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Major article

Changes in hand hygiene compliance after a multimodal intervention and seasonality variation

Rodrigo Pires dos Santos MD, PhD [a,b,*], Loriane Rita Konkewicz ICP [a], Fabiano Marcio Nagel MD [a], Thiago Lisboa MD, PhD [a], Renan Cortez Xavier Stat [a], Thalita Jacoby PharmD [a], Sandra Ludwig Gastal MD [a], Nádia Mora Kuplich ICP [a], Márcia Rosane Pires ICP [a], Carem Gorniak Lovatto ICP [a], Caroline Deutschendorf MD, MSc [a], Ricardo Kuchenbecker MD, PhD [a]

[a] Hospital Infection Control Committee, Hospital de Clínicas de Porto Alegre, Porto Alegre, Brazil
[b] Hospital Infection Control Committee, Instituto de Cardiologia do Rio Grande do Sul, Porto Alegre, Brazil

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Background: Hand hygiene is the most important measure to reduce health care-related infections and colonization with multiresistant micro-organisms. We sought to determine the rate and seasonality of handwashing compliance in a university-affiliated hospital.

Methods: In January 2006 (baseline period), handwashing observation was first made in an intensive care unit. From March to May 2006, there was an intervention period; and, from June 2006 to August 2009, we followed hand hygiene compliance. Seasonality curves for handwashing compliance were made during follow-up period.

Results: During baseline period, a total of 166 observations was made. During follow-up, 17,664 opportunities for hand hygiene were observed. Compliance improved from 30.0% to a mean of 56.7% after the intervention ($P < .001$). The highest mean rate of compliance was 77.9% for nurses, compared with 52.6% for technicians ($P < .001$) and 44.6% for physicians ($P < .001$). Compliance was lower during summer days (first trimester of the year) and increased after March and April and slowly decreased through the end of the year.

Conclusion: One of the reasons for the lower handwashing compliance in the first 3 months of the year is that, in Brazil, this is the summer vacation time; and, because of that, the staff's workload and the number of less well-trained personnel are higher. We emphasize the importance of continuously monitoring hand hygiene to determine the seasonal aspects of compliance.

Health care-associated infections (HCAIs) represent a major risk to patient safety and contribute to prolong hospital length of stay, increase costs, and mortality.[1] Hand hygiene is the most important measure to reduce HCAIs and colonization with multiresistant micro-organisms.[2]

Hand hygiene can be performed by washing hands with soap and water or rub hands with alcohol antiseptics. Most studies show that the use of alcohol hand rub or gel is associated with better compliance rates.[3,4] The World Health Organization (WHO) Alliance for Patient Safety "Clean Care is Safer Care" vigorously recommends the adoption of alcohol hand rub by all health care workers (HCWs).[5] This practice has been adopted by many hospitals.[6] However, most of the time, HCWs compliance rates to hand hygiene are disappointing.[7]

Hand hygiene compliance can suffer social, cultural, educational, behavioral, and individual influences. Reasons for poor hand hygiene among hospital workers have been studied and are diverse. Minimal improvements in compliance might lead to better patient outcomes and substantial cost savings. Improving compliance requires leadership, collaboration, accessibility of hand hygiene products, feedback on compliance and infection rates, and individual accountability.[8-10] Previous studies found that significant improvements in compliance might be obtained during a hand hygiene campaign. However, compliance improvement is often not sustained over time or else the follow-up was so short that long-lasting improvement could not be evaluated.[11] We conducted an observational study on hand hygiene compliance in an intensive

* Address correspondence to Rodrigo Pires dos Santos, MD, PhD, Rua Ramiro Barcelos, 2350, CEP: 90035-903, Porto Alegre-RS, Brazil.
E-mail address: rpsantos@hcpa.ufrgs.br (R.P. dos Santos).

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care unit (ICU) to evaluate the compliance rate and the seasonality influence during a 4-year period.

METHODS

Setting

Hospital de Clínicas de Porto Alegre, a 749-bed, university, tertiary-level, public hospital is located in the city of Porto Alegre, Brazil. Our ICU is divided into 3 wards: 1 for clinical and surgical patients with 13 beds, another for clinical and surgical patients with 11 beds, and 1 for coronary and cardiac surgery patients with 10 beds.

The infection control team is composed of 4 physicians (responsible for antimicrobial stewardship program), 4 infection control nurses (responsible for surveillance of infection), 1 pharmacist, and 10 trainee nurses (responsible for the handwashing observation technique, and epidemiology surveillance).

Study design and intervention

Trainee nurses observed hand hygiene compliance. The ICU staff was well acquainted with the infection control program and was aware of this observation. However, they did not know the time periods when observations were made and who was responsible for each observation. The trainees had other activities in the ward, so ICU staff could not predict when the observation was being done.

During January 2006, handwashing observation was first made in our ICU (baseline handwashing compliance). Based on these results, a handwashing program was started. By that time, the entire ICU had 4 sinks with 4% chlorhexidine handwash dispensers and paper towels distributed in each of the 3 wards. Alcohol for hand disinfection was available in small, individual, 100-mL bottles since 2003. In the intervention period (from March to May 2006), another 2 sinks were installed in each ICU; alcohol gel dispensers were distributed near each bed; educational meetings were set for all ICU staff; educational material was distributed to staff; and all ICU protocols for patient care and safety reinforced hand hygiene practices. After that intervention period, monthly feedback (meetings and handwashing rates results posted at the entry of ICU) was given to the ward. Annually, educational meetings for all ICU staff were scheduled to reinforce the routines and review indications for handwashing. In 2009, a new campaign based on WHO recommendations was started. All ICU staff were trained for the WHO "5 Moments for Hand Hygiene," and the educational material released was also based on these 5 moments.[5]

From June 2006 to August 2009, handwashing episodes of physicians, nurses, and technicians were daily observed for 20- to 30-minute intervals during 5 morning, 5 afternoon, and 3 night shifts, all 5 week days. Ten observers were trained to follow the opportunities for hand hygiene. Weekends were excluded from the observation schedule.

Nine opportunities for hand hygiene were observed: (1) before touching a patient, (2) after touching a patient, (3) after body fluid exposure, (4) before aseptic procedure, (5) after aseptic procedure, (6) before gloving, (7) after gloving, (8) before preparing medication, and (9) among different procedures at the same patient (eg, manipulation surgical wound and catheter hub, for example). Hand hygiene applied to soap (plain or antimicrobial soap) and water use or alcohol hand rub use.

The seasonality analysis included the monthly rate of hand hygiene (overall compliance and rates of hand hygiene by professional category) from all study period (June/2006 to August/2009). The results are depicted in a curve where the y-axis is deviations from the mean compliance, and the x-axis represents the months and its seasonal trend decomposition from the all month rates included in the study.

Statistical analysis

The proportion for handwashing compliance was made by the division of the number of handwashing opportunities by the total number of opportunities for handwashing. The 1-sample Student *t* test was used to compare the mean rate of handwashing during 39-month study period using the baseline survey as the reference value. One-way analysis of variance analysis with 2-sided Tukey multiple comparisons test was performed to compare mean differences in compliance between groups of professionals. Linear regression model was used to determine significant changes in trends of handwashing compliance rate, hand rub, or soap and water use during 39-month observation period.

Seasonality curves for handwashing compliance were made using the stl, from stats package, function of *R* language for statistical computing and graphics. The seasonal trend decomposition of handwashing monthly compliance was based on Loess method and can be addressed by the following model:

$Y_t = T_t + S_t + \varepsilon_t$

Here, T_t and S_t estimate tendency and seasonality at time t, respectively, while ε_t is a random error not explained by the decomposition. The model described above was considered an additive model because of the supposed homogeneity of the series along the time. The Loess method is a nonparametric way of filtering time series into these tree components based on a sequence of applications of the Loess smoother. For more details, see Cleveland et al.[12]

All *P* values less than .05 were considered to be statistically significant. All collected data were analyzed using SPSS 16.0 program (SPSS Inc, Chicago, IL) and *R* software (version 2.9.0; Free Software Foundation, Boston, MA).

RESULTS

The mean ICU occupation rate from June 2006 through August 2009 was 88.7% ± 3.6%, for a mean of 918.9 ± 51.0 patient-days/month. The mean length of ICU stay was 5.8 ± 0.9 days. There was no variation in the occupation rate ($P = .38$), patient-days ($P = .49$), or length of stay ($P = .69$) during the study period by regression analysis.

During baseline period, a total of 166 observations was made. Overall rate of compliance to handwashing was 30.0% (N = 51). Analyzing data stratified by professional category, compliance rate for nurses was 40% (n = 10), 30% for physicians (n = 9), and 23% (n = 28) for technicians. In 8% of handwashing opportunities, HCWs used alcohol hand rub.

From June 2006 to August 2009, 17,664 opportunities for hand hygiene were observed. Of these, 11,376 opportunities were for technicians; 3,656 for nurses; and 2,632 observations for physicians. Forty-seven percent of opportunities were observed during morning shifts; 36.5% in the afternoon shits; and 16.5% in the night shifts. Overall compliance in the postintervention period improved from 30.0% (baseline period) to a mean of 56.7% in the subsequent 39 months ($P < .001$). Considering only the postintervention period, there was no significant increase in hand hygiene compliance rate, by regression analysis, through the study period ($P = .16$). The mean compliance rate in 2006 was 57.7% (95% confidence interval [CI]: 53.5%-61.9%), 55.9% in 2007 (95% CI: 52.9%-60.0%), 55.8% in 2008 (95% CI: 53.1%-58.5%), and 58.5% in 2009 (95% CI: 53.5%-63.4%).

After the intervention period, the highest mean rate of handwashing compliance was 77.9% (95% CI: 75.3%-80.5%) for nurses, compared with 52.6% (95% CI: 51.0%-64.2%) for technicians ($P < .001$), and 44.6% (95% CI: 41.2%-48.1%) for physicians ($P < .001$). Comparing technicians and physicians, the difference in the mean rate of adherence was also significant ($P < .001$). Technicians and physicians adherence curves correlated with each other ($r = 0.34$; $P = .041$). There was no correlation comparing nurses and technicians ($r = 0.26$; $P = .11$) or physicians and nurses ($r = -0.09$; $P = .59$).

The mean adherence rate stratified by the 9 opportunities observed was 56.0% (95% CI: 53.1%-58.8%) before touching a patient, 76.9% (95% CI: 74.9%-78.9%) after touching a patient, 86.5% (95% CI: 79.5%-93.5%) after body fluid exposure, 57.1% (95% CI: 47.5%-66.8%) before aseptic procedure, 73.1% (95% CI: 64.7%-81.4%) after aseptic procedure, 27.1% (95% CI: 22.3%-31.9%) before gloving, 70.4% (95% CI: 66.6%-74.4%) after gloving, 30.3% (95% CI: 25.9%-38.8%) before preparing medication, and 28.9% (95% CI: 21.3%-36.5%) among different procedures at the same patient. The mean rate of compliance for the moments before patient contact was significantly lower compared with those after patient contact: 41.3% and 74.6%, respectively (RR, 1.80; 95% CI: 1.76-1.86; $P < .001$).

The mean rate of alcohol hand hygiene compliance improved from 8.0% in the baseline observation to 45.0% after the intervention ($P < .001$). There was a significant increase in trend of alcohol hand rub and, consequently, a decrease in water and soap use through the months of observation ($P = .02$) (Figure 1).

The night shift (7 PM to 7 AM) had the highest mean compliance rate (63.2%; 95% CI: 58.6%-67.9%), followed by the morning (7 AM to 1 PM) shift (56.9%; 95% CI: 53.5%-60.4%; $P = .06$) and the afternoon (1 PM to 7 PM) shift (53.5%; 95% CI: 50.0%-56.0%; $P = .002$). There was no statistically significant difference comparing morning and afternoon shifts ($P = .36$).

Seasonal variations of hand hygiene compliance were determined (Fig 2). Overall, hand hygiene compliance was lower during summer days (first trimester of the year), increased after March and April, and slowly decreased through the end of the year. The first trimester mean adherence rate was significant lower than the second trimester of the year (53.7% vs 60.3%, respectively; $P = .015$). Mean adherence rates for the second (60.2%), third (57.4%), and fourth trimester (55.2%) were similar (P = nonsignificant). This handwashing seasonal behavior correlated better with hand hygiene compliance of technicians ($r = 0.94$; $P < .001$), whereas correlation with nurses ($r = 0.47$; $P = .003$) and physicians ($r = 0.50$; $P = .002$) was not so strong.

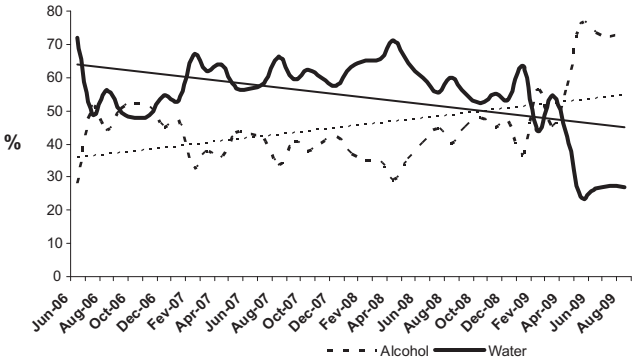

Fig 1. Rate of alcohol hand rub or soap and water hand hygiene practice (%).

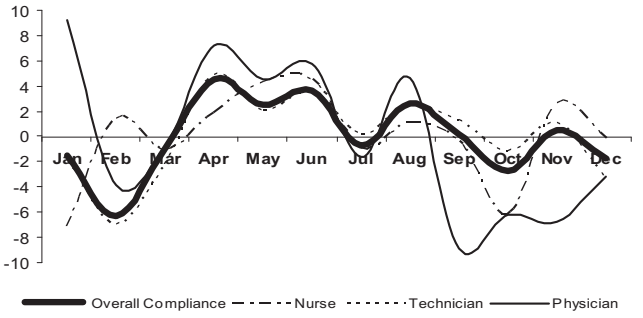

Fig 2. Seasonality of handwashing compliance comparing overall and professional category compliance curve. The graph shows 1 cycle (12 months—x-axis) of the seasonal component (T_t) of the additive decomposition. The y-axis is deviations from the mean compliance rate throughout the study period (represented by zero).

DISCUSSION

Noncompliance with hand hygiene practices is a universal problem. There is a large variation in the rate of compliance to hand disinfection, varying from 4% to 100%, with a median rate of 40%, or even lower in ICUs (30%-40%).[7,13] This is the first study to determine the impact of seasonality on hand hygiene compliance rates in a continuous way throughout 4 years of observation.

Many factors appear to play their role in affecting compliance: physicians are associated with lower rates of compliance[14,15]; dirty tasks situations[14,16] and moments involving after patients contacts are associated with better compliance.[16] Other types of interventions that have been implicated in improving compliance include introduction of an alcohol-based hand rub and improved accessibility to materials[3,17,18] and use of performance feedback.[19-21] If our intervention did not manage to improve compliance throughout the years after baseline, it was able to maintain the higher rates of compliance during the 4 years of continuous follow-up. Pittet et al have significantly increased hand hygiene adherence practices from 48% in 1994 to 66% in 1997 in Geneva, with subsequent reduction of HCAIs and methicillin-resistant *Staphylococcus aureus* transmission.[3] In the study by Apisarnthanarak et al,[22] a multifaceted intervention to control acquisition of pandrug-resistant *Acinetobacter baumanii*, there was a 23% increase in hand hygiene compliance (31% before intervention and 54% after), rates similar to our results. Others have documented different increases in compliance after several modes of intervention.[23-25]

There is no definition about which is the optimal rate of hand hygiene compliance that impacts on reduction of hospital infection or multiresistance rate, although based on published literature, an increase in baseline compliance per se, or a compliance rate between 50% and 80% seems to be a reasonable goal.[3,20-22,25] Of note, in 2009 we reached our peaks in terms of compliance (69.7%).

On the other side, Hass et al have documented only transient increases (during the first month after intervention, and a decrease thereafter) to handwashing compliance.[26] van de Mortel et al proposed an optimum time to repeat performance feedback to maximize hand hygiene compliance. In their study, compliance decreased significantly after 12 months of feedback, suggesting that feedback should be repeated at least within 12 months after last intervention.[19] As we performed continuous observations in our units, we gave monthly feedback to these wards, and this could be an explanation to the sustained increase after 4 years of follow-up.

Studies have addressed time and compliance to hand hygiene. Time of day, hospital shifts, and day of week have been studied, but, to the best of our knowledge, this is the first study to determine compliance related to the months of the year (seasonality) in a continuous way. We found that, during the first 3 months of the year, compliance was lower. In Brazil, January and February

are the summer vacation time, and during these months, the staff's (mostly nurse technicians) workload is higher because of the imbalance related to patient/staff ratio. As a public institution, the hospital works with its full capacity throughout the year, even in summer vacation time. Furthermore, there is more repositioning of less well-trained personnel and untrained residents who begin working in February. These may lead the staff to give lower priority to handwashing activities. For example, "clean" opportunities, such as bed changing, pulse taking, or touching the environment, are not perceived as a risk for infection transmission as stated by Whitby et al,[27] and they rank these handwashing opportunities as less important ones.

Our adherence rate during night shifts was higher than morning and afternoon shifts. The observation schedule in the night was most of the time during the beginning of the shift (between 7 PM and 10 PM). Duggan et al found that afternoon and night shifts (3 PM to 11 PM shift) had also higher rates of compliance compared with morning shifts (7 AM to 3 PM shift). Others have demonstrated no differences in compliance throughout shifts.[28] High workloads seem to be related to suboptimal patient care and with the potential transmission of resistant bacteria and mortality.[29-31] Although the nurse/patient ratio does not change among 24-hour shifts in the ICU, in a regular day, decisions about elective procedures are made during morning rounds. These procedures, like imaging scanning, catheter insertion, and others are made during afternoon shifts. The mean time nurses spend on a single scanning procedure and the mean time for patient transportation can impact significantly on nurses' workload.[32] Therefore, we speculate that, during day shifts, there is a higher level of activities that could result in lower compliance to hand hygiene.

The adherence rate per professional category was similar to other published studies.[3,14,15] Hand hygiene adherence was better among nonmedical staff than among attending physicians. The nurse team adherence rate was significant higher than the technicians, which was significant higher than the physicians' rate. In the study by Duggan et al, the nonmedical staff had the strongest correlation to hand hygiene compliance on multivariate analysis.[33] In their study, adherence rate was inversely correlated with level of professional education. We did not evaluate the barriers to adherence or behavioral factors. Examples and norms provided by senior staff are important for hand hygiene compliance. Medical students copy the behavior of their superiors. Hospital staff believe their behavior in most of times is similar to their peers.[8,34] Surprisingly, in our study, adherence rate curves of technicians correlated to the physicians curve. We speculate that technicians copy physicians' behavior, perceiving the physicians as leaders, or in a negative way, condition their efforts to improve adherence to physicians change of behavior.

The curve depicted in Figure 2 alerted us to when to start and who should be addressed in preventing campaigns for hand hygiene compliance. For example, intervention should be started in December and continued until March to address the new and less well-trained staff during vacation months. Different educational strategies should address mostly nurse technicians and the new residents in February. The medical staff should be also included because they serve as leaders mostly to new residents and, at least in our study, to nurse technicians.

As first demonstrated by Erasmus et al,[13] in our study compliance after patient contact (75% of compliance) was 34% higher than compliance before patient contact (41% of compliance) during months after intervention. The type of task (dirty vs clean) is one of the factors that is consistently associated with compliance. In the behavioral study by Whitby et al,[27] the need to wash hands was influenced by emotional concepts of "dirtiness" and "cleanliness." Nurses interpreted that contact to "dirty places" such as axillae or genitals would be moments to wash hands after contact. Through the complexity of human behavior, our observational study suggests this practice.

Moreover, as suggested by Whitby et al, inherent community handwashing practice is a predictor of in-hospital handwashing behavior, which means that it would be performed with soap and water.[27] With a vigorous campaign in 2009, which included the WHO Alliance for Patient Safety material, we could consistently change this behavior toward the adoption of alcohol hand rub as the primary practice for hand hygiene in our hospital, similar to the findings from the Geneva study,[3] where handwashing with water was performed in one-third of all hand hygiene opportunities, despite ready accessibility alcoholic hand rub.

Our study has some limitations. Despite the daily observation, each shift observation covered only half an hour of opportunities to hand hygiene. The differences among each observer could have affected accuracy. The Hawthorne effect could have resulted in a super estimation of real compliance data. However, the continuous nature and the power of the amount of observations made may have limited the impact of these potentially biases.

In summary, intervention in 2006 improved hand hygiene compliance in our ICU. Continuous observation enabled us to give systematic feedback to the wards, which contributed to maintenance of compliance after intervention. In addition, it provided substantial information to determine the seasonal aspects of compliance. This will help us to understand and design future strategies to improve and achieve optimal rates of hand hygiene compliance.

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