Effectiveness of a hospital-wide programme to improve compliance with hand hygiene

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Summary

Background Hand hygiene prevents cross infection in hospitals, but compliance with recommended instructions is commonly poor. We attempted to promote hand hygiene by implementing a hospital-wide programme, with special emphasis on bedside, alcohol-based hand disinfection. We measured nosocomial infections in parallel.

Methods We monitored the overall compliance with hand hygiene during routine patient care in a teaching hospital in Geneva, Switzerland, before and during implementation of a hand-hygiene campaign. Seven hospital-wide observational surveys were done twice yearly from December, 1994, to December, 1997. Secondary outcome measures were nosocomial infection rates, attack rates of meticillin-resistant *Staphylococcus aureus* (MRSA), and consumption of handrub disinfectant.

Findings We observed more than 20 000 opportunities for hand hygiene. Compliance improved progressively from 48% in 1994, to 66% in 1997 (p<0·001). Although recourse to handwashing with soap and water remained stable, frequency of hand disinfection substantially increased during the study period (p<0·001). This result was unchanged after adjustment for known risk factors of poor adherence. Hand hygiene improved significantly among nurses and nursing assistants, but remained poor among doctors. During the same period, overall nosocomial infection decreased (prevalence of 16·9% in 1994 to 9·9% in 1998; p=0·04), MRSA transmission rates decreased (2·16 to 0·93 episodes per 10 000 patient-days; p<0·001), and the consumption of alcohol-based handrub solution increased from 3·5 to 15·4 L per 1000 patient-days between 1993 and 1998 (p<0·001).

Interpretation The campaign produced a sustained improvement in compliance with hand hygiene, coinciding with a reduction of nosocomial infections and MRSA transmission. The promotion of bedside, antiseptic handrubs largely contributed to the increase in compliance.

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Introduction

Hand hygiene, either by handwashing or hand disinfection, remains the single most important measure to prevent nosocomial infections.[1] The importance of this simple procedure is not sufficiently recognised by health-care workers (HCWs),[2] and poor compliance has been documented repeatedly.[3–5] Although some previous interventions to improve compliance have been successful, none has achieved lasting improvement.[2,6,7] This situation led to the creation of a Handwashing Liaison Group[8] in the UK in 1997, whose mission is "to modify the behaviour of HCWs to produce sustained improvement in compliance with agreed handwashing standards and so improve the quality of patient care".[8]

In our hospital, we documented disappointing levels of hand hygiene compliance and identified several risk factors for non-compliance.[5] The observed relation between increased workload and reduced compliance suggested that promotion of bedside hand disinfection, less time-consuming than handwashing, may improve compliance.[5,9] Hence, we implemented a hospital-wide campaign to promote hand hygiene and, in particular, the use of alcohol-based handrubs.[7] We hypothesised that our programme would not only increase compliance with hand hygiene, but also diminish meticillin-resistant *Staphylococcus aureus* (MRSA) transmission and nosocomial infection rates. We describe the programme and its effectiveness.

Methods

Procedure

The University of Geneva Hospitals (UGH) is a large acute-care teaching hospital serving residents of Geneva, Switzerland, and the surrounding area. Handwashing facilities are available everywhere with one to three sinks in every patient's room together with unmedicated soap and paper towels.[5]

The hand-hygiene promotion programme started in January 1995 after a baseline survey.[5] The most prominent component was a visual display with A3-size colour posters that emphasised the importance of hand-cleansing, particularly hand disinfection, and performance feedback. The posters were displayed in 250 strategic areas within the institution, previously identified by visiting the wards and common areas with senior nurses. Location criteria were maximal visibility during daily work and during transit within the hospital.

The content of the promotional material (available at http://www.hopisaffe.ch, accessed Oct 3, 2000) was prepared in association with collaborative groups of HCWs across all wards and translated by an artist into a cartoon-like message. Subjects included: nosocomial infection, cross transmission, hand carriage, hand hygiene, hand disinfection, and hand protection with creams. Posters were selected for use during regular meetings (six to eight times per year) with a multidisciplinary group of HCWs. This group, the project team, included representatives (senior nurses and doctors) from each medical department, senior administrative managers, and representatives from other hospital service departments. Each poster featured the name of the ward that proposed the message so that

authorship could be recognised hospital-wide and hospital staff would have a sense of ownership of the campaign. 70 different posters were produced in multiple copies with three to five posters displayed simultaneously throughout the hospital at any given time. Housekeeping staff replaced the posters once to twice weekly during 1995, and weekly thereafter, according to a predetermined order of appearance.

Individual bottles of handrub solution (alcohol-based preparation with 0·5% chlorhexidine gluconate and skin emollients) were distributed in large amounts to all wards, and custom-made holders were mounted on all beds to facilitate access to hand disinfection. HCWs were also encouraged to carry a bottle in their pocket and, in 1996, a newly-designed flat (instead of round) bottle was made available to further facilitate pocket carriage.

Recognising that a strong institutional commitment was indispensable to implement behavioural changes among HCWs,[6] the infection-control programme, with the support of the medical and nursing directors, secured the approval of senior hospital management to have the programme designated as a hospital-wide priority. The human resources for the intervention were essentially those of the infection-control programme. Senior management provided funding to implement the programme and for an additional nurse for 4 months to start the programme; they also authorised the permanent use of hospital walls for poster display, encouraged the involvement of senior staff from various departments to participate in the programme development, participated themselves in regular meetings of the project team, and voiced publicly their support for the programme. There was no external source of funding during the study period.

Compliance with hand-hygiene procedures

We did seven surveys as previously described[5] twice yearly, in June and December, from 1994 to 1997. Infection-control nurses monitored hand-hygiene practice of HCWs with a structured protocol during 2–3 weeks. They recorded potential opportunities for hand hygiene according to recommended guidelines,[1,5,10] and the actual number of episodes of handwashes and handrubs. Handwashing referred to washing hands with either water alone or unmedicated soap and water, and hand disinfection to the use of an alcohol-based handrub solution.[1,10] Potential confounders of hand-hygiene compliance included: professional category, hospital ward, time of day/week, patient-to-nurse ratio at time of observation, and type and intensity of patient care according to the number of opportunities for hand hygiene per hour of care.[5]

Observations were done at prespecified time periods throughout the day and night during 20 min periods, distributed equally during the survey duration. HCWs did not know the schedule of observation periods. The observers were as unobtrusive as possible, but were not hidden. Interobserver variability was recorded during at least 10% of monitoring sessions in which two to three observers worked simultaneously.[5] Concordance among observers was excellent; sensitivity to detect predetermined opportunities for hand hygiene averaged 98% (SD 1) and interrater reliability was high for all variables (kappa values=0·92; range 0·79–1·0).

Performance feedback was reported in March and September of each year through the hospital newsletter distributed together with salary slips. In addition, grand rounds were given (by DP) in all medical departments at the time of the initial performance feedback (Spring 1995). Demonstration of correct hand-hygiene technique is an integral part of regular educational sessions for new employees at the hospital and was not further reinforced during the study period. In accordance with the institutional review board's requirements, we did not identify staff members observed during the surveys by unique identifier.[5]

Secondary outcome measures

Nococomial infections were identified by trained infection-control nurses as described elsewhere[11] and classified according to standard definitions of the Centers for Disease Control and Prevention.[12] Annual prevalence surveys for nosocomial infections have been carried out in our hospital since 1994 with standardised methods.[11] MRSA surveillance and control consisted of prospective follow-up of all colonised or infected patients, weekly screening of patients, weekly visits of the infection-control nurses, surveillance cultures from room-mates, and contact isolation for the duration of hospital stay and on readmission.[13] Selected patients were treated with nasal mupirocin ointment for 5 days, and daily chlorhexidine body cleansing for 10 days.[14] A computerised MRSA alert system allowed early isolation of newly identified patients and recognised known carriers during readmission. The attack rate of MRSA transmission was expressed as the number of new hospital-acquired MRSA cases per 100 hospital admissions.[12,13]

As additional process indicator, we examined the amount of alcohol-based handrub solution distributed in the hospital, as monitored by the Pharmacy Department. Information on hospital-wide antimicrobial use was summarised in daily defined doses, one daily defined dose being the standard adult daily dose of an antibiotic agent for one day's treatment.

Statistical analysis

Differences in proportions were compared by χ^2 tests and by means of odds ratios and corresponding 95% CIs. Modification of compliance over time was first estimated in an univariate analysis with the first survey as the reference point. We used logistic regression, with compliance versus non-compliance as the outcome variable, to control for factors that are already associated with compliance.[5] Linear trend tests were used to assess general trends in compliance and nosocomial infection rates during the study period. Changes in the incidence of MRSA infections and bacteraemia over time were analysed by Poisson regression with the generalised linear models procedure (STATA, version 6.0). Trends in compliance over time were analysed separately by type of ward, care, and HCW, and by activity index, and first-order interactions were tested. To account for interdependence of observations, we used robust estimates of variance by including each observation period as a cluster (generalised estimating equation[5,15]).

Two-tailed p values of less than 0·05 were considered to indicate statistical significance.

Results

Between 1994 and 1997, data were collected from 2629 scheduled observation periods, of which 120 (4·6%) produced no data, mostly during the night when no hand-hygiene opportunities occurred. The remaining 2509 periods totalled 833 h and 52 min of observation and lasted between 5 and 45 min, most being of 20 min duration (2384 [95%] of observations). We obtained data on 20082 opportunities for hand hygiene in total.

Hand-cleansing opportunities were spread evenly among the seven surveys, between hospital locations, and according to the level of contamination risk. The distribution of hand-hygiene opportunities according to

	Dec 1994	June 1995	Dec 1995	June 1996	Dec 1996	June 1997	Dec 1997
Opportunities	2834 (100)	3273 (100)	3019 (100)	2607 (100)	3044 (100)	2736 (100)	2569 (100)
Professional activity							
Nurses	2006 (71)	2068 (63)	2034 (67)	1736 (66)	2134 (70)	1977 (72)	1823 (71)
Doctors	281 (10)	332 (10)	301 (10)	216 (8·3)	208 (6·8)	196 (7·2)	152 (5·9)
Nursing assistants	378 (13)	621 (19)	535 (18)	543 (21)	557 (18)	504 (18)	493 (19)
Other*	169 (6·9)	252 (7·7)	149 (4·9)	112 (4·3)	145 (4·8)	59 (2·2)	101 (3·9)
Hospital location							
Medical ward	1118 (39)	1441 (44)	1163 (39)	1164 (45)	1375 (45)	982 (36)	1091 (42)
Surgical ward	980 (35)	1251 (38)	1175 (39)	908 (35)	1080 (35)	1117 (41)	970 (38)
Gynaecology/obstetrics	151 (5·3)	119 (3·6)	69 (2·3)	76 (2·9)	47 (1·5)	46 (1·7)	81 (3·2)
Paediatrics	133 (4·7)	85 (2·6)	83 (2·7)	115 (4·4)	118 (3·9)	139 (5·1)	130 (5·1)
Intensive care	458 (16)	375 (11)	529 (18)	344 (13)	424 (14)	452 (17)	297 (12)
Activity index†							
⩽20	473 (17)	663 (20)	708 (23)	758 (29)	642 (21)	571 (21)	678 (26)
21–40	1258 (44)	1371 (42)	1245 (41)	1284 (49)	1475 (48)	1383 (51)	1339 (52)
41–60	825 (29)	855 (26)	636 (22)	466 (18)	648 (21)	449 (16)	435 (17)
>60	278 (9·8)	384 (12)	430 (14)	99 (3·8)	279 (9·2)	333 (12)	117 (4·6)
Level of risk of contamination‡							
Low risk procedure	944 (36)	1307 (40)	1181 (39)	1046 (40)	1202 (39)	1052 (38)	909 (35)
Medium risk	1251 (48)	1468 (45)	1340 (44)	1156 (44)	1358 (45)	1170 (43)	1203 (47)
High risk	413 (16)	498 (15)	498 (16)	405 (16)	484 (16)	514 (19)	457 (18)

All data are number (%) of opportunities for hand hygiene (%). *Other includes: midwifes, respiratory and mobilisation therapists, radiology technicians, nutrition therapists, a well as HCWs of all professional categories apart from nurses, nursing assistants, and doctors. †Refers to the number of opportunities for hand hygiene per h of care. ‡Level of risk of contamination is ranked according to the scale proposed by Fulkerson.[2]

Table 1: **Observed opportunities for hand hygiene in consecutive observational studies, University of Geneva Hospitals, Switzerland, 1994–97**

parameters previously identified as influencing compliance was homogenous throughout the study period (table 1). Among major staff categories, nurses contributed an average of 68·8% (SD 3·3) of all opportunities; nursing assistants 18·0 (2·4); doctors 8·3 (1·7); and other HCWs 4·9 (1·8).

Overall compliance improved from 47·6% in 1994, to 66·2% in December 1997 (p<0·001; figure 1). Although compliance achieved through standard handwashing remained stable at around 30%, that associated with hand disinfection substantially increased from 13·6% to 37·0% (p<0·001) between the first and the last survey (figure 1). In support of this observation, the annual amount of alcohol-based handrub solution used increased from 3·5 L per 1000 patient-days in 1993, to 4·1 L in 1994, 6·9 L in 1995, 9·5 L in 1996; 10·9 L in 1997, and 15·4 L 1998 (p for linear trend, p<0·001). Compared with the first observation period, odds ratios for compliance increased progressively even after adjustment for factors independently associated with non-compliance (table 2).

Although average compliance differed between hospital locations, compliance improved significantly during the study period in medical, surgical, and intensive-care wards (all p<0·001). Although not statistically significant, similar trends were observed in gynaecology/obstetrics (p=0·17), and paediatric wards (p=0·12; figure 2A). We observed lower compliance rates for activities associated with a high risk of transmission, compared with a medium or low risk; however, compliance increased in all three groups after the intervention (all p<0·001; figure 2B).

The number of opportunities for hand cleansing per h of care was constant during the study period. We confirmed previous observations of a link between a higher demand and reduced compliance.[5] Compliance improved in the same manner at all levels of demand for hand cleansing (p=0·019 for the high-demand group, and p<0·001 for the others; figure 2C).

Compliance improvement with hand-hygiene practice differed significantly between HCWs (figure 2D). Remarkably, although it increased among nurses and nursing assistants (both p<0·001), average compliance remained low among doctors and other HCWs (31·1% [SD 5·3] and 39·5 [6·2], respectively) with no significant trends over time (linear trends, p=0·92 and p=0·54, respectively). Importantly, although doctors' overall compliance with hand cleansing did not improve, they switched from handwashing to hand disinfection during the study period. On average, from one survey to the next, the odds ratio for hand disinfection (as opposed to handwashing) was 1·12 (95% CI 1·02–1·24; p=0·023).

Based on annual hospital-wide surveys at our hospital, the prevalence of nosocomial infections decreased from 16·9% in 1994 to 9·9% in 1998 (p=0·04; figure 3). Furthermore, on-site surveillance showed that the attack rate of newly detected MRSA patients decreased from 1994 onwards (p=0·021). Between 1994 and 1998, the overall incidence of MRSA infections decreased from 2·16 to 0·93 episodes per 10 000 patient-days (p<0·001). In particular, the annual incidence of hospital-acquired MRSA

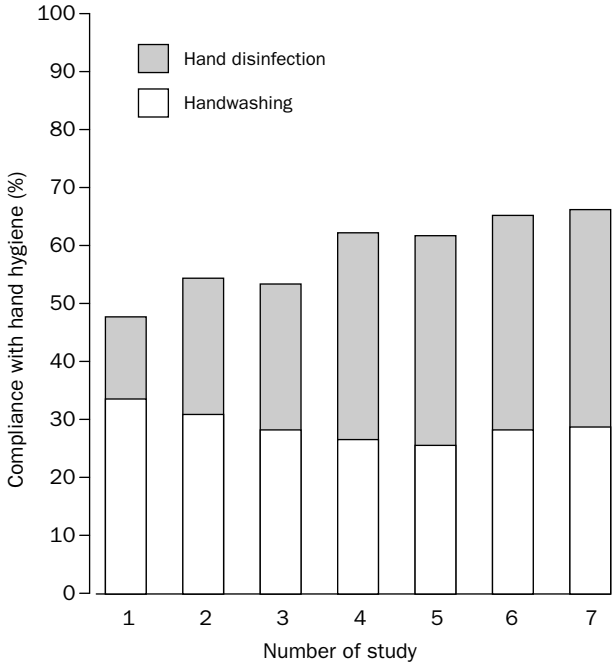

Figure 1: **Hand-hygiene compliance trend during seven consecutive hospital-wide surveys, University of Geneva Hospitals, 1994–97**

	Dec 1994	June 1995	Dec 1995	June 1996	Dec 1996	June 1997	Dec 1997
Overall compliance (95% CI)	47·6 (46·8–48·5)	54·2 (53·4–55·1)	53·4 (52·4–54·4)	62·2 (61·2–63·3)	61·8 (60·8–62·8)	65·1 (64·1–66·0)	66·2 (65·1–67·2)
Univariate odds ratios (95% CI)	1·00	1·30 (1·11–1·53)	1·26 (1·05–1·51)	1·81 (1·51–2·17)	1·78 (1·48–2·14)	2·05 (1·69–2·47)	2·15 (1·78–2·60)
Adjusted* odds ratios (95% CI)	1·00	1·31 (1·11–1·55)	1·26 (1·06–1·50)	1·65 (1·38–1·96)	1·70 (1·42–2·04)	1·97 (1·64–2·36)	1·92 (1·59–2·33)

*Adjusted for hospital ward, type of HCW, level of risk of transmission, and activity index categorised as shown in table 1.

Table 2: **Compliance with hand hygiene in successive observational surveys, and odds ratios for compliance, unadjusted and adjusted for known risk factors, University of Geneva Hospitals, Switzerland, 1994–97**

bacteraemia decreased from 0·74 to 0·24 episodes per 10000 patient-days (p<0·001).

No antimicrobial restriction or improvement programme was initiated during the study period. Between 1994 and 1997, we observed a decrease in the use of aminoglycosides and intravenous amoxicillin/clavulanate (16·97 to 12·57, and 44·92 to 19·43 daily defined doses per 1000 patient-days, respectively), whereas the use of imipenem and extended-spectrum β-lactam antibiotics increased from 13·85 to 20·07, and 21·42 to 27·18 daily defined doses per 1000 patient-days. The use of other agents did not change substantially.

Discussion

Compliance with hand-hygiene recommendations improved significantly following a hospital-wide education programme, coinciding with a reduction of nosocomial infections and MRSA transmission. The programme was mainly based on a poster campaign together with a generalised promotion of alcoholic handrubs as an alternative to soap-and-water handwashing. Improved adherence was sustained and observed across most hospital locations, in all types of patient-care activities, and among most HCWs present on the ward, with the notable exception of doctors.

Prior attempts to improve compliance with hand-cleansing practice have been associated with, at best, transient improvement.[2,7] The most effective measure has been routine observation and feedback,[16] but no intervention has reported a long-term effect.[16–18] We observed a sustained improvement that accompanied an equally sustained intervention. Whether improved hand-hygiene practice will outlast the intervention remains uncertain; we decided to refrain from testing this issue by maintaining a permanent component of the intervention.

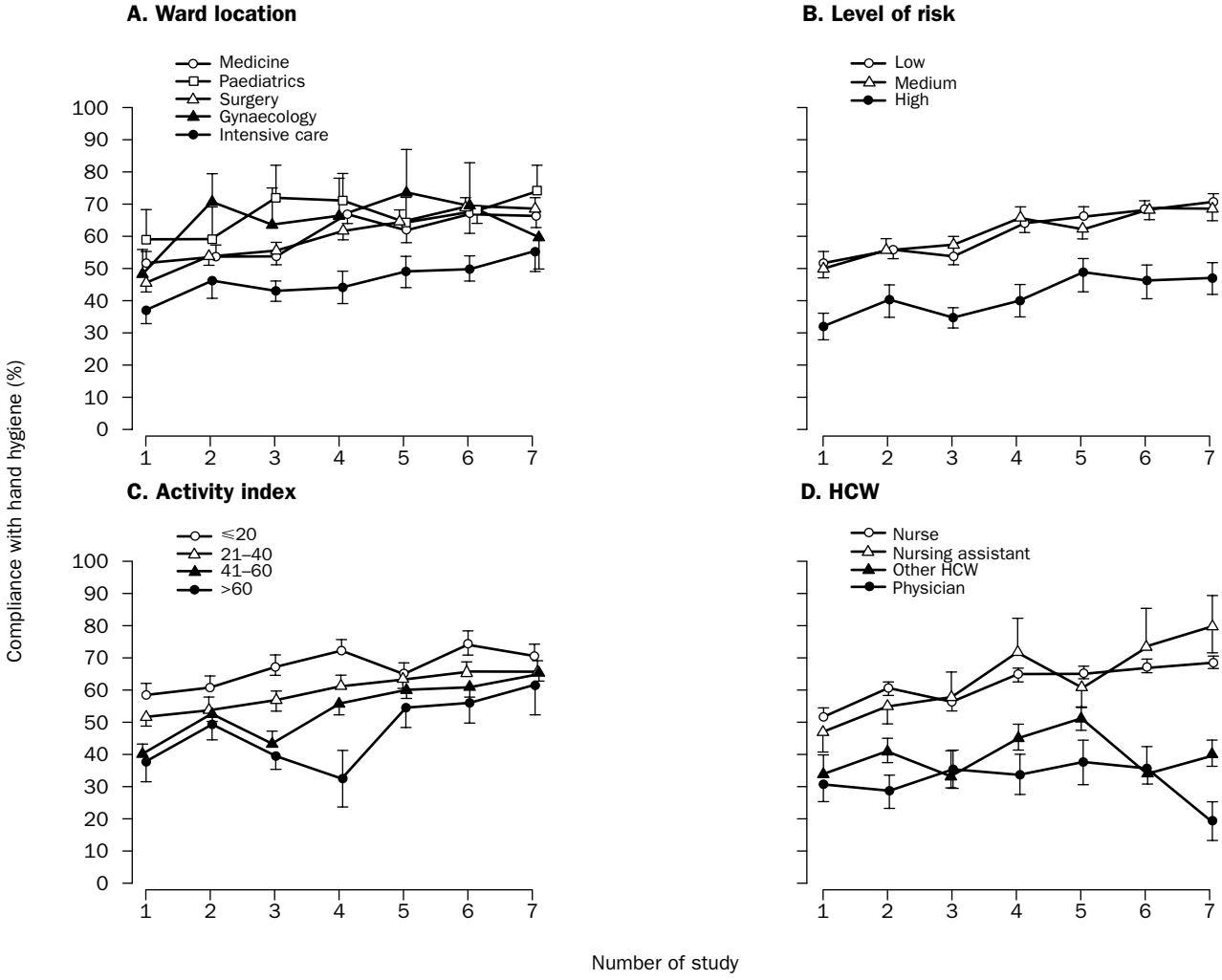

Figure 2: **Hand-hygiene compliance trends in seven consecutive hospital-wide surveys**
A, according to ward location; B, level of risk for contamination; C, level of activity at time of observation; D, type of HCW. Level of activity at time of observation refers to the number of opportunities for hand hygiene per h of care (activity index).

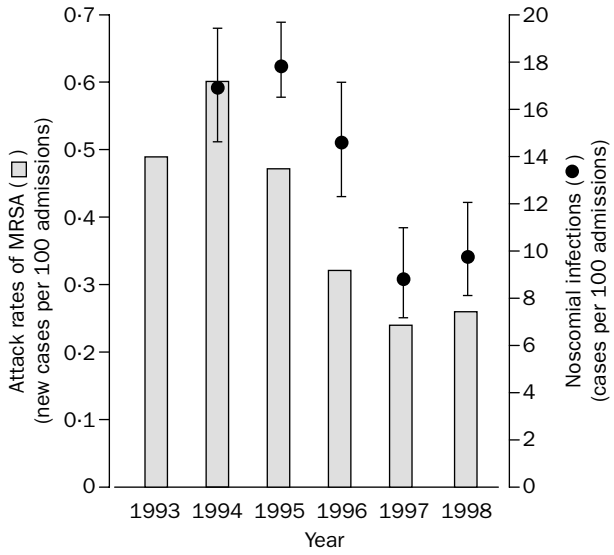

Figure 3: **Trends in prevalence of nosocomial infections and annual attack rate of MRSA, 1993–98, University of Geneva Hospitals**

Poor compliance with hand hygiene is common among HCWs. Reported reasons for not washing hands include skin irritation, inaccessible handwashing supplies, wearing gloves, "being too busy", or "not thinking about it".[2,6,16–18] Of note, some HCWs believed that they washed their hands when necessary even when observations indicated otherwise.[16] Our intervention targeted three of these reasons by facilitating hand hygiene through easy access to hand disinfection and through repeated reminders using the poster campaign.[7,17,18]

As high demand for hand cleansing is associated with low compliance,[5] and because full compliance with conventional guidelines may be unrealistic[5,9] we tested whether bedside hand antiseptics could help improve this situation. We found that most groups of HCWs modified their practice and compliance improved mainly as a result of the increasing use of alcohol-based handrub solution. HCWs were repeatedly encouraged to consult the employee health unit for any concern linked to the use of hand-hygiene products, but no case of substantial skin damage (excessive skin irritation and dryness with fissuring or cracking, severe irritant contact dermatitis, allergic or toxic reactions) was notified. Current experience with alcohol-based rubs confirms that hand disinfection reduces hand contamination more than handwashing in certain clinical conditions.[19,20] In addition, handrubs offer the advantage of being less time-consuming, probably a factor influencing compliance, especially in demanding situations.[5,9] Therefore, our results confirm the validity of the suggestion in the UK handwashing initiative to investigate the possible benefit of promoting bedside, alcohol-based handrub as the main hand-hygiene compliance tool.[7]

This intervention expands previous research experience on attempts to modify HCWs behaviour.[17] In our study, contributing factors to the success were: the multimodal and multidisciplinary approach, including communication and education tools, reminders in the work environment, active participation and feedback at both individual and organisational levels, and involvement of institutional leaders.[7,17,18,21] Furthermore, special care was taken to ensure that HCWs identified strongly with the institution's goals by involving them directly in the promotional campaign. For instance, the most visible components—ie, the posters—carried the name of the ward that had proposed the message.

Behavioural theories and interventions based on these theories have primarily targeted individuals. This may be insufficient to effect sustained change.[7,8,17] The inter-dependence of individual factors (eg, knowledge, attitudes), environmental constraints (eg, access to washing facilities), and organisational climate (eg, feedback, positive reinforcement) may have a key role in the success of behavioural interventions.[7,8,17,18]

As observed by others,[4] lower compliance rates were associated with activities with a high risk of cross-transmission. This is a troublesome problem, which may be explained by the difficulty in finding hand-hygiene opportunities in the sequence of busy patient care.[5,6,18] Our intervention was not focused primarily on improving compliance with high-risk activities, but subsequent educational efforts will specifically target this aspect.

Poor doctor compliance with hand hygiene remains an unsolved and vexing issue.[2,5,6,8] Whether increased staff rotation and lower campaign awareness among doctors compared with other HCWs could explain the low compliance in our study requires further research.[8] Previous interventions to change doctors' behaviour have included education, feedback, financial rewards and penalties, and administrative changes.[8,22] Research suggests that combinations of interventions targeted at multiple behavioural factors are more likely to suceed than isolated actions,[23] but the best way to improve hand hygiene among doctors remains to be determined.[18,21]

The decrease in nosocomial infections and MRSA transmission rates strengthens the case that our intervention was beneficial to patients. Seven quasi-experimental studies published between 1977 and 1995 assessed the impact of hand hygiene on the risk of hospital-acquired infection.[24] Although most reports showed a temporal relation between improved hand-hygiene practice and reduced infection rates, none achieved a lasting improvement in hand hygiene of more than 6 months. By contrast, the strength of our study lies in its hospital-wide approach and extended time frame. However, our infection-control programme uses additional measures other than the promotion of hand hygiene, including on-site surveillance, implementation of prevention guidelines, outbreak investigations, and issues related with disinfection, sterilisation, air and water control, and building construction.[25] The design of our study precludes ascertainment of the proportion of reduction in infection rates that was attributable to the hand-hygiene campaign alone. However, the latter was the only preventive measure applied hospital-wide during the entire study period.

Our findings confirm reports of the value of hand hygiene in the control of MRSA transmission,[26,27] even in the absence of a restrictive antibiotic-prescribing policy. Although the effect of the latter in preventing the spread of MRSA remains the subject of debate,[28] we still consider it as an important additional control measure, since certain antibiotic-prescribing patterns may promote multidrug-resistant MRSA.[29]

Our study has several limitations. First, randomisation was not feasible since the intervention was a hospital-wide, single-centre study. The ethical acceptibility of control groups in situations perceived as threatening to patients (high endemic nosocomial infection and MRSA transmission rates) was an additional obstacle. Second, because the intervention was multimodal, it is difficult to assess which part of the strategy was the most effective. However, partitioning the intervention effect may be irrelevant since a multimodal approach may be more effective than the sum of its parts.[17,18,21] Third, although our

field observations were as unobtrusive as possible, observation bias and the Hawthorne effect must be considered. However, a systematic bias is unlikely to have induced temporal trends. Furthermore, no such bias could have affected the secondary outcome variables. Since this study was not a controlled trial, unmeasured confounders perhaps accounted for some of the improvement in hand-hygiene compliance. However, this factor seems unlikely, given the stability of our institution and its surrounding community. Fourth, because flat bottles of handrub solution were introduced in 1996 amid a pattern of continued improvement in hand-hygiene compliance, we were not able to ascertain whether bottle design had an important role in the subsequent improvement in compliance. Fifth, even though the sample size was large overall, the study may have lacked power to detect significant changes in subgroups. Finally, whether the results and impact of our intervention can be generalised to other health-care institutions needs to be tested.

We did not collect prospective costing information for our intervention. Certainly, the major expense was personnel time. In addition, increased used of handrub solution from 1995 to 1997 represented extra costs of SFr 110 833, an average of SFr 101·15 per 1000 patient-days. Adding up crude direct costs (SFr 129 733 for artist work, posters, wall displays, and handrubs) and indirect costs (SFr 240 140 for salaries and fringe benefits of participating nurses, support staff, housekeeping personnel, project-team members, and expenses for office supplies) associated with our intervention, we estimate that the entire programme cost less than SFr 380 000. Given a conservative estimate of SFr 3500 saved per nosocomial infection averted,[11,30,31] prevention of 108 infections during the 1995–97 study period would have offset programme costs. Assuming that only 25% of the observed reduction in the infection rate has been associated with improved hand-hygiene practice, our intervention might have prevented more than 900 infections. These figures indicate that the programme was cost-effective from a societal perspective. However, a refined analysis is necessary to validate these crude estimates.

Contributors

Didier Pittet initiated the project, designed the study, did the field observations and the validation of the observers, did part of the data analysis, and wrote the paper. Stéphane Hugonnet, Philippe Mourouga, and Thomas Perneger did the data analysis and wrote the paper. Stéphane Hugonnet and Philippe Mourouga also participated in field observations. Stephan Harbarth analysed MRSA surveillance data, generated information on antibiotic prescribing practice, monitored surveillance of nosocomial infections, and helped with the revision of the paper. Valérie Sauvan and Sylvie Touveneau were involved in the study design and promotion campaign, the field observations, and on-site surveillance of nosocomial infections.

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