

Nickel on the Swedish market: follow-up 10 years after entry into force of the EU Nickel Directive

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Background: The EU Nickel Directive, aimed at primary and secondary prevention of nickel allergy by limitation of nickel release from certain items, came fully into force in July 2001.

Objectives: To assess the prevalence on the market of items with nickel release and to compare the outcome with previous studies performed in Sweden in 1999 and 2002–2003.

Materials and Methods: Nickel release from 659 items covered by the EU Nickel Directive was assessed with the dimethylglyoxime (DMG) test. Special attention, as compared with the previous surveys, was given to cheap jewellery in street markets and sewing materials in haberdashery shops.

Results: Nickel release was shown for 9% of the tested items, all of which were intended for direct and prolonged contact with the skin. A high proportion of items bought at haberdashery shops and street markets, 34% and 61%, respectively, showed nickel release.

Conclusions: The Swedish market for products intended for direct and prolonged contact with the skin has largely adapted to the Nickel Directive. It is suggested that authorities should monitor the market regularly and give attention to areas where compliance with the requirements is poor, for protection of public health.

Key words: allergic contact dermatitis; dimethylglyoxime test; EU legislation; follow-up; nickel allergy; Nickel Directive; prevention. © John Wiley & Sons A/S, 2010.

Conflicts of interest: There are no conflicts of interest to disclose for Jacqueline Biesterbos, Kerem Yazar, or Carola Lidén.

Accepted for publication 18 July 2010

Nickel allergy is by far the most frequent contact allergy, with the median nickel allergy prevalence in the general population being approximately 9% (17% in women and 3% in men) in Western Europe and in North America (1). Nickel allergy and dermatitis are caused by nickel ions deposited onto the skin. Different types of consumer items, such as jewellery, buttons, and spectacle frames, that are in repeated or prolonged contact with the skin, have for many decades been important sources of sensitization to nickel and elicitation of nickel dermatitis. Other sources of consumer and occupational exposure to nickel are also important. Thirty to forty per cent of nickel-sensitive people develop hand eczema, which may become recurrent or chronic, affecting their ability to work and

causing large expenses in society (2). To protect consumers from excessive nickel exposure, nickel release from certain products in direct and prolonged contact with the skin is limited by the EU Nickel Directive. Examples of such products are jewellery, buttons, clothing fasteners, watches, hair clasps, belts, and mobile phones. The Directive, aimed at primary and secondary prevention of nickel allergy, was adopted in 1994, entered into force in July 2000, and came fully into force in July 2001. It was partly revised in 2004, and was included in the EU chemicals regulation REACH from 2009 (3). A brief summary of the three points of the Nickel Directive is presented in Table 1 (4–6).

A baseline study for future follow-up of the effect of the legislation was performed in Stockholm,

Table 1. Brief summary of the EU Nickel Directive (4–6)

Point	Limitation
1	<i>Before 2005:</i> Posts (rings or other items) used during epithelialization after piercing shall not contain more than 0.05% nickel. <i>From 2005:</i> Nickel release from all items inserted into pierced parts of the body (not only during epithelialization after piercing) shall be less than 0.2 µg/cm²/week.
2	Objects intended to be used in direct and prolonged contact with the skin shall not release more than 0.5 µg nickel/cm²/week; the Directive lists examples of such items, including jewellery, watches, buttons, and zips. <i>From 2009:</i> also mobile phones.
3	Items covered by point 2 shall fulfil the requirements for 2 years of normal use.

Sweden in 1999, when 725 products on the market were subjected to the dimethylglyoxime (DMG) test for nickel release (7). Of the tested items, 25% were DMG test-positive, indicating that they would not comply with the Nickel Directive. The first follow-up was performed in 2002–2003 (8). Nickel release was shown for 8% of 786 items intended for direct and prolonged contact with the skin, a significant decrease as compared with the baseline study in 1999. It was concluded that there had been significant adaptation to the requirements of the Nickel Directive in Sweden. More limited studies of nickel release from jewellery and some other types of item on the market have been performed in some other countries with the DMG test (9–14) or by nickel release in artificial sweat (13).

Nickel allergy is still the most frequent cause of contact allergy worldwide. Several studies from Denmark strongly indicate a beneficial effect of the limitation of nickel exposure introduced in Denmark before the Nickel Directive (15–17). The prevalence of nickel allergy among young female dermatitis patients and in the general population has decreased in Denmark. Similar developments have been shown in some other countries (18, 19).

The objective of the present study was to assess the effect of the EU Nickel Directive, 10 years after its entry into force, with regard to nickel release from certain items on the market in Sweden. The aim was also to compare the current situation with what was found in a baseline study before and a follow-up study shortly after entry into force of the regulation.

Materials and Methods

The study was performed in May 2010 in Stockholm, Sweden. The intention was to select items that would be as representative as possible of consumer exposure in Sweden to items covered by the Nickel Directive.

Selection of the shops and items

The central managements of 10 nationwide chains or local shops selling jewellery, accessories, watches or clothes were contacted. All accepted the invitation to participate in the study, and contact with shops in the city of Stockholm was provided. Eight of 10 such shops had participated in previous years, and two had not participated previously. Eight of the shops belonged to nationwide chains, some of them being present also on the international market. A local shop specialized in piercing and selling jewellery for pierced holes, and a shop with jewellery/accessories directed to young people, participated, as in the two previous studies. Thus, a total of 10 shops selling jewellery, watches and clothes participated, and selected items were tested in the shops. Additionally, three haberdashery shops, two street markets in the city centre and one hobby shop were visited to buy items. In total, 659 items with metal parts in contact with the skin were sampled for DMG testing (Table 2); 561 were tested at the shops and 98 in our laboratory.

As compared with the studies in 1999 and 2002–2003, the selection was widened to also include items from a shop selling products for customers to make their own jewellery and clothing (hobby store), and increased numbers of items from street markets and from haberdashery shops. Shoes,

Table 2. Product types and types of item tested with the dimethylglyoxime (DMG) test in 2010 in Stockholm, Sweden (*n* = 659)

Product type	Types of item (number of items tested)
Jewellery and accessories (<i>n</i> = 458) ^a	Ankle bracelet (5), belt (46), bracelet (82), braces (6), brooch (6), cufflink (2), diadem (5), earring (86), finger ring (67), hair band (6), hair clasp (30), hair pin (2), hair slide (1), lip piercing jewellery (4), lock (2), navel piercing jewellery (11), necklace (80), nose piercing jewellery (2), nose ring (2), pendant (10), tiara/crown (2), toe ring (1)
Watches (<i>n</i> = 23) ^b	Watch (23)
Clothes (<i>n</i> = 123), metal items in	Bathrobe (1), bikini (2), body (4), bra (10), cap (1), cardigan (1), dress (13), gardener's trousers (2), jacket (17), jeans (23), night gown (3), overalls (1), raincoat (1), shorts (3), skirt (10), suspenders (3), sweater (7), swimming trunks (1), trousers (17), T-shirt (3)
Sewing materials (<i>n</i> = 38)	Belt buckle (11), chain (2), clasp (6), jeans button (2), push button (3), safety pin (3), watchband (1), zipper (10)
Hobby materials (<i>n</i> = 17)	Chain (4), earring (2), hair clasp (1), pendant (9), push button (1)

^aIncluding 38 items bought at a street market: ankle bracelet (3), belt (6), bracelet (10), earring (2), finger ring (8), navel piercing jewellery (2), and necklace (7).

^bIncluding five items bought at a street market.

spectacle frames and watches in watch shops were not included in the present study.

The item selection was made by one of the authors (J.B.) on the basis of current fashion and availability in the stores, to cover different designs, producers, price levels, and intended user groups. No help from shop assistants was received in the selection of items for testing. The intention was to select roughly the same types of item, in equal proportions as in the previous studies, with some exceptions.

DMG test

The DMG test was carried out in the shops, often behind the shopping area, to detect nickel release from jewellery, watches, and metal parts in clothing. Items purchased from street markets, the hobby store and haberdashery shops were tested in our laboratory. Two investigators carried out the work together; one of the authors (J.B.) was always present.

Metal parts that may come into contact with the skin during normal use of items were tested with the DMG test. More than one spot was tested in many items. In total, 659 items and 1182 spots were tested. The DMG test (Chemo Nickel Test™; Chemotechnique Diagnostics®, Vellinge, Sweden), containing 1% DMG, ethanol and ammonium hydroxide (9.9%) solution in one bottle together, was administered by placing two or three drops of the test solution on a white cotton-wool-tipped stick that was rubbed for up to 20 seconds against the spot to be tested. The colour of the cotton was then read against a white background. The result was recorded and classified as negative (no colour), positive (pink or red colour), or doubtful (discoloration, not possible to classify) (Fig. 1). In case of discoloration, the surface was wiped with ethanol and the test was repeated; both the results and the colour of the discoloration were recorded. Items that showed discoloration during the second test were classified as doubtful. Items that did not show discoloration or pink coloration during the second test were classified as negative. Items tested on more than one spot were classified as DMG test-positive when at least one spot was positive.

Results

The results from the DMG test are presented in Table 3 and in Figs. 2 and 3. The results from the baseline study in 1999 (7) and the follow-up study in 2002–2003 (8) are included for comparison.

In total, 659 items and 1182 spots were subjected to the DMG test in the present study; 9% of the items and 8% of the spots tested positively (Figs. 2

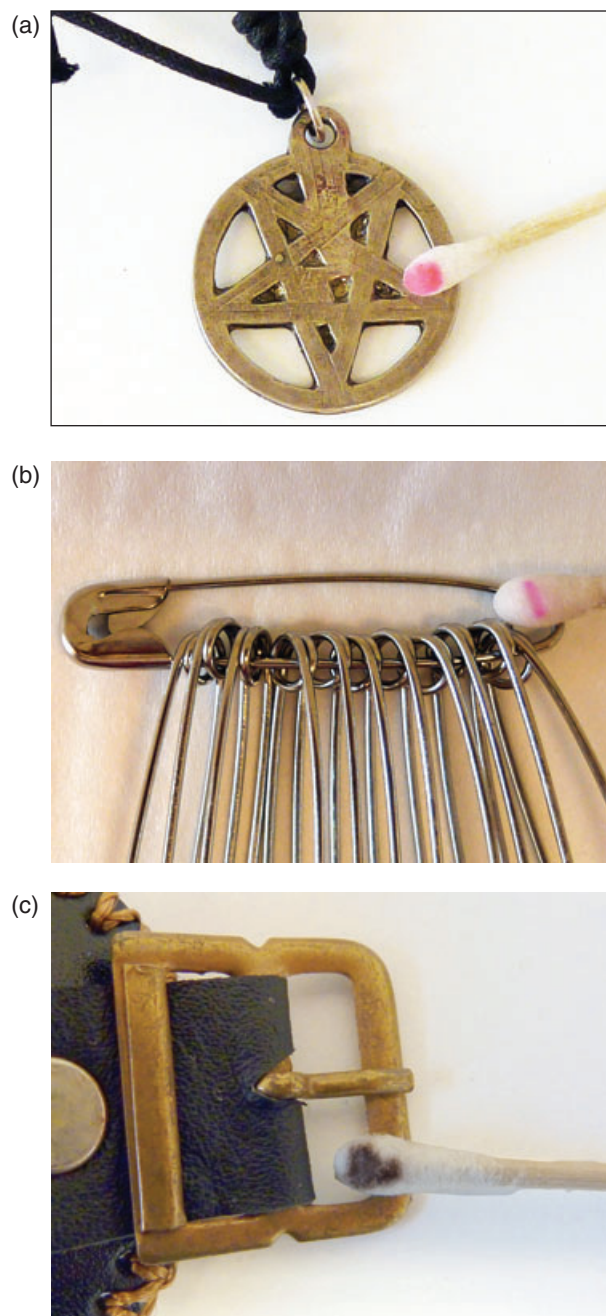


Fig. 1. Examples of reactions with the dimethylglyoxime (DMG) test in a follow-up study in 2010 of nickel on the Swedish market: (a) necklace and (b) safety pins with positive DMG test results (red colour indicates nickel release); (c) belt with doubtful DMG test result (discoloration that may mask a red colour produced by nickel).

and 3). Doubtful results owing to discoloration were recorded for 7% of the items. Most cases of discoloration were found in items with a goldish or yellowish colour, mainly in zippers, jeans buttons, and cheap jewellery.

The proportion of DMG test-positive items varied between product types (Fig. 2). The largest proportion of DMG test-positive items was found

Table 3. Summary of results of dimethylglyoxime (DMG) testing of items in 1999 (7), 2002–2003 (8) and 2010 in Stockholm, Sweden

DMG test result	Number (% of all tested)		
	Baseline study, 1999, <i>n</i> = 725	Follow-up study, 2002–2003, <i>n</i> = 786	Follow-up study, 2010, <i>n</i> = 659
Positive	180 (25)	66 (8)	62 (9)
Negative	524 (72)	651 (83)	551 (84)
Doubtful	21 (3)	69 (9)	46 (7)

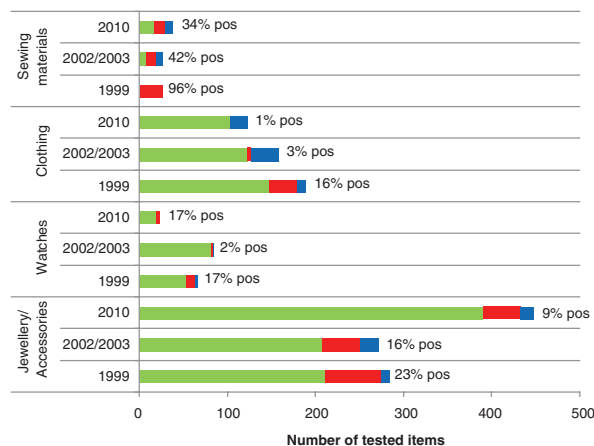


Fig. 2. Results of dimethylglyoxime (DMG) testing of items on the Swedish market in 1999 (*n* = 725), 2002–2003 (*n* = 786) and 2010 (*n* = 659) by product type. Twenty-five per cent of all tested items were DMG test-positive in 1999, as were 8% in 2002–2003 and 9% in 2010. Note that the product group hobby materials (6% positive in 2010, data not shown) was not tested in 1999 and 2002–2003. ■ = DMG test-negative; ■ = DMG test-positive; ■ = Doubtful.

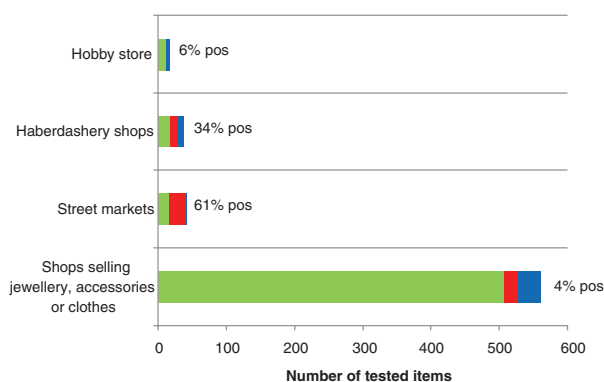


Fig. 3. Results of dimethylglyoxime (DMG) testing of items on the Swedish market in 2010 by source of selection. In total, 659 products were tested in shops selling jewellery, accessories or clothes (*n* = 561), street markets (*n* = 43), haberdashery shops (*n* = 38), and the hobby store (*n* = 17). ■ = DMG test-negative; ■ = DMG test-positive; ■ = Doubtful.

among sewing materials (34%; 13 positive/38 tested), followed by watches (17%; 4 positive/23 tested) and jewellery/accessories (9%; 43 positive/458 tested).

The type of item, among jewellery/accessories, with the largest proportion of DMG test-positive results was belts (22%; 10 positive/46 tested), followed by bracelets and necklaces (11% each; 9 positive/82 or 80 tested). Four per cent of all earrings were DMG test-positive (3 positive/86 tested). No DMG-positive test results were found for hair clasps etc. (34 tested). The lowest proportions of DMG test-positive items were found in clothing (1%; 1 positive/123 tested) and hobby materials (1 positive/17 tested). The types of sewing materials from haberdashery shops with the highest rate of DMG test positive results were safety pins (2 positive/3 tested), clasps (3 positive/6 tested), belt buckles (4 positive/11 tested) and zippers (3 positive/10 tested).

The proportion of DMG test-positive items varied between sources of selection (Fig. 3). Shops for jewellery/accessories and clothes demonstrated an overall small proportion of DMG test-positive items (4%; 22 positive/561 tested; two items in shops belonging to nationwide chains, and 20 items in a local shop directed at young people). The proportion of DMG test-positive items was small (1 positive/17 tested) in the shop selling products for customers to make their own jewellery and clothes. Items from street markets and haberdashery shops had much larger proportions of DMG test-positive items: 61% (26 positive/43 tested) and 34% (13 positive/38 tested), respectively. The watches in the present study were mainly from street markets, whereas in the two previous studies they were mainly from watch shops.

Discussion

We have shown that the significant reduction in the number of items with nickel release on the market in Sweden, noted from 1999 to 2002–2003, has been sustained 10 years after the EU Nickel Directive entered into force. The present study shows only small differences between 2002–2003 and 2010 in the proportion of DMG test-positive items. In 2010, 9% of the selected items were DMG test-positive, as compared with 8% in 2002–2003 and 25% in 1999. This indicates that those responsible for what is made available to consumers by large chains and some small shops are continuing to make serious efforts to adapt to the requirements of the Nickel Directive.

In the present study, we did not test shoes, spectacle frames, or watches in watch shops, although this was done in the two previous studies. Instead, special attention was paid to sewing materials sold in haberdashery shops and cheap jewellery sold on street markets, as our previous studies (7, 8) and studies in other countries (9, 12) indicate larger

problems in these areas. These results were confirmed by our present study showing that 34% of the items bought in haberdashery shops and 61% of those bought in street markets were DMG test-positive. Recent publications have described excessive nickel release and contact dermatitis from mobile phones, which are increasingly used by all groups in the society (11). Mobile phones were recently included among items covered by the EU Nickel Directive (6), but they were not tested in the present study.

The DMG test is cheap, quick, and easy to perform. It is generally recommended to nickel-allergic patients by dermatologists for exposure reduction. Sometimes, its sensitivity and suitability for control of compliance with the Nickel Directive has been questioned. However, a recent validation study (20) clearly showed that the DMG test is a valuable screening tool for this purpose. Because of the modest sensitivity of the DMG test, it is possible that some items with nickel release around the limit values of 0.5 and 0.2 $\mu\text{g}/\text{cm}^2/\text{week}$ are not detected by the test. Therefore, the figures for positive DMG test results in the present study may be underestimations. The reference test method, EN 1811, which involves chemical analysis of nickel released from items stored for 1 week in artificial sweat, is labour-intensive and expensive, and thus less suitable for large market surveys (20). The DMG test, however, is considered to be very useful for monitoring the market concerning compliance with the EU Nickel Directive.

The larger proportion of items with doubtful DMG test results owing to discoloration in the present study and 2002–2003 (7% and 9%, respectively) than in 1999 (3%) indicates a change in the materials used. It is known among metallurgists and chemists that metals other than nickel may produce colours other than the typical red colour (light pink to strong cerise) produced by nickel, for example, reddish–brown by iron and black or blue by cobalt. However, these reactions are not specific enough for assessment of other metals. Discoloration has, to the best of our knowledge, not been discussed in publications on market surveys with the DMG test, except by us (7, 8). Perhaps the phenomenon has not been noted by those who have mainly tested jewellery; we recorded it mainly in zippers and jeans buttons, and in only some cheap jewellery. It is important to recall that discoloration may mask the red or pink colour of a positive DMG test result. Specific spot tests for other sensitizing metals are needed. A spot test for cobalt has recently been developed and described (21).

Studies of nickel release from items on the market have been performed with the DMG test in some other countries, particularly concerning

earrings (9, 12), belts (10), hair clasps (22), and items intended for children (13). In all studies that we are aware of, the proportion of items with positive DMG test results has been much larger than in the present study in Sweden. The results have generally been similar to those in the 1999 baseline study (7). No study, except for ours, has adopted a broad approach covering many types of items, shops and consumer groups in the same study. No DMG test-positive hair clasps were found in the present study; the majority were intended for children or young persons, and all were tested in shops belonging to national chains. It is considered likely that the result would have been different if hair clasps from street markets had been included. Twenty-five per cent of all belts and belt buckles in the present study were DMG test-positive, including items from shops belonging to nationwide chains, local shops, and street markets. It is important to recall that belts and hair clasps may come into direct and prolonged contact with the skin, and this may easily be overlooked.

The present study shows that nickel release from items on the market in Sweden has decreased substantially during the 10 years with the EU Nickel Directive. The situation is obviously more positive than in other countries where studies of items on the market have been performed. We consider it most likely that a nationwide information campaign implemented in Sweden in 2000 concerning nickel allergy and the Nickel Directive contributed significantly to the positive development (23). The campaign was led by the Swedish National Institute of Public Health, together with the Swedish Chemicals Agency, the National Board of Health and Welfare, the Swedish Consumer Agency, Stockholm County Council Centre for Public Health, Apoteket AB, and the Asthma and Allergy Association. Information was designed for and aimed at producers, importers, retailers, the general public, consumers, and authorities responsible for control. A video for public service TV, an information package sent to all local government environmental health offices and campaign postcards directed at young people were used in the campaign.

During the testing in ordinary shops, we noticed that some sales assistants were aware of the EU Nickel Directive, whereas others had no knowledge of the legislation. Most of the participating large companies have a policy regarding nickel in products. Products are, according to company representatives, tested with the DMG test before they appear in the shop. Furthermore, several shops labelled jewellery and accessories as 'nickel-free'. We, however, consider such labelling to be misleading, confusing, and unnecessary. One reason is that high-quality stainless steel products containing

nickel generally release very small amounts of nickel, and thus comply with the Nickel Directive, but it is wrong and misleading to label them as 'nickel-free'. Another reason is that all items covered by the Nickel Directive have to comply with the requirements. The label may also be used falsely, as illustrated by one earring in the present study, which was DMG test-positive but declared to be 'nickel-free'. In general, the shop assistants were interested in the study, but they are not responsible for what is sold. Manufacturers, importers and retailers are responsible for items made available to consumers. Therefore, it is important that they are informed about the risks and health problems caused by nickel released from products in contact with the skin. Responsible authorities and producers' associations should give such information. Authorities are responsible for control of compliance with the legislation, and are organized differently across Europe. It is suggested that authorities should give special attention, by information and control, to areas where the proportion of nickel-releasing items is high, and the level of knowledge concerning the regulation is low.

The amount of nickel deposited onto the skin by exposure to consumer products is not known. It would be of interest to compare the level of consumer exposure with occupational exposure. Lidén et al. have developed a method (acid wipe sampling) for assessment of skin exposure to metals (24) that has been used in workplace studies (25, 26). The amounts of nickel deposited onto the skin in carpenters, locksmiths, cashiers, metal workers and secretaries were judged to be capable of eliciting allergic contact dermatitis and to cause or contribute to sensitization.

It is concluded that large retailers on the Swedish market have largely adapted to the EU Nickel Directive. However, some parts of the market that may be difficult to reach with information, such as street markets and haberdashery shops, have not yet adapted. It is suggested that authorities should give extra attention to such areas, inform the relevant retailers, manufacturers, and importers, and monitor the market regularly. The DMG test is a suitable tool; it is simple, quick, and cheap. Such actions would help to reduce the risk of sensitization and elicitation of nickel dermatitis, which still is a major public health problem.

Acknowledgements

We thank Anna Ohlén for technical assistance and Stina Johnsson for technical assistance and sharing her experience from the baseline study in 1999. The Swedish Council for Working Life and Social Research gave financial support.

References

1. Thyssen J P, Linneberg A, Menné T, Johansen J D. The epidemiology of contact allergy in the general population – prevalence and main findings. *Contact Dermatitis* 2007; 57: 287–299.
2. Lidén C, Bruze M, Menné T. Metals. In: *Contact Dermatitis*, 4th edition, Frosch P J, Menné T, Lepoittevin J-P (eds): Berlin-Heidelberg, Springer-Verlag, 2006: pp. 537–568.
3. The Commission of the European Communities. Commission Regulation (EC) NO 552/2009 of June 2009 amending Regulation (EC) NO 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards Annex XVII. *Off J Eur Union* 2009; L64: 7–31.
4. 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 certain dangerous substances and preparations. *Off J Eur Union* 1994; L188: 1–2.
5. 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 purpose of adapting its Annex I to technical progress. *Off J Eur Union* 2004; L301: 51–52.
6. Thyssen J P, Johansen J D. Mobile phones are now covered by the European Union Nickel Directive. *Contact Dermatitis* 2009; 61: 56–57.
7. Lidén C, Johnsson S. Nickel on the Swedish market before the Nickel Directive. *Contact Dermatitis* 2001; 44: 7–12.
8. Lidén C, Norberg K. Nickel on the Swedish market. Follow-up after implementation of the Nickel Directive. *Contact Dermatitis* 2005; 52: 29–35.
9. Hamann C R, Hamann D J, Hamann Q J, Hamann C P, Boonchai W, Li L F, Thyssen J P. Assessment of nickel release from earrings randomly purchased in China and Thailand using the dimethylglyoxime test. *Contact Dermatitis* 2010; 62: 232–240.
10. Byer T T, Morrell D S. Periumbilical allergic contact dermatitis: blue jeans or belt buckles? *Pediatr Dermatol* 2004; 21: 223–226.
11. Thyssen J P, Johansen J D, Zachariae C, Menné T. The outcome of dimethylglyoxime testing in a sample of cell phones in Denmark. *Contact Dermatitis* 2008; 59: 38–42.
12. Thyssen J P, Menné T, Johansen J D. 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.
13. Heim K E, McKean B A. Children's clothing fasteners as a potential source of exposure to releasable nickel ions. *Contact Dermatitis* 2009; 60: 100–105.
14. Thyssen J P, Maibach H I. Nickel release from earrings purchased in the United States: the San Francisco earring study. *J Am Acad Dermatol* 2008; 58: 1000–1005.
15. Thyssen J P, Johansen J D, Menné T, Nielsen N H, Linneberg A. Nickel allergy in Danish women before and after nickel regulation. *N Engl J Med* 2009; 360: 2259–2260.
16. Thyssen J P, Linneberg A, Menné T, Nielsen N H, Johansen J D. The association between hand eczema and nickel allergy has weakened among young women in the general population following the Danish nickel regulation: results from two cross-sectional studies. *Contact Dermatitis* 2009; 61: 342–348.
17. Thyssen J P, Hald M, Avnstorp C et al. Characteristics of nickel-allergic dermatitis patients seen in private dermatology clinics in Denmark: a questionnaire study. *Acta Derm Venereol* 2009; 89: 384–388.
18. Rudzki E, Rebandel P. Changes in the pattern of sensitization to nickel in different age groups in Poland. *Contact Dermatitis* 2005; 53: 177.

19. Schnuch A, Uter W. Decrease in nickel allergy in Germany and regulatory interventions. *Contact Dermatitis* 2003; 49: 107–108.
20. Thyssen J P, Skare L, Lundgren L, Menné T, Johansen J D, Maibach H I, Lidén C. Sensitivity and specificity of the nickel spot (dimethylglyoxime) test. *Contact Dermatitis* 2010; 62: 279–288.
21. Thyssen J P, Menné T, Johansen J D et al. A spot test for detection of cobalt release – early experience and findings. *Contact Dermatitis* 2010; 63: 63–69.
22. Thyssen J P, Jensen P, Johansen J D, Menné T. Contact dermatitis caused by nickel release from hair clasps purchased in a country covered by the EU Nickel Directive. *Contact Dermatitis* 2009; 60: 180–181.
23. Swedish National Institute of Public Health. To prevent nickel allergy - How an EU directive is introduced in Sweden. No. 29, Stockholm, 2001 (in Swedish).
24. Lidén C, Skare L, Lind B, Nise G, Vahter M. Assessment of skin exposure to nickel, chromium and cobalt by acid wipe sampling and ICP-MS. *Contact Dermatitis* 2006; 54: 233–238.
25. Lidén C, Skare L, Nise G, Vahter M. Deposition of nickel, chromium, and cobalt on the skin in some occupations – assessment by acid wipe sampling. *Contact Dermatitis* 2008; 58: 347–354.
26. Julander A, Skare L, Mulder M, Grandér M, Vahter M, Lidén C. Skin deposition of nickel, cobalt, and chromium in production of gas turbines and space propulsion components. *Ann Occup Hyg* 2010; 54: 340–350.

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