

ORIGINAL RESEARCH

Occupational allergic contact dermatitis to chromium from cement: Estimating the size of the problem in Australia

Celestine C Wong, Sarah E Gamboni, Amanda M Palmer and Rosemary L Nixon

Occupational Dermatology Research and Education Centre, Skin and Cancer Foundation, Melbourne, Victoria, Australia

ABSTRACT

Background: Allergic contact dermatitis (ACD) caused by chromium in cement is a significant occupational hazard. However, legislation in Europe over the past two decades to reduce the concentration of chromium in cement to <2 ppm through the addition of ferrous sulphate to cement, has seen a significant decrease in the incidence of chromium allergy. No such legislation exists in Australia.

Methods: A retrospective analysis of results from the Patchcams database of patients attending the Occupational Dermatology Clinic at the Skin & Cancer Foundation, Melbourne, who were patch tested for chromium between 1 January 1993 to 31 December 2013, was conducted.

Results: Our review revealed that there has not been any significant change in the number of cases of ACD to chromium attributed to sensitisation through cement. Based on our data, we estimate that a minimum of 24 cases of chromium occupational ACD (OACD) from cement is found in Australia yearly, causing considerable morbidity, often associated with an inability to work, costly workers' compensation claims and sometimes the development of the disabling condition, persistent post-occupational dermatitis.

Conclusion: These findings highlight the need for high-level discussions about adopting European legislation in Australia in order to reduce the likelihood of developing chromium OACD from cement.

Key words: allergic contact dermatitis, cement, chromium, contact dermatitis, occupational allergic.

INTRODUCTION

Occupational exposure to cement is a significant risk factor for the development of chromium sensitivity. Hexavalent chromium (chromium VI) in cement is a common cause of allergic contact dermatitis (ACD).¹ Over the past few decades legislative changes in Europe have mandated a reduced concentration of chromium in cement to reduce exposure.

Contact dermatitis from cement is caused by both irritation and allergy. Wet cement is an irritant because of its abrasive texture and marked alkalinity resulting from the addition of accelerators. Plain cement has a pH of around 11, but the introduction of additives, including various accelerators, makes it even more alkaline.² It was not until 1950 that the cause of cement allergy; water-soluble chromium, was discovered.⁵ Both chromium and cobalt are impurities found in the clay used to make cement and, interestingly, dual sensitivity to both substances often occurs.⁴ Chromium is converted from an inert, insoluble, trivalent form to a soluble, allergenic, hexavalent form

Correspondence: Dr Celestine Wong, Occupational Dermatology Research and Education Centre, Skin and Cancer Foundation Inc., Level 1, 80 Drummond St, Carlton, Vic. 3053, Australia. Email: celest1306@gmail.com

Celestine C Wong, MBBS, Sarah E Gamboni, MBBS, Amanda M Palmer, MPH, Rosemary L Nixon, FACD.

Conflict of interest: none

Submitted 28 March 2014; accepted 30 June 2014.

Abbreviations:

ACD	allergic contact dermatitis
NICAS	National Industrial Chemicals Notification & Assessment Scheme
OACD	occupational ACD

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 sensitisation.⁵

Legislative changes in Denmark in 1983 enforced the compulsory addition of ferrous sulphate to cement, reducing the amount of water-soluble chromium from approximately 10 ppm to <2 ppm.⁶ This resulted in an overall decrease in chromium allergy in those attending patch test clinics, from 3% in 1985–1986 to 1% in 1997–1998 ($P = 0.001$), primarily among those of working age (from 19 to 60 years of age). The proportion of chromium occupational ACD (OACD) also decreased from 43% in 1985–1986 to 20% in 1997–1998.⁷ Since then, the prevalence of chromium sensitisation to cement in Denmark has been declining.^{8,9} 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 chromium OACD subsequently decreased to less than one-third of the previous level.¹⁰

A high prevalence of occupational dermatitis (332 of 1138 workers; 29%) and chromium sensitisation (96 of 180 workers exposed, 53%) was observed during the construction of the Channel Tunnel between England and France during 1990–1992.⁴ Likewise, German and Austrian data from 1992–2000 showed a high prevalence of chromium OACD in construction workers.¹¹ 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 >2 ppm of chromium.¹² An analysis of UK data since 2003 found a significant reduction in the incidence of OACD attributed to chromium, suggesting that the EU 2003/53/EC intervention was a successful intervention.¹³ These findings have been reproduced in Scandinavia, Germany and Austria following legislation to reduce chromium levels in cement.^{7,10,13,14}

However, where there was no regulation of the chromium content in cement there was no significant change in the rate of contact allergy to chromium. The North American Contact Dermatitis Group and St John's Institute of Dermatology Contact Dermatitis Clinic in London found no significant differences in the frequency of contact allergy to chromium between from 1985–1989 to 1992–1994.^{15,16} A review of two occupational surveillance health schemes (EPIDERM and OPRA) from 1993 to 2004 also concluded that there had been no change in the number of chromate-related cases during this time period, when there had been no legislation reducing the chromate concentration in cement.¹⁷

Despite long-standing awareness of this problem in Australia and, in particular, the poor prognosis of chromium OACD, estimates of those affected have been limited. In 1991 Wall and Gebauer reported a staggering 248 cases of chromium ACD over an 8-year period in Western Australia from all causes.¹⁸ In a 6-year retrospective study of a patch test population in New South Wales, 40/218 (18%) of those with occupational skin disease had chromium OACD. The source of chromium was attributed to cement, paint and

leather.^{19,20} This study aims to estimate the magnitude of chromium OACD from cement in Australia and to facilitate a discussion on the costs and benefits of adopting European-style legislation.¹²

METHODS

We retrospectively analysed results from the Patchcams (Occupational Dermatology Research, Melbourne) database of patients attending the Occupational Dermatology Clinic (ODC) at the Skin & Cancer Foundation, Melbourne from 1 January 1993 to 31 December 2013. Allergens used for patch testing were obtained from Chemotechnique Diagnostics (Malmö, Sweden) and applied to the back using Finn Chambers (SmartPractice, Phoenix, AZ, USA) or Scanpor (Epitest, Tuusula, Finland; now Smart Practice, Phoenix, AZ, USA). The patches were removed after 48 h and test readings were performed at day 2 and day 4/5. Chromium allergy was assessed by testing with potassium dichromate at a dilution of 0.5% and often at 0.25% in petrolatum as well. The population of Victoria was compared to the population of Australia from the 2011 census data. This study was performed as part of a quality assurance activity, approved by the Board of the Skin and Cancer Foundation.

RESULTS

A total of 3685 patients were patch tested to chromium. There were 116 cases where a positive patch test result to chromium was assessed as being relevant to the patient's presenting dermatitis, based on clinical history of dermatitis, positive patch test and history of exposure. The percentage of chromium OACD in patients attending ODC annually ranged from 5% in 1993 to 3% in 2013. After a review of the patient histories, 47 (41%) cases of chromium OACD caused by cement were identified. There were also 37 (32%) cases where the primary source of chromium exposure was clearly attributed to leather. In nine (8%) cases, the source of chromium exposure was attributed to both chromium and leather and it was not possible to conclude which exposure had caused sensitisation. There were 23 (24%) cases of chromium OACD from other sources, which included rust-proof paints and coatings (Table 1).

In the 10 years from 2004 to 2013 the mean number of annual cases of OACD caused by chromium in cement, and cement and leather combined, was 4.0 cases (total 40 cases). Additional cases may have been patch tested at the Skin and Foundation Contact Dermatitis Clinic, in Monash Medical Centre and by private dermatologists and allergists, so that we estimate that patch testing at our clinic has captured approximately 66–80% of the cases of chromium OACD, yielding 5–6 cases annually in Victoria. Based on the recent 2011 census, Victoria represents 25% of the population of Australia.²¹ Thus, we estimate that, at an absolute minimum, 20–24 cases of OACD to chromium from cement occur annually in Australia.

Table 1 Chromium patch test results from 1993 to 2013

Year	Total tested chromium (<i>n</i>)	Relevant reactions to chromium <i>n</i> (% total tested)	Source of chromium allergy is cement (<i>n</i>)	Source of chromium allergy is leather (<i>n</i>)	Source of chromium allergy is both cement and leather (<i>n</i>)	Other sources of chromium including rustproof paints and coatings (<i>n</i>)
1993	94	5 (5)	1			4
1994	127	7 (6)	2	3		2
1995	123	4 (3)	1	2		1
1996	148	4 (3)	1			3
1997	144	3 (2)	1			2
1998	116	4 (3)	1	1	1	1
1999	133	3 (2)	1	2		
2000	135	1 (1)		1		
2001	194	6 (3)	2	3		1
2002	220	5 (2)	2	1		2
2003	277	6 (2)	1	4		1
2004	264	10 (4)	3	4	2	1
2005	240	5 (2)	3	2		
2006	252	6 (2)	2	2	1	1
2007	196	9 (5)	4	3	1	1
2008	177	6 (3)	3	2		1
2009	166	8 (5)	6	1	1	
2010	190	6 (3)	3	1		2
2011	174	6 (3)	3	2	1	
2012	155	7 (5)	5	1	1	
2013	160	5 (3)	2	2	1	
Total	3685	116	47	37	9	23

DISCUSSION

It is clear that there has been little change in the number of annual cases of chromium OACD from cement between 1993 and 2013 in Victoria. More cases of chromium OACD were identified from exposure to cement as compared to leather, which is no longer the case in Europe.^{8,15} Our estimate is that at least 24 cases of chromium OACD occur annually in Australia. It is also important to note that some workers with OACD in Australia are not referred for patch testing. In a previous workplace-based study we found that almost 30% of workers with OACD or occupational contact urticaria had not been referred for testing.²²

The prognosis for chromium OACD is notoriously bad.^{20,23} Many workers with chromium OACD will experience this debilitating condition, together with persistent post-occupational dermatitis, and suffer severe and disabling dermatitis, with marked economic consequences and adverse effects on their quality of life.^{20,24}

Based on 430 chromium OACD cases from cement per year, the 10-year maximum cost in the UK associated with the European legislation on chromium reduction in cement was estimated to be £28.6 million (2001 £) and the benefit £53.3 million (2001 £), providing a cost-benefit ratio of up to 1:1.9.²⁵ The cost of the ferrous sulphate addition to cement was approximately 1% the total value of cement.⁸ The enforcement of the European legislation has been shown to be both economically viable and successful in reducing the prevalence of occupational chromium allergy.^{7,10,15,25}

In Australia the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) assesses industrial

chemicals for their health and environmental effects prior to use, or chemicals already in use on a priority basis, under the Industrial Chemicals Notification and Assessment Act 1990.²⁶ As yet, NICNAS has not undertaken an assessment of chromium VI in cement or leather products and has not made a recommendation on its safe use. Current legislation under the Approved Criteria for Classifying Hazardous Substances (National Occupational Health and Safety Commission, 1008 [2004]), Appendix 8.22 states: 'The packaging of cements and cement preparations containing more than 0.0002% soluble chromium (VI) of the total dry weight of the cement must bear the inscription: "Contains chromium (VI). May produce an allergic reaction" unless the preparation is already classified and labelled as a sensitizer with phrase R43'.²⁷

A limitation of this study is that our extrapolation of the number of cases in Australia is based on Victorian data. However, the New South Wales study referred to earlier reported 40 cases of chromium OACD from all sources over 6 years, so that would suggest a similar rate of cases occurring in that state.¹⁹ Much higher numbers of chromium OACD were reported from Western Australia around the same time.¹⁸

In summary, we believe that it is now important to evaluate the costs of chromium OACD from cement and the costs of the reduction of chromium in cement through the widespread addition of ferrous sulphate, and subsequently evaluate the cost-benefit to Australia of enacting the legislation that has been enacted in Europe. The estimate of the magnitude of the problem provides the first step in this analysis.

Conclusion

The success of European legislation in reducing the amount of chromium in cement and subsequently, the number of cases of chromium OACD caused by cement, suggests that this approach is feasible. This is the first Australian study to attempt to estimate the number of annual cases of chromium OACD from cement. These data enable us to facilitate a debate on the cost-benefit implications of the widespread addition of ferrous sulphate to cement, in order to reduce the incidence of this debilitating dermatological condition. It goes without saying that all suspected cases of OACD should be referred for diagnostic patch testing.

REFERENCES

1. Winder C, Carmody M. The dermal toxicity of cement. *Toxicol. Ind. Health* 2002; **18**: 321–31.
2. Paglia C, Wombacher F, Böhni H. The influence of alkali-free and alkaline shotcrete accelerators within cement systems: I. Characterization of the setting behavior. *Cement Concrete Res.* 2001; **31**: 913–18.
3. Burrows D, Calnan C. Cement dermatitis. II. Clinical aspects. *Trans. St Johns Hosp. Dermatol. Soc.* 1964; **51**: 27–39.
4. Irvine C, Pugh C, Hansen E *et al.* Cement dermatitis in underground workers during construction of the Channel Tunnel. *Occup. Med.* 1994; **44**: 17–23.
5. Gammelgaard B, Fullerton A, Avnstorp C *et al.* Permeation of chromium salts through human skin *in vitro*. *Contact Dermatitis* 1992; **27**: 302–10.
6. Danish Working Environment Service. *Statutory Order of the Danish Working Environment Service*. No. 661 of 28 November 1985.
7. 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**: 490–5.
8. Zachariae C, 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**: 83–5.
9. Thyssen J, Jensen P, Carlsen B *et al.* The prevalence of chromium allergy in Denmark is currently increasing as a result of leather exposure. *Br. J. Dermatol.* 2009; **161**: 1288–93.
10. 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.
11. Uter W, Rühl R, Pfahlberg A *et al.* Contact allergy in construction workers: results of a multifactorial analysis. *Ann. Occup. Hyg.* 2004; **48**: 21–7.
12. 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**: 24–8.
13. 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**: 150–2.
14. 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**: 405–11.
15. Marks JJG, 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**: 911–18.
16. Olsavszky 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**: 329–31.
17. Athavale P, Shum K, Chen Y *et al.* Occupational dermatitis related to chromium and cobalt: experience of dermatologists (EPIDERM) and occupational physicians (OPRA) in the UK over an 11-year period (1993–2004). *Br. J. Dermatol.* 2007; **157**: 518–22.
18. Wall LM, Gebauer KA. Occupational skin disease in Western Australia. *Contact Dermatitis* 1991; **24**: 101–9.
19. Rosen RH, Freeman S. Occupational contact dermatitis in New South Wales. *Australas. J. Dermatol.* 1992; **33**: 1–10.
20. Halbert A, Gebauer K, Wall L. Prognosis of occupational chromate dermatitis. *Contact Dermatitis* 1992; **27**: 214–19.
21. Australian Bureau of Statistics. *2011 Census*. Available from URL: http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/2?opendocument&navpos=220. (Accessed 19 Mar 2014.)
22. Nixon R, Frowen K. Allergic contact dermatitis caused by epoxy resins. *J. Occup. Health Saf. Aust. N.Z.* 1991; **7**: 417–24.
23. Cahill J, Keegel T, Nixon R. The prognosis of occupational contact dermatitis in 2004. *Contact Dermatitis* 2004; **51**: 219–26.
24. Sajjachareonpong P, Cahill J, Keegel T *et al.* Persistent post-occupational dermatitis. *Contact Dermatitis* 2004; **51**: 278–83.
25. Health and Safety Executive. Appendix 5 to HSC Paper HSC/04/14: Annex F 2004. Available from URL: <http://www.hse.gov.uk/aboutus/meetings/hscarchive/2004/100204/c14f.pdf>. (Accessed 19 Mar 2014.)
26. Australian Government, Com Law. *Industrial Chemicals (Notification and Assessment) Regulations 1990*. Available from URL: <http://www.comlaw.gov.au/Details/F2010C00477>. (Accessed 7 Mar 2014.)
27. Australian Government National Occupational Health and Safety Commission. *Approved Criteria for Classifying Hazardous Substances [NOHSC:1008 (2004)]*, 3rd edn. October 2004. Available from URL: <http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/ns2004criteriaforclassifyinghazardous> (Accessed 13 Jul 2014.)