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The impact of bedside wipes in multi-patient rooms: a prospective, crossover trial evaluating infections and survival

M. Dadon [a,b,†], K. Chedid [c,†], E.T. Martin [c], I. Shaul [a], O. Greiver [a], I. Katz [a], H. Saadon [b], M. Alfaro [a], L. Hod [a], A. Shorbaje [a], A. Braslavsky-Siag [a], S. Moscovici [a], K.S. Kaye [d], D. Marchaim [a,b,*]

[a] Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel
[b] Unit of Infection Control, Shamir (Assaf Harofeh) Medical Center, Zerifin, Israel
[c] Department of Epidemiology, University of Michigan School of Public Health, Ann Arbor, MI, USA
[d] Division of Allergy, Immunology and Infectious Diseases, Robert Wood Johnson Medical School, NJ, USA

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SUMMARY

Background: Multidrug-resistant organisms (MDROs) are prevalent on high-touch surfaces in multi-patient rooms.
Aim: To quantify the impact of hanging single-use cleaning/disinfecting wipes next to each bed. Pre-specified outcomes were: (1) hospital-acquired infections (HAIs), (2) cleaning frequency, (3) MDRO room contamination, (4) new MDRO acquisitions, and (5) mortality.
Methods: Clustered randomized crossover trial at Shamir Medical Center, Israel (October 2016 to January 2018). Clusters were randomly assigned to use for cleaning either single-use quaternary ammonium wipes (Clinell) or standard practices (reusable cloths and buckets with bleach). Six-month intervention periods were implemented in alternating sequence, separated by a washout period. Five high-touch surfaces were monitored by fluorescent markers. Study outcomes were compared between periods using generalized estimating equations, Poisson regression, and Cox proportional hazards models.
Findings: Overall, 7725 patients were included (47,670 person-days), 3793 patients in rooms with intervention cleaning and 3932 patients in rooms with standard practices. During the intervention, there was no significant difference in HAI rates (incidence rate ratio: 1.6; 95% confidence interval (CI): 0.7–3.5; $P = 0.3$). However, in intervention rooms, the frequency of environmental cleaning was higher (odds ratio: 3.73; 95% CI: 2.0–7.1; $P < 0.0001$), MDRO environmental contamination rate was insignificantly lower (odds ratio: 0.7; 95% CI: 0.5–1.0; $P = 0.06$), new MDRO acquisition rate was lower (hazard ratio: 0.4; 95% CI: 0.2–1.0; $P = 0.04$), and in-hospital mortality rate was lower (incidence rate ratio: 0.8; 95% CI: 0.7–1.0; $P = 0.03$).
Conclusion: Hanging single-use cleaning/disinfecting wipes next to each bed did not affect the HAI rates but did improve the frequency of cleaning, reduce MDRO environmental contamination, and was associated with reduced incidence of new MDRO

* Corresponding author. Address: Unit of Infection Control, Shamir (Assaf Harofeh) Medical Center, Zerifin, 7030000, Israel. Tel.: +972-8-977-9049; fax: +972-8-977-9043.
E-mail address: drormarchaim@gmail.com (D. Marchaim).
† These authors contributed equally to this publication.

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acquisitions and reduced mortality. This is a feasible, recommended practice to improve patient outcomes in multi-patient rooms.

Introduction

The hospital environment serves as reservoir for nosocomial pathogens, specifically multidrug-resistant organisms (MDROs), which could then lead to hospital-acquired infections (HAIs) [1]. HAIs worsen patient outcomes and increase healthcare costs [2]. Bleach (sodium hypochlorite), which is commonly used for environmental decontamination in hospitals, can cause degradation of surfaces and is associated with toxic fumes [3,4]. Reusable cleaning items may themselves harbour MDROs [5,6]. Availability of ease of use of cleaning/disinfecting single-use wipes located in patients' immediate environment could facilitate staff compliance with cleaning protocols. This could improve the frequency of cleaning of high-touch surfaces associated with MDRO transmissions [7,8].

Clinell Universal Wipes and Clinell Sporicidal Wipes have been shown to be active (*in vitro*) against common MDROs. However, there are no controlled data pertaining to the impact of Clinell wipes, or any other wipes, with regards to clinical outcomes of patients.

Our aim was to conduct a unit-level crossover, interventional study to quantify the impact of placing single-use cleaning/disinfecting wipes in multi-patient rooms on: (1) HAI rate, (2) cleaning frequency, (3) MDRO room contamination, (4) MDRO new acquisitions (by naïve patients), and (5) in-hospital mortality.

Methods

Study design and participants

Study design and setting

A crossover, interventional study was conducted in four Medicine departments at Shamir Medical Center (SMC), central Israel. The departments are similar in size, number of beds, number of staff, and patients' baseline characteristics. The units house a range of patients from younger, healthier patients to dependent or cognitively impaired patients, unconscious individuals, and even some mechanically ventilated patients. Medicine A/D are on the northern side of the building, and Medicine B/C on the southern side of the building. The intervention was limited to one side of the building at a time to minimize crossover effects between arms. The rooms of medical floors have two or three occupants separated by fabric curtains.

The study lasted 15 months, from October 20th, 2016 to January 19th, 2018. The study consisted of two six-month study phases during which one of two clusters (departments A/D vs departments B/C) was subjected to an intervention phase (single-use wipes installed at the bedside) and to a non-intervention phase (standard practice according to Israeli Ministry of Health (MOH) guidelines, as described below). The first intervention phase was randomly (Excel; Microsoft) assigned to be executed at departments A/D. There was an additional pre-study period (one month), a washout period (one month), and a post-study period (one month) (Figure 1). All patients (>18 years) admitted to one of the study departments were included. The ethics Helsinki Committee of SMC approved the study prior to its initiation.

Standard and intervention cleaning practices

The cleaning guidelines at SMC, as per Israeli MOH regulations, were as follows: for all patients, regardless of MDRO status, standard cleaning practices were carried out once per day and included multi-use buckets and cloths with a bleach solution (1000 ppm, referring to the freely available chlorine) [9]. For patients with *Clostridium difficile*, the bleach solution was increased to 2000 ppm (daily cleaning) and 5000 ppm (terminal cleaning upon discharge). During intervention periods, high-touch surfaces (e.g. bed, bed rails, bedside table, infusion pump, monitor, cables) were cleaned with Clinell wipes, and the floor, walls, and sink were cleaned with bleach once per day. Cleaning of the immediate patient environment was performed by nurse assistants who received identical training across units regarding the implementation of the single-use wipes. Whereas it is possible that untrained individuals may have used the wipes, wipes were designated with signage as 'for staff use only' to discourage use by patients and/or visitors.

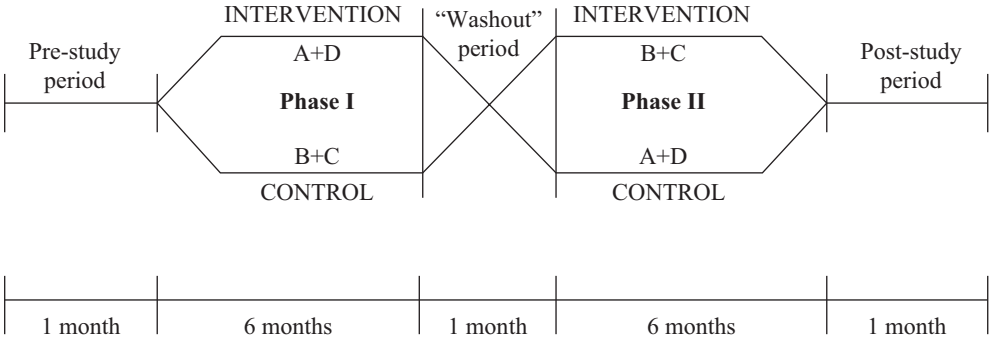

Figure 1. Schematic diagram of the study design.

Outcomes and statistical analyses

HAI rates

The primary outcome of the study was device-related HAI rates, i.e. central-line-associated bloodstream infections (CLABSIs) and catheter-associated urinary tract infections (CAUTIs), monitored in accordance with Centers for Disease Control and Prevention criteria [10,11]. Separate analyses were performed to compare incident rates of newly acquired CLABSI, CAUTI and both outcomes combined. Inclusion criteria for this analysis included: admission at the beginning of a study period for at least three days, without prior development of the outcome of interest during that hospitalization. CLABSI and CAUTI were counted from three days after phase start through three days after phase end to account for incubation time. Patients with admissions spanning both study phases were treated as separate observations for each study phase. Incident rate ratios and differences per 10,000 person-days were determined using Poisson regression. Models were clustered on a variable including both unit and study phase (e.g. unit A during study phase 1) with a random intercept and variance components covariance structure, when sample size allowed. The CAUTI-only model was non-clustered as the clustered model did not converge.

New MDRO acquisitions

MDROs included meticillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococcus (VRE), carbapenemase-producing and non-carbapenemase-producing carbapenem-resistant Enterobacterales (CRE-CP and CRE-non-CP, respectively), and non-lactose fermenting Gram-negative bacilli (*Acinetobacter baumannii*, *Pseudomonas aeruginosa*). Per SMC infection control policy, rectal swabs (to identify CRE, VRE, MRSA), nasal swabs (to identify MRSA, *A. baumannii*, *P. aeruginosa*) and bronchoaspirate samples from mechanically ventilated patients (to identify *A. baumannii*, *P. aeruginosa*) are obtained upon admission to the unit (first 24 h) and weekly thereafter. New MDRO acquisition was defined as a positive clinical or surveillance result from a naïve patient. New *C. difficile* acquisitions were determined based on clinical samples only, according to established criteria [12]. Prior MDRO carriers are flagged in the electronic medical record. MDRO acquisition analysis included patients with negative admission screen for at least one MDRO with ongoing screening during the study phase, with exclusion for patients admitted to multiple units. The association between MDRO acquisition and intervention status was evaluated by a Cox proportional-hazard model with robust sandwich variance estimates which adjusted for patient factors that differed between intervention and non-intervention groups (data not shown): long-term care facility stay in the prior three months and presence of permanent foreign device. In addition to hazard ratios, an estimated average risk difference for 26 days and the longest time to event for a single patient were calculated along with bootstrapped 95% CI [13].

Cleaning frequency

The assessments of adherence to cleaning guidelines and protocols were performed by the Clinell EvaluClean fluorescent marker system twice weekly (Mondays and Thursdays) in all participating departments, throughout the study period. The assessments included morning markings of five pre-defined locations (Figure 2) with results collected after 6 h. Markers were placed prior to the arrival of the nurse assistants who did not see the placement of the markers. Results were summarized by study phase and intervention cluster, and by department, and by time period to evaluate patterns within and between correlated locations. Cleaning was compared between intervention and non-intervention periods for each cleaning location using generalized estimating equations (GEE) including the intervention status of the room with an exchangeable correlation structure and clustering of multiple observations by individual room. Similar models were used to compare unit groups (A and D versus B and C) during intervention periods.

In-hospital mortality

In-hospital mortality was collected from medical charts. The endpoint was defined as the proportion of patients with in-hospital deaths during the measurement period. Poisson regression models including the intervention status of the patient's room prior to death and an offset term to calculate incidence rates per 10,000 person-days were used to determine the incident rate ratios and differences for the intervention. Clustered models were not used for this endpoint due to a lack of convergence; stratified results are presented.

MDRO environmental contamination

Environmental contamination measurements of MDRO were performed for all patients with a current or recent (prior two

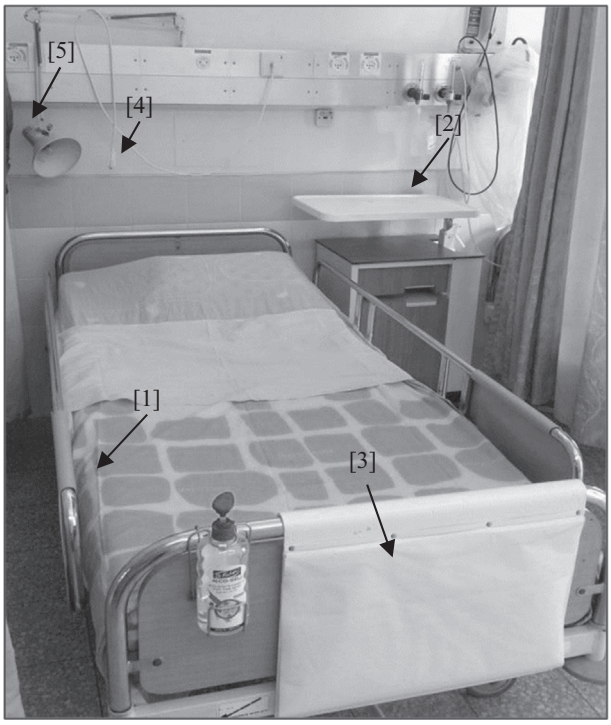

Figure 2. The five tested locations at the patient unit. The five high touch locations that were marked were: (1) right bedrail, (2) the tray of the bedside table, (3) under the binder that contains the fluid balance pages, hanging at the foot of the bed, (4) the nurse's call-on button, and (5) the lamp switch.

years) culture of MRSA, VRE, CRE, *A. baumannii*, or *P. aeruginosa*. Environmental cultures were obtained with specified sponges (Polywipe), from five locations as shown in Figure 2. Selective microbiological processing was executed for each MDRO separately [14]. The study team conducted daily surveillance, including weekends and holidays, for both clinical and surveillance positive cultures, to identify MDRO carriers (new or from the past two years). The environment was then cultured in <72 h either from admission (past carriers) or upon acquisition (new carriers). Generalized estimating equations (GEEs), including the intervention status of the room with an exchangeable correlation structure clustering by unit, were used to calculate the odds ratio and the difference in predicted probability to determine the association between MDRO contamination and intervention status overall. Non-clustered models assessed the association for each location.

Sensitivity analysis of crossover effects

The order of unit allocation was randomly chosen. However, an imbalance in patient characteristics was possible due to the small number of clusters. For this reason, a sensitivity analysis was performed to evaluate the main effect. Analyses were stratified by study phase and unit group (units A/D versus units B/C) to evaluate heterogeneity (Supplementary Table S1). These analyses allow for the assessment of any cluster effect or period effect [15]. Additional analyses using non-clustered models including study phase and an interaction term between intervention and study phase were performed to assess carryover effects for each outcome. All statistical analyses were performed using SAS version 9.4.

Results

In all, 7725 hospitalized patients were enrolled (47,670 patient-days), including five whose admissions spanned both phases: i.e. 3793 (23,792 patient-days) were hospitalized in units under intervention and 3932 (23,878 patient-days) in units not subjected to the intervention.

Device-related HAI rates

Overall, 7602 patients were included in the CLABSI-only analysis, 7592 in the CAUTI-only analysis, and 7588 in the combined analysis. There were 22 CLABSIs (14 during intervention and eight during the non-intervention period) and 57 CAUTIs (33 during intervention and 24 during the non-intervention period). The incidence rates of CLABSI, CAUTI, or both combined, were somewhat increased during the intervention, but did not reach statistical significance: i.e. for CLABSI, the incidence rate ratio (IRR) was 2.0 (95% CI: 0.5–8.0; $P = 0.3$) and the incidence rate difference (IRD) was 5.2 per 10,000 person-days (95% CI: −5.4 to 15.7; $P = 0.3$); for CAUTI the IRR was 1.4 (95% CI: 0.8–2.4; $P = 0.2$) and the IRD was 6.7 per 10,000 person-days (95% CI: −4.2 to 17.7; $P = 0.2$); and for the composite outcome the IRR was 1.6 (95% CI: 0.7–3.5; $P = 0.3$) and the IRD was 12.2 per 10,000 person-days (95% CI: −9.7 to 34.2; $P = 0.3$), as shown in Table I. When calculating the IRR while using non-clustered models including an interaction term between the intervention and study phase (Supplementary Tables S1 and S2), the interaction term effects indicated the presence of effect modification with significant differences in the association occurring, with units A and D having higher HAI rates in the first study phase (IRR: 5.2; 95% CI: 0.6–43.2; $P = 0.1$ for CLABSI; IRR: 3.2; 95% CI: 1.2–8.6; $P = 0.02$ for CAUTI; IRR: 3.4, 95% CI: 1.4–8.5; $P = 0.007$ for both combined; Supplementary Table S2).

Cleaning frequency

Cleaning frequency assessments included 400 patient units (five locations at each unit, Figure 2): 200 units of patients under the intervention and 200 units of patients not under the intervention (i.e. control period). The number of successfully cleaned locations was higher during intervention periods

Table I
Impact of locating cleaning/disinfecting wipes in patients' units at multi-patient rooms, on various hospitalization outcomes, Shamir Medical Center (October 20th, 2016 to January 19th, 2018)

Outcome	Effect (95% CI)	*P*-value
CLABSI/CAUTI[a]		
IRR	1.6 (0.7, 3.5)	0.3
IRD	12.2/100,000 person-days (−9.7, 34.2)	0.3
CLABSI[a]		
IRR	2.0 (0.5, 8.0)	0.3
IRD	5.2/10,000 person-days (−5.4, 15.7)	0.3
CAUTI[b]		
IRR	1.4 (0.8, 2.4)	0.2
IRD	6.7/10,000 person-days (−4.2, 17.7)	0.2
MDRO contamination[c]		
OR	0.7 (0.5, 1.0)	0.06
Predicted probability difference	−7.0% (−13.6%, −0.5%)	0.04
MDRO acquisition[d]		
HR	0.4 (0.2, 1.0)	0.04
Risk difference	−7.6% (−7.7%, −7.4%)	NA
In-hospital mortality[e]		
IRR	0.8 (0.7–1.0)	0.03
IRD	−19.8/10,000 person-days (−37.9, −1.6)	NA

CI, confidence interval; CLABSI, central line-associated bloodstream infection; CAUTI, catheter-associated urinary tract infection; IRR, incidence rate ratio; IRD, incidence rate difference; MDRO, multidrug-resistant organism; OR, odds ratio; NA, not applicable.

[a] Calculated using Poisson regression, clustered on a combined variable for unit and study phase.

[b] Calculated using Poisson regression with a non-clustered model.

[c] Calculated using a generalized estimating equations model clustering on unit.

[d] Calculated using a Cox proportional-hazard model. The absolute effect was calculated using the Austin method, which only provides a point estimate, along with bootstrapped confidence intervals.

[e] Calculated using a non-clustered Poisson regression.

compared to control periods for each location in models accounting for clustering by room (Figure 3). The effect was greatest for the light switch with 59% of light switches cleaned during the intervention and 26% during the control period (OR: 4.17; 95% CI: 2.6—6.8; $P < 0.001$). During intervention periods, no differences were observed by unit group, with the exception of the nurse's call-on button, which was cleaned more frequently during the intervention in units A/D compared to the intervention period in B/C.

Environmental MDRO contamination

Overall, 220 patients' units were assessed for environmental contamination: 108 during an intervention period and 112 during a non-intervention period. There were 139 (63%) contaminated units (≥1 location per carrier): 66 units under intervention, and 73 units not under intervention. The odds of environmental contamination with an MDRO was reduced during intervention periods, though it did not reach statistical significance, for all departments combined (OR: 0.7; 95% CI: 0.5—1.0; $P = 0.06$; Table I). The predicted probability of environmental contamination was significantly reduced in the intervention group (predicted probability difference: −7.0%; 95% CI: −13.6 to −0.5%; $P = 0.04$). MDRO isolation was significantly reduced during the intervention, from the tray of the bedside table (OR: 0.38; 95% CI: 0.2—0.7), from under the hanged binder (OR: 0.5; 95% CI: 0.4—0.6), and from the lamp switch (OR: 0.5; 95% CI: 0.4—0.6; Figure 2). Growth of MDROs was also reduced on the bedrail and the call-on button, though non-significantly. The most prevalent MDROs that grew from carriers' environment were *A. baumannii* (237/525 sites), followed by MRSA (125/508 sites), *P. aeruginosa* (29/225 sites), VRE (14/40 sites), CRE-CP (5/45 sites), and CRE-non-CP (2/83 sites). The prevalence of each MDRO was significantly reduced during the intervention periods in separate analyses (data not shown).

New MDRO acquisitions

A total of 984 patients (surveillance cultures obtained upon admission and at least once thereafter) were included. Overall 29 patients acquired ≥1 MDRO (21 MRSA, five *A. baumannii*, five CRE-non-CP, two *P. aeruginosa*, 1 CRE-CP): 20 acquisitions occurred during control periods and nine during intervention periods. Incident ratio was significantly lower during intervention, with a hazard ratio of 0.4 (95% CI: 0.2—1.0; $P = 0.04$; Table I). The risk difference was 7.6% (95% CI: −7.7 to −7.4). Acquisition was consistent between study phases. The overall effect was driven by units A/D (HR: 0.3; 95% CI: 0.1—0.7). A model with an interaction term between intervention and study phase indicated no effect modification.

In-hospital mortality

The in-hospital mortality analysis included 7725 patients (47,670 person-days). Four-hundred and eighty-six patients died: 267 patients during control periods, and 219 during intervention periods. The mortality incidence rate was significantly lower during an intervention period (IRR: 0.8; 95% CI: 0.7—1.0; $P = 0.03$; IRD: −19.8; 95% CI: −37.9 to −1.6; $P = 0.03$; Table I). The results were consistent between study phases, and between units, with a slightly stronger effect in units B/C (IRR: 0.7; 95% CI: 0.6—0.9; $P = 0.01$). A model with an interaction term between intervention and study phase indicated no effect modification.

Discussion

This large 'real-world' interventional study involved 7725 patients and 47,670 patient-days. The study was executed on crowded governmental Medicine floors with multi-patient rooms. By simply placing cleaning/disinfecting wipes in patients' immediate environment, we have been able to

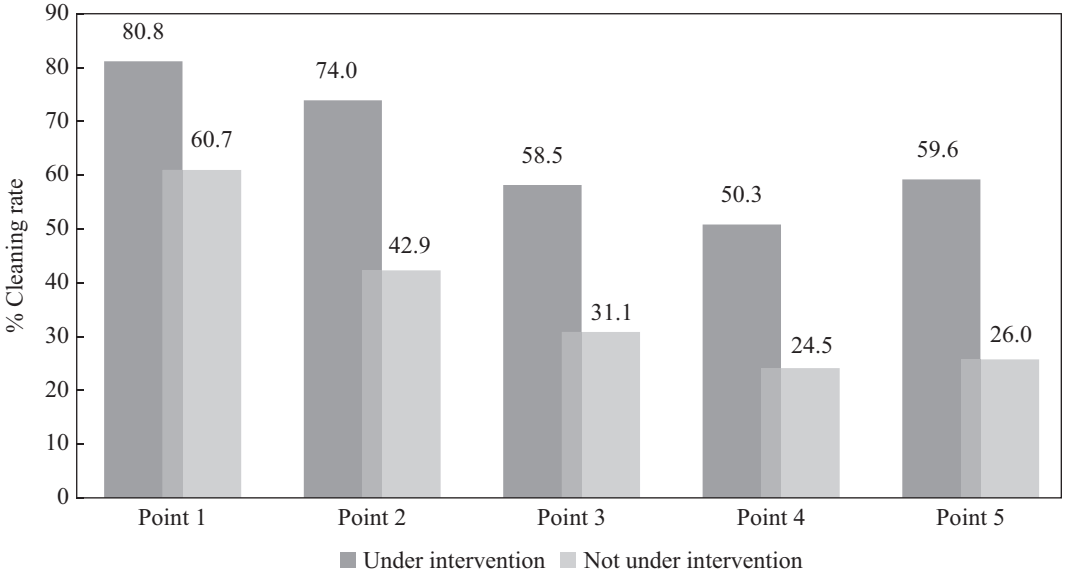

Figure 3. Percent of markers cleaned, by room location and intervention. *Cleaning points refer to: (1) the right bedrail, (2) the tray of the bedside table, (3) under the binder that contains the fluid balance pages, hanging at the foot of the bed, (4) the nurse's call-on button, and (5) the lamp switch. Results were compared to point 1.

generate controlled estimates for the impact of improved cleaning on patient outcomes. The frequency of cleaning was significantly improved while the unit was under the intervention, and the environmental contamination rates of MDRO on high-touch surfaces were also reduced (albeit not significantly for all locations), including a significant reduction in the difference in probability between intervention and control groups. This was then translated to reduced acquisitions of MDRO by naïve patients subjected to the intervention, although the absolute difference in incidence was reduced but did not reach clinical significance. Units A/D, subjected first to the intervention (Figure 1), mainly drove this effect. These stratified results are in accordance with previous studies showing that difference by time and intervention group can impact overall estimates in crossover studies [15]. The intervention had reduced acquisitions of the most epidemiologically significant human pathogens according to the World Health Organization, namely MRSA, VRE, CRE (CRE-CP, CRE-non-CP), *A. baumannii*, and *P. aeruginosa* [16].

The most prominent finding of this study is the fact that this simple practical intervention significantly improved in-hospital survival. A crossover design was used to estimate an independent association between improved cleanliness and improved survival, controlling for multiple potential biases and confounders. Our findings, both ratios and absolute effects, demonstrated a reduction in MDRO contamination and acquisition and in-hospital mortality, which should lead to implementation of this intervention in other hospitals with multi-patient rooms. We noticed the importance of locating the wipes in a hanger that is connected to the wall at the patient's unit, as it is easily noticed when the hanger is empty, so that missing wipes should be replaced. It is important to note that this study did not trial the direct efficacy of a specific wipe, but rather the general concept of using single-use wipes in these settings, in comparison to traditional practices with reusable materials [5,6]. Other single-use wipes may also prove to be effective in a similar setting. The improved outcomes with this intervention, specifically improved survival rates, outweigh, we believe, the potential environmental protection disadvantages associated with single-use materials [17].

Overall, the improved cleanliness did not impact the incidence of device-related HAI (CLABSI, CAUTI). On Medicine floors, these infections result from non-adherence to line management techniques, as the majority of catheters are not inserted in Medicine units. Environmental cleaning may have less of an impact on line management. Of note, during the intervention period, there was a cluster of CAUTI cases on Medicine C while they were under the intervention (six cases). Root-cause analysis, conducted at the time by the SMC Infection Control team, discovered large knowledge gaps in catheter management procedures among newly hired staff.

Our study was limited to a single centre and therefore monitoring of patient outcomes is warranted when generalizing these findings to other facilities. We also had a small number of randomized units and time trends of background infection rates may have impacted our results. Due to the need for training and the presence of the wipes only when a unit was under intervention, staff were aware of the study. The crossover design helped mitigate the Hawthorne effect by implementing the intervention in parallel with the control in different units and consecutively (with a washout period between study phases and between units). However, we conducted a large 'real-world' study, which measured a simple intervention to improve environmental cleanliness, and this should prompt facilities to change their practices in multi-patient rooms. Additional studies are warranted, that propose and trial additional interventions that could increase the level of cleanliness in hospitals.

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Author contributions

Conceptualization: E.T.M. and D.M.; data curation: M.D., I.S., O.G., I.K., H.S., M.A., L.H., A.S., A.B.S., S.M., and D.M.; formal analysis: M.D., K.C., E.T.M., and D.M.; investigation: M.D., K.C., E.T.M., I.S., O.G., I.K., H.S., M.A., L.H., A.S., A.B.S, S.M., and D.M.; methodology: M.D., K.C., E.T.M., and D.M.; project administration: M.D. and D.M.; resources: E.T.M. and D.M.; software: M.D., K.C., E.T.M., and D.M.; supervision: E.T.M. and D.M.; validation: M.D., K.C., E.T.M., and D.M.; writing — original draft, M.D., K.C., E.T.M., and D.M.; writing — review and editing, M.D., K.C., E.T.M., I.S., O.G., I.K., H.S., M.A., L.H., A.S., A.B.S., S.M., K.S.K., and D.M.

Conflict of interest statement

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2022.11.025.

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