



A quasi-randomized controlled before–after study using performance feedback and goal setting as elements of hand hygiene promotion

S. Diefenbacher^{a,*}, P.M. Fliss^b, J. Tatzel^c, J. Wenk^b, J. Keller^a

^a Department of Social Psychology, Ulm University, Ulm, Germany

^b Bode Science Center, BODE Chemie GmbH, Hamburg, Germany

^c Institute for Infection Control, Hospitals Heidenheim, Heidenheim, Germany

ARTICLE INFO

Article history:

Received 28 November 2018

Accepted 4 February 2019

Available online 8 February 2019

Keywords:

Goal setting

Feedback

Hand hygiene

Electronic monitoring

Direct observation

Random sampling



SUMMARY

Background: Hand hygiene (HH) plays an important role in infection prevention but is often suboptimal.

Aim: To test the potential of goal setting and performance feedback in improving HH.

Methods: A prospective controlled intervention study was conducted at a German hospital. The study involved four phases: habituation to novel count dispensers and observers (T0), baseline (T1), intervention (T2) and postintervention (T3). Four non-intensive-care units were assigned to one of four conditions: goal setting, performance feedback, both goal setting and performance feedback, or none (control). During all phases, dispenser usage was electronically recorded 24/7. In addition, randomly sampled direct observation was conducted by trained external observers during each phase. The main outcome measure was the daily average of electronically counted hand hygiene events (HHEs) per patient room.

Findings: In the feedback condition, a marginally significant increase in HHEs was found from T1 to T2 ($M_{T1} = 7.3$, $M_{T2} = 10.3$, $M_{T3} = 8.2$). In the goal-setting condition, HHEs increased only descriptively from T1 to T2 ($M_{T1} = 6.8$, $M_{T2} = 8.7$, $M_{T3} = 7.8$). In the combined condition, HHEs increased significantly from T1 to T2, and were still significantly elevated at T3 ($M_{T1} = 7.9$, $M_{T2} = 17.0$, $M_{T3} = 12.9$). Over all wards and study phases, count dispenser usage frequency was highly correlated with HH compliance ($\rho = 0.766$, $P < 0.001$).

Conclusion: This study suggests that combining goal setting and feedback is a useful approach for improving HH.

© 2019 The Healthcare Infection Society. Published by Elsevier Ltd. All rights reserved.

Introduction

It is well established that hand hygiene (HH) is one of the key measures to prevent transmission of infectious agents, and to reduce healthcare-associated infections [1]. To increase health care workers' (HCWs) hand hygiene compliance (HHC), diverse intervention strategies were developed and broadly

* Corresponding author. Address: Albert-Einstein-Allee 47, 89081, Ulm, Germany. Tel.: +49 731 50 31165.

E-mail address: svenja.diefenbacher@uni-ulm.de (S. Diefenbacher).

implemented with positive results [1,2]. Despite these and other efforts, HH is still suboptimal with mean HHC rates after interventions of 57.0% as shown by a recent analysis of eight clinical trials published after 2010 [3]. Thus, there is a need for new strategies which extend and complement existing improvement programmes. Of particular interest are programmes that use behavioural approaches [4].

Feedback on performance and knowledge of results is well-accepted in the behavioural sciences as a means of guiding behaviour [5]. These factors are also integrated into most HH programmes [3,6] and recommended by the World Health Organization (WHO) as one of the most effective strategies of HH promotion [1]. Feedback is mostly given as HHC rates, but surrogate parameters are also an option [7]. Different feedback types and forms have been tested in practice so far, for example, individualized or aggregated (at different levels), one-on-one setting or group setting [6,8]. Regarding the timing of feedback, automated HH monitoring systems can be advantageous since they provide feedback near or at real-time [9]. Despite much research, it is as yet unknown what is the best approach to provide performance feedback on HH and there is a call for more research [8].

In contrast to feedback, goal setting has received little attention in HH research so far. It was applied in only a few interventions as an improvement measure, in which it was embedded in larger HH programmes (for a review, see [2]). Drawing conclusions on its effectiveness is difficult due to the multifaceted nature of the approaches, however, previously published results have been promising.

By contrast, in the behavioural sciences the concept of goal setting has been extensively investigated and was shown to increase performance in various areas [10–12]. The concept works for simple as well as for complex tasks [12,13] and it was found that challenging goals are more effective than easy goals, and challenging, specific goals are superior to vague ones (e.g. 'do your best') [10,14].

Goal setting is not only applicable at the individual level but also to groups, that is, the performance of a group can be increased by setting specific group goals [13,15]. One important difference between individual and group goals has been observed with respect to the role of participation in goal setting. As a recent meta-analysis by Kleingeld *et al.* demonstrates, a high degree of participation in goal setting is associated with a larger effect of setting specific goals for groups in field studies [13], whereas the effect of participation is only small in individual goal setting [14].

Research on individual performance demonstrates that goal setting should be combined with feedback. The combination of both elements has a higher impact on task performance than goal setting alone [5,10]. Interestingly, Neubert found little or no distinction between personal and impersonal feedback in his meta-analysis, suggesting that the use of technology for providing feedback is an option [5]. In the context of group performance, the combined effect of goal setting and feedback has not been addressed so far [13].

Given these positive results obtained in the behavioural sciences, this study aimed to investigate whether goal setting and feedback at group level led to improved HHC. To test this hypothesis, a quasi-randomized before–after study was conducted on four general wards of a tertiary hospital and compared a combined intervention with two single interventions and a control condition.

In addition, the study addresses a methodological angle. Specifically, hand hygiene events (HHEs) are assessed using dispensers equipped with electronic counters and HHC based on direct observation. The direct observation data were obtained using a random sampling scheme. Small samples of HH opportunities are problematic when it comes to detecting changes in HHC rates below 20 percentage points [16]. In addition, the sampling strategy is also vital regarding the accuracy of HHC rates assessed by direct observation. A study by Fries and colleagues simulated different HHC rates based on real entry/exit data (as proxy measures of indications 1 and 4/5) and compared sampling strategies with different observation intervals during a total of 60 min [17]. Small observation intervals (i.e. 1–15 min) sampled fewer HH opportunities, but asserted HHC more accurately. A 60-min static sampling plan (i.e. permanent observation) resulted in the biggest sample of HH opportunities, but was the least accurate. Nevertheless, the mean standard deviation of HHC rates with the best sampling strategy was with 17% still high, especially when compared to the average improvement in HHC rates of 22.9% in recent intervention studies [3]. This stresses how difficult it can be to evaluate HH interventions when directly observed HHC is the outcome measure. By using disinfectant dispensers with electronic counting, in contrast, huge sample sizes can easily be generated, but the data reflect only HHEs (as a proxy measure of hand disinfection frequency), not actual HHC [1,18]. Therefore, the degree to which the use of electronic count dispensers actually reflects HHC was carefully evaluated, specifically by condition and study phase.

Materials and methods

Design and setting

A prospective, controlled, before–after, intervention study was conducted from April 2017 to August 2017 at four non-intensive-care units of a large tertiary hospital after approval by hospital management and employee representation, as well as informed consent by ward managers and head physicians of all selected units. The study was divided into four phases: habituation to novel dispensers and observers (T0), baseline (T1), intervention (T2), and postintervention (T3). Each ward was assigned to one of four conditions: feedback, goal setting, goal setting and feedback, or none (i.e. control group). Selection of the four wards was partially based on spatial reasons, all wards were comparable in size and patients' illness severity. In all study phases, usage of hand rub dispensers was assessed continuously, and direct observations were performed on 10 days of each phase. The habituation phase served the main purpose of allowing HCWs to become familiar with HH assessments, thus reducing reactivity towards new dispensers and observers during the three critical phases [1,18].

Assessment of HH behaviour

Electronically counted dispenser usage. A few weeks prior to the start of the study all existing wall-mounted hand-disinfectant dispensers in patient rooms were replaced with electronic dispensers that counted dispenser usage and transferred data via WiFi (ingo-man Weco, Ophardt). During the habituation phase, additional dispensers were installed in a few three-

bed rooms in order to finally achieve a ratio of at least one dispenser per two beds [7]. Dispensers in patient rooms were located near the patients' beds. Overall, 92 electronic dispensers were installed on the four wards. All dispensers in patient rooms were count dispensers. Initial shortcomings in data transmission were overcome in the habituation phase. Dispenser usage data were collected as HHEs, that is, all activations of a dispenser that occurred within 2s were counted as one HHE. Time and number of activations was provided for each HHE. Data were collected continuously 24/7.

Direct observation. The main objective of direct observations was to assess to what degree electronically counted HHEs reflect HHC. Three psychology students of Ulm University served as external observers after extensive training (approximately 37 h). At the end of their training, observers reached high agreement in their ratings of indications and actions. Observers were blinded to conditions. Observations were performed on 10 days of each study phase (weekends and holidays excluded) between 06:00 and 18:00. Evidence from a simulation study [17] indicates that a more frequent change of location during observations results in a more diverse sample of HCWs and, ultimately, in a more accurate HHC rate. Therefore, time (i.e. starting time of 15-min observation windows) and place (i.e. one of four groups of patient rooms per each ward) were randomly selected for each observation day, resulting in four observation windows per ward and day (i.e. 40 observation windows per ward in each observation period). The target population comprised all HCWs working in patient care at the participating wards (caregivers, physicians and others such as physical therapists). Observers were instructed to conduct an observation in the first patient room that would be entered by one or more HCWs during the observation window. Using a modified WHO observation form, observers recorded indications (according to WHO five moments) and HH actions (hand rub performed or missed) with source of hand rub (i.e. count dispenser, other local dispenser, or personal dispenser)¹ as well as HH actions performed without indication. Importantly, observation data were recorded separately for each patient encounter (i.e. for each time an observer entered a patient room). This allowed more refined statistical testing (using patient encounters as units of analysis). When a group of HCWs was involved in patient care only the two HCWs that first engaged in patient care were observed with separate recordings, resulting in two cases out of one observation session. It was expected that a minimum of 40 patient encounters per ward and study phase could be sampled using this approach.

Intervention procedures

The intervention consisted of two components, goal setting and performance feedback, and reflected a 2 × 2 design, resulting in four conditions as mentioned above. Both intervention components were initialized on the first day of the intervention phase and included material that remained at the

staff room over the whole intervention phase. After the intervention phase (i.e. postintervention phase), all materials were removed and the intervention officially ended.

Goal setting (collective level). The goal-setting intervention started with a guided team session during change of shift with all members of the early and late shift present at the respective day. One member of the study team (J.K.) moderated the team sessions at both goal-setting wards. As an introduction, participants received information about the meaning of HHC rates, the ward's observed compliance rate,² and information about goal setting (specific, quantifiable) as a tool for improving HHC. In order to motivate participants to aim for a sufficiently challenging goal they were told that according to research [19] a minimum of 80% HHC is needed for reducing nosocomial infections. After the introduction, team members had the opportunity to discuss what goal they wanted to set for the next four weeks (i.e. specific HHC rate). Finally, every team member wrote a proposition on a piece of paper. The mean of all individual propositions was set as the ward's collective goal, written on a poster and handed over to the wards' manager for putting up on the staff room's notice board. The goal-setting wards aimed at improving their compliance rates by 23 and 24 percentage points, respectively, starting from a similarly low compliance rate. The message on the poster read 'The employees of ward XY set themselves the goal of achieving within the next four weeks (i.e. until ...) an increase of the average hand hygiene compliance rate to ...%!'

Performance feedback (collective level). Performance feedback was continuously given by screens that had been installed on the first day of intervention in the staff room in both feedback wards. The screens displayed the mean compliance rate of the last seven days. Rates were updated continuously. Compliance rates were estimated from HHEs per 24 h applying a ward-specific conversion factor, which had been calculated by combining baseline data from direct observations and electronic count dispensers. The conversion factor in the feedback condition was 0.2235 percentage points per HHE, the conversion factor in the combined condition was 0.1705 percentage points per HHE.

Outcomes and statistical analyses

The primary outcome was the average number of electronically counted HHEs per patient room and day (daily HHEs/room). The units of analysis are patient rooms. Development over time of electronically counted HHEs was tested with Friedman's test. To adjust for multiple testing Bonferroni adjustment was applied. Dispenser usage per patient day (HHEs/PD) was considered as a secondary outcome. Primary and secondary outcomes were compared descriptively to see if patterns were similar. To assess the usefulness of dispenser usage data for evaluating HH performance, count dispenser usage frequency during each observed patient encounter was compared to each patient encounter's HHC rate. HHC was calculated by dividing all HH actions (using electronic dispensers, mobile dispensers, or portable bottles) that

¹ All dispensers in patient rooms were count dispensers. A few treatment carts were available at study wards and equipped with non-count dispensers. At the time of the study, no explicit hospital policy existed to encourage the use of pocket-sized bottles. Specifying source of hand rub was needed to clarify how many hand rubs were performed without registering at count dispensers.

² HHC rates had to be calculated using pooled data of both habituation phase and baseline phase, given that data for baseline phase alone resulted in less than 150 HH opportunities. Observations were performed within six weeks.

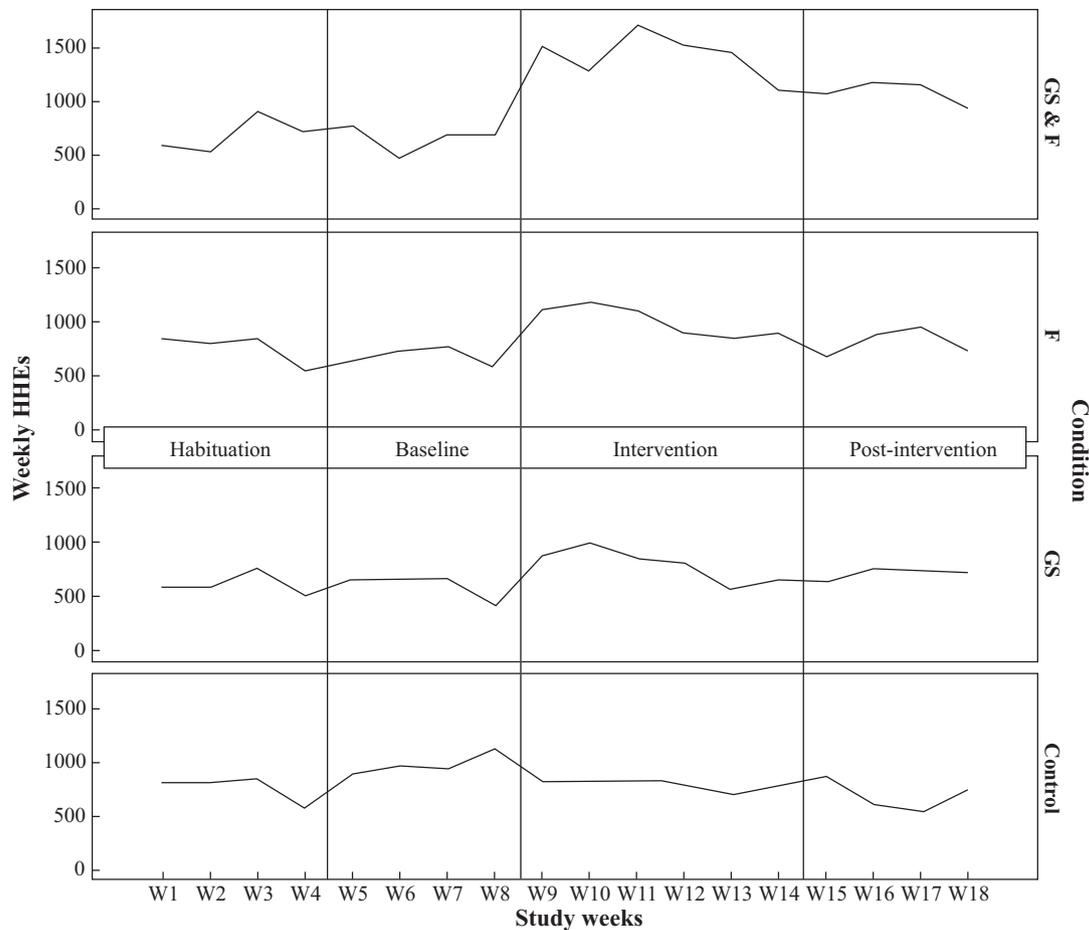


Figure 1. Accumulated hand hygiene events (HHEs) during one-week intervals by ward and study phase. F, feedback; GS, goal setting.

corresponded to at least one of the five indications by all HH opportunities. It can be assumed that the stronger the association between count dispenser usage frequency and the HHC rate, the more indicative are the electronically counted data for actual HHC. Importantly, with this approach the units of analysis are patient encounters (not HH opportunities). For statistical testing, Spearman's correlations were computed for HHC and HHE. All statistical analyses were conducted using SPSS 24 and significance tests performed two-sided. The significance level was set at 0.05.

Results

Effectiveness of the interventions (intention-to-treat analysis)

Overall, 1894 HHEs were electronically registered; 422 at T0, 427 at T1, 576 at T2, and 469 at T3. Progression of HHEs during one-week intervals by ward are given in Figure 1.

To test the effectiveness of the intervention, daily HHEs/room were compared; first, between baseline and intervention phase and, second, between baseline and postintervention phases, to test if an initially found intervention effect would

last even after the intervention had ended. A strong significant increase from baseline to intervention occurred in the goal-setting and feedback condition (from $M_{T1} = 7.9$, standard deviation $(SD)_{T1} = 1.9$, 95% confidence interval (CI) 6.6, 9.1 to $M_{T2} = 17.0$, $SD_{T2} = 4.9$, 95% CI 14.0, 20.1, $\chi^2(1, N = 12) = 12.000$, $P_{adj} = 0.004$). In the feedback condition, the increase in dispenser usage was marginally significant (from $M_{T1} = 7.3$, $SD_{T1} = 3.9$, 95% CI 5.0, 9.5 to $M_{T2} = 10.3$, $SD_{T2} = 3.6$, 95% CI 8.2, 12.3), $\chi^2(1, N = 14) = 7.143$, $P_{adj} = 0.060$). In the goal-setting condition, an increase could be observed descriptively but did not reach statistical significance (from $M_{T1} = 6.8$, $SD_{T1} = 1.9$, 95% CI 5.7, 7.9 to $M_{T2} = 8.7$, $SD_{T2} = 2.3$, 95% CI 7.3, 10.1), $\chi^2(1, N = 13) = 1.923$, $P_{adj} = 1.000$). During the post-intervention phase, dispenser usage was still significantly elevated above baseline level in the combined condition ($M_{T1} = 7.9$, $SD_{T1} = 1.9$, 95% CI 6.6, 9.1 vs $M_{T3} = 12.9$, $SD_{T3} = 5.1$, 95% CI 9.6, 16.1, $\chi^2(1, N = 12) = 12.000$, $P_{adj} = 0.004$). In the control condition, daily HHEs/room did not differ significantly between baseline and intervention ($M_{T1} = 10.2$, $SD_{T1} = 3.9$, 95% CI 7.9, 12.4 vs $M_{T2} = 8.2$, $SD_{T2} = 3.8$, 95% CI 6.0, 10.4, $\chi^2(1, N = 14) = 1.143$, $P_{adj} = 1.000$), nor between baseline and post-intervention ($M_{T1} = 10.2$, $SD_{T1} = 3.9$, 95% CI 7.9, 12.4 vs $M_{T3} = 7.1$, $SD_{T3} = 3.6$, 95% CI 5.0, 9.2, $\chi^2(1, N = 14) = 2.571$, $P_{adj} = 0.870$). However, descriptively a downward trend could be

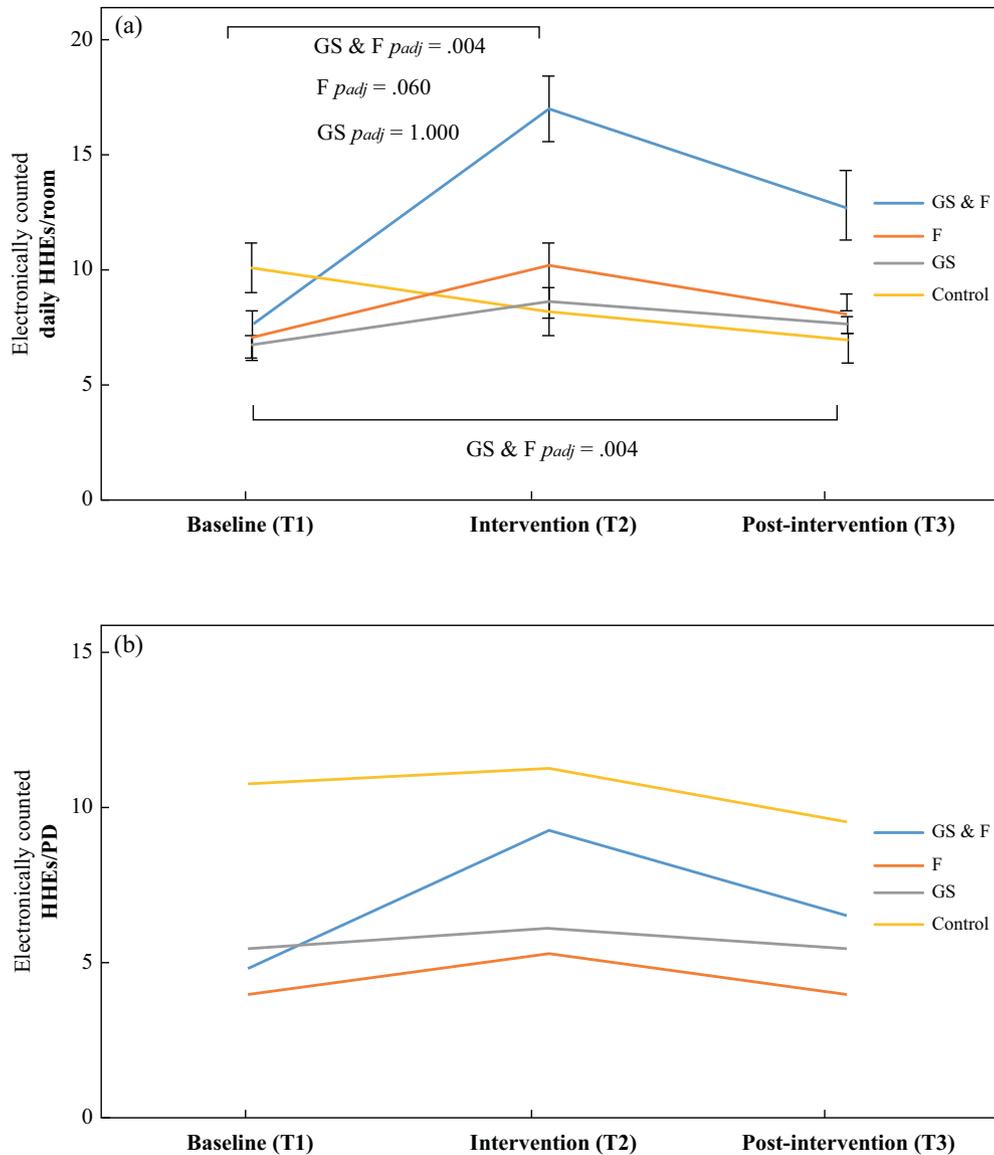


Figure 2. Effectiveness of the goal setting and feedback intervention. (a) Mean dispenser usage per day and patient room with standard errors (unit of analysis: patient room). P-values are Bonferroni adjusted. (b) Dispenser usage per patient day (unit of analysis: ward). F, feedback; GS, goal setting; HHE, hand hygiene event; PD, patient day.

observed over all three phases. Results for both comparisons (T1 vs T2 and T2 vs T3) are displayed in Figure 2a.³

To corroborate these findings, the pattern of daily HHEs/room was compared to that of HHEs/PD (see Figure 2b). In both single component interventions, HHEs/PD increased only slightly during the intervention phase and went back to baseline during postintervention (feedback: $M_{T1} = 3.9$ vs $M_{T2} = 5.2$ vs $M_{T3} = 3.9$; goal setting: $M_{T1} = 5.4$ vs $M_{T2} = 6.0$ vs $M_{T3} = 5.3$). Again, this increase was higher for the feedback condition than

for the goal-setting condition. In the combined intervention, HHEs/PD nearly doubled during the intervention phase (compared to baseline) and were still increased in the post-intervention phase ($M_{T1} = 4.8$ vs $M_{T2} = 9.2$ vs $M_{T3} = 6.5$). In the control condition, the pattern differed from the one observed in the main outcome measure in the sense that the downward trend over time was less pronounced and interrupted by a small peak during T2, paralleling the pattern in all three experimental conditions ($M_{T1} = 10.7$ vs $M_{T2} = 11.2$ vs $M_{T3} = 9.5$).

Usefulness of electronically counted dispenser usage data

Observation data were used to evaluate the usefulness of electronic count data regarding HH performance according to recommendations. Overall, 1395 HH opportunities with 354 HH actions according to WHO's five moments, as well as 325 hand

³ To test both intervention components in a joint analysis, a two-factor ANOVA with study phase (T1 vs T2 vs T3) and condition (GS vs F vs GS & F vs control) as factors and electronically counted daily HHEs/room as outcome measure was also performed and revealed a strong significant interaction effect ($F(6, 98) = 9.141$, $P < 0.001$, $\text{part}\eta^2 = .359$).

rubs using count dispensers were directly observed in a total of randomly sampled 572 patient encounters during more than 34h (see Table 1 for more details). All HH actions were hand rubs and most were performed using count dispensers (77.6%), while other types of dispenser (local or personal) were little-used (14.3% and 8.1%, respectively). The realized sample of patient encounters and HH opportunities, however, varied considerably between study phases and conditions (27–47 patient encounters, 56–143 HH opportunities).

The association strength between count dispenser usage frequency and HHC during patient encounters was calculated using Spearman's correlations. Over all wards and phases, a highly significant positive correlation was found ($\rho = 0.766$, $P < 0.001$), indicating that electronic count data are likely to be indicative of the HHC rate. Calculating correlation coefficients for each ward and study phase separately revealed that the lowest correlation was $\rho = 0.507$ and the highest correlation $\rho = 0.900$, thus, all correlations were high but varied considerably between wards and study phases (see Figure 3).

Discussion

Success of the intervention

Goal setting and continuous feedback was applied at the group level as single-component intervention as well as a combined intervention. A substantial positive impact on electronically counted dispenser usage was found when goal setting and feedback were combined. This impact was still measurable during a four-week postintervention phase. This pattern was not only found for HHEs per room, the primary outcome, but also for HHEs per patient day. Continuous feedback alone resulted in elevated HH performance only during the intervention phase, while during the post-intervention performance dropped to baseline level. However, when looking at HHEs/PD this increase was only little

above a peak detected in the control condition during T2. Goal setting alone appeared to be less effective than feedback alone as reflected in the primary and the secondary outcome measures (HHEs/room and HHEs/PD, respectively). The different patterns in the control condition regarding primary and secondary outcomes (i.e. continuous downwards trend vs overall downwards trend with peak during T2) might be due to escalating sick leaves in the control condition which forced hospital management to increasingly close beds at the control ward from T0 to T2. Fewer patients should be associated with less overall patient-care activity at the ward, which could at least partially explain the downwards trend in HHEs/room and the deviation from this downwards trend for HHEs/PD.

The results of this study are in line with research in the behavioural sciences on individual performance, showing that the combination of goal setting and feedback has a higher impact on task performance than goal setting alone [5,10]. Similarly, a previous study on HH performance had provided promising results regarding goal setting as a complementary element for feedback by comparing a state-of-the-art intervention strategy including two-time feedback with an extended intervention strategy including both feedback and goal setting [20]. Our study advances these findings by showing the advantage of combining goal setting and feedback to improve group performance compared to both single-component interventions. However, research in psychological science also showed that the performance of a group can be increased by setting specific group goals *per se* [13,15]. This finding was not replicated in our study. In part, this might be attributable to the fact that the goal-setting poster was not posted in the staff room until two weeks after the team session involving the goal-setting implementation.

Thus, when applying goal setting in future HH interventions it should preferably be applied in combination with feedback in order to maximize the impact. Both continuous feedback as in

Table 1
Descriptive statistics of direct observations

	Σ	%	Mean (standard deviation) per PE
Patient encounters	572	—	—
Observation time*	34:45 h (approx.)	—	3:40 min (4:35 min)
Details regarding observed HH opportunities**			
HH opportunities (one or more indications)	1395	100%	2.44 (2.36)
Indication 1	411	29.5%	—
Indication 2	148	10.6%	—
Indication 3	81	5.8%	—
Indication 4	329	23.6%	—
Indication 5	426	30.5%	—
Details regarding observed HH actions			
HH actions = hand rubs	419	100%	0.73 (0.88)
Hand washing with soap and water	0	0%	—
HH actions according to indication	354	84.5%	0.62 (0.81)
HH actions without indication	65	15.5%	—
HRs using count dispensers (i.e. count dispenser usage frequency)	325	77.6%	0.57 (0.72)
HRs using mobile dispensers	34	8.1%	—
HRs using personal dispensers	60	14.3%	—

HH, hand hygiene; HRs, hand rubs; PE, patient encounter.

* Approximation, determining the exact time observers spent in patient encounters was not a focus of the study.

** All indications corresponding to each opportunity were recorded.

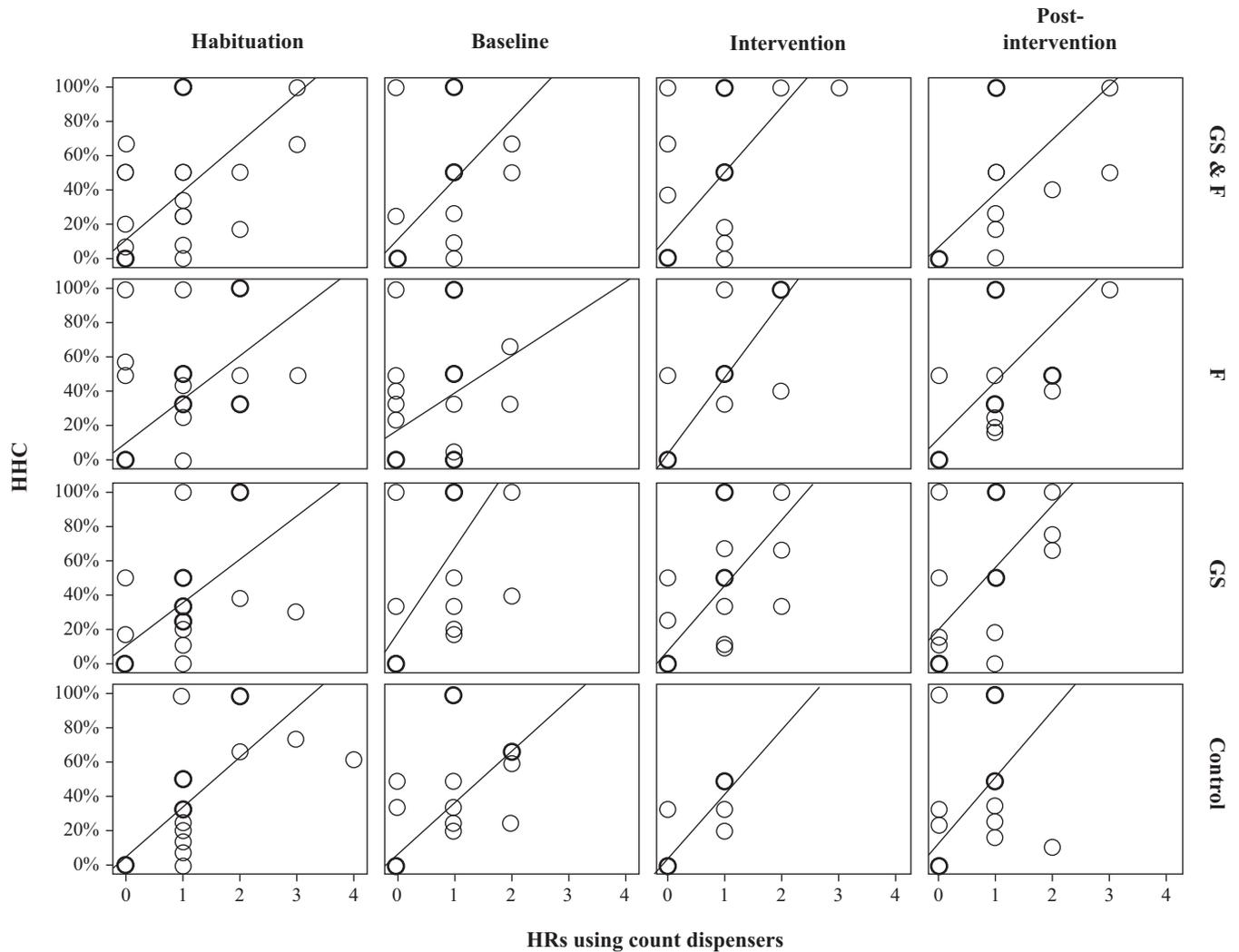


Figure 3. Scatterplots and regression lines of the associations between hand hygiene compliance (HHC) and count dispenser usage frequency during observed patient encounters by ward and study phase. F, feedback; GS, goal setting; HRs, hand rubs.

our study as well as feedback at selected points in time [20] seem to be eligible. Likewise, this study suggests that the positive effect of feedback, which was already demonstrated in several HH interventions [21], can be amplified by adding goal setting. As in the present study, the importance of participation in goal setting at group level in naturalistic groups should be accounted for [13]. For basic research, however, it would also be interesting to further investigate the effect on group performance of goal setting *per se*.

Our group approach is valuable given that working in teams is nowadays common and increasingly required in organizations including healthcare facilities. This is also in line with the request by Huis *et al.* for more team-directed strategies to improve HHC rather than approaches that mainly target the individual or organizational level [4].

Importantly, a novel element of this study was providing continuous feedback on HHC. For this purpose, the electronically counted HHEs were transformed to compliance rates. This was possible by calculating a ward-specific conversion factor based on integrating observation data and electronic count data from disinfectant dispensers. A consistency check of these conversion factors comparing data of habituation phase and

baseline phase showed satisfyingly high consistency with slightly higher consistency for the combined condition than for the feedback condition. Repetition of calculations with data from study phases three and four, however, demonstrated further oscillation of resulting conversion factors, thus violating the assumption that conversion factors should be stable over time. For both feedback wards, conversion factors calculated with data of the critical intervention phase would have resulted in lower compliance rates. Therefore, the impact of the delivered feedback can be assumed to be comparable between the two feedback conditions. Nevertheless, future research needs to determine how inaccurate feedback influences HHC and whether potential disadvantages of inaccurate feedback are compensated for by HHC rates being easier to interpret than mere HHE numbers.

Usefulness of dispenser usage data

A methodological aspect of this study was to determine to what degree HH frequency assessed by electronic count dispensers is useful regarding actual HHC. The results of our study suggest that data obtained from electronic count dispensers

can be highly informative of HH performance regarding adherence to the WHO's five moments as indicated by the high correlations between count dispenser usage frequency and conventional compliance rates in 572 patient encounters. The overall correlation found in this study is even slightly higher than the one reported by Hagel and colleagues [22]. Due to the differential association strengths between both HH parameters as a function of study phase and condition, electronically counted HHEs should, however, not be used for testing an intervention's effect on HHC (instead of sheer HH frequency) without further validation.

Of note, the randomized sampling strategy applied in this study's direct observations resulted in smaller samples of patient encounters and HH opportunities than initially planned. Moreover, sample sizes varied considerably between study phases and conditions. With a larger sample of patient encounters, the relationships by ward and study phase between HHC and count dispenser usage frequency could be evaluated more validly. Future studies should, therefore, adapt the sampling strategy. A simulation study provides insights into fruitful modifications [17]. In this study, simulated observers generated samples of nine to 17 daily patient encounters during day shifts with a similar sampling strategy (i.e. observation sessions of 1–15 min, total time budget of 60 min per day and ward). Our observers only captured between one and seven patient encounters per day and ward. The main difference between both sampling strategies seems to be that simulated observers spent their total time budget at different locations of one ward, while our observers switched wards after each observation reaching a daily net observation time of only 13 min per ward.

Importantly, larger samples of patient encounters would also result in larger samples of HH opportunities with the potential effect that a valid HHC rate for each ward and study phase could be calculated. Provided that larger samples were realized, the effect of an intervention could also be tested for HHC. However, according to Sax and colleagues, the number of HH opportunities needed for each ward and study phase should be clearly above 200 if improvements in HHC are expected to be lower than 20 percentage points [16]. This is also stressed by results of the aforementioned simulation study, which found large variations in compliance rates even with the best sampling strategy in the study [17].

Limitations

One limitation of this study concerns the control condition. During the study period, escalating staff shortage occurred and led to increasing numbers of closed beds until only half the beds were operated during T2 and T3. In this aspect, the control condition is not comparable to the three experimental conditions. Problems were also experienced in implementing the interventions. In the goal-setting condition, the poster announcing the wards' goal was available at the staff rooms' notice board with a delay of two weeks. In addition, performance feedback was interchanged between the feedback and the combined condition during the first two weeks (i.e. conversion factor of one ward was applied in the second ward and vice versa). This resulted in a mean difference of 4 percentage points from the wards' actual estimation. The accuracy of the estimation itself or lack thereof is another potential limitation of this study as mentioned above.

Conclusions

This paper reports first evidence for a strong intervention effect on HH frequency by combining goal setting and performance feedback at group level. HH programmes can benefit by not only providing feedback as recommended, for example, by the WHO multimodal strategy [1], but also integrating a goal-setting component at group level. In addition, the study contributes to HHC research by comparing HHC and HH frequency using count dispensers. Overall, a high correlation was found.

Acknowledgements

The authors want to thank Dr. Heide Niesalla for her valuable input during project meetings and on the manuscript; Hans Eberhardt, Manfred Bechtel, and Bernd Linsmeier for their dedication in preparing and conducting the study; Anja Spechtner for her support with study materials, for fostering exchange of information within the project team, for her contributions to project meetings, and her help with the manuscript; Alexandra Nick for her help with finalizing the manuscript; and all staff who participated in the study.

Conflict of interest statement

J. Wenk is an employee of BODE Chemie GmbH. Throughout the study, P. Fliss was an employee of BODE Chemie GmbH. S. Diefenbacher's and J. Keller's work was partially funded by BODE Chemie GmbH. J. Tatzel declares no conflict of interests.

Funding sources

This study was funded by BODE Chemie GmbH.

References

- [1] World Health Organization. Guidelines on hand hygiene in health care: first global patient safety challenge clean care is safer care. WHO guidelines approved by the guidelines review committee. Geneva. 2009.
- [2] Luangsanatip N, Hongsuwan M, Lubell Y, Cooper BS. Effectiveness of hand hygiene promotion in relation to level of investment: a systematic review. *Value Health* 2014;17(7):A803. <https://doi.org/10.1016/j.jval.2014.08.507>.
- [3] Kingston L, O'Connell NH, Dunne CP. Hand hygiene-related clinical trials reported since 2010: a systematic review. *J Hosp Infect* 2016;92(4):309–20. <https://doi.org/10.1016/j.jhin.2015.11.012>.
- [4] Huis A, van Achterberg T, de Bruin M, Grol R, Schoonhoven L, Hulscher M. A systematic review of hand hygiene improvement strategies: a behavioural approach. *Implement Sci* 2012;7:92. <https://doi.org/10.1186/1748-5908-7-92>.
- [5] Neubert MJ. The value of feedback and goal setting over goal setting alone and potential moderators of this effect: a meta-analysis. *Hum Perform* 1998;11(4):321–35. https://doi.org/10.1207/s15327043hup1104_2.
- [6] Schweizer ML, Reisinger HS, Ohl M, Formanek MB, Blevins A, Ward MA, et al. Searching for an optimal hand hygiene bundle: a meta-analysis. *Clin Infect Dis* 2014;58(2):248–59. <https://doi.org/10.1093/cid/cit670>.
- [7] KRINKO. Händehygiene in Einrichtungen des Gesundheitswesens: Empfehlungen der Kommission für Krankenhaushygiene und Infektionsprävention (KRINKO) beim Robert Koch Institut (RKI). *Bundesgesundheitsblatt* 2016;59(9):1189–220. <https://doi.org/10.1007/s00103-016-2416-6>.

- [8] Stewardson AJ, Sax H. Performance Feedback. In: Pittet D, Boyce JM, Allegranzi B, editors. *Hand hygiene: a handbook for medical professionals* 2017. p. 172–179.
- [9] McGuckin M, Govednik J. A review of electronic hand hygiene monitoring: considerations for hospital management in data collection, healthcare worker supervision, and patient perception. *J Healthc Manag* 2015;60(5):348–61. <https://doi.org/10.1097/00115514-201509000-00009>.
- [10] Locke E, Shaw KN, Saari LM. Goal setting and task performance: 1969–1980. *Psychol Bull* 1981;125–52. <https://doi.org/10.1037//0033-2909.90.1.125>.
- [11] McEwan D, Harden SM, Zumbo BD, Sylvester BD, Kaulius M, Ruissen GR, et al. The effectiveness of multi-component goal setting interventions for changing physical activity behaviour: a systematic review and meta-analysis. *Health Psychol Rev* 2016;10(1):67–88. <https://doi.org/10.1080/17437199.2015.1104258>.
- [12] Wood R, Mento A, Locke E. Task complexity as a moderator of goal effects: a meta-analysis. *J Appl Psychol* 1987;72(3):416–25. <https://doi.org/10.1037/0021-9010.72.3.416>.
- [13] Kleingeld A, van Mierlo H, Arends L. The effect of goal setting on group performance: a meta-analysis. *J Appl Psychol* 2011;96(6):1289–304. <https://doi.org/10.1037/a0024315>.
- [14] Tubbs ME. Goal setting. A meta-analytic examination of the empirical evidence. *J Appl Psychol* 1986;71(3):474–83. <https://doi.org/10.1037/0021-9010.71.3.474>.
- [15] O’Leary-Kelly AM, Martocchio JJ, Frink DD. A review of the influence of group goals on group performance. *Acad Manag J* 1994;37(5):1285–301. <https://doi.org/10.5465/256673>.
- [16] Sax H, Allegranzi B, Uckay I, Larson E, Boyce J, Pittet D. ‘My five moments for hand hygiene’: a user-centred design approach to understand, train, monitor and report hand hygiene. *J Hosp Infect* 2007;67(1):9–21. <https://doi.org/10.1016/j.jhin.2007.06.004>.
- [17] Fries J, Segre AM, Thomas G, Herman T, Ellingson K, Polgreen PM. Monitoring hand hygiene via human observers: how should we be sampling? *Infect Control Hosp Epidemiol* 2012;33(7):689–95. <https://doi.org/10.1086/666346>.
- [18] Diefenbacher S, Siegel A, Keller J. Verfahren zur Erfassung des Händehygieneverhaltens – Eine methodische Betrachtung aus verhaltenswissenschaftlicher Perspektive [Methods for measuring hand hygiene behavior – a methodological examination from a behavioral scientific perspective]. *Hyg Med* 2016;41(6):D105–19. <https://doi.org/10.18725/OPARU-5127>.
- [19] Kirkland KB, Homa KA, Lasky RA, Ptak JA, Taylor EA, Splaine ME. Impact of a hospital-wide hand hygiene initiative on healthcare-associated infections: results of an interrupted time series. *BMJ Qual Saf* 2012;21:1019–26. <https://doi.org/10.1136/bmjqs-2012-000800>.
- [20] Huis A, Schoonhoven L, Grol R, Donders R, Hulscher M, van Achterberg T. Impact of a team and leaders-directed strategy to improve nurses’ adherence to hand hygiene guidelines: a cluster randomised trial. *Int J Nurs Stud* 2013;50(4):464–74. <https://doi.org/10.1016/j.ijnurstu.2012.08.004>.
- [21] World Alliance for Patient Safety. *WHO guidelines on hand hygiene in health care (advanced draft): a summary*. 2005. Geneva.
- [22] Hagel S, Reischke J, Kesselmeier M, Winning J, Gastmeier P, Brunkhorst FM, et al. Quantifying the Hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. *Infect Control Hosp Epidemiol* 2015;36(8):957–62. <https://doi.org/10.1017/ice.2015.93>.