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Major Article

Effect of electronic real-time prompting on hand hygiene behaviors in health care workers

Steven Pong MDes [a,b,*], Pamela Holliday MSc(PT) [a,c], Geoff Fernie PhD [a,b,c,d]

[a] iDAPT, Toronto Rehabilitation Institute, University Health Network, Toronto, Ontario, Canada
[b] Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, Ontario, Canada
[c] Department of Surgery, University of Toronto, Toronto, Ontario, Canada
[d] Institute of Biomaterials and Biomedical Engineering, University of Toronto, Toronto, Ontario, Canada

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Background: Poor hand hygiene by health care workers is a major cause of nosocomial infections. This research evaluated the ability of an electronic monitoring system with real-time prompting capability to change hand hygiene behaviors.

Methods: Handwashing activity was measured by counting dispenser activations on a single nursing unit before, during, and after installation of the system. The effect of changing the prompt duration on hand hygiene performance was determined by a cluster-randomized trial on 3 nursing units with 1 acting as control. Sustainability of performance and participation was observed on 4 nursing units over a year. All staff were eligible to participate.

Results: Between June 2015 and December 2016, a total of 459,376 hand hygiene opportunities and 330,740 handwashing events from 511 staff members were recorded. Dispenser activation counts were significantly influenced by use of the system ($\chi^2[3] = 75.76$; $P < .0001$). Hand hygiene performance dropped from 62.61% to 24.94% (odds ratio, 0.36; 95% confidence interval, 0.34-0.38) when the prompting feature was removed. Staff participation had a negative trajectory of –0.72% ($P < .001$), whereas change in average performance was –0.18% ($P < .001$) per week for the year.

Conclusions: Use of electronic monitoring with real-time prompts of 20 seconds' duration nearly doubles handwashing activity and causes handwashing to occur sooner after entering a patient room. These improvements are sustainable over a year.

Improving the hand hygiene (HH) performance of health care workers will significantly reduce the chance of their patients contracting nosocomial infections.[1-3] Numerous electronic monitoring systems (EMSs) have been developed to improve HH performance but rigorous validation of these systems is lacking.[4-13]

A novel EMS developed at Toronto Rehabilitation Institute uses electronic badges worn by health care workers to increase HH performance by providing real-time prompting in the form of a discrete vibration when HH is required upon entering and exiting a patient area.

Whereas earlier studies conducted using this system indicated doubling of HH activity,[14,15] further investigations to more fully understand its effect on HH behaviors were undertaken. The aims of this work were to determine whether the EMS changes health care worker HH behaviors when measured independent of any assumptions made by the EMS, the contribution of the prompting signal and the optimal duration of that signal to changing behavior, and whether long-term use of the EMS can be sustained in terms of both health care worker participation and HH performance improvements.

MATERIALS AND METHODS

Study design and participants

Three studies are presented. A quasiexperimental trial with a reversal phase was conducted to evaluate the effect of the EMS on HH

* Address correspondence to Steven Pong, MDes, Toronto Rehabilitation Institute, 550 University Ave, 12th Fl, Research, Toronto, ON, M5G 2A2 Canada.
E-mail address: steven.pong@uhn.ca (S. Pong).

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Conflicts of interest: GF is named on patents issued (CA2682361, EP20080733638, US12/078186, US12/569770, GB1107048.9, and GB1217739.0). GF and SP are named on patents pending (CA2920688, EP20140835925, and US14/911067).

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activity. Dispenser activation counts were monitored on a single nursing unit before the EMS was installed, during use of the EMS, and after the system was removed. The influence of real-time prompting on HH behavior was evaluated with a cluster-randomized trial with a reversal phase on 3 participating nursing units. These 3 units that provide care to similar patients at the same hospital site were randomly selected as either the control group, or to receive 1 of 2 interventions that reduced the prompt duration. To measure changes in HH performance and staff participation over time, 4 nursing units using the EMS were observed continuously for 1 year.

The research was completed at Toronto Rehabilitation Institute (Toronto, Canada). The 5 nursing units were from 2 different hospital sites with a musculoskeletal and a geriatric unit at 1 site, and 3 brain and spinal cord rehabilitation units at a second site. Every staff, student, and volunteer assigned to the participating units was eligible to participate, including nurses, physicians, allied health practitioners, administration members, and facilities employees.

All installations were conducted as part of a quality improvement initiative. The University Health Network Ethics Board waived the requirement for consent based on the quality improvement focus of the projects.

Procedures

The EMS utilizes electronic badges worn by health care staff members that communicate with sensors installed at monitored zone entrances and in all wall-mounted handwash dispensers. The badges apply rules to the information gathered from these sensors about when staff should wash based on the wearer's location, HH activity, and time constants. When appropriate, the badge prompts wearers to wash by vibrating if they have missed an opportunity. After washing at an instrumented dispenser, lights on the badge glow green, indicating the action has been recognized. All information collected by the badge is uploaded to a database by a docking station for report generation. HH performance is calculated by dividing the number of times handwashing occurred within 1 minute before or 20 seconds after entering or exiting a monitored zone, by the total number of zone entries and exits (opportunities). The operation of this system has been previously reported.[16-18]

This system was installed on all 5 study units. Electronic badges were assigned to every member of staff and labeled with the name of the user. Several additional badges were given professional category names for use by occasional visiting staff.

In addition to prompts and LED indicators on the badges, performance feedback was provided by displaying graphs of aggregate nursing unit performance on a screen attached to the docking station. The system-defined compliance of the unit for the previous week was shown as a prominent circle graph. A secondary bar graph of the proceeding 8 weeks was also presented to indicate performance trends. In addition to the performance within the nursing unit where the dock was installed, performance graphs of other units were displayed.

Staff were given multiple demonstrations and training sessions. It was explained that information about their handwashing activities and movement on the units was being continuously recorded by the electronic badges. Information and instructions were also posted beside the docking stations along with researcher contact information. After the project launch, training was provided on an ad hoc basis when new staff arrived.

The effect on dispenser activation counts was measured in all 47 soap and 64 alcohol-based handrub (ABHR) wall-mounted dispensers on the participating musculoskeletal nursing unit (10 single patient rooms and 10 double rooms). The dispensers were instrumented with both the standard EMS dispenser electronics and a secondary electronic time-stamped event recording device. These event recorders provided an independent, objective measure of change in HH behavior by documenting every time handwash dispensers were used whether a badge was worn or not. Data collection consisted of 3 phases: count-baseline, count-intervention, and count-return. The number of times dispensers were used during the count-baseline phase was collected for 4 consecutive weeks from August 22 to September 18, 2016. Data collection was then suspended for 2 weeks while staff members were trained in the use of the EMS and the remaining system components, including the docking station, were installed. On the first day of the count-intervention phase, staff were issued individual electronic badges and dispenser use data collection resumed for 4 weeks. At the end of the count-intervention phase, the badges and docking station were removed from the unit. An immediate increase in activity was expected to occur with the introduction of the EMS and a slower decrease in activity when the system was removed. To capture the anticipated slower decrease, the count-return phase lasted twice as long as each of the previous phases. The count-return phase ran for 8 consecutive weeks ending December 25, 2016. The automated collection of all dispenser activations was not revealed to staff members.

The prompt duration investigation consisted of 3 back-to-back, 6-week phases: prompt-baseline, prompt-intervention, and prompt-return. Data were collected during the 18 weeks between April 11 and August 14, 2016. The EMS was already in use by the 3 participating brain and spinal cord rehabilitation nursing units (8 single patient rooms and 17 quad rooms) before prompt-baseline data collection to allow staff to become familiar with the devices and for HH performance levels to stabilize. Prompt duration was set at the default 20 seconds for all participants during prompt-baseline. Each of the 3 participating units formed a cluster and was randomly assigned 1 of 3 different prompt duration settings: default 20 seconds (control), half duration 10 seconds, or no prompt 0 seconds. Prompt changes could not be concealed because of the nature of the intervention. After collecting 6 weeks of prompt-baseline data, all badges were set to the assigned prompt durations. Prompt-intervention began at week 31 of the 52-week EMS installation. Although prompt duration on badges was changed, HH performance calculations remained based on users having 20 seconds to wash after room entry if required. Upon completion of the 6-week prompt-intervention phase, all badges were reset to the default prompt duration. Data collection continued in the prompt-return phase for 6 more weeks.

The exploration of performance and participation sustainability required continuous collection of data for 1 full year on 4 nursing units at 2 sites: 1 geriatric rehabilitation nursing unit (10 single patient rooms and 9 double rooms) and the 3 nursing units that were also involved in the prompt duration study. The data were collected between June 15, 2015, and November 13, 2016 (Table 1).

Outcomes

The primary outcome of the dispenser activation study was the amount of HH activity, as measured by the number of times wall-mounted handwash dispensers were used.

The primary outcome of the prompt duration study was overall HH performance as measured by the EMS. The secondary outcome was time to wash after room entry when handwashing had not occurred within 1 minute before entering the patient room. This measure was used to determine whether the prompt duration, in addition to changing if staff washed, also influenced when they washed.

The primary outcomes of the sustainability exploration were change in overall average HH performance as measured by the system and the change in the number of participants as measured by the difference in numbers of unique badges used.