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Onno K. Helder RN, MSa, Anne Marie Weggelaar MSc, Daniël C.J. Waarsenburg MSc, Caspar W.N. Looman MSc, Johannes B. van Goudoever MD, PhD, Johannes Brug PhD, René F. Kornelisse MD, PhD

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Onno K. Helder RN, MSc [a], *, Anne Marie Weggelaar MSc [b], Daniël C.J. Waarsenburg MSc [b], Caspar W.N. Looman MSc [c], Johannes B. van Goudoever MD, PhD [d, e], Johannes Brug PhD [f], René F. Kornelisse MD, PhD [a]

[a] Department of Pediatrics, Division of Neonatology, Erasmus MC-Sophia Children's Hospital, Erasmus University Medical Center, Rotterdam, The Netherlands
[b] Institute of Health Policy and Management, Erasmus University, Rotterdam, The Netherlands
[c] Department of Public Health, Erasmus University Medical Center, Rotterdam, The Netherlands
[d] Department of Pediatrics, VU University Medical Centre, Amsterdam, The Netherlands
[e] Department of Pediatrics, Emma Children's Hospital, Amsterdam, The Netherlands
[f] EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands

* Address correspondence to Onno K. Helder, RN, MSc, Department of Pediatrics, Division of Neonatology, Erasmus MC-Sophia Children's Hospital, PO Box 2060, 3000 CB, Rotterdam, The Netherlands.
E-mail address: o.helder@erasmusmc.nl (O.K. Helder).
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Background: Appropriate hand hygiene among health care workers is the most important infection prevention measure; however, compliance is generally low. Gain-framed messages (ie, messages that emphasize the benefits of hand hygiene rather than the risks of noncompliance) may be most effective, but have not been tested.
Methods: The study was conducted in a 27-bed neonatal intensive care unit. We performed an interrupted time series analysis of objectively measured hand

disinfection events. We used electronic devices in hand alcohol dispensers, which continuously documented the frequency of hand disinfection events. In addition, hand hygiene compliance before and after the intervention period were directly observed. Results: The negative trend in hand hygiene events per patient-day before the intervention (decrease by 2.3 [standard error, 0.5] per week) changed to a significant positive trend (increase of 1.5 [0.5] per week) after the intervention ($P < .001$). The direct observations confirmed these results, showing a significant improvement in hand hygiene compliance from 193 of 303 (63.6%) observed hand hygiene events at pretest to 201 of 281 (71.5%) at posttest. Conclusions: We conclude that gain-framed messages concerning hand hygiene presented on screen savers may improve hand hygiene compliance.

Hospital-acquired infections are associated with mortality and morbidity in neonatal intensive care unit (NICU) settings. The reported incidence of these infections varies between 11% and 53%.[1-3] Research shows that increasing compliance of health care workers (HCWs) with hand hygiene protocols reduces these infections and limits the spread of pathogens.[4] Overall compliance with hand hygiene protocols in hospitals is low, however.

It has been shown that hand hygiene compliance can be improved by such strategies as education, audits and feedback, environmental improvements, multimodal interventions, and reminders.[4,5] Improved hand hygiene compliance is known to reduce the rate of hospital-acquired bloodstream infections.[1] However, over time, a “washout” effect can be observed, in which the new behavior is not internalized, and participants relapse and return to their former automatic behavior, which includes insufficient hand hygiene.[6] Up to now, there has not been a proven optimal intervention that leads to lasting high compliance with hand hygiene measures. It is hypothesized that repeated attention is needed over a prolonged period to reduce the washout effect. Therefore, it is also important to address the subconscious, automatic behavior of HCWs to maintain a high level of compliance with hand hygiene protocols.

Grol and Grimshaw[7] showed that multiple interventions lead to a more sustained implementation of protocols by HCWs. Pittet et al[8] used different interventions, including poster campaigns, to promote hand hygiene; however, they did not provide any theoretical rationale behind their poster design. Gain-framed messages not only provide recommendations, but also emphasize the advantages of hand hygiene, rather than the risks of noncompliance. A literature review suggested that posters with gain-framed messages are theoretically effective in motivating HCWs’ hygiene behaviors.[9] Therefore, gain-framed messages may help promote hand hygiene in daily practice. The use of such gain-framed messages for improving hand hygiene has not been tested on hand hygiene practices in a real-life clinical setting, however.

The purpose of this study was to test the impact of gain-framed messages on the frequency of hand disinfection events and compliance in the NICU. Hand disinfection events per complete day and shifts during the day, evening, and night shift were compared.

METHODS

Design and setting

We used an interrupted time series (ITS) design with objective measures of hand disinfection events. Two segmented periods of 8 weeks before the intervention and 8 weeks during the intervention were compared by an ITS to detect changes in the longitudinal trend in hand hygiene events associated with the introduction of the intervention. In addition, observations of hand hygiene behavior were systematically performed by research associates before and after the intervention. The study was conducted in a 27-bed, level IIID NICU10 at the Erasmus MCeSophia Children's Hospital in Rotterdam, The Netherlands, between January 25, 2008, and May 25, 2008. A level IIID NICU center is equipped for all kinds of complex care for infants, including, for example, care for extremely low birth weight infants (<1,000 g), extracorporal membrane oxygenation, and surgical repair of complex congenital cardiac malformations. The NICU is divided into 3 identical subunits with 9 beds each. Approximately 750 newborns are admitted annually.

Study population

All NICU HCWs who had physical contact with infants were included in the study. These HCWs included 14 neonatologists, 8 residents, 105 nurses, 12 nursing assistants, and 4 nurse practitioners.

Intervention

As a substitute for static posters, we used a screen saver on computer displays placed in front of the desk as a communication vehicle. The computer screen saver is an efficient medium with which to communicate with employees and expose employees to hand hygiene promotion messages in a more dynamic way compared with the static medium of posters.[11-13] A total of 6 computer screens, 2 per unit, were involved. Computer screens were placed behind each desk in the 3 subunits, which were used by all HCWs and were located in high traffic areas. The computers enter "sleep mode" 5 minutes after their last use, and the screen saver is automatically displayed on the monitor. The screen saver messages included a 2-screen series with different messages that completed a cycle every 10 seconds.[12] The messages were replaced by a newly designed 2-screen series every 2 weeks, to maintain the attention of the staff and avoid desensitization to the messages.[12,13]

The screen saver messages emphasized the need for improved adherence to hand hygiene protocols and were designed according to theoretical principles of message framing.9 Images of hands, germs, and disinfection methods were shown, and titles were designed to attract attention. We added gain-framed messages aimed at promoting hand hygiene, in which we focused on the benefits to the patients and on the responsibility of HCWs to their patients and appealed to their instinctive altruistic motivation to "take good care" (example messages: "By performing appropriate hand disinfection, you maintain good health for the infants

you are caring for;" "Don't take it personally. Your hands look fantastic, but you should disinfect your hands to maintain good health for the patients and yourself"). We used images that were compatible with the message. No other interventions were performed to improve compliance with hand hygiene measures during the study period.

Five months before the initiation of the present study, a multidisciplinary infection prevention education program was organized at our NICU. This program reiterated general hygiene guidelines, encouraging HCWs to culture all types of surfaces in the NICU to improve the awareness of invisible microorganisms, and reinforced the importance of appropriate hand hygiene.

Data collection

Electronic devices were used to objectively document the frequency of hand disinfection events. Wall-mounted bedside hand alcohol dispensers were replaced by identical dispensers with a concealed electronic counter and wireless transmitting equipment (ComSens; NewCompliance, Delft, The Netherlands). These electronic dispenser devices provided continuous documentation of hand disinfection events, including documentation of date and time of the individual dispenser usage. Each press of the lever generated a click of the sensor, and an additional click occurring within 2 seconds of the previous click was considered a single hand disinfection event.[14]

In addition, the compliance of HCWs with hand hygiene protocols was evaluated during the final 2 weeks of the observation period before and after the intervention using a guided observation tool. Data from observations of HCWs who performed rescue procedures or who were visiting from other units (and thus who could not be exposed to the screen savers during the intervention period) were excluded from the analyses of these observation data. Hand disinfection should be done before touching a patient, before sterile procedures, before and after the use of gloves, after contact with body fluids, and after touching a patient. Failure to disinfect the hands during any of these events was recorded as noncompliance. Washing the hands with soap and water is appropriate when hands are visibly soiled or after bodily fluid contact.[15] Two medical students performed observations; the HCWs were unaware of the reason for the observations. HCWs are frequently observed for training as well as research purposes, and thus are used to these practices, reducing the risk of the Hawthorne effect (a usually positive short-term effect on the dependent variable caused by subjects' awareness that they are under study). The observers were not blinded to the intervention.

Along with compliance with hand disinfection protocols, we also documented the nature of the procedure (elective or rescue). Before study commencement, interobserver reliability was assessed using Cohen's k. The mean k value was >0.8, indicating good agreement. The following potential confounding factors were documented: birth weight, gestational age, and Clinical Risk Index for Babies (CRIB) score.[16]

For analysis, the day shift was defined as 8:00 AM to 4:00 PM, the evening shift

as 4:00 PM to 11:00 PM, and the night shift as 11:00 PM to 8:00 AM.

Power analysis

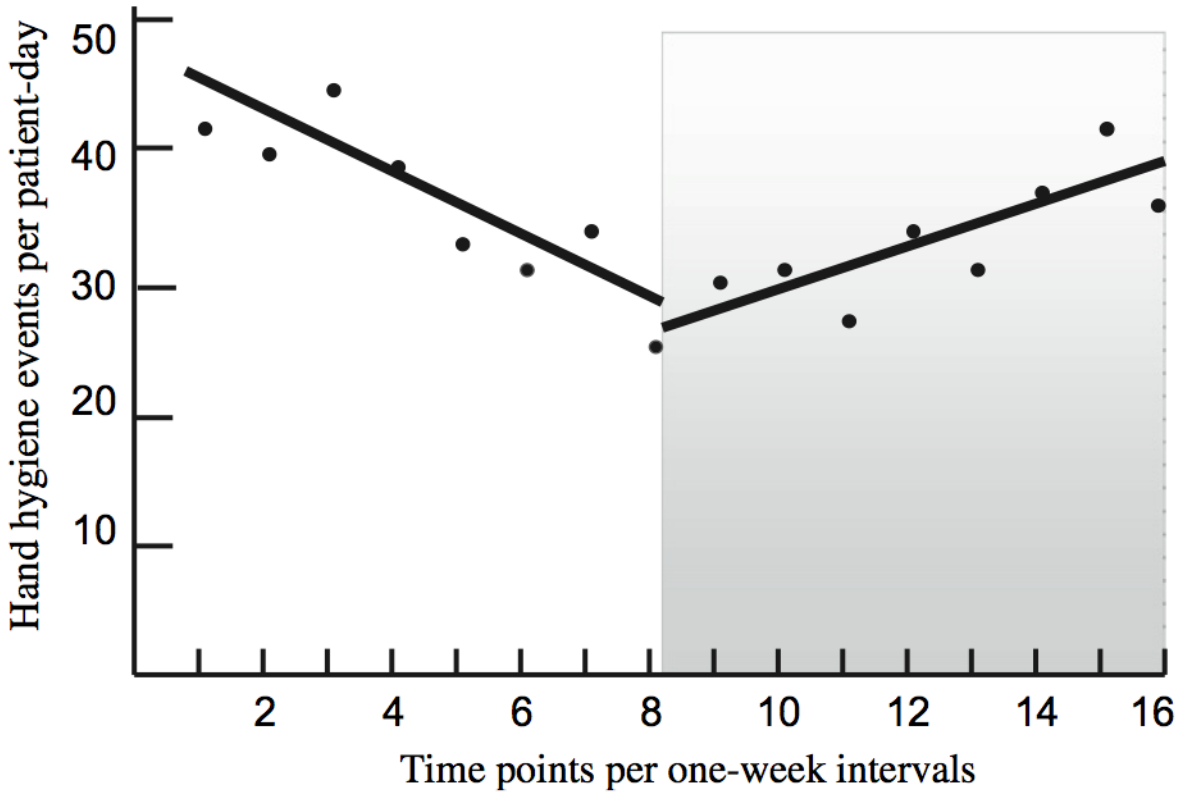

Fig 1. Time series of the aggregated hand hygiene events per patient-day over 1-week intervals. The trend shows predicted volumes from the segmented linear regression analyses. The hatched area indicates the period from which the screen savers were introduced.

We previously measured the mean number of hand disinfection events per week as 5,750 ± 450. A power analysis showed that an

increase of 675 hand hygiene disinfection events per week can be significantly detected with 80% power and a 2-sided 5% significance level. We previously showed a baseline compliance with hand hygiene of 65%, which improved after intervention to 88%. Therefore, we considered a target compliance of 80% to be realistic.1 Given the target improvement in compliance rate from 65% to 80%, we found that 135 observations in each observation period were needed to detect a significant difference with 80% power and a 2-sided 5% significance level.

Statistical analysis

We evaluated the effect of the intervention on hand disinfection practices with a segmented linear regression analysis of interrupted time series data, dividing the time series into a pretest segment and a posttest segment. We aggregated hand disinfection events over a 1-week period to determine the longitudinal effects and avoid autocorrelation. Hand disinfection events are influenced predominately by the number of patient-days; thus, we adjusted the number of hand hygiene events by dividing by the number of patient-days. The data are expressed as median and

interquartile range (IQR) unless indicated otherwise.

For the additional observations, data on compliance with hand hygiene are expressed as a percentage of all events that necessitate hand hygiene procedures. Univariate analyses using the c2 test were performed for a simple pretesteposttest comparison. P values <.05 were considered statistically significant. SPSS version 17 (IBM, Chicago, IL) was used for data analysis.

Ethical considerations

The Erasmus Medical Center's Institutional Review Board approved the study. Because of the study's observational nature, the need for informed consent from the parents was waived.

RESULTS

The patient characteristics during the preintervention period (n = 125) and postintervention period (n = 144) were well balanced. The median (IQR) birth weight was 1,980 g (1,367-3,170 g) vs 1,810 g (1,177-2,956 g) (P = .14), mean gestational age was

34 weeks (31-38 weeks) vs 33 weeks (28-37 weeks) (P = .33), and mean CRIB score was 1 (0-2) vs 1 (0-3) (P = .99).

The daily median number of hand hygiene events during the 4-month study period was 792 (705-930), with a preintervention value of 804 (686-940) and a postintervention value of 783 (726-899). The plotted interrupted time series data showed a clear change from a negative trend toward fewer hand hygiene events before the intervention to a positive trend after the intervention was introduced (Fig 1). Table 1 presents the separate analyses of all shifts combined and specific shifts, showing similar results for the different shifts separately and all shifts combined. The number of hand disinfection events per patient-day before the intervention decreased by 2.4 (standard error [SE], 0.5) per week (P = .001) per patient day. The immediate effect of the screen saver after its introduction was not significant (-1.4 [3.3]; P = .681). The posttest trend showed a significant

increase of 1.5 (0.5) hand disinfection events per week per patient-day (P = .001). The change in trend before and after the intervention was highly significant. A total of 677 observations were performed before and after the intervention was started. After excluding 51 rescue HCWs and 46 visiting HCWs, 584 observations were analyzed, including 303 observations before the intervention and 281 after starting the intervention. The compliance with hand hygiene protocols before patient contact showed a relative increase of 12.4%, from 63.6% (193 of 303 events for which the protocol required hand hygiene procedures) before the intervention to 71.5% (201 of 281) after the intervention (P = .05).

DISCUSSION

The present study provides evidence, based on objectively measured hand hygiene events, that gain-framed screen saver messages designed to improve compliance with hand hygiene protocols may have beneficial effects on the frequency of hand hygiene events. The introduction of the screen saver messages was associated with a change from a negative trend to a positive trend. This change was observed for all shifts combined as well as for the day and evening shifts separately, but it was not significant for the night shift. Additional evidence indicating that the screen savers improved hand hygiene compliance was obtained from direct and systematic observations.

Before the screen savers were introduced, a negative trend toward fewer hand hygiene events was seen in our unit. Various interventions have been implemented in efforts to improve hand hygiene, and the negative trend may be due to a washout effect of such earlier interventions. This may indicate that hand hygiene promotion requires continuous efforts. The fact that health education intervention might not have long-lasting effects has been observed for a range of health behaviors.[6,17]

During the intervention period, a clear shift in trend was observed, with an increased number of hand disinfection events per patient-day. This positive trend was more pronounced for the day and evening shifts compared with the night shift. Earlier research has indicated that hand hygiene compliance is generally lower during the night shift, possibly related to less peer pressure to perform appropriate hand hygiene.[18]

The additional observations indicate that before the intervention, HCWs on the unit were compliant with hand hygiene procedures for 63.6% of the relevant events. Previous research reported compliance rates of 23%-44% by direct observations in NICU settings,[19-21] but the relatively high compliance rate at baseline in the present study is in line with earlier observations in our NICU in 2005.[1] The observations after introduction of the screen savers indicated that hand hygiene compliance increased to 71.5%. These observational data support the time series results, but should be interpreted with more caution given the simple pretesteposttest comparison used. Although >70% observed compliance is certainly high compared with other studies,[19] it still represents an unacceptably high number of potentially dangerous opportunities for the spread of

pathogens among patients during planned patient contacts.[17]

Message framing for encouraging disease prevention behavior has been well studied. A meta-analytical review in 2007 found 93 studies and concluded that gain-framed messages are more persuasive in encouraging prevention behavior compared with loss-framed appeals.[22] Because we did not compare gain-framed messages with other messages, we cannot conclude that gain-framed messages are superior in improving hand hygiene compliance. The electronic device could be used in a study comparing different message strategies.

To the best of our knowledge, 3 previous studies have used screen savers to change behavior or for educational purposes,[11-13] but only 1 of these studies evaluated the effects.[13] It is unclear how screen saver health education can best be applied in terms of, for example, exposure time, replacement schedule, and screen design.[11,12] We chose to change the screen saver messages and pictures after 10 seconds, which appeared to be long enough for HCWs to read the message when they walked past the screen saver, but short enough to avoid boredom. New screen saver messages were introduced after 2 weeks, similar to the earlier examples.[11,12] Further research could focus on varying exposure time, replacements and screen designs to inform further improvements of screen saver education.

This study had some potential limitations. The data collection period was relatively short, given that the linear trends both before and after the intervention must flatten or reverse at some point. We may overcome this problem in future studies by collecting data for a longer period until a reverse point is obtained. Another limitation was the interrupted time series design study without a control group, which precludes us from ruling out any effects of unknown confounding factors. However, a randomized controlled trial is not feasible for evaluating health education interventions via public announcements and messages. We considered a “community” intervention trial in which units were randomly allocated to receive the intervention or not, but there are insufficient units of similar size and focus in The Netherlands for conducting such a study. An interrupted time series design was our best option. We presume that the observed beneficial shift in trend of hand hygiene events might have been caused by the intervention with gain-framed messages.

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