Antimicrobial Resistance & Infection Control

RESEARCH Open Access

Antimicrobial surface coating in the emergency department as protective technology for infection control (ASEPTIC): a pilot randomized controlled trial

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Abstract

Study objective We examined the effectiveness of an antimicrobial surface coating for continual disinfection of high touch-frequency surfaces in the emergency department (ED).

Methods Following a preliminary observation identifying stretcher rails as the surface with highest touch-frequency in the ED, we conducted a pilot randomized controlled trial involving 96 stretcher rails. The stretchers were randomized to receive an antimicrobial surface coating or placebo coating. Routine cleaning of stretchers subsequently continued as per hospital protocol in both arms. Sampling for total aerobic, gram-positive halophilic, gram-negative and methicillin-resistant *Staphylococcus aureus* bacteria was performed pre- and post-treatment at 24 h, 7 days and 180 days. Individuals who applied the coating and outcome assessors were blinded to the allocated arms. The primary outcome is contamination of antimicrobial versus placebo rails measured as colony forming units per cm^2(CFU/cm^2).

Results Baseline total aerobic bacteria was comparable between placebo and intervention arms (0.84 versus 1.32 CFU/cm^2, $P=0.235$). Total aerobic bacteria contamination was significantly lower on antimicrobial versus placebo rails at 24 h (0.61 versus 1.01 CFU/cm^2, median difference 0.40 CFU/cm^2, 95% confidence interval [CI] 0.01 to 1.01 CFU/cm^2). There was a non-statistically significant tendency for contamination to be lower on antimicrobial versus placebo rails at 7 days (1.15 versus 1.50 CFU/cm^2, median difference 0.35 CFU/cm^2, 95% CI -0.64 to 1.28 CFU/cm^2), but higher at 180 days (2.06 versus 1.84 CFU/cm^2, median difference −0.22 CFU/cm^2, 95% CI -1.19 to 0.78 CFU/cm^2).

Conclusion This is the first double-blinded, placebo-controlled, randomized trial to evaluate an antimicrobial surface coating on high touch-frequency surfaces in the emergency department. Total aerobic bacteria found on antimicrobial-coated patient transport stretcher rails was significantly lower than placebo rails at 24 h.

Keywords Emergency Service, Hospital (MeSH term), Infection Control (MeSH term), Disinfection (MeSH term), Strechers (MeSH term), Surface cleaning, Antimicrobial coating

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Introduction

Healthcare-associated infection (HAI) is a major public health problem and part of the global threat of antimicrobial resistance [1]. HAIs are independently associated with in-hospital mortality, longer length of stay, higher hospital costs and poorer health-related quality of life [2].

It is recognized that hospital surfaces are an important source of transmitting healthcare-associated pathogens including vancomycin-resistant enterococci (VRE), *Clostridium difficile*, *Acinetobacter* spp., methicillin-resistant *Staphylococcus aureus* (MRSA) and norovirus [3–5]. Disinfecting these surfaces has been shown to prevent this transmission and reduce HAIs, hence constituting a core component of infection prevention strategies [3, 6, 7]. However, current methods of routine cleaning using standard disinfectants are inadequate [8, 9]. Even if bacterial burden is reduced after routine cleaning, it rebounds quickly to pre-disinfection levels due to a lack of residual antimicrobial activity, resulting in opportunities for pathogen transmission between cleaning [10]. Consequently, more recent reviews have recommended exploring novel methods of disinfection to achieve persistent antimicrobial activity [9, 11].

Self-disinfecting surfaces is one such method that acts by continuous antimicrobial activity, independent of cleaning frequency, with very low or no toxicity to humans. The development of these enhanced surfaces has recently received accelerated adoption in the global effort to control the coronavirus disease 2019 pandemic [12–14]. Despite the enthusiasm, evidence of efficacy is limited to in vitro laboratory testing against coronaviruses, which leaves in vivo healthcare trials a continued area of need in hospital disinfection identified in recent reviews [6, 11].

One type of self-disinfecting surfaces that has been studied is surface impregnation using nanoparticles or heavy metals like copper and silver. A rare example is a randomized trial which reported significantly lower rates of HAI and colonization with MRSA/VRE for patients in intensive care unit (ICU) rooms with copper-impregnated surfaces [15]. However, heavy metal impregnation is limited to select surfaces and requires replacement of equipment.

Of growing interest are antimicrobial surface coatings which can be easily applied to any compatible surface on existing equipment. A few studies, including one randomized trial, demonstrated sustained reduction of bacterial contamination following application on high-touch surfaces in ICU and ward rooms [16–18]. However, surfaces with highest touch frequency are commonly equipment that are moved from room to room, limiting the generalizability of room-level assignment in such trials. Additionally, there have been no studies done in the emergency department (ED), which is a unique environment of high patient turnover and movement.

The objective of this study was to evaluate the effectiveness of an antimicrobial surface coating – NOMOBAC (E.R.S.T Project GmbH, Salching, Germany) to produce sustained reduction of bacterial contamination of high-touch surfaces in the ED.

Methods

Study design, setting and population

We conducted a single-centre, double-blind, placebo-controlled, randomized trial from June 2018 to January 2019, in the ED of National University Hospital, a 1,200-bed tertiary academic medical centre in Singapore with an annual ED census of 110,000 visits. As the study did not involve human subjects, ethics approval was deemed unnecessary by the National Healthcare Group Domain Specific Review Board.

In order to focus on high-risk surfaces, we conducted a preliminary observation to determine ED surfaces with highest frequencies and longest duration of touch, which at the time of study had not been quantified before [8, 19]. Two consecutive hours of surveillance camera footage of the ED was randomly selected and reviewed. The frequencies and duration of touch between a healthcare worker or patient, and hospital surfaces were manually counted. Consistent with a later observational study, a right-sided rail of a patient transport stretcher (Stryker Model 1037 Transport Stretcher, Stryker Corporation, Kalamazoo, MI) had the highest frequency and duration of touch and hence, was selected as the target surface for the trial [20]. To maintain a standard surface area for intervention coating and subsequent measurement, the entire 1,120 cm^2 surface area of the right-sided rail was included. All 96 available transport stretchers in the ED were enrolled. Stretcher flow was documented and recorded in accordance with the Consolidated Standards of Reporting Trials statement (Fig. 1).

Randomization

We generated a randomization sequence (262164837823123) in random blocks of 4, 6 and 8 using a web-based program (http://sealedenvelope.com), accessible only to the principal investigator to allocate stretchers to two allocated arms of NOMOBAC coating and placebo saline coating, thus ensuring allocation concealment. NOMOBAC is colourless and visually indistinguishable from saline. To ensure blinding, 5 mL of substance was contained in opaque syringes to be administered through needles of concealed gauges selected to create similar resistance when pushing the plunger. These syringes were labelled using a generic color-coded system with exhaustive permutations. After patient-use and routine cleaning, coating was applied once on the first day

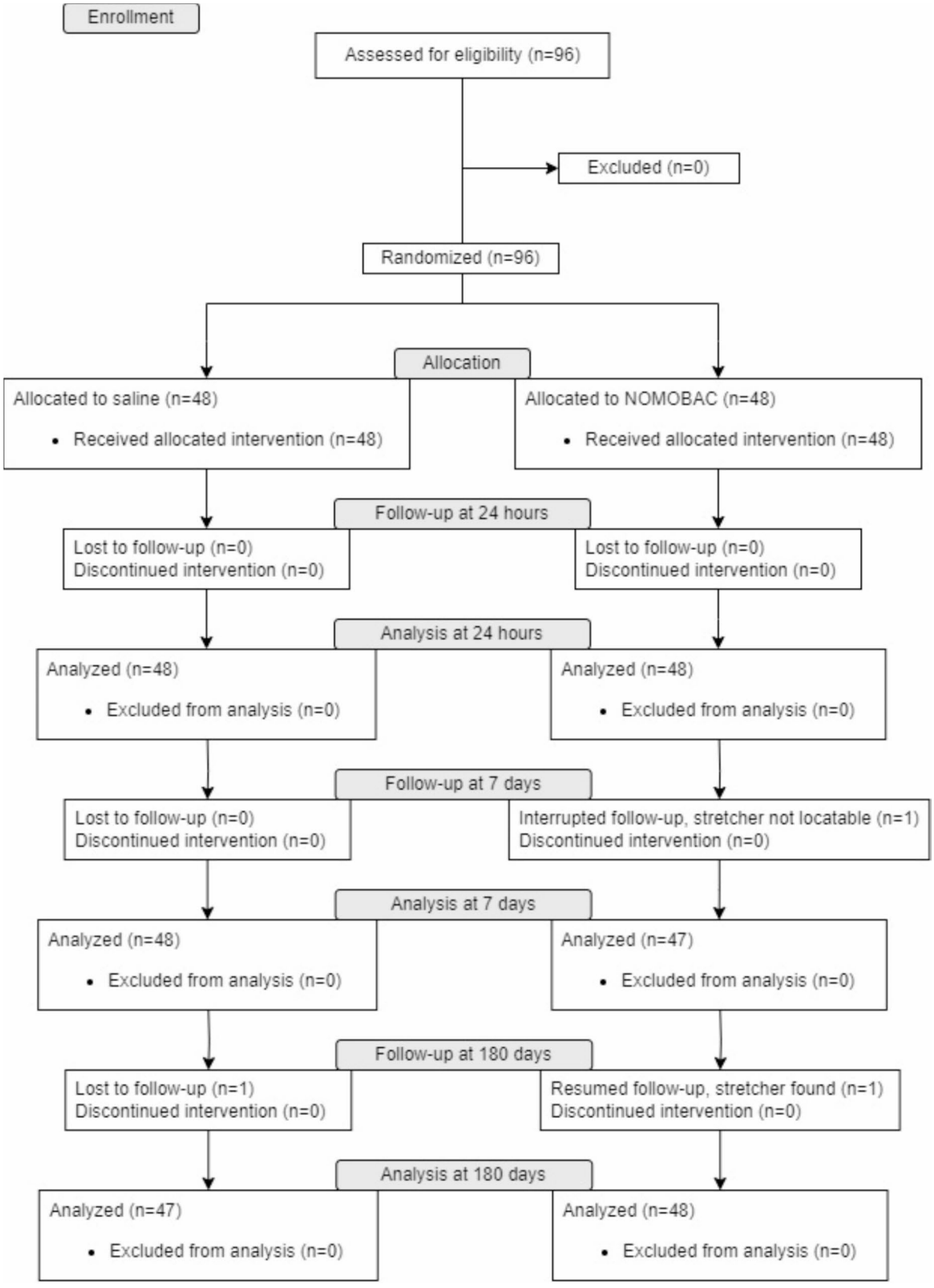

Fig. 1 CONSORT diagram of stretcher rail enrollment, allocation, follow-up, and analysis
CONSORT, Consolidated Standards of Reporting Trials

by two industry staff (Innovative German Technology Pte Ltd, Singapore) blinded to the allocation and trained in a standard application technique, wearing masks (3M™ Particulate Respirator 8210, N95) to ensure that odor was indistinguishable. Industry staff matched coating syringe to the corresponding color-codes labelled beforehand by the principal investigator, who remained otherwise uninvolved in coating application. Coated stretchers were subsequently returned to patient-use and underwent routine cleaning regardless of allocation, according to local cleaning and disinfection practices that require patient-transport staff to wipe stretchers using 70% isopropyl alcohol wipes (HospiCare™ 70) and housekeepers to wipe stretchers using Virex (Virex II 256, Diversey, Inc, Sturtevant, Wisconsin) between each patient-use.

The intervention substance is a modified acrylate and silane that produces continual non-exhaustive and non-leaching biocidal activity against bacterial cell membrane and murein layer. In vitro studies according to the International Organization for Standardization ISO 22196:2011 demonstrated this antimicrobial activity against a wide range of bacteria including resistant pathogens like MRSA and VRE [21]. NOMOBAC, previously termed Ultra Low-Technologie, is approved by United States Food and Drug Administration (Code of Federal Regulations Title 21, Sect. 175.300) and registered under bAauA (N-75661).

Microbiologic methods

Microbial sampling and detection were performed by two study members (J.T., N.H.J.) who were trained and experienced in the required technique. They remained blinded to the allocation and used a standard sampling method. Sponge sticks with neutralizing buffer (3M™ Sponge-Stick with 10 ml Neutralizing Buffer, SSL10NB) were applied across all contact surfaces of the coated stretcher rail and individually isolated into aseptic containment pouches for transport to the Digital Healthcare Innovation Centre, Department for Technology, Innovation and Enterprise, Singapore Polytechnic for processing. Bacteria suspensions were extracted from each sponge stick by manual agitation within 2 h of rail sampling. A volume of 0.1 ml bacteria suspension was inoculated via spread plating onto triplicate sets of tryptic soy agar with 5% sheep blood (TSA-SB), mannitol salt agar (MSA), MacConkey agar (Mac) and CHROMagar II (Chrom) chromogenic solid media (Becton Dickinson, Franklin Lakes, NJ). TSA-SB, MSA, Mac and Chrom were utilised to enumerate total aerobic bacteria, gram-positive halophilic bacteria, gram-negative bacteria and MRSA, respectively. Agar plates were incubated at 37 °C for 24 h before documentation of colony counts.

Collection of data

Microbial sampling was performed once on the first day after routine cleaning, before coating application, to provide a baseline of bacterial contamination of stretchers that were designated clean for patient-use. Samples were then collected 24 h, 7 days, and 180 days after coating application, immediately after patient-use, before routine cleaning. This allowed comparison of bacterial contamination between the two coatings, before routine cleaning across short and long periods of time without repeat coating application.

Outcome measures

The primary outcome was total aerobic bacteria contamination measured in colony forming units (CFU) per cm^2. Secondary outcomes include proportion of stretcher rails with contamination exceeding the recommended level of 2.50 CFU/cm^2 [8, 22–24]. Contamination by gram-positive halophilic bacteria, gram-negative bacteria and MRSA were also measured in CFU/cm^2.

When it was observed at the 24-hour sampling point that some stretcher rails in the intervention arm had visible signs of coating stripped by adhesives on plastic bags for waste disposal which were glued onto rails, a post hoc analysis was designed to evaluate bacterial contamination in a subgroup of rails with uninterrupted coating (Fig. 2). The principal investigator independently collected information on whether NOMOBAC coating was visibly intact. To ensure consistent sampling technique across all surfaces, laboratory staff were kept unaware of the intention to evaluate this subgroup separately. Moreover, the rails with intact coating were indistinguishable from stretcher rails in the placebo arm.

Statistical analysis

The primary and secondary outcomes are continuous data in non-normal distributions. We used median with interquartile ranges (IQR) for continuous variables and frequencies with percentages for categorical variables. We compared both groups on the medians of all continuous outcomes, and we derived 95% confidence intervals using percentile bootstrapping (1000 samples). The secondary outcome, rail contamination, was coded as a binary variable (yes/no) and analysed using a logistic regression model regressed on the treatment group variable. All analyses were done in R software (http://www.r-project.org).

Results

Baseline characteristics

In the preliminary observation determining touch frequencies and duration of surfaces in the ED, a right-sided rail of a patient transport stretcher was touched 112 times for 1744 s over two hours (Table 1).

Fig. 2 (Left) Photograph of plastic bag adhered onto stretcher rail via adhesive strip. (Right) Photograph of stretcher rail with visible signs of stripped antimicrobial coating (white arrow)

Table 1 Touch frequency and duration of ED surfaces over two hours

Surfaces	Touch frequency	Touch duration (seconds)
Right-sided patient stretcher rail	112	1744
Doctor's table	80	1376
Nurse's table	78	672
Doctor's chair	50	224
Patient cubicle curtain	46	512
Doctor's mouse	33	736
Doctor's telephone	4	396

A total of 96 right-sided rails of patient transport stretchers were included and randomly assigned, 48 rails to the placebo arm and 48 rails to the intervention arm. One stretcher from the intervention arm was not locatable at the 7-day sampling point but was located and sampled at the 180-day sampling point, while 1 stretcher from the placebo arm was not locatable at the 180-day sampling point (Fig. 1). The median baseline total aerobic bacteria contamination of rails after routine cleaning, before coating was 1.15 CFU/cm^2 (IQR 0.55 to 2.76 CFU/cm^2). Twenty-seven (28.1%) rails had contamination exceeding the recommended level of 2.50 CFU/cm^2. Median baseline total aerobic bacteria on rails was comparable between the antimicrobial and placebo arms (1.32 CFU/cm^2 [IQR 0.66 to 2.97 CFU/cm^2] versus 0.84 CFU/cm^2 [IQR 0.46 to 2.32 CFU/cm^2]) (Table 2).

Main results

The primary outcome of total aerobic bacteria contamination after patient-use, before routine cleaning was significantly lower on antimicrobial versus placebo rails at 24 h (0.61 vs. 1.01 CFU/cm^2, median difference 0.40 CFU/cm^2, 95% CI 0.01 to 1.01 CFU/cm^2) (Table 3). At 7 days, total aerobic bacteria contamination tended to be non-significantly lower in antimicrobial rails (1.15 vs. 1.50 CFU/cm^2, median difference 0.35 CFU/cm^2, 95% CI -0.64 to 1.28 CFU/cm^2). At 180 days, total aerobic bacteria contamination was non-significantly higher (2.06 vs. 1.84 CFU/cm^2, median difference −0.22 CFU/cm^2, 95% CI -1.19 to 0.78 CFU/cm^2).

Table 2 Baseline contamination after routine cleaning before coating

Types of organisms	Contamination in CFU/cm^2, median (IQR)		
	Total rails (*n* = 96)	Saline (*n* = 48)	NOMOBAC (*n* = 48)
Total aerobic bacteria	1.15 (0.55–2.76)	0.84 (0.46–2.32)	1.32 (0.66–2.97)
Gram-positive halophilic bacteria	0.53 (0.20–1.29)	0.42 (0.14–1.08)	0.63 (0.30–1.32)
Gram-negative bacteria	0.70 (0.32–1.53)	0.60 (0.29–1.44)	0.86 (0.36–1.82)
MRSA	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00-0.01)

MRSA, methicillin-resistant *Staphylococcus aureus*; *IQR*, interquartile range

Table 3 Contamination after patient-use, before routine cleaning, at 24 h, 7 days, and 180 days

Variables	Contamination in CFU/cm^2, median (IQR)		
	Saline (*n* = 48)	NOMOBAC (*n* = 48)	Difference of Medians (95% CI)
Total aerobic bacteria			
24 h	1.01 (0.56–2.43)	0.61 (0.30–1.42)	0.40 (0.01 to 1.01)
7 days†	1.50 (0.88–4.19)	1.15 (0.68–2.45)	0.35 (-0.64 to 1.28)
180 days‡	1.84 (1.05–3.45)	2.06 (1.23–4.85)	-0.22 (-1.19 to 0.78)
Gram-positive halophilic bacteria			
24 h	0.46 (0.17–0.91)	0.30 (0.11–0.70)	0.17 (-0.06 to 0.43)
7 days†	0.90 (0.28–1.99)	0.67 (0.31–1.13)	0.23 (-0.18 to 0.79)
180 days‡	1.10 (0.58–2.40)	0.96 (0.48–2.59)	0.14 (-0.75 to 0.71)
Gram-negative bacteria			
24 h	0.57 (0.19–1.02)	0.24 (0.15–0.75)	0.33 (0.09 to 0.45)
7 days†	0.00 (0.00-0.39)	0.00 (0.00-0.05)	0.00 (-0.01 to 0.02)
180 days‡	0.98 (0.59–2.63)	1.01 (0.60–2.97)	-0.02 (-1.06 to 0.48)
MRSA			
24 h	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00 to 0.00)
7 days†	0.00 (0.00-0.01)	0.00 (0.00–0.00)	0.00 (0.00 to 0.01)
180 days‡	0.02 (0.00-0.02)	0.00 (0.00-0.02)	0.01 (-0.00 to 0.02)

† NOMOBAC arm, *n* = 47

‡ Saline arm, *n* = 47

Table 4 Number of stretcher rails with contamination exceeding the recommended level of 2.50 CFU/cm^2

Variables	Clean (< 2.50 CFU/cm^2)	Dirty (> 2.50 CFU/cm^2)	Odds ratio (95% CI)
24 h			0.57 (0.19 to 1.61)
Saline ($n=48$)	37 (77.1%)	11 (22.9%)	
NOMOBAC ($n=48$)	41 (85.4%)	7 (14.6%)	
7 days			0.56 (0.23 to 1.32)
Saline ($n=48$)	30 (62.5%)	18 (37.5%)	
NOMOBAC ($n=47$)	35 (74.5%)	12 (25.5%)	
180 days			1.30 (0.57 to 2.95)
Saline ($n=47$)	29 (61.7%)	18 (38.3%)	
NOMOBAC ($n=48$)	27 (56.3%)	21 (43.7%)	

Table 5 24-hour contamination in subgroup of rails with visibly intact coating

Types of organisms	Contamination in CFU/cm^2, median (IQR)		
	Saline ($n=48$)	NOMOBAC ($n=21$)	Difference of Medians (95% CI)
Total aerobic bacteria	1.01 (0.56–2.43)	0.70 (0.24–1.02)	0.31 (0.03 to 0.98)
Gram-positive halophilic bacteria	0.46 (0.17–0.91)	0.20 (0.06–0.39)	0.26 (0.02 to 0.54)
Gram-negative bacteria	0.57 (0.19–1.02)	0.18 (0.12–0.33)	0.39 (0.15 to 0.51)
MRSA	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00 to 0.00)

The secondary outcome of proportion of stretcher rails exceeding the 2.50 CFU/cm^2 threshold of contamination was non-significantly lower in the antimicrobial than placebo rails at 24 h (14.6% vs. 22.9%, OR 0.57 [95% CI 0.19 to 1.61]) and at 7 days (25.5% vs. 37.5%, OR 0.56 [95% CI 0.23 to 1.32]). A non-significantly higher proportion of antimicrobial rails exceeded the threshold compared with placebo rails at 180 days (43.7% vs. 38.3%, OR 1.30, 95% CI 0.57 to 2.95) (Table 4).

The secondary outcome of gram-negative bacteria contamination was significantly lower in antimicrobial than placebo rails at 24 h (0.24 vs. 0.57 CFU/cm^2, median difference 0.33 CFU/cm^2, 95% CI 0.09 to 0.45 CFU/cm^2). Contamination with gram-positive halophilic bacteria was non-significantly lower in antimicrobial compared to placebo rails (0.30 vs. 0.46 CFU/cm^2, median difference 0.17 CFU/cm^2, 95% CI -0.06 to 0.43 CFU/cm^2). MRSA was detected on 20 (20.8%) rails at baseline sampling, at concentrations between 0.01 and 0.06 CFU/cm^2. No rail had MRSA contamination exceeding the 2.50 CFU/cm^2 threshold. MRSA contamination at 7 days and 180 days were too low to detect significant differences between the placebo and intervention rails (Table 3).

In a post-hoc subgroup of 21 (43.8%) antimicrobial rails with visibly intact coating versus placebo rails, contamination at 24 h with total aerobic, gram-positive halophilic, and gram-negative bacteria was significantly lower on antimicrobial rails (0.70 vs. 1.01 CFU/cm^2, median difference 0.31 CFU/cm^2, 95% CI 0.03 to 0.98 CFU/cm^2; 0.20 vs. 0.46 CFU/cm^2, median difference 0.26 CFU/cm^2, 95% CI 0.02 to 0.54 CFU/cm^2; and 0.18 vs. 0.57 CFU/cm^2, median difference 0.39 CFU/cm^2, 95% CI 0.15 to 0.51 CFU/cm^2) (Table 5). Three (6.4%) intervention rails had visibly intact coating at 7 days and further subgroup analysis was omitted due to this small number.

Discussion

This study confirms that current methods of routine cleaning are inadequate, reporting 28.1% of high-touch ED patient stretcher rails to exceed contamination threshold of 2.5 CFU/cm^2 despite routine cleaning. This finding is consistent with the widely acknowledged deficiency of traditional disinfection methods, an alarming cause for concern considering the established relationship between contaminated hospital surfaces, HAI, and patient safety [8, 9, 25–27].

Our study advances the solution to ineffective disinfection by answering the call to develop complementary cleaning technology [11, 25, 26]. As a double-blind, placebo-controlled, randomized trial, our project demonstrates that an antimicrobial surface coating significantly reduced bacterial contamination of a high-touch ED surface. Our study builds on the sporadic existing observations, including only one other trial reporting the promise of emerging antimicrobial surface coating technology in the hospital setting [16–18, 28]. This represents an early but crucial step towards innovation in healthcare environmental hygiene, a global agenda towards improving patient safety [11].

Contamination of antimicrobial rails at 24 h was significantly lower (0.61 vs. 1.01 CFU/cm^2, median difference 0.40 CFU/cm^2, 95% CI 0.01 to 1.01 CFU/cm^2) than placebo rails. While a widely-accepted benchmark for disinfection efficacy has yet to be established, an absolute

reduction of 0.40 CFU/cm^2 is likely to be important considering the target threshold for cleanliness is 2.5 CFU/cm^2 and often exceeded. Although contamination reduction is not statistically significant at 7 days (1.15 vs. 1.50 CFU/cm^2, median difference 0.35 CFU/cm^2, 95% CI -0.64 to 1.28 CFU/cm^2), the effect size remains consistent and considerable. Indeed, to further convey the clinical meaning of the treatment effects, stretcher rails were classified as "contaminated" if they exceeded the 2.50 CFU/cm^2 threshold, and we observed that antimicrobial rails had approximately 43% lower odds of exceeding this threshold than did placebo rails at both timepoints (Table 4).

The potentially short-lived antimicrobial action, when coupled with the significantly lower bacterial contamination seen in the subgroup of rails with visibly intact antimicrobial surface coating, suggests that the lost antimicrobial effect is attributable to stripping of the coating by adhesive-wear. Durability of surface coatings is known to be important for sustained effectiveness of antimicrobial coatings, and wear-resistance to factors like friction, heat, and alcohol solvents are routinely tested [29, 30]. However, testing is limited to in vitro laboratory settings, and to our knowledge durability against adhesive stripping has not been studied. In the context of high-touch frequency healthcare surfaces that are frequently adapted to patient-needs, as in the case of adhering plastic bags to stretcher rails, our results highlight a new potential coating property that needs to be improved.

As the first ED-based study, our finding of short-lived antimicrobial effect of stretcher rail coatings suggests activity- and department-specific considerations when developing and applying antimicrobial surface coatings. Although customizing disinfection protocols to account for different healthcare settings is a known requirement, specific recommendations for self-disinfecting technology is still lacking [31]. In most EDs, high patient-turnover may require more frequent re-application than routine recommendations by antimicrobial coating manufacturers. Properties of antimicrobial coatings may also need to be modified to withstand ED conditions. Furthermore, time between touch instances is particularly short in the ED, posing particular challenges for chemical-based antimicrobials that rely on contact-free time for microbe killing [32]. Taking into account the difficulty of routine cleaning in EDs, developing and studying specific antimicrobial technology is especially important.

MRSA was detected on 20 out of 96 (20.8%) post routine-cleaning, pre-patient-use stretcher rails, with a median of 0.00 CFU/cm^2 (IQR 0.00 to 0.00 CFU/cm^2). MRSA was detected on 50 out of 143 (35.0%) pre-routine-cleaning, post-patient-use, non-intervention stretcher rails, sampled across three time-points, with a median of 0.00 CFU/cm^2 (IQR 0.00 to 0.02 CFU/cm^2). Similar rates of environmental MRSA contamination have been shown in other studies. However, most focus on the immediate environment of patients in whom MRSA was already detected, making our undifferentiated, pre-detection research setting unique [33–35]. Given the acknowledged conundrum of MRSA carriers contaminating their environment even before detection and precaution can be instituted, our study calls further attention to disinfection in hospital settings with high turnover of patients and equipment like the ED.

The novel methods in this study improves on limitations in previous projects identified in a recent review [6]. While most prior studies used before-and-after study designs, we implemented a control arm to ensure that any observed reduction in bacterial contamination we found was attributable to the antimicrobial coating intervention instead of other inadvertent change in conditions within the study period. Additionally, our ED study setting randomizing individual stretchers instead of ward-and room-based methods used in most studies allowed direct comparison of contamination between each surface. This avoids the limitation of intervention and non-intervention surfaces mixing when individual items move between randomized rooms. Blinding of both coating applicators and microbiological samplers by using an individually unique color-coded system rather than a two-arm method of labelling population groups A or B was also unique. We tracked each stretcher at all sampling points and scheduled sampling strictly after patient-use and before routine cleaning to ensure an accurate assessment of antimicrobial efficacy by treatment coating without interference from routine cleaning.

This study identifies areas for improvement in future research. Trials using alternate antimicrobial surface coatings in the ED are needed given the unique nature of this healthcare setting. Advancement in and testing of coating mechanical properties for greater wear-resistance against adhesive stripping is important, especially for surfaces in which repeat coating is infeasible. Studies comparing different antimicrobial surface coatings may generate valuable information on ideal coating properties. Larger studies that evaluate patient-oriented outcome measures will ultimately be required to demonstrate actual reduction in HAIs, rather than relying on surrogate microbiological outcomes.

Limitations

Our study had several limitations. Firstly, sample size was not calculated and instead based on all 96 available patient stretchers, likely underpowering the study to show significant differences in contamination. Despite this small sample size, contamination at 24 h was significantly lower in the antimicrobial rails. A pre-specified sample size estimation is likely to demonstrate the full extent of antimicrobial effect. Secondly, as a single-centre

trial investigating only ED stretcher rails based on touch-frequency, our findings may not be generalizable to other surfaces or settings [36]. Additionally, sampling between 07:00 to 19:00 h omits after-hour conditions which may affect contamination.

Stretchers were occupied by patients for varying periods of time before sampling was performed, resulting in unequal opportunity for contamination. We ensured that patients occupied stretchers for at least 30 min to represent significant use. Nevertheless, the association between contamination and occupancy-time was not investigated in this study. The subgroup of intervention stretchers with visibly intact coating was acquired post hoc, as adhesive-degradation of intervention coating was unforeseen. However, the blinding that was originally planned was maintained within this subgroup since the coating remained indistinguishable, minimizing potential detection bias. The mechanism of action stated in our methods was provided by the manufacturer and, especially given the short-lived antimicrobial action with observed adhesive-wear, the study was unable to separate an active biocidal effect of the contained ingredients from passive restriction of bacterial surface binding conferred by the coating. Lastly, the secondary outcomes did not include important pathogens like VRE, against which in-vitro experiments using NOMOBAC demonstrated adequate antimicrobial activity.

Conclusions

This study reports that the surface coating NOMOBAC significantly reduces total aerobic bacteria contamination of high-touch surfaces in the ED represented by stretcher rails, for at least 24-hours after coating application. Our results suggest need for further development of antimicrobial coating technology to be durable and specific for ED conditions.

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This manuscript is original and has not already been published in another journal. A related study on touch-frequency and bacterial contamination in the emergency department was presented as a conference abstract in International Conference on Emergency Medicine.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13756-024-01481-7.

Supplementary Material 1

Author contributions

L.C. - conception, design, acquisition, analysis, interpretation of data, draft of manuscript; S.L. - design, acquisition, analysis, review of manuscript; B.Y. - acquisition, analysis, review of manuscript; C.G. - acquisition, analysis, review of manuscript; A.N. - acquisition, review of manuscript; J.T. - design, acquisition, interpretation of data, review of manuscript; N.H.J. - acquisition, interpretation of data, review of manuscript; Y.P. - analysis, interpretation of data, review of manuscript; M.C. - design, analysis, interpretation of data, review of manuscript; W.K. - conception, design, analysis, interpretation of data, review of manuscript.

Funding

This study was funded by a grant Junior Pitch For Funds from the Residents' Research Sub-Committee, National University Health System, Singapore, Singapore. The funds were used for retail purchase of NOMOBAC (E.R.S.T Project GmbH, Salching, Germany). The funding source was not involved in the preparation, submission, and review of the manuscript.

Data availability

Data is provided within the supplementary information files.

Declarations

Ethical approval

The National Healthcare Group Domain Specific Review Boards deemed ethics approval unnecessary as the study did not involve human subjects.

Competing interests

The authors declare no competing interests.

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Received: 1 June 2024 / Accepted: 6 October 2024
Published online: 29 October 2024

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