nickel allergy. How an EU directive was introduced in Sweden. (Translated from Swedish). 2001: 29.
 - 24 Spiewak R, Pietowska J. Nickel – the unique allergen. From molecular structure to legal regulations. *Alergol Immunol* 2006; **3**: 58–62.
 - 25 Shah M, Lewis FM, Gawkrödger DJ. Nickel as an occupational allergen. A survey of 368 nickel-sensitive subjects. *Arch Dermatol* 1998; **134**: 1231–1236.
 - 26 Hamann C, Hamann DJ, Hamann QJ *et al.* Assessment of nickel release from earrings randomly purchased in China and Thailand using the dimethylglyoxime test. *Contact Dermatitis* 2010; **62**: 232–240.
 - 27 Thyssen JP, Maibach HI. Nickel release from earrings purchased in the United States: the San Francisco earring study. *J Am Acad Dermatol* 2008; **58**: 1000–1005.
 - 28 European Committee for Standardization. Screening tests for nickel release from alloys and coatings in items that come into direct and prolonged contact with the skin. CR12471, 2002: 1–10.
 - 29 Thyssen JP, Skare L, Lundgren L *et al.* Sensitivity and specificity of the nickel spot (dimethylglyoxime) test. *Contact Dermatitis* 2010; **62**: 279–288.
 - 30 European Committee for Standardisation (CEN). Reference test method for release of nickel from products intended to come into direct and prolonged contact with the skin. EN 1811, 1998: 1–15.
 - 31 Schnuch A, Uter W. Decrease in nickel allergy in Germany and regulatory interventions. *Contact Dermatitis* 2003; **49**: 107–108.
 - 32 Thyssen JP, Johansen JD, Carlsen BC *et al.* Prevalence of nickel and cobalt allergy among female patients with dermatitis before and after Danish government regulation: a 23-year retrospective study. *J Am Acad Dermatol* 2009; **61**: 799–805.
 - 33 Thyssen JP, Johansen JD, Menné T *et al.* Nickel allergy in Danish women before and after nickel regulation. *N Engl J Med* 2009; **360**: 2259–2260.
 - 34 Rietschel RL, Fowler JF, Warshaw EM *et al.* Detection of nickel sensitivity has increased in North American patch-test patients. *Dermatitis* 2008; **19**: 16–19.
 - 35 The Commission of the European Communities. Commission Directive 2004/96/EC of 27 September 2004 amending Council Directive 76/769/EEC as regards restrictions on the marketing and use of nickel for piercing post assemblies for the purpose of adapting its Annex I to technical progress. *OJ* 2004; **L301**: 51–52.
 - 36 European Committee for Standardisation (CEN). Body piercing post assemblies. Reference test method for determination of nickel content by flame atomic absorption spectrometry. EN 1810: 1998.
 - 37 European Committee for Standardisation (CEN). Method for the simulation of wear and corrosion for the detection of nickel release from coated items. EN 12472: 1998.