The impact of national-level interventions to improve hygiene on the incidence of irritant contact dermatitis in healthcare workers: changes in incidence from 1996 to 2012 and interrupted times series analysis*

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Summary

Background Reducing healthcare-associated infections (HCAI) has been a priority in the U.K. over recent decades and this has been reflected in interventions focusing on improving hygiene procedures.

Objectives To evaluate whether these interventions coincided with an increased incidence of work-related irritant contact dermatitis (ICD) attributed to hand hygiene or/and other hygiene measures in healthcare workers (HCWs).

Methods A quasi-experimental (interrupted time series) design was used to compare trends in incidence of ICD in HCWs attributed to hygiene before and after interventions to reduce HCAI with trends in the same periods in control groups (ICD in other workers). Cases of ICD reported to a U.K. surveillance scheme from 1996 to 2012 were analysed. The time periods compared were defined objectively based on the dates of the publication of national evidence-based guidelines, the U.K. Health Act 2006 and the Cleanyourhands campaign.

Results The reported incidence of ICD in HCWs attributed to hygiene has increased steadily from 1996 to 2012 [annual incidence rate ratio (95% confidence interval): hand hygiene only 1.10 (1.07–1.12); all hygiene 1.05 (1.03–1.07)], whereas the incidence in other workers is declining. An increase in incidence of ICD in HCWs attributed to hand hygiene was observed at the beginning of the Cleanyourhands campaign.

Conclusions The increasing incidence of ICD in HCWs combined with the popularity of interventions to reduce HCAI warrants increased efforts towards identifying products and implementing practices posing the least risk of ICD.

What’s already known about this topic?

• Addressing healthcare-associated infections (HCAI) through improved hygiene has been a priority for the National Health Service since 2000.
• Irritant contact dermatitis (ICD) frequently occurs in healthcare workers (HCWs) as a result of hand hygiene measures or wet work.

What does this study add?

• ICD in U.K. HCWs attributed to hand and/or other hygiene has substantially increased since 1996, consistent with interventions to reduce HCAI including the Cleanyourhands campaign.
During the last three decades of the 20th century there was a resurgence of healthcare-associated infections (HCAI) in the U.K. and, following a National Audit Office report to the House of Commons in 1999, prevention of HCAI became a National Health Service (NHS) priority. In response the national evidence-based guidelines (EPIC1) for preventing HCAI in NHS hospitals were developed during 1998–2000 and published in January 2001. The recommendations promoted better hygiene related to hands, equipment and the hospital environment. These guidelines were updated in 2007 (EPIC2) and 2014 (EPIC3) following a systematic review of the evidence.

Other reports and guidelines addressing infection control through improving hygiene (and other measures) include the National Institute for Clinical Excellence (NICE) guidelines for preventing HCAI in primary and community care (2003, updated 2012) and the World Health Organization (WHO) guidelines on hand hygiene in healthcare (advanced draft 2006, final guidelines 2009). The Health Act 2006 provided for the publication of a code of practice for the prevention and control of HCAI and set out statutory criteria for infection control, since superseded by the Health and Social Care Act 2008. A post-legislative assessment of the Health Act 2006 reported that although compliance with the standards was low it had improved by 2008/2009. In 2009 a report by the National Audit Office was presented to the House of Commons assessing the effectiveness of national initiatives on HCAI since 2004.

A national-level initiative, the ‘Cleanyourhands’ campaign, was rolled out across England and Wales from 2004 to 2008. This promoted hand hygiene in acute NHS trusts through providing alcohol hand rub at the bedside, posters aimed at healthcare workers (HCWs) and patients, audit, and feedback of compliance. An independent evaluation [using an interrupted time series (ITS) design] found a reduction in methicillin-resistant Staphylococcus aureus (MRSA) and Clostridium difficile infections. A simultaneous increase in procurement of hand-cleaning products was independently associated with the reduction in MRSA. The campaign was extended to primary care and mental health trusts in 2008 and in Scotland a national campaign was rolled out from 2007.

Occupational irritant contact dermatitis (ICD) is frequently associated with hand washing and wet work. It is of particular concern in the healthcare sector. Besides the effect on the health of HCWs and costs to the health provider it may also be counterproductive as skin irritation may reduce compliance. Furthermore, workers with dermatitis remain colonized with MRSA longer than those with healthy skin although the level of risk of transmission to patients is not clear.

We hypothesize that increased hand hygiene and cleaning of equipment or the environment in the healthcare setting in response to the interventions described above will be associated with an increased incidence of occupational ICD in HCWs, particularly during the ‘Cleanyourhands’ campaign. To test this hypothesis we used a quasi-experimental study design to:

1. Estimate the annual changes (‘trends’) from 1996 to 2012 in cases of ICD attributed to hand hygiene alone, and to any agents related to hygiene in HCWs, reported by dermatologists to The Health and Occupation Research Network (THOR, a U.K.-based voluntary reporting scheme) and compare with the trends in two control groups – wet workers and all other occupations.

2. Use an ITS approach based on the dates of interventions described above to compare the trend in incidence between different time periods.

3. Take the same approach to evaluate the effect of the ‘Cleanyourhands’ campaign on the incidence of ICD attributed to hand hygiene in HCWs using time periods already published.

Ethical approval was obtained from NRES Committee North West – 11/NW/0832.

Methods

Dermatologists have voluntarily reported new cases of work-related skin disease to THOR since 1996; during 2005–2007 approximately 60% of eligible U.K. dermatologists participated. They are asked to report cases which in their opinion, on a balance of probabilities, have been caused or aggravated by work and also report the occupation and suspected causal agent. If no cases are seen a zero case report should be made. Some dermatologists report each month and others during a randomly assigned month of the year.

Definition of cases of irritant contact dermatitis attributed to hand hygiene or all hygiene agents, comparison groups and time periods

The occupations of cases were classified into three groups representing HCWs, wet workers (cleaners, hairdressers and food handlers) and all other occupations (excluding HCWs) using the Labour Force Survey Standard Occupational Classification codes (Table 1).

All cases of ICD in HCWs (excluding those co-reported with allergic contact dermatitis) were coded according to the suspected causal agents (Table 1) using text provided by the dermatologists. Coding to distinguish between routine hand hygiene alone and other hygiene measures was conservative in that ambiguous text such as detergent and disinfectant without further information were considered to be ‘hand hygiene with other hygiene’ (group A, Table 1). Scrub solutions and scrubs were also coded as ‘hand hygiene with other hygiene’ as this may be preparation for procedures rather than routine hand hygiene. The groups used in the analysis are defined below; groups 1 and 2 are cases in HCWs and groups 3 and 4 are control groups defined by occupation.

1. ICD attributed to hand hygiene alone in HCWs (excluding co-reporting of other hygiene agents (group A, Table 1).

2. ICD attributed to all hygiene (hand hygiene and wet working) in HCWs (groups A–C, Table 1).

3. ICD attributed to all agents in hairdressers, cleaners and food handlers (wet workers, Table 1).
Table 1 Definition of occupations and coding of suspected agents in healthcare workers reported to THOR by dermatologists (1996–2012)

| Occupational group (cases of ICD) | Occupation codes (SOC2000) |
|----------------------------------|---------------------------|
| Healthcare workers (1796)        | Medical practitioners; psychologists; pharmacists/pharmacologists; ophthalmic opticians; dental practitioners; nurses; midwives; paramedics; medical radiographers; chiropodists; dispensing opticians; pharmaceutical dispensers; medical and dental technicians; physiotherapists; occupational therapists; speech and language therapists; nursing auxiliaries; nursing assistants; ambulance staff; dental nurses; hospital porters |
| Wet workers (1734):              | Hairdressers; beauticians; cleaners; butchers; meat cutters; bakers; flour confectioners; fishmongers; poultry dressers; chefs; cooks; food, drink and tobacco process operatives; kitchen and catering assistants; waiters; waitresses; bar staff |
| cleaners (363);                  |                           |
| food handlers (998);             |                           |
| All other occupations (5342)     | All SOC2000 codes except healthcare workers |
| Cases of ICD in healthcare workers (1796) | Common causal agents for ICD |
| A Hand hygiene alone (775)       | Hand washing or hand hygiene product specified (659); Hibiscrub or chlorhexidine (46) |
| B Hand hygiene with other hygiene (193) | Hand washing (84) or soap (71); with wet work or wet-working agents specified; scrubbing or scrub solutions (38) |
| C Other hygiene (551)            | Wet works (359); detergent/disinfectant/antiseptic/cleaning agents (192) |
| D Other agents (266)             | For example, latex/nitrile/rubber/gloves, glutaraldehyde, X-ray processing chemicals |
| E Missing (11)                   | Causal agents not specified (excluded from analysis) |

ICD, irritant contact dermatitis; THOR, The Health and Occupation Research Network.

4 ICD attributed to all agents in all other workers excluding HCWs (all other workers, Table 1).

Group 3 was selected as a control group because these workers are exposed to hygiene procedures and/or wet work but were not targeted by the interventions addressing HCAI. Group 4 is a second control group in case of change in incidence specific to the occupations included in group 3 that are not relevant to their exposure to wet work. For example, these wet-working occupations might be more impacted by the economic climate than other occupations or HCWs.

Four time periods to be compared were defined prospective to the analysis and based on the dates of interventions relevant to reducing the impact of HCAIs described above (Table 2). A second analysis to test the hypothesis that an increase in ICD attributed to hand hygiene would be associated with the ‘Cleanyourhands’ campaign used time periods defined elsewhere (with an additional pre-intervention time period, Table 2) and cases reported in England and Wales (where the campaign was rolled out). Quarterly procurement of soap and alcohol hand rub during the Cleanyourhands campaign has been published (Stone et al.) and has been re-plotted (Fig. 1) to show the increasing trend in procurement of soap and alcohol rub [using DATA THIEF III software, 2006 (B. Tummers; http://datathief.org/)]. The second analysis was repeated allowing a 3-month lag based on a median wait of 10 weeks from referral to seeing a dermatologist in 2007.

Statistical model

Temporal trends in incidence rates were estimated from monthly case counts (including zero reports) using a negative binomial (i.e. overdispersed Poisson) regression model with β distributed reporter random effects [xtnbreg in STATA 13 (StataCorp, College Station, TX, U.S.A.)]. An offset variable was included in the model to allow for changes in the size of the relevant populations (e.g. HCWs) as defined in Table 1 using the Labour Force Survey working population estimates. The model also controlled for seasonal variation, frequency of reporting (monthly or 1 month per year) and first month as a new reporter. In some models, time was treated as a categorical variable so as to estimate incidence rate ratios (IRR) for each year relative to 1997, the reference year, or reference time period (July 2003 to June 2004 for the Cleanyourhands campaign). In other models, where time was treated as a continuous variable, the analysis estimated a ‘trend’ IRR, which can be interpreted as the average annual change in incidence from 1 year to the next. To fit models that allowed different trend IRRs in different time periods, the Stata function mkspline was used to create linear spline time functions for each period and these were included in the model. The marginal option of this command was used to compare the trend IRR for one period to that for the previous one (ITS analysis) and to test whether there was a significant change in trend (PWW).

Changes in trend over time in a group might occur for reasons other than the interventions described above, e.g. due to reporting behaviour. Therefore the linear spline time functions for each period in the ‘case’ groups were compared with those in the control groups. To assess the significance of differences in linear spline time functions for each period between the two groups, variables representing the product of group with each of the linear spline functions generated by the mkspline command were added to the model (POW and PWW).

Results

Between 1996 and 2012, 7138 cases of ICD were reported by dermatologists; 1796 occurred in HCWs and 5342 in other occupations. Of the 1796 cases in HCWs 1519 were attributed
Table 2 The estimated change in incidence of irritant contact dermatitis attributed to hygiene in HCWs and all agents in control groups

| Time period | Timeline of events related to reducing healthcare-associated infections | Years | Estimated annual incidence rate ratio (95% confidence intervals) | Control group 3 | Control group 4 |
|-------------|------------------------------------------------------------------------|-------|---------------------------------------------------------------|----------------|----------------|
| All         | Average annual change over entire period                               | 1996–2012 | 1:10 (1:07–1:12) | $p_{\text{HCWs}} < 0.001$ | $p_{\text{HCWs}} < 0.001$ | 0.98 (0.97–1.00) | 0.96 (0.95–0.97) |
| 1           | Pre-intervention: NAO Report made to House of Commons 1999$^1$          | 1996–1999 | 1:18 (0.99–1.41) | $p_{\text{HCWs}} = 0.02$ | $p_{\text{HCWs}} = 0.002$ | 1:19 (1:07–1:32) | $p_{\text{HCWs}} < 0.001$ | $p_{\text{HCWs}} < 0.001$ | 0.96 (0.90–1.04) | 0.93 (0.89–0.97) |
| 2           | Publication of first national evidence-based guidelines 2001$^2$        | 2000–2003 | 1:10 (0.99–1.22) | $p_{\text{HCWs}} = 0.06$ | $p_{\text{HCWs}} = 0.002$ | 0.99 (0.92–1.05) | $p_{\text{HCWs}} = 0.41$ | $p_{\text{HCWs}} < 0.01$ | 0.98 (0.92–1.04) | 0.94 (0.90–0.97) |
| 3           | CleanYourHands campaign 2005–08$^1$3                                  | 2004–2008 | 1:11 (1:03–1:18) | $p_{\text{HCWs}} = 0.01$ | $p_{\text{HCWs}} = 0.005$ | 1:07 (1:01–1:12) | $p_{\text{HCWs}} = 0.21$ | $p_{\text{HCWs}} = 0.007$ | 1.00 (0.95–1.05) | 0.99 (0.96–1.02) |
| 4           | Final WHO guidelines on hand hygiene 2009$^4$                          | 2009–2012 | 1:01 (0.88–1:14) | $p_{\text{HCWs}} = 0.41$ | $p_{\text{HCWs}} = 0.66$ | 1:04 (0.94–1:14) | $p_{\text{HCWs}} = 0.22$ | $p_{\text{HCWs}} = 0.36$ | 0.95 (0.85–1.06) | 0.97 (0.90–1.04) |
| CleanYourHands campaign |                                                                 |       | Estimated quarterly incidence rate ratio (95% confidence intervals) |       |       |
| a           | Pre-campaign: NAO Report made to House of Commons 2001$^2$             | July 2003–June 2004 | 0.59 (0.41–0.86) | $p_{\text{HCWs}} = 0.18$ | $p_{\text{HCWs}} = 0.17$ | 0.75 (0.62–0.91) | $p_{\text{HCWs}} = 0.50$ | $p_{\text{HCWs}} = 0.42$ | 0.88 (0.70–1.10) | 0.87 (0.76–1.00) |
| b           | Alcohol rub available and roll-out                                      | July 2004–June 2005 | 1:48 (1:20–1:84) | $p_{\text{HCWs}} = 0.03$ | $p_{\text{HCWs}} < 0.01$ | 1:06 (0.95–1:19) | $p_{\text{HCWs}} = 0.52$ | $p_{\text{HCWs}} = 0.82$ | 1:14 (1:00–1:30) | 1:08 (1:00–1:17) |
| c           | Post roll-out                                                          | July 2005–June 2008 | 0.96 (0.92–1:01) | $p_{\text{HCWs}} = 0.82$ | $p_{\text{HCWs}} < 0.01$ | 0:97 (0.94–1:01) | $p_{\text{HCWs}} = 0.41$ | $p_{\text{HCWs}} = 0.41$ | 0.96 (0.93–1:00) | 0.98 (0.95–1:00) |

$^a$P-values for comparing annual or quarterly average change in incidence (slope) between cases and controls ($p_{\text{HCWs}}$ and $p_{\text{HCWs}}$) or preceding time period ($p_{\text{ITS}}$); $p_{\text{HCWs}}$ comparison with wet workers (group 1 or 2 vs. group 3); $p_{\text{HCWs}}$ comparison with other workers (group 1 or 2 vs. group 4); $p_{\text{ITS}}$ within group comparison of change in annual or quarterly average incidence compared with preceding time period (time period 1 vs. time period 1, etc.); HCWs, healthcare workers.
to hygiene measures and 775 of these were attributed to hand hygiene alone; 168 reports also specified alcoholic hand rub. The incidence in ICD for each year compared with 1997 in each of the four groups – HCW cases attributed to hand hygiene only (group 1); HCW cases attributed to all hygiene (group 2); wet workers, any agent (group 3); and all other workers excluding HCWs, any agent (group 4) – is shown in Figure 2. The change in incidence for ICD in HCWs attributed to hand hygiene and all hygiene compared with the change in wet workers and all other occupations (\(P_{\text{WW}}\) and \(P_{\text{OW}}\)) and with the preceding time period (\(P_{\text{ITS}}\)) is shown in Table 2.

From 1996 to 2012 there were significant increases in incidence of ICD in HCWs attributed to hand hygiene alone and in those attributed to all hygiene [IRR (95% confidence interval): 1.10 (1.07–1.12), 1.05 (1.03–1.07), respectively; Table 2]. This means that in 2012 there were around 4.5 times as many reports of ICD attributed to hand hygiene as in 1996 [4.59 (2.95–6.13)]. On the other hand, the incidence of ICD decreased in control groups 3 and 4 over the same period. The changes in incidence in groups 1 and 2 (hand hygiene and all hygiene) were statistically significantly different from those in the two control groups, wet workers and all other occupations (\(P_{\text{WW}}\) and \(P_{\text{OW}}\) < 0.001; Table 2). The increase in incidence for ICD in HCWs attributed to hand hygiene alone and all hygiene was steepest during the pre-intervention time period (1996–1999). However, when the incidence rates within the individual time periods were compared with the preceding time period only time period 2 showed a significant reduction relative to time period 1 for all hygiene (\(P_{\text{ITS}} = 0.02\)). For hand hygiene alone time periods 1–3 showed a significant increasing trend compared with both controls (except for time period 2 where \(P_{\text{WW}} = 0.06\), Table 2) but not during time period 4 where \(P_{\text{WW}} = 0.41\) and \(P_{\text{OW}} = 0.66\) (Table 2). For all hygiene the significant differences were observed only compared with all other workers (\(P_{\text{OW}}\)) and not wet workers (\(P_{\text{WW}}\)). The increasing trend appears to reverse during 2012 for hand hygiene and 2011 for all hygiene (Fig. 2).
The analysis focusing on the Cleanyourhands campaign showed a significant increase in incidence of ICD attributed to hand hygiene during the roll-out period [1.48 (1.20–1.84), \(P_{PR} = 0.001\), Table 2], which was also significant compared with both control groups (\(P_{CVW} = 0.03\) and \(P_{COW} < 0.01\), Table 2). However, this was followed by a post roll-out period with nonsignificant declining trend [0.96 (0.92–1.01), Table 2, Fig. 1], which was significantly different from the increasing trend observed during the roll-out period (\(P_{PR} < 0.001\), Table 2). Repeating this analysis allowing for the lag from onset of symptoms to consulting a dermatologist did not substantially alter these results (data not shown).

**Discussion**

Between 1996 and 2012 the incidence of ICD in HCWs attributed to hand hygiene and all hygiene reported by dermatologists increased substantially. Over the same time period there was no significant change in the incidence of ICD in wet workers (cleaners, hairdressers, food handlers) or all other workers (Table 2, Fig. 2), suggesting that the increase is not due to bias arising from voluntary reporting or the THOR study design. This supports our hypothesis that increased hygiene-related activities in response to consecutive national-level interventions (Table 2) resulted in an increased incidence of ICD in HCWs. There was also an increase in incidence of ICD in HCWs attributed to hand hygiene during the Cleanyourhands campaign roll-out period but this should be interpreted with some caution. It may just be random variation in reporting. Furthermore, it is preceded and followed by a decline in incidence that might reflect dermatologists being more likely to specify hand hygiene as the cause of ICD in a HCW compared with other occupations at the start of the campaign. However, the same pattern was observed for ICD attributed to all hygiene, which would not be explained by dermatologists increasingly specifying hand hygiene as the cause (Table 2). The post roll-out decline seems surprising given the increasing procurement of hand hygiene products but the campaign also promoted the use of hand hygiene products among visitors and patients. Finally, not all HCWs would have received the intervention as it was rolled out only in acute trusts during 2004–2008; we cannot reliably distinguish HCWs employed in primary and secondary care.

The rate of the increase in incidence of ICD in HCWs attributed to hygiene procedures was steepest during 1996–2003 and there seems to have been a reduction in incidence post-2011 (Table 2, Fig. 2). Awareness of the importance of skin care seems to have increased with each revision of the guidance; the EPIC1 (2001), NICE (2003) and EPIC2 (2007) guidelines advise contacting an occupational physician in case of skin problems whereas the WHO (2005) and NICE (2007) guidelines include a section on skin care and the WHO (2009) guidelines devote three pages to the topic of skin care. All the guidelines recommend using hand rubs when appropriate for more effective decontamination and there is evidence that the use of alcoholic hand rub is less irritating than soap and water. The four-fold increase in the reporting of alcohol hand rubs post 2004 suggests that compliance with the guidelines is improving or perhaps HCWs have become more aware of the problem and changed their behaviour, e.g. by using less irritating skin care products. Recent evidence shows that early treatment is important in prevention, and secondary prevention programmes can be effective. A less optimistic explanation would be that susceptible HCWs are changing their role or leaving their profession (i.e. a healthy worker effect).

The study benefits from the long period of nationwide continuous observation spanning 17 years, allowing us to look at the impact of several consecutive interventions and place individual interventions within the context of preceding interventions. The control group not only allows us to see the change in the cases relative to an exposed group not targeted by the intervention but also mitigates some of the bias arising from the nature of voluntary reporting, e.g. decreasing reporting with increasing membership time. However, the control group addresses only reporting bias arising equally in all occupations. For example, changes in working practices increasing exposure to wet work but unrelated to infection control or changes in occupational healthcare for HCWs resulting in increased referrals to a dermatologist would bias our findings.

There are several ways in which misclassification can occur during this analysis. Our aim was to include cases with ICD as the sole diagnosis and exclude ICD co-diagnosed with allergic contact dermatitis. (Allergic contact dermatitis may predispose HCWs to ICD resulting in ICD without frequent hand hygiene.) It is possible that some cases also had an allergic component but we believe this to be unlikely as most reporters have access to patch testing (i.e. 98% made at least one report of allergic contact dermatitis with a diagnosis requiring a patch test). Secondly, dermatologists are not asked systematically whether or not a case is attributed to hand hygiene or all hygiene; it is coded from free text (Table 1). The criteria for coding into the hand hygiene group were conservative in order to underestimate rather than overestimate trends. Misclassification within the all hygiene group is unlikely as the distinction between hygiene and other agents was very clear.

As far as we are aware, this is the first report of time trends in ICD in HCWs attributed to hygiene measures. The importance of addressing ICD attributed to hygiene measures in HCWs extends well beyond the U.K.; in 2009 alone 38 national or sub-national level campaigns to promote hand washing in HCWs occurred throughout the world [Europe (17); Eastern Mediterranean (8); Americas (5); Western Pacific (5); South-East Asia (3)]. Few studies have evaluated the effectiveness of primary prevention to reduce ICD attributed to hand hygiene in HCWs. We suggest that future evaluations of interventions promoting infection control through hygiene should also assess the impact on the skin of the HCWs. Furthermore, the existing recommendations on the use of conditioning creams and alcoholic hand rubs where appropriate should be emphasized through education and skin care programmes. While the benefits of good hand hygiene in controlling HCAI are indisputable, it is also important to
consider the risks to the HCW fully and identify and promote products and practices with the least risk of ICD.

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