

Excessive nickel release from mobile phones – a persistent cause of nickel allergy and dermatitis

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Summary

Background. Despite the political intention to limit nickel allergy and dermatitis in Europeans, nickel allergy remains frequent. There are several explanations for the persistence of nickel allergy and dermatitis, including the increasing use of mobile phones. Before regulation of nickel release from mobile phones, we showed that eight (19.5%) of 41 mobile phones marketed in Denmark between 2003 and 2007 released nickel in concentrations that may result in nickel allergy and dermatitis. In 2009, the EU Nickel Directive was revised to include nickel-releasing mobile phones.

Objectives. To investigate the proportion of mobile phones sold in Denmark that release nickel after regulation.

Methods. Metallic parts from 50 randomly selected mobile phones currently for sale in Denmark were tested for nickel release by use of the dimethylglyoxime (DMG)–nickel spot test.

Results. Nine (18%) phones showed at least one positive DMG test reaction and two phones had more than one DMG test-positive spot.

Conclusions. Apparently, the proportion of mobile phones with significant nickel release remains unchanged, despite the 2009 revision of the EU Nickel Directive. We encourage manufacturers to measure nickel release from metallic components used in the assembly of mobile phones to ensure safe products.

Key words: allergy; contact dermatitis; dimethylglyoxime; mobile phones; nickel.

Nickel allergy affects up to 17% of women and 3% of men, and is the most common cause of contact sensitization, both in the general population and in dermatitis patients (1, 2). Over the second half of the 20th century, nickel contact allergy was caused by cutaneous exposure to different categories of consumer products: (i) nickel-plated suspenders in the 1950–1960s (3), (ii) metal buttons, zippers and rivets from blue jeans

in the 1970s (4), and (iii) ear-piercing jewellery in the 1980s (5). As a response to the increasing prevalence of nickel allergy and related morbidity, nickel regulations were introduced to protect consumers in 1990, 1991 and 1994 in Denmark, Sweden and the EU, respectively (6, 7). The Nickel Directive is from 2009 part of Annex XVII of the European Community Regulation on chemicals and their safe use [registration, evaluation, authorization and restriction of chemical substances (REACH)], and dictates that certain consumer products should not release more than 0.5 µg nickel/cm²/week (8). Recently, an effect of nickel regulation in terms of decreasing prevalences of nickel allergy, nickel dermatitis and hand eczema was shown in young women and dermatitis patients (5, 9–12). Also, the proportion of dimethylglyoxime (DMG) test-positive items (i.e. items that release nickel in

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concentrations that result in nickel dermatitis in nickel-sensitized individuals) among the broad range of consumer items covered by the EU Nickel Directive decreased significantly in Sweden, from 25% of 725 tested items in 1999 to 8% of 786 in 2002–2003 and 2010 (13). For further details, see a recent review (8).

Despite the political intention to limit nickel allergy and dermatitis in Europeans, nickel allergy remains frequent and seems to have stabilized at a high level in young women (11, 14). There are several explanations for the persistence of nickel allergy and dermatitis (8), including the increasing use of mobile phones (15–22), which is reflected by global sales figures exceeding 1 billion units annually (<http://www.marketingcharts.com/topics/asia-pacific/global-mobile-phone-sales-to-grow-11-in-2008-5857/>). Before regulation of nickel release from mobile phones, we showed that eight (19.5%) of 41 mobile phones marketed in Denmark between 2003 and 2007 released nickel in concentrations that may result in nickel allergy and dermatitis (23). We also showed that more than 100 million units of a particular mobile phone had been sold worldwide (23). One study performed by the Danish Broadcasting Corporation in 2008 showed excessive nickel release from 13 of 50 mobile phones (26.0%) (<http://www.dr.dk/DR1/kontant/2008/10/14152657.htm>). An American study showed, in a similar way, that four (18.2%) of 22 mobile phones randomly collected from an office gave positive DMG test reactions (24). The clinical importance of these findings was also supported in larger data collections. Thus, a recent Danish study from private dermatology practice confirmed the significance of the mobile phone problem, as both nickel-allergic patients and dermatologists reported allergic nickel dermatitis resulting from the use of mobile phones (10). Also, a Danish patient-based study conducted between 2007 and 2009 showed that mobile phones accounted for nearly one-third of DMG test-positive items considered being of clinical relevance and collected from nickel-allergic patients (25). The growing mobile phone issue attracted attention from the public, the media and the political system in 2009, and upon a request by the Danish Minister of the Environment, the European Commission agreed to revise the EU Nickel Directive to cover nickel-releasing mobile phones in January 2009 (26) (http://ec.europa.eu/enterprise/sectors/chemicals/files/reach/restr-faq-may-2011_en.pdf).

The present study aimed to re-investigate the proportion of mobile phones sold in Denmark that release too much nickel (as indicated by a positive DMG test reaction) 1 year after the revision of the EU Nickel Directive.

Materials and Methods

Selection

In 2011, we contacted a large vendor of mobile phones on the Danish market, and permission to test 50 randomly selected mobile phones currently for sale in Denmark was given. DMG testing was performed by P.J. in the company office. All phones selected for the study had metallic exteriors, and were chosen randomly by P.J. with the assistance of a company representative. No manufacture of mobile phones occurs in Denmark, and the phones therefore represented a subsample of available devices produced by international manufacturers and sold worldwide. No earphones/headsets were available for testing. Photographs of positive spot test reactions were obtained with a standard digital camera (Nikon D300).

Nickel testing

Testing for nickel release was performed with the DMG–nickel spot test. This 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 (27, 28). All metallic parts of the mobile phones were examined, but we did not record the total number of spots tested on each phone. The test was administered by placing two drops of each solution in succession on a white cottonwool-tipped applicator that was rubbed for up to 20 seconds against the test object. A positive reaction was indicated by pink coloration of the applicator (Fig. 1), and a negative reaction was registered when no colour change was observed. In cases of doubtful reactions, defined as very weak pink reactions

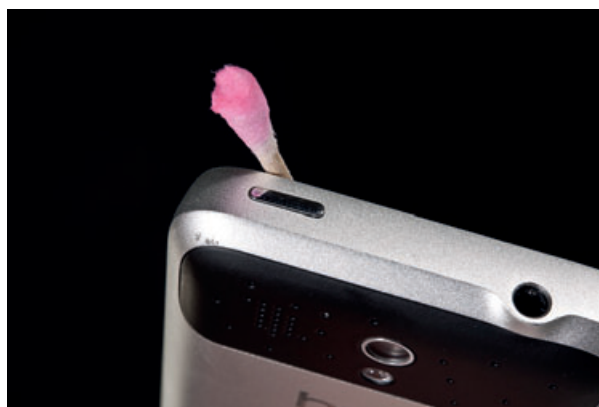


Fig. 1. Excessive nickel release from a mobile phone button as indicated by pink coloration of a white cotton stick (dimethylglyoxime test).

or discoloration possibly masking a pink colour, the test was repeated, and if the reaction remained doubtful it was considered to be negative.

Results

Table 1 shows the outcome of DMG testing of 50 phones from seven different international mobile phone manufacturers. Nine (18%) phones showed at least one positive DMG test reaction, and two phones had more than one DMG test-positive spot. All DMG test-positive spots were located in such a way that skin contact was likely to occur. No doubtful reactions were observed. Table 2 presents studies that have investigated nickel release from mobile phones as well as information on the specific locations of DMG test-positive spots.

Discussion

Despite the 2009 revision of the EU Nickel Directive to include mobile phones, nine (18%) of 50 mobile phones currently for sale on the Danish (and therefore international) market released excessive amounts of nickel as indicated by positive DMG test results. The DMG test becomes positive when $>0.5 \mu\text{g nickel/cm}^2/\text{week}$ is released from an item under investigation (Fig. 1). This release rate is derived from the EN 1811 reference test method developed by CEN (8); this is a chemical analysis used to test items for compliance with the EU Nickel Directive, whereby the object under investigation is immersed in artificial sweat for 1 week at 30°C . A recent validation study showed that the DMG test has high specificity (98%) but modest sensitivity (59%) as compared with the EN 1811 method (29). It therefore tends to underestimate nickel release from investigated items, whereas positive test outcomes are considered to be reliable. Although the proportion of DMG test-positive mobile phones is similar to those found in previous Danish (19.5%) and Canadian (18.2%) studies conducted prior to the revision (19, 23), the proportion of mobile phones that release too much nickel may be even higher. The $0.5 \mu\text{g nickel/cm}^2/\text{week}$ limit dictated by the EU Nickel Directive is derived from a patient-based study conducted prior to the regulation, in which 267 nickel-allergic individuals were patch tested with 15 metal alloy discs of known composition (nickel content ranged from 0% to 100%) (30). The discs were also analysed in synthetic sweat for 1 week (corresponding to the EN 1811 method). The study showed that discs that released $>1 \mu\text{g nickel/cm}^2/\text{week}$ gave strong patch test reactions, whereas discs that released $<0.5 \mu\text{g nickel/cm}^2/\text{week}$ showed weak reactivity.

Table 1. Nickel release as assessed in Copenhagen, Denmark, 2011 by the dimethylglyoxime (DMG) test from 50 current mobile phones produced by seven different manufacturers

Mobile phone	Manufacturer	Model	No. of positive spots	Location of positive spots
1	Apple	Iphone 4	0	—
2	Apple	Iphone 3GS	0	—
3	Blackberry	9700	0	—
4	Garmin	Nüvifone A10	0	—
5	HTC	Legend	1	Power button, top of device
6	HTC	Wildfire	0	—
7	HTC	Snap	1	Metal bar, front of device
8	HTC	Tattoo	2	Buttons, front of device
9	HTC	Smart	0	—
10	HTC	Desire	0	—
11	HTC	Desire HD	0	—
12	LG	GT400	0	—
13	LG	GT540	0	—
14	LG	T320	0	—
15	Nokia	C7	0	—
16	Nokia	6700 Classic	0	—
17	Nokia	N8	0	—
18	Nokia	6600	0	—
19	Nokia	C5	0	—
20	Nokia	6600i	0	—
21	Nokia	C6-00	0	—
22	Nokia	E66	0	—
23	Nokia	E52	0	—
24	Nokia	5230	0	—
25	Nokia	5800	0	—
26	Nokia	N79	0	—
27	Nokia	X6	0	—
28	Nokia	2730	0	—
29	Samsung	S3370	0	—
30	Samsung	LGH-L700	1	Multifunction button, front of device
31	Samsung	GT-S3650	0	—
32	Samsung	GT-S8300	1	Button, side of device
33	Samsung	SGH-i900	3	Three buttons, side of device
34	Samsung	S5350	0	—
35	Samsung	SGH-F480	1	Metal frame by camera lens, back of device
36	Samsung	Galaxy s i9000	1	Headset jack, top of device
37	Samsung	SGH507	1	Metal frame by camera lens, back of device
38	Sony Ericsson	W595	0	—
39	Sony Ericsson	U1i	0	—
40	Sony Ericsson	U10i	0	—
41	Sony Ericsson	Xperia x2	0	—
42	Sony Ericsson	Xperia	0	—
43	Sony Ericsson	W508	0	—
44	Sony Ericsson	T700	0	—
45	Sony Ericsson	J10i2	0	—
46	Sony Ericsson	F100i	0	—
47	Sony Ericsson	Xperia Mini	0	—
48	Sony Ericsson	Vivaz Pro	0	—
49	Sony Ericsson	W20 Xylo	0	—
50	Sony Ericsson	J10Si	0	—

Table 2. Overview of available studies reporting on excessive nickel release from mobile phones

% (n/n total)	
Thyssen et al. (23), dimethylglyoxime (DMG) test, Denmark	19.5 (8/41)
Luo and Bercovitch (24), DMG test, USA	18.2 (4/22)
Danish Environmental Protection Agency, study 1, DMG test, Denmark; see text for reference	3.7 (1/27)
Danish Environmental Protection Agency, study 2, EN 1811, Denmark; see text for reference	25 (5/20)
Danish Broadcasting Corporation, DMG test, Denmark; see text for reference	26 (13/50)
Present study, 2011	18 (9/50)
Total	19 (40/210)

At present, there is no scientific evidence regarding the minimum exposure time required to sensitize and elicit allergic nickel dermatitis. However, recently, the European Commission defined long-term exposure as > 30 min of continuous skin contact and/or > 1 hr discontinuously in total per day (http://ec.europa.eu/environment/chemicals/reach/pdf/minutes-101025-27_en.pdf). Case reports describing allergic nickel dermatitis resulting from the use of mobile phones are accumulating, and this underscores the importance of removing nickel from items that are in prolonged contact with the skin. In addition, the so-called smartphones have gained popularity, suggesting that mobile devices might spend an ever-increasing amount of time in contact with our skin, as they can be used for a wide variety of tasks other than phoning, such as playing games and typing e-mails. Our results and the accumulating number of case reports and clinical series describing nickel dermatitis resulting from the use of mobile phones (10, 15–25) show that excessive nickel release remains a problem despite the regulatory intervention introduced by the EU in 2009. A recent case series documented the mobile phone nickel problem in adolescents, resulting in dermatitis and severe hyperpigmentation (17). The Danish Environmental Protection Agency (part of the Danish Ministry of the Environment)

very recently conducted two surveys of nickel release from mobile phones purchased in Denmark. In one study of 27 mobile phones, only one released excessive amounts of nickel (31). However, the other study showed excessive nickel release from five of 20 mobile phones, and one phone released as much as 20 µg nickel/cm²/week (32). Thus, up to one-quarter of mobile phones currently for sale in Denmark do not comply with the EU Nickel Directive and may cause morbidity. Thus, the risk of developing nickel allergy and allergic nickel dermatitis following the use of mobile phones remains unchanged, and European consumers are still unnecessarily exposed to high concentrations of nickel.

As mobile phones are often very costly, it is surprising that some manufacturers remain unable to deliver safer products with low nickel release. Parts and components for mobile phones are mostly produced by Asian component suppliers (23), and identical phones are therefore assembled from different components, depending on price and availability. We encourage the manufacturers of mobile phones to measure nickel release from metallic components used in the assembly of these devices with either the DMG test or the EN 1811 reference test method, in order to prevent the use of such parts. Fortunately, awareness about the nickel problem in parts of the mobile phone industry seems to be increasing.

Despite the unambiguous revision of the EU Nickel Directive in 2009, a considerable proportion of mobile phones continue to release significant amounts of nickel. Therefore, to ensure safe products, manufacturers of mobile phones should assess nickel release from metallic components with the DMG test.

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