

Chromate Allergy in Northern Israel in Relation to Exposure to Cement and Detergents

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Background: The prevalence of chromate allergy has declined worldwide in the last decades.

Objectives: The aim of the study was to assess tendencies in chromate allergy in northern Israel and its possible causes.

Methods: Retrospective analysis of patch test data during 1999–2013 and a review of the medical records of patients with chromate allergy were conducted.

Results: A total of 4846 consecutive patients were patch tested, of whom 146 (3%) were found to be chromate sensitive. The prevalence of chromate allergy decreased significantly from 4.7% in 1999–2001 to 2.8% in 2002–2004 ($P = 0.02$). Since then, no significant fluctuations have occurred. A gradual and consistent decline in chromate allergy was recorded among women from 4.8% in 1999–2001 to 2.3% in 2008–2010. Cement (18.4%) was the most frequent source of exposure and was mainly observed in men. The frequency of clinically relevant cement exposure increased significantly from 7.7% in 2002–2004 to 28.7% in 2011–2013 ($P = 0.04$), whereas the frequency of relevant detergent exposure decreased significantly from 25% in 1999–2001 to 5.7% in 2011–2013 ($P = 0.04$). Hand (68.5%) was the most frequently involved anatomical site.

Conclusions: The prevalence of chromate allergy in northern Israel is stable in the general population and gradually decreasing among women. These changes may be caused by reduced exposure to water-soluble hexavalent chromium in detergents but not in cement.

Exposure to hexavalent chromium is a common cause of allergic contact dermatitis. There has been a general decline in the prevalence of chromate allergy in the last decades.^{1–3} Reduction in water-soluble hexavalent chromium to less than 2 ppm in cement⁴ and legislation limiting its concentration in detergents and consumer products to 1 ppm⁵ have resulted in decreased chromate allergy. In countries and during periods in which such interventions were not implemented, there were no consistent declines in chromate allergy, and cement exposure continued to be a major cause of chromate dermatitis.^{6–8}

Most data from Israel show potassium dichromate to be the second most common allergen in routine patch testing.^{9–11} In a study published half a century ago, 91.6% of Israeli housewives who presented with hand eczema had a positive patch test to

potassium dichromate.¹² Since then, the concentration of hexavalent chromium in Israel has been regulated in detergents and bleaches but not in cement.

The present study was performed to determine trends in chromate allergy in northern Israel in view of these regulatory changes

PATIENTS AND METHODS

Study Population and Design

All patients with suspected allergic contact dermatitis who were patch tested between January 1999 and December 2013 at the patch test clinic, Rambam Medical Campus, Haifa, were included in the study. Only the first result was used in patients who were patch tested on more than 1 occasion during this period. Data were stratified according to date of test, sex, and age. Information according to the MOAHLFA (males, occupational dermatitis, atopic background, hand dermatitis, leg dermatitis, facial dermatitis, age of older than 40 years) index¹¹ was recorded, together with the patch test data from the allergen database.

Medical records of patients with positive patch test reactions to potassium dichromate were reviewed regarding the anatomical location of dermatitis (hand, foot, leg, face/neck, arms, trunk, universal, only hand dermatitis) and relevant causative exposures (leather shoes, other leather exposure, cement, detergents, metal, cosmetics, graphic work and paint, soil, and other chromium materials).

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K.K. and S.W. collected the data, performed the study procedures, and conducted the study operations. K.K., S.W., R.B., and M.K. conceived the analysis and manuscript. K.K., R.B., and M.K. prepared the manuscript. All the authors reviewed and edited the manuscript.

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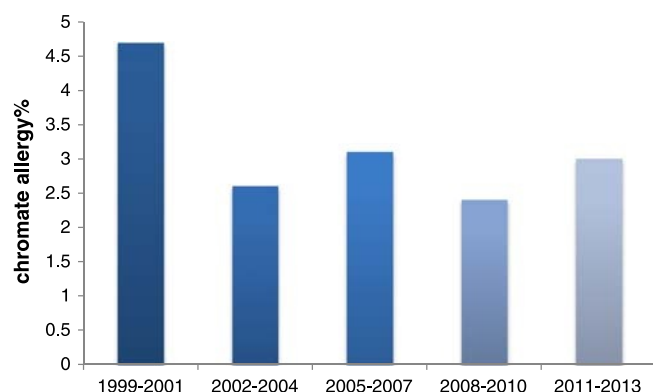


Figure 1. The prevalence of chromate allergy among patients with dermatitis patch testing between 1999 and 2013. The columns represent 3-year periods. The decreasing prevalence observed between 1999–2001 and 2002–2004 was significant ($P_{\text{trend}} = 0.02$). From then on, no significant changes were observed.

The relevance of positive allergens was recorded as probable, possible, past, unknown, or not relevant.^{13,14} For the purpose of this study, current relevance was defined as present relevance (probable or possible), unless otherwise stated. Relevance was assessed as probable if the substance identified by patch testing could be verified as present in the known skin contactants of the patient. Relevance was defined possible if the patient was exposed to circumstances in which skin contact with materials known to contain the putative allergen would likely occur.

An atopic predisposition was defined as having at least one of the atopic markers (a history of atopic dermatitis, asthma, or allergic rhinitis).

Patch Testing

Patch testing was performed with the European baseline series. The allergens were supplied by Chemotechnique Diagnostics (Malmö, Sweden). All tests were applied with Finn Chambers on Scanpor tape. Potassium dichromate 0.5% in petrolatum was used for testing. The patch tests were applied to the upper back and were occluded for 48 hours, and readings were performed on day 2 and day 4.

The reactions were scored as negative (–), irritant reaction (IR), doubtful reaction (?), positive reactions (+, ++, +++), according

to the recommendations of the International Contact Dermatitis Research Group. Negative reactions (–), IRs, and doubtful reactions (?) were registered as a negative response. One + or more on both reading days or solely on day 4 was registered as a positive response.

Statistics

Comparisons were made using the χ^2 test and Fisher exact test, when necessary. A χ^2 trend test (linear-by-linear association) was performed to test for significant trends across test years.

The statistical significance level was set to 5% in all analyses. The statistical analyses were performed with SAS statistics 9.2.

RESULTS

A total of 4846 patients with suspected allergic contact dermatitis, 52% females and 49% males, aged 5 to 96 years were patch tested between 1999 and 2013. The overall prevalence of chromate allergy was 3% (3.1% in women and 2.9% in men). The overall prevalence of chromate allergy decreased significantly from 4.7% in 1999–2001 to 2.8% in 2002–2004 ($P = 0.02$, Fig. 1). No significant changes in prevalence were observed during the remaining years (January 2002–December 2013). A gradual and consistent decrease in chromate allergy was observed in women, from 4.8% in 1999–2001 to 2.3% in 2008–2010, although this decrease was statistically insignificant ($P_{\text{trend}} = 0.06$). Among men, a dramatic decrease was observed between 1999–2001 and 2002–2004 ($P = 0.025$), followed by a subsequent insignificant increase in 2005–2008 and stable prevalence until the end of 2013.

The prevalence rates did not differ significantly between men and women as a whole and not when stratified by 3-year periods (Table 1); however, in 2002–2004, the rate for women was higher than that for men (3.4% vs 1.7%, respectively).

Noteworthy, 63 (43.1%) of our chromate-sensitive patients had +++ reaction, 76 (52.1%) had ++, and only 7 (4.8%) had +; 1.26 ± reactions were excluded.

Table 2 presents the clinical characteristics of the 146 patients with chromate allergy tested, according to the MOAHLFA index. Occupational dermatitis, as well as hand dermatitis, occurred significantly more often in men, whereas atopic background (positive

TABLE 1. The Prevalence of Chromium Allergy Among 4846 Patients With Dermatitis Stratified by Patch Test Year

Patch Test Year	All	Male Patients	Female Patients	P^*
1999–2001	4.7 (28/596)	4.5 (12/265)	4.8 (16/331)	0.86
2002–2004	2.6 (26/984)	1.7 (8/458)	3.4 (18/526)	0.10
2005–2007	3.1 (31/1014)	3.0 (15/508)	3.2 (16/506)	0.80
2008–2010	2.4 (26/1083)	2.5 (13/510)	2.3 (13/573)	0.76
2011–2013	3.0 (35/1167)	3.3 (18/547)	2.7 (17/620)	0.58

Chromate allergy. Data are presented as % (n/n).

* P value of χ^2 test comparing male and female patients.

TABLE 2. Clinical Characteristics of 146 Patients With Dermatitis and Chromate Allergy Between 1999 and 2013

	Total (n = 146), % (n)	Male (n = 65), % (n)	Female (n = 81), % (n)	P*
MOHALFA index				
Males	44.5 (65)	—	—	—
Occupational Dermatitis	31.5 (46)	64.6 (42)	4.9 (4)	<0.0001
Atopic background	19.2 (28)	9.2 (6)	27.2 (22)	0.006
Hand dermatitis	68.5 (100)	81.5 (53)	58.0 (47)	0.002
Leg and foot dermatitis	39.0 (57)	41.5 (27)	37.0 (30)	0.58
Face dermatitis	15.1 (22)	6.2 (4)	22.2 (18)	0.007
Age > 40 yrs	49.3 (72)	41.5 (27)	55.6 (45)	0.09
Relevant exposures				
Cement	18.5 (27)	41.5 (27)	0.0 (0)	<0.0001
Detergents and bleaches	13.0 (19)	4.6 (3)	19.8 (16)	0.007
Leather shoes	4.8 (7)	4.6 (3)	4.9 (4)	1.0†
Leather products	6.8 (10)	6.2 (4)	7.4 (6)	0.08†
Metals	6.2 (9)	10.8 (7)	2.5 (2)	0.08†
Paint and graphic	1.4 (2)	1.5 (1)	1.2 (1)	1.0†
Soil	2.1 (3)	4.6 (3)	0.0 (0)	0.09†
Anatomical location of dermatitis				
Feet	39.0 (57)	41.5 (27)	37.0 (30)	0.58
Face	15.1 (22)	6.2 (4)	22.2 (18)	0.007
Universal distribution	4.1 (6)	4.6 (3)	3.7 (3)	1.0†
Hands only	34.9 (51)	43.1 (28)	28.4 (23)	0.064
Hands	68.5 (100)	81.5 (53)	58.0 (47)	0.002
Neck	2.1 (3)	1.5 (1)	2.5 (2)	1.0†

Some patients had dermatitis in more than 1 anatomical location.

*P value of χ^2 test comparing male and female patients.

†P value of exact Fisher test comparing male and female patients.

medical history for atopic dermatitis [4.1%], asthma [10.2%], or allergic rhinitis [12.1%]) and face dermatitis were significantly more frequent in women. Age older than 40 years was more prevalent in women, although this difference was not statistically significant ($P = 0.09$). The median age of patients at the onset of their contact allergy was 40.5 years. Men were younger than women (33 vs 44 years, respectively). Among men, 58.2% were younger than 40 years, compared with 43.2% among women.

Cement was the most frequent source of exposure in chromate allergy, observed in 18.4% of the 146 chromate-allergic patients and more commonly in men ($P < 0.0001$). Detergents and bleaches (13.1%) were the second most frequent source of exposure and were mainly registered in women ($P = 0.0069$). Exposures to leather products (6.8%) including leather shoes (4.8%) were registered more commonly in women ($P = 0.0079$). Exposures to metals (6.1%), soil (2%), and graphic work and paint (1.4%) were also recorded. Exposure to metal was reported mainly in men, although the differences were not statistically significant between the sexes ($P = 0.08$). Relying on medical history, a current relevance (probable and possible) of positive patch test to potassium dichromate was detected in 70 (47.9%) of the allergic patients.

Interestingly, 5 pediatric patients, aged 9 to 18 years, were positively patch tested to chromate. In 2 patients (aged 9 and 18 years), the allergy was attributed to leather shoes and in 2 patients (aged

16 years) to cement. For the fifth 9-year-old girl, no relevant exposure was detected.

Hand dermatitis (68.5%) was the most frequent anatomical location, presenting significantly more often in men (81.5%) than in women (58%, $P = 0.002$). Foot and leg dermatitis (39%) was also a common anatomical site. Face involvement (15.1%) was significantly more common in women (22.2%) than in men (6.2%, $P = 0.007$). Few patients had dermatitis of the neck (2.1%) or generalized distribution (4.1%). More than one third (36.6%) of the patients with chromate allergy had dermatitis in more than 1 location.

Of the chromate-sensitive patients, 64.4% suffered from a concurrent allergy to another allergen. The most frequent additional allergens were cobalt chloride (31.5%) and nickel sulphate (26%). The latter allergen was significantly more common in women than in men ($P = 0.009$).

Information about sources of chromate exposure was examined in relation to the 3-year periods. A statistical analysis was performed to determine whether the frequencies of reported sources of chromate exposure (detergents and bleaches, leather products, and cement) changed significantly across the test years. The frequency of clinically relevant cement exposure increased significantly among patients with chromate allergy from 7.7% in 2002–2004 to 28.7% in 2011–2013 ($P = 0.04$, Fig. 2), whereas the frequency of exposure to detergents decreased significantly from 25% during 1999–2001 to

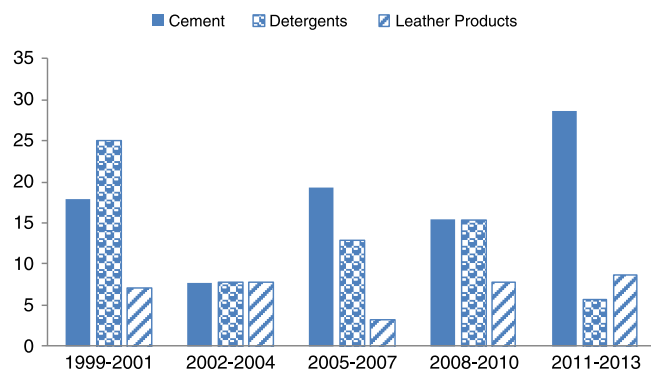


Figure 2. Sources of chromium exposure in patients with dermatitis and chromate allergy. The decreasing proportion observed between 1999 and 2011 in relevant detergents exposure was significant ($P = 0.02$). The increasing proportion observed between 2002 and 2011 in relevant cement exposure was also significant ($P = 0.02$).

5.7% during 2011–2013 ($P = 0.042$). No significant fluctuations in the frequency of exposure to leather products were identified.

In subgroup analysis, differences between Jewish and Arab patients regarding prevalence of chromate allergy were also examined. No significant fluctuations in the prevalence in Jewish patients were noted throughout the years, whereas a significant decline in 2002–2004 was observed among Arabs ($P = 0.028$).

DISCUSSION

The present study demonstrated a significant decrease in the prevalence of chromate allergy in northern Israel from 1999–2001 to 2002–2004, followed by a steady prevalence between 2002 and 2013. The prevalence rates were lower than those reported in most European countries, during the same period.^{15,16} In women, consistent and gradual decreases in prevalence were observed between 1999 and 2010.

The most common location of affected skin was the hands, occurring significantly more frequently in men, as previously reported^{17–19} owing to the predominant occupational dermatitis in men. Face dermatitis occurred significantly more frequently in women, which theoretically might be attributed to exposure to chromate in cosmetic products. Hwang et al²⁰ found chromium content more than the detection limit of 0.1 ppm, ranging from 0.2 to 3.15 ppm in 7 cosmetic products available for purchase on the Korean market. No data about chromium content in cosmetic products exist in the Israeli market. However, exposure to cosmetics was not defined as having “current relevance” in anyone of our 146 chromate-allergic patients. Thus, the relevance of this exposure is highly uncertain.

There was a tendency in men to present with chromate-allergic contact dermatitis at an earlier age, which may be due to the fact that occupational dermatitis, particularly cement dermatitis, affects more young Arab construction workers. Arabs constitute up to 53% of the northern Israel district population.²¹ They work in

the construction industry at a younger age and are exposed to hexavalent chromium in cement during the first decades of life. The age differences between sexes are paradoxical to Denmark, where chromate allergy is no longer an occupational disease because of legislative changes implemented in 1983.^{18,19}

The proportion of allergic contact dermatitis caused by cement exposure increased more than the 15-year period of the current study. In contrast, detergents and bleaches, which were common exposure sources in Israel in the past,¹² were less recorded during 2011–2013 than in 1999–2011. No fluctuations in the frequency of exposure to leather products were identified, in contrast to reports from Denmark.^{18,19,22}

The gradual decrease of chromate allergy prevalence among women patch tested between 1999 and 2013 was due in part to a decrease in exposure to detergents and bleaches, because 25% of 146 patients with chromate allergy tested between 1999 and 2001 had relevant exposure to detergents in their medical history, compared with only 5.7% between 2011 and 2013. Israeli legislation from the early 1990s, which recommended that chromium concentrations in consumer products should be lower than 5 ppm, with manufacturers aiming for a concentration of no more than 1 ppm,^{23,24} may also account for the decrease in chromate allergy among women.

There is no legislation in Israel mandating a reduced concentration of chromium in cement, and this may account for the steady prevalence of chromate allergy among men. Chromium is converted from an inert, insoluble, trivalent form to a soluble, allergenic, hexavalent form during kiln processing. The addition of ferrous sulphate to cement reduces the hexavalent form to a trivalent state (chromium III), which has a low degree of skin permeation and therefore rarely causes sensitization.²⁵

Legislative changes in Denmark in 1983 dictated a compulsory addition of ferrous sulphate to cement, reducing the amount of water-soluble chromium from approximately 10 ppm to less than 2 ppm.²⁶ This resulted in a decreased rate of chromate allergy in those attending patch test clinics, from 3% in 1985–1986 to 1% in 1997–1998 ($P = 0.001$), particularly among those of working age (19–60 years). The proportion of chromate occupational allergic contact dermatitis also decreased, from 43% in 1985–1986 to 20% in 1997–1998.²⁷ The prevalence of chromate sensitization to cement in Denmark has declined since then.^{18,22} In 1987, Finland also enforced the addition of ferrous sulphate to cement. Follow-up data from the Finnish Register of Occupational Diseases revealed that the occurrence of occupational chromate allergy subsequently decreased to less than one third of the previous level.²⁸

A high prevalence of occupational dermatitis (332 of 1138 workers, 29%) and chromate sensitization (96 of 180 workers exposed, 53%) was observed during the construction of the tunnel across the channel between England and France in 1990–1992.²⁹ Likewise, German and Austrian data from 1992–2000 showed a high prevalence of chromate occupational allergic contact dermatitis among construction workers.³⁰ The abundance of information about this occupational hazard finally led to the introduction of an

EU directive 2003/53/EC in January 2005, which restricted the marketing and use of cement containing more than 2 ppm of chromium.³¹ An analysis of UK data since 2003 found a significant reduction in the incidence of chromate allergy, suggesting that the EU 2003/53/EC intervention was successful.³² These findings have been reproduced in Scandinavia, Germany, and Austria, after legislation to reduce chromium levels in cement.^{27–30} Before the regulation of the chromium content in cement, there was no significant change in the rate of contact allergy to chromate. The North American Contact Dermatitis Group and St John's Institute of Dermatology Contact Dermatitis Clinic in London did not find significant differences in the frequency of contact allergy to chromate between the periods 1985–1989 and 1992–1994.^{6,7} A review of 2 occupational surveillance health schemes (EPIDERM and OPRA) between 1993 and 2004 also concluded that there had been no change in the number of chromate-related cases in the period during which legislation reducing the chromate concentration in cement was not imposed.⁸

Apart from legislative changes, several strategies have been proposed to prevent chromate hypersensitivity among cement workers, including the use of protective gloves to prevent direct hand contact with cement²⁸ and the use of protective barrier cream, such as ascorbic acid cream.³⁰

Lack of decline in chromate allergy among men is attributed predominantly to the absence of legislation regulating cement manufacturing and other industries implicated in chromate exposure. Noteworthy, 42 (64.6%) of the chromate-allergic males had occupational relevant exposure to chromate, significantly more often than females (4.9%, $P < 0.0001$); 27 (41.5%) construction workers, 6 (9.2%) automobile and airplane mechanics, 4 (6.1%) textile workers, 3 (4.6%) metalworkers, and 2 (3.1%) farmers were identified.

The prognosis for chromate-allergic contact dermatitis is poor, particularly among construction workers.^{33,34} This debilitating condition, together with persistent post occupational dermatitis, is accompanied by marked financial consequences and adverse effects on quality of life.³⁵

Study Limitations

There are several limitations to this study. First, relevance was determined by the physician on the basis of patient history and potential exposure and nearly always was recorded soon after patch testing. Probable category of relevance represents the most robust elements of the relevance data. On the other hand, possible relevance, which means that the allergen identified can be found in products of the type used by the patient but confirmation of the actual presence of the allergen in said product is not required, is less certain. Second, after the first-study calendar period (1999–2001), we patch tested almost twice as many patients as in the other study calendar periods. This fact may cause a “dilution effect” of the patch test pool and may account for part of the declining prevalence observed. Third, our study provides data from a small region populated with no more than 2 million inhabitants.

In conclusion, the present study demonstrated a decrease in the prevalence of chromate allergy among women and a steady prevalence in the general population and among men during a 15-year period. This may be attributed to a decline in relevant exposure to water-soluble hexavalent chromium in detergents due to legislation from the early 1990s, whereas no regulation on the cement industry was implemented.

REFERENCES

- Proctor DM, Fredrick MM, Scott PK, et al. The prevalence of chromium allergy in the United States and its implications for setting soil cleanup: a cost-effectiveness case study. *Regul Toxicol Pharmacol* 1998;28:27–37.
- Nguyen SH, Dang TP, MacPherson C, et al. Prevalence of patch test results from 1970 to 2002 in a multi-centre population in North America (NACDG). *Contact Dermatitis* 2008;58:101–106.
- Farm A. Changing patterns in chromate allergy. *Contact Dermatitis* 1986;15:298–310.
- Avnstorp C. Follow-up of workers from the prefabricated concrete industry after the addition of ferrous sulphate to Danish cement. *Contact Dermatitis* 1989;20:365–371.
- Basketter DA, Briatico-Vangosa G, Kaestner W, et al. Nickel, cobalt and chromium in consumer products: a role in allergic contact dermatitis? *Contact Dermatitis* 1993;28:15–25.
- Marks JG, Belsito DV, DeLeo VA, et al. North American Contact Dermatitis Group patch test results for the detection of delayed-type hypersensitivity to topical allergens. *J Am Acad Dermatol* 1998;38:911–918.
- Olsavsky R, Rycroft R, White I, et al. Contact sensitivity to chromate: comparison at a London contact dermatitis clinic over a 10-year period. *Contact Dermatitis* 1998;38:329–331.
- Athavale P, Shum KW, Chen Y, et al. Occupational dermatitis related to chromium and cobalt: experience of dermatologists (EPIDERM) and occupational physicians (OPRA) in the U.K. over an 11-year period (1993–2004). *Br J Dermatol* 2007;157:518–522.
- Freireich-Astman M, David M, Trattner A. Standard patch test results in patients with contact dermatitis in Israel: age and sex differences. *Contact Dermatitis* 2007;56(2):103–107.
- Lazarov A. European Standard Series patch test results from a contact dermatitis clinic in Israel during the 7-year period from 1998 to 2004. *Contact Dermatitis* 2006;55(2):73–76.
- Magen E, Mishal J, Schlesinger M. Sensitizations to allergens of TRUE test in 864 consecutive eczema patients in Israel. *Contact Dermatitis* 2006;55(6):370–371.
- Feuerman E. Chromates as the cause of contact dermatitis in housewives. *Dermatologica* 1971;143:292–294.
- Pratt MD, Belsito DV, DeLeo VA, et al. North American Contact Dermatitis Group patch-test results, 2001–2002 study period. *Dermatitis* 2004;15:176–183.
- Zug KA, Rietschel RL, Warshaw EM, et al. The value of patch testing patients with a scattered generalized distribution of dermatitis: retrospective cross-sectional analyses of North American Contact Dermatitis Group data, 2001 to 2004. *J Am Acad Dermatol* 2008;59:426–431.
- Hegewald J, Uter W, Aberer W, et al. The European Surveillance System of Contact Allergies (ESSCA): results of patch testing the standard series, 2004. *J Eur Acad Dermatol Venereol* 2008;22:174–181.
- Uter W, Rääsch C, Aberer W, et al. The European baseline series in 10 European Countries, 2005/2006—results of the European Surveillance System on Contact Allergies (ESSCA). *Contact Dermatitis* 2009 61:31–38.

17. Wang BJ, Wu JD, Sheu SC, et al. Occupational hand dermatitis among cement workers in Taiwan. *J Formos Med Assoc* 2011;110(12):775–779.
18. Thyssen JP, Jensen P, Carlsen BC, et al. The prevalence of chromium allergy in Denmark is currently increasing as a result of leather exposure. *Br J Dermatol* 2009;161(6):1288–1293.
19. Carøe C, Andersen KE, Thyssen JP, et al. Fluctuations in the prevalence of chromate allergy in Denmark and exposure to chrome-tanned leather. *Contact Dermatitis* 2010;63(6):340–346.
20. Hwang M, Yoon EK, Kim JY, et al. Safety assessment of chromium by exposure from cosmetic products. *Arch Pharm Res* 2009;32(2):235–241.
21. Israeli Central Bureau of Statistics data for 2011. Available at: cbs.gov.il. Accessed January 6, 2016.
22. Zachariae CO, Agner T, Menné T. Chromium allergy in consecutive patients in a country where ferrous sulfate has been added to cement since 1981. *Contact Dermatitis* 1996;35(2):83–85.
23. Technical Report No. 45. *Nickel, Cobalt and Chromium in Consumer Products: Allergic Contact Dermatitis*. Brussels, Belgium: European Chemical Industry Ecology and Toxicology Center; 1992.
24. Ingber A, Gammelgaard B, David M. Detergents and bleaches are sources of chromium contact dermatitis in Israel. *Contact Dermatitis* 1998;38(2):101–104.
25. Gammelgaard B, Fullerton A, Avnstorp C, et al. Permeation of chromium salts through human skin in vitro. *Contact Dermatitis* 1992;27:302–310.
26. Danish Working Environment Service. Statutory Order of the Danish Working Environment Service. No. 661 of November 28, 1983.
27. Menné T, Christophersen J, Kaaber K, et al. Changes in the pattern of sensitization to common contact allergens in Denmark between 1985–86 and 1997–98, with a special view to the effect of preventive strategies. *Br J Dermatol* 2000;142:490–495.
28. Roto P, Sainio H, Reunala T, et al. Addition of ferrous sulfate to cement and risk of chromium dermatitis among construction workers. *Contact Dermatitis* 1996;34:43–50.
29. Geier J, Krautheim A, Uter W, et al. Occupational contact allergy in the building trade in Germany: influence of preventive measures and changing exposure. *Int Arch Occup Environ Health* 2011;84:403–411.
30. Stocks S, McNamee R, Turner S, et al. Has European Union legislation to reduce exposure to chromate in cement been effective in reducing the incidence of allergic contact dermatitis attributed to chromate in the UK? *Occup Environ Med* 2012;69:150–152.
31. Irvine C, Pugh CE, Hansen EJ, et al. Cement dermatitis in underground workers during construction of the Channel Tunnel. *Occup Med* 1994;44(1):17–23.
32. Uter W, Rühl R, Pfahlberg A, et al. Contact allergy in construction workers: results of a multifactorial analysis. *Ann Occup Hyg* 2004;48:21–27.
33. Halbert A, Gebauer K, Wall L. Prognosis of occupational chromate dermatitis. *Contact Dermatitis* 1992;27:214–219.
34. Cahill J, Keegel T, Nixon R. The prognosis of occupational contact dermatitis in 2004. *Contact Dermatitis* 2004;51:219–226.
35. Directive 2003/53/EC of the European Parliament and the Council Directive of 18 June 2003 amending for the 26th time Council Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations (nonylphenol, nonylphenol ethoxylate und cement). *Off J Eur Commun* 2003;178:24–28.