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Major article

The use of real-time feedback via wireless technology to improve hand hygiene compliance

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Background: Hand hygiene (HH) is widely regarded as the most effective preventive measure for health care-associated infection. However, there is little robust evidence on the best interventions to improve HH compliance or whether a sustained increase in compliance can reduce rates of health care-associated infection.

Methods: To evaluate the effectiveness of a real-time feedback to improve HH compliance in the inpatient setting, we used a quasiexperimental study comparing the effect of real-time feedback using wireless technology on compliance with HH. The study was conducted in two 20-bed step-down units at a private tertiary care hospital. Phase 1 was a 3-month baseline period in which HH counts were performed by electronic handwash counters. After a 1-month washout period, a 7-month intervention was performed in one step-down unit while the other unit served as a control.

Results: HH, as measured by dispensing episodes, was significantly higher in the intervention unit (90.1 vs 73.1 dispensing episodes/patient-day, respectively, $P = .001$). When the intervention unit was compared with itself before and after implementation of the wireless technology, there was also a significant increase in HH after implementation (74.5 vs 90.1 episodes/patient-day, respectively, $P = .01$). There was also an increase in mean alcohol-based handrub consumption between the 2 phases (68.9 vs 103.1 mL/patient-day, respectively, $P = .04$) in the intervention unit.

Conclusion: We demonstrated an improvement in alcohol gel usage via implementation of real-time feedback via wireless technology.

Hand hygiene (HH) is widely regarded as the most effective preventive measure for health care-associated infection (HAI).[1] Many strategies for improving HH compliance have been adopted in different studies[1-4] with a variety of interventions.[5-7] However, there is little robust evidence regarding the best interventions to improve HH compliance or to determine whether a sustained increase in compliance can reduce rates of HAI.[1,3]

Improving HH compliance is one of the performance improvement objectives of our institution, especially in units serving critically ill patients. In our intensive care unit, we have personnel who perform HH observations. Although direct observation has been considered the gold standard method, only a very small fraction of

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HH opportunities can be observed (approximately 1% in our hospital).[8] Observers can follow health care workers (HCWs) to perform direct HH observations; however, given that our step-down rooms are private, HCWs would be prompted to clean their hands when observers were so close to them (Hawthorne effect), and thus it would not represent real-world conditions. Moreover, having observers walk into patient rooms violates patient privacy.

HH episodes can be recorded by electronic handwash counters for alcohol gel.[8-10] The electronic handwashing counter is an important tool for collecting information about HH, giving us the possibility to provide feedback to HCWs about their HH performance. However, feedback of product use has not resulted in significant improvement in HH.[5] Other measures, including positive deviance[7] for developing accountability among HCWs, should be considered to increase and sustain HH compliance.

Feedback loops are profoundly effective tools for changing human behavior. This is based on a simple premise: give people information about their actions in near real time then show them how to transform those actions into better behaviors.[11] The purpose of this study was to prospectively evaluate compliance with HH in 2 similar adult step-down units (SDU) using electronic handwash counters with the application of a feedback loop strategy using wireless technology.

METHODS

The study was performed in 2 medical-surgical SDU in a 610-bed, private, tertiary care hospital in São Paulo, Brazil. The units have the same physical layout, and each have 20 private patient rooms. Because of the prior success of positive deviance methodology in both units,[12] positive deviance has been institutionalized in the SDU daily routine as an intervention for HH compliance since 2009.

From April 1 to June 15, 2013, baseline rates of HH episodes and HAIs were established in both units. A 4-week "washout period" from June 15 to July 15 was observed for installation of the device for monitoring HH compliance using wireless technology inside the intervention unit rooms and for explaining the feedback technology to unit employees. Next, a 7-month trial of the feedback intervention was performed in the intervention unit while the other SDU served as a control. All HCWs from the intervention unit were enrolled from all shifts, and consent was not required.

HH episodes were recorded by electronic handwash counters for alcohol gel (PURELL Hand Instant Sanitizer [GOJO Industries, Inc, Akron, OH], 62% ethyl alcohol + 4% isopropyl alcohol 1 L bag). The alcohol gel dispenser (NXT 1-L model; GOJO Industries) records only 1 episode in any 2-second period even if more than 1 aliquot of alcohol is dispensed. Alcohol gel dispensers dispensed the same volume of product per use (approximately 1.3 mL) and are located inside the patient rooms and in the corridor.

The total volume of product used in milliliters per patient-days and the alcohol gel aliquots (HH episodes) per patient-days were determined in both SDUs. Data were collected on a weekly basis. The total volume of product was collected every week keeping the empty bags in a box for the calculation. The study was approved by the facility's Institutional Review Board.

Feedback technology

Real-time feedback technology was implemented in the intervention unit in the second phase of the study. This technology uses a wireless identification device (badge) for the HCW to record when a HCW performs HH with alcohol handrub using electronic dispensers inside the patient room. The identification devices use Zigbee technology (iHealthSys, Sao Carlos, Sao Paulo, Brazil) (wireless communication protocol based on IEEE 802.15.3 standards).[13] A red light flashes above the patient bed when a HCW approaches the patient bed if HH has not been performed. A green light flashes if HH has been performed. Thus, the HCW is provided real-time feedback on HH compliance. Software integrated with a database allows reports to be generated showing how many HCWs entered the rooms, how many performed HH, and how many patients were provided care by individual HCWs, but we did not have these data during the time that the study was performed. We have data from the HH episodes that were recorded by electronic handwash counters for alcohol gel.

Our study used an interesting technology, employing a HH system that uses a wall-mounted sensor to create a radiofrequency safety zone around a patient's bed, which can detect the presence of badge-wearing HCWs near the bed. Unlike other systems, it is not necessary for the HCW to place their hands near a sensor to detect alcohol handrub on their hands.[14] Our system is activated at the same time that the HCW presses the alcohol gel dispenser for HH.

Detection of the signal identification badge by the electronic dispenser had a challenge: calibrating the correct distance to the signal identification badge without interference from the adjacent bed, wherein the dispenser is positioned on the same wall but near another bed in another closed room.

The difficulty that we had in the project was initially to calibrate the electronics of the dispenser to prevent the detection of a badge in the adjacent bed, in the case of activation of the dispenser by a HCW without the badge. In this condition, because radio waves fail to pass through the walls of the bed adjacent the software for detection of the badge in the dispenser allows for an analysis of radio signal strength over a certain time interval, and detection of the tag is properly achieved without badge interference in the adjacent bed. This means the radio frequency could be detected in adjacent room and now the tag is properly adjusted without badge interference in the adjacent bed. Another problem that was identified was the condition in which a user without the badge drives the dispenser next to another user with the badge. The maximum distance for detection of the badge dispenser is around 1 m. A distance less than or equal to 1 m, with the activation of the dispenser by a user without the badge, the system will also detect the hygiene for the user with the badge.

The detection signal of the badge within the limits of the physical space of the patient's bed was one of the major challenges in developing the system. Before the beginning of this project, there were several cases of detection of buttons in the adjacent bed, causing a red light to flash without any people in the room with a badge.

With the refinement of software and system calibration, that problem was solved. The system monitors in real time the signal strength of the radio and through statistical analysis determines whether the person with the badge is within the limits of the physical space of the bed. The range of the bedside sensor was delimited around 3 m to avoid an interference signal coming from the adjacent bed (in which a HCW may have a badge with a shorter distance than 3 m), and a physical barrier (metal plate) was added behind the radio faceplate bedside sensor. Therefore, the bedside sensor is able to detect the radio signal of the badge when the badge is in the field of vision in front of the bedside radio up to a distance of about 3 m.

HAI surveillance was performed by trained infection preventionists using Centers for Disease Control and Prevention definitions[15] in both units during the study. Invasive device utilization ratios (number of device-days/number of patient-days) were calculated for the duration of the study.

Statistical analysis

Statistical analyses were performed using SPSS 17.0 (SPSS Inc, Chicago, IL). Two analyses were performed: (1) a prospective