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Near-patient environmental contamination of an intensive care unit with Vancomycin-resistant Enterococci (VRE) and Extended-Spectrum Beta-Lactamase-Producing Enterobacteriaceae (ESBL-E) before and after the introduction of chlorhexidine bathing for patients.

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Near-patient environmental contamination of an intensive care unit with Vancomycin-resistant enterococci (VRE) and Extended spectrum beta-lactamase producing Enterobacteriaceae (ESBL-E) before and after the introduction of chlorhexidine bathing for patients.

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Running title: VRE/ESBL-E contamination in the ICU following introduction of chlorhexidine bathing.

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In the intensive care unit (ICU), prior room contamination by patients with, for example vancomycin-resistant enterococci (VRE), and extended spectrum β-lactamase-producing Enterobacteriaceae (ESBL-E) is predictive for the acquisition of infections [1]. However, while daily chlorhexidine bathing reduces infection rates due to multidrug-resistant pathogens, [2] the effect of this practice on environmental contamination rates are largely unknown. Surveillance of the healthcare environment is usually only conducted in response to outbreaks along with other infection prevention and control (IPC) investigations and interventions [3]. This is largely due to resource constraints, the transient nature of environmental contamination, low yields from environmental screening, and culture delays, precluding rapid decision-making based on these results. In an observational study in a 12-bedded adult medical/surgical ICU during non-outbreak periods, we assessed the overall bacterial contamination of near-patient surfaces of occupied beds, including VRE and ESBL-E, before and after the introduction of chlorhexidine bathing.

A total of 1703 swabs (Copan E-swabs, Copan Diagnostics, Inc) were taken from the immediate environment (within a one meter radius approximately) of 157 ICU patients in seven, three-week intervals from October 2012 to June 2014. Chlorhexidine bathing was introduced after period four (October 2013). For patient washing, 2% Chlorhexidine Gluconate cloths, (Sage Products Inc. Illinois)

were universally adopted in 100% of ICU patients following a one-month staff-training period. In each three-week period, six 'high-touch' sites in occupied beds (Figure 1.A) were swabbed twice-weekly, as described previously [4]. For some patients, their environment was sampled more than once as their ICU stay exceeded 48 h and some patients moved beds. Swabs were processed for identification of VRE and ESBL-E among enterococci and Enterobacteriaceae as described previously [4].

The majority of environmental swabs, 1186/1703 (70%) were positive for bacterial growth. In total 176/1186 (14.8%) were *Enterococcus* spp. of which 61 % were VRE and 49/1186 (4.1 %) were Enterobacteriaceae of which 20 % were ESBL-E. Of the 1703 sites sampled, 745 (43.7 %) were taken pre-chlorhexidine and 958 (56.3 %) post-chlorhexidine introduction.

Following the introduction of chlorhexidine cloths for patient bathing there was a statistically significant reduction in overall contamination of the environment (74 % before *vs* 62 % after, p=0.0005 Fisher's exact test) and in VRE/ESBL-E contamination (9.4 % *Vs* 5.0 %, p<0.0001). The distribution of VRE/ESBL-E between the surfaces sampled pre- and post-chlorhexidine introduction is shown in Figure 1B. A statistically significant reduction in VRE/ESBL-E was found for wash-hand basins only. Cleaning practices, which involved sequentially cleaning patient bed-spaces and general ICU areas with 1000ppm sodium dichloroisocyanurate (Precept) were unchanged pre- and post-chlorhexidine introduction. Hand hygiene audits conducted over the periods in which sampling took place averaged 80.3 ± 10.5% pre-chlorhexidine vs 85.5 ± 6.5 % post-chlorhexidine introduction and the difference was not statistically significant (p=0.52, unpaired t-test). ICU annual audit data revealed a 15% increase in the number of patients admitted to the unit over the study period with bed-space occupancy increasing from 98 % to 110% and mean length of stay

decreasing from 7.0 to 6.3 days. Increased bed occupancy is reported to positively correlate with HCAI rates. [5,6] Therefore, the reduction in environmental contamination found following the introduction of chlorhexidine bathing, despite increased pressure on the unit in terms of bed occupancy, is notable. Other potential confounders that may have affected ward activity in the two phases included ambient temperature (as a measure of seasonal alterations) and antibiotic consumption. The mean ambient monthly temperature recorded by the nearest weather station (< 6 km) over the two sampling phases and available from the Irish Meteorological Service, MetEireann [7] was lower in the post-chlorhexidine period but not significantly so (7.9 ± 0.47^{o}C *Vs* 8.5 ± 0.37^{o}C, p=0.7). The ICU ambient temperature was constant between study phases (temperature 22-24^{o}C, humidity 30-60^{o}C). ICU antibiotic consumption, measured by total defined daily dose (DDD) over the two time-periods indicated a 16% increase in the post-chlorhexidine phase (6023 to 6982) but the difference was not statistically significant (p=0.176).

The microbiome of the ICU may be affected by factors including the patient cohort, changes in staff, the nature of and compliance with cleaning regimens, IPC policies, and seasonal changes in ward activity. The sampling periods investigated here can be regarded as 'snapshots' in time over 20 months based on environmental sampling of 'high-touch' ICU surfaces.

Patient chlorhexidine bathing has been reported to reduce acquisition of VRE, MRSA and coagulase-negative staphylococcal bloodstream infection rates [2] but few studies have investigated its potential impact on the healthcare environment. Of the seven MDR organisms of major public health importance, VRE and ESBL-E were investigated here as target Gram-positive and Gram-negative MDR-pathogens due to the relatively high VRE rates in Ireland and the growing ESBL-E rates [8]. The small but significant reduction in contamination overall of the healthcare environment, but particularly the significant reduction in environmental VRE/ESBL-E found

here, warrants further investigation. Limitations to this study include; a single centre, before and after design, the absence of molecular typing to characterise recovered bacteria, and the identification of environmental contamination without linking to individual patients (e.g. patients with incontinence/diarrhoea) and their flora.

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Figure Legend

Figure 1. Surface contamination with MDRO (VRE/ESBL-E). (A) Schematic of patient representative bed-space indicating the six sampling points. 1. Drip stand 2. Chart-holder/Keyboard, 3. Bed control, 4. Mattress, 5. Monitor, 6. Wash-hand basin. For sampling of wash-hand basins, those located in isolation rooms were sampled or the unit wash-hand basin, if in the open plan area. (B) Percentage of sampled sites positive for VRE/ESBL-E, before and after the introduction of chlorhexidine wipes for patient bathing. Number of sites sampled = 745 pre-chlorhexidine (63 VRE-positive, 7 ESBL-positive) and 958 post-chlorhexidine (45 VRE-positive, 3 ESBL-E positive). *** indicates statistical significance *p* value <0.005.

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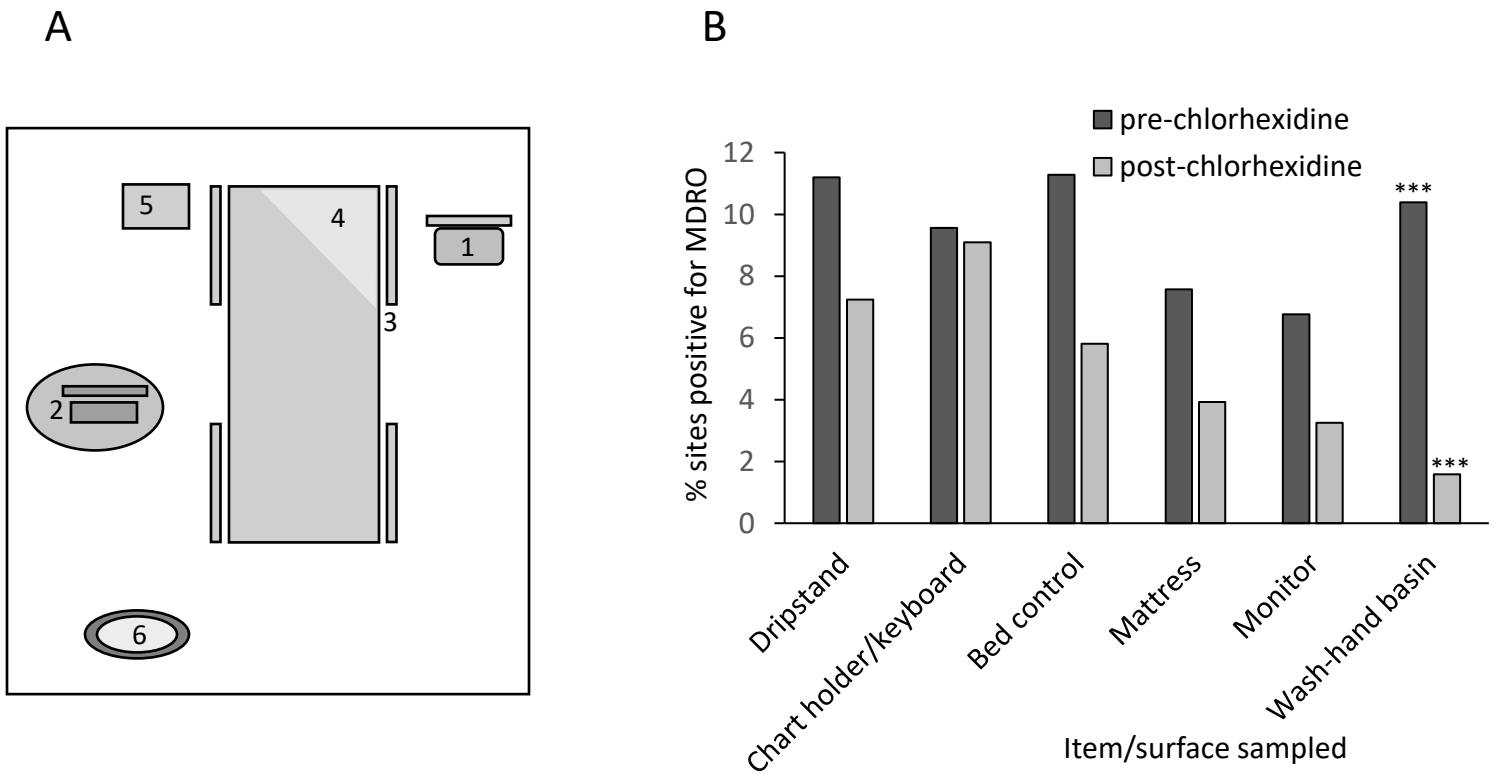
Figure 1


A
5
4
1
3
2
6
B
pre-chlorhexidine
post-chlorhexidine
% sites positive for MDRO
0
2
4
6
8
10
12
***
***
Dripstand
Chart holder/keyboard
Bed control
Mattress
Monitor
Wash-hand basin
Item/surface sampled