Reducing spread of Airborne and Surface Pathogens in Healthcare Practice

1. Outline

Mid May to Early August 2022 a study was undertaken in 8 locations within Ninewells Hospital, Dundee by Insite Specialist Services Ltd and the disinfection testing unit University of the West of Scotland as part of the Haarsain SBRI Challenge and hosted by NHS Tayside Innovation.

Scott McMillan *BSc (hons),* ***Chris Pearson*** *TM and* ***Gordon Bruce - Insite Specialist Services Ltd, Steven Lardner – SJL Innovations Ltd, Chris Lochrin*** *MBChB MRCP-UK FRCA FFICM –* ***NHS GGC****,* ***Gordon MacKay*** *BSc (hons), PhD, PgC TLHE, MRSB, FHEA,* ***Steven Kelly*** *PhD, B.Sc. (Hons), HEA (Fellow)* ***University of the West of Scotland, Ben Parcell NHS Tayside, Kate Cheesebrough NHS Tayside****.*

2. Summary/Abstract

Background. Systematic reviews reinforced the role of environmental contamination of hospitals & transmission of Health care- associated infections (HAI).[1,2] Whole room antimicrobial treatment is designed to reduce the microbial burden of the built environment. We investigated the impact of a combined air and surface decontamination strategy to reduce microbial burden and improve air quality within large university teaching hospital.

Methods. A transparent antimicrobial surface coating and installation of photo-catalytic oxidation driven air purification units were applied in 8 areas comprising both clinical and non clinical areas. Descriptive statistical analysis including pairwaise comparison were used to describe total surface bioburden, presented as CFU (Colony Forming Units)/1000mm^2 at pre-installation, post installation month 1 and post installation month 2 of all test areas. Measures of air quality were assessed. These were PM2.5, PM10, Particle counts (P), and CO_2. Tests were undertaken pre-installation and post-installation using an M2000 air quality monitor. Values were expressed as a percentage of 3 replicates for each result (per week). The average values were calculated for the pre-installation and post-installation phases of the study.

Results. Across test areas, surface and airborne contamination were reduced post-treatment compared to pre-treatment. Bacterial median CFU/1000mm^2 reduced from 7.00 in month 1 (pre-installation) to 3.00 in month 2 (first month post-installation) and then increased to 6.50 in month 3 (P<0.001). Fungal analysis the median CFU/1000mm^2 reduced from 6.00 in month 1 to 3.00 in month 2 and then increased to 5.00 in month 3. pairwise comparison analysis demonstrated that there was a significant difference between months 1 and 2 (P=0.005). The cleaning of areas reverted to pre covid guidance from 11th July 2022. (This was the first day of Month 3) The use of chlorine-based products would still remain for infected areas and sanitary fittings only. Air quality, described in terms of PM (particulate matter) and carbon dioxide showed overall reductions in post-installation values in comparison to pre-installation values for each of the measurands was as follows (expressed as %). PM2.5 -43%, PM10 -42%, P -34%, CO_2 -13%. We can confirm that the median results showed a further reduction other than for CO2. PM 2.5 47% to 43%, PM10 45% to 42%, P 36% to 34% CO2 9% to 13%.

Insite Specialist Services – Design of research and owners of IP.
SJL Innovations – Gathering of DATA as independent.
Dr Chris Lochrin – overview and guide to ISS.
UWS – DATA analysis and outcomes.
NHS Tayside Innovation – Host tay.innovation@nhs.scot

Keywords. Air quality, antimicrobial surface coating, health care-associated infections; hospital environment; cleaning; infection prevention.

Conclusions. Statistically significant reductions in environmental bioburden (air and surface) occurred in areas receiving antimicrobial surface coatings and air sanitisation demonstrating persistent reductions in environmental contamination. Future studies should assess optimal implementation methods and long-term impacts and association with healthcare associated infection.

3. Introduction

Systematic reviews reinforced the role of environmental contamination of hospitals & transmission of Health care- associated infections (HAI).[1,2] Whole room antimicrobial treatment is designed to reduce the microbial burden of the built environment.

In this study, the authors focused a combined (KPP) system of continuous air and surface decontamination to reduce microbial burden and thus disease. The limitations of this study prevent long term follow up monitoring of staff & patient sickness/HAI to determine if disease transmission has been reduced. Instead, we acknowledge disease transmission happens through environmental surfaces and that pathogens may survive for several weeks contributing to HAI's[3] Cleaning products and systems lack persistent efficacy so surfaces can be immediately re-contaminated after cleaning measures.[4]

Kill:
An initial decontamination is carried out using our proprietary PB2012™ disinfection to achieve as baseline level of disinfection to surfaces.

Prevent:
Antimicrobial surface protection is achieved by using Biotouch ™ organosilane formulation using a patented system of covalent grafting to ensure permanency. Biotouch ™ has broad spectrum antimicrobial activity with ultra-low toxicity. It is applicable to almost any surface without affecting aesthetics, functionality or safety. This antimicrobial coating (AMC) acts independently and autonomously in the time gap between surface disinfections. This causes a permanent reduction of the mean number of microbes on coated surfaces and thereby reducing the risk of their transmission[1,5,6,7] Thus Biotouch ™ coated 'self-sanitising' surfaces have the ability to supplement manual cleaning, which is itself subject to considerable variation.[8]

Protect:
Photo-catalytic oxidation (PCO) generated air purification is achieved by AirSanifier™ units PCO is established and is regarded as one of the most promising methods of air pollution remediation and has been the focus of research on the indoor air environment and the impact on human health.[9,10]

4. Aims & Objectives

The primary aims of this investigation were to document levels of the following before a suite of interventions referred to as the KPP system were installed.
Aim 1: Assess the microbial burden of the surfaces in the test room before and after treatment
Aim 2: Assess the air quality in the test rooms before and after treatment

We then hypothesise that reduction in these measurements with the KPP system represented cleaner air and surfaces. Cleaner healthcare environments has been postulated to impact positively on healthcare associated infections.[2]

5. Materials and Methods

Ninewells Hospital is situated on the western outskirts of Dundee and is part of NHS Scotland (Tayside) and is a Teaching Hospital. Affiliated to University of Dundee, Abertay University, Robert Gordon University.

Opened in 1974 it has approx 862 with a Major Trauma Centre

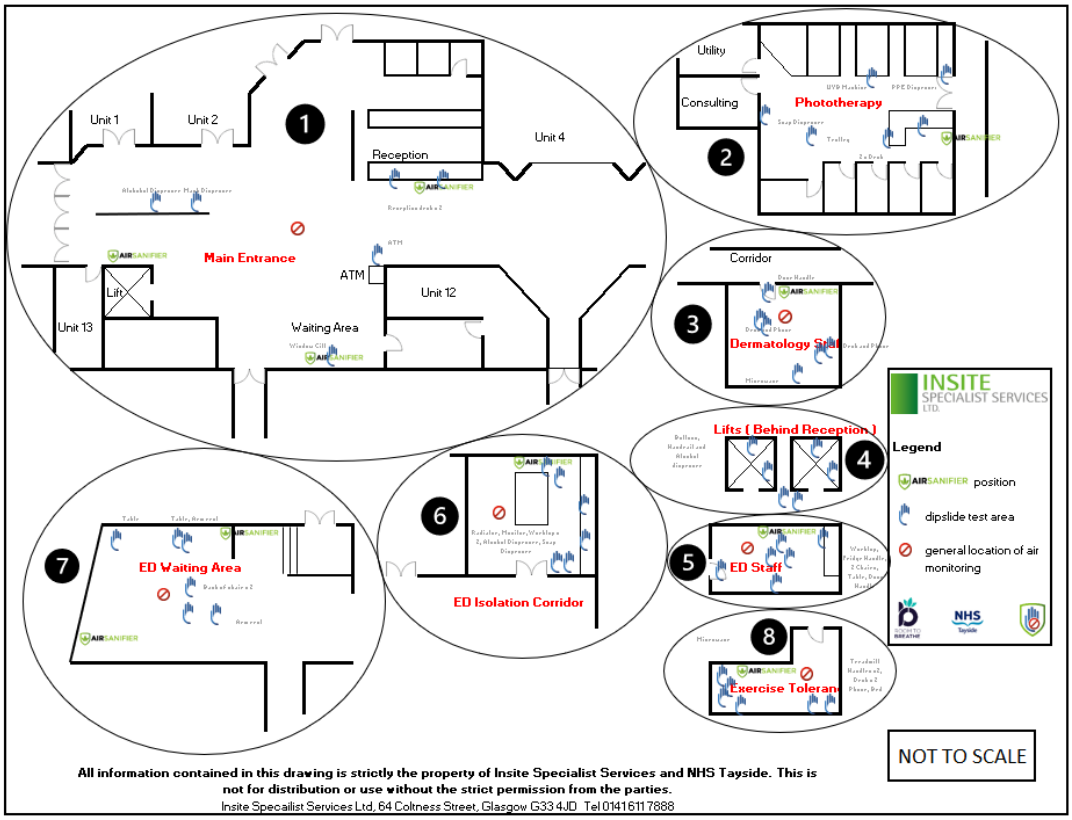
The overall installation and sampling procedures were finalised by the study team and project management team, following two onsite visits. Sites and processes for surface microbiological assessment were agreed jointly between the independent microbiologist (Mackay) and the clinical microbiologist (infection control lead), based on a review of literature and clinical / environmental microbiological expertise (Rawlinson 2019, Somsen 2020, and Al-Hamad 2008). Sites for the installation of the AirSanifiers were agreed based on clinical expertise, professional expertise (correct choice of device) and ease of installation. A risk assessment was then undertaken jointly between NHS estates and the project management team before the project was approved.

The final installation and testing protocol consisted of:

- Seven rooms or spaces available for testing.
- Six surface tests and three replicate air tests per room.
- Tests were done once per week.
- One month of testing pre-installation – once per week.
- Two months of post-installation testing once per week.
- All dipslides to be incubated at 35 – 38 degrees centigrade for 48 hours before analysis.

Figure 1 shows a schematic of the installation and testing sites.

Figure 1: Schematic of the installation and testing sites, showing each of the areas in the study



Key: The overall installation and sampling procedures were finalised by the study team and project management team, following two onsite visits. Sites for microbiological assessment were agreed jointly between the independent microbiologist and the clinical microbiologist (infection control lead). Sites for the installation of the airsanifiers were agreed based on clinical expertise, professional expertise (correct choice of device) and ease of installation.

Area 1 – Main Entrance to Hospital
Area 2 – Phototherapy
Area 3 - Dermatology Staff Room
Area 4 – Staff Lifts
Area 5 – Emergency Department Staff Room
Area 6 – Emergency Department Isolation Room
Area 7 – Emergency Department Waiting Room
Area 8 – Exercise Tolerance Room

Please see Appendix 2 for Cleaning Protocol at the start of the research. We are unable to confirm the exact protocol used by the clinical staff performing a terminal clean. This is assumed to be using Actichlor + at 1000ppm with microfiber cloths.

A protocol for accessing the testing areas, and conduct while there, was agreed in advance, and was as follows.

Responsibility
It was the responsibility of the investigator to follow Infection Control and waste management procedures, and report to the Nurse in charge of Ward area, before sampling commences, and when sampling was completed.

Safety considerations
All personnel completed the contractors induction process including infection control and PPE and occupational safety processes.

The following standard operating procedure was used for all on site visits.
Procedure
No Jewellery was worn. Long sleeve tops were not to be longer than elbow length. A surgical face mask was worn at all times. Cuts and abrasions were with an appropriate bandage/dressings. Identification badge was worn and visibly displayed at all times. Hand hygiene guidance as per NIPCM and local policy was observed. The investigator reported directly to Nurse in Charge, at Nurses station, and explained which organisation they were from, their intention to sample, how many times, and over what time frame. Confirmation from Nurse in charge regarding which area could be sampled was confirmed. The sampling procedure was undertaken quickly and quietly, to minimise any disturbance to ward occupants.

Upon leaving the area, a double check that no equipment had been left behind was completed. The nurse in charge was reported to, explaining that sampling had finished, and reiterated our intention to return for further sampling the following week. Upon exiting ward, hands were cleansed following NIPCM and local guidelines.

(1) Microbial burden of the surfaces in the room

All surfaces were sampled in the same way. The surface testing was carried out in the same locations throughout the research period and adjacent to “Biotouch Protected” stickers to identify areas as well as maintaining consistency. This was explained within the report, if there are specific information you would like to see please advise.

Commercially available microbiological dipslides were supplied by dip-slides.com (Fife Resource Base, Unit 1, Faraday Road, Glenrothes, KY6 2RU, United Kingdom). They contained two different agars, Total Cell Count Agar for enumeration of bacteria, and Malt Extract Agar for enumeration of fungi. We acknowledge that

these media are not absolutely selective for bacteria or fungi and some crossover between media is expected. Each test site identified for microbiological testing was tested in the same way. The dipslide was carefully removed from the tube and pressed on the test surface for 5 seconds and then replaced in the tube for transportation back to the laboratory. Each surface was tested for cultivable bacteria and fungi. All dipslides were incubated at 37 degrees centigrade for 48 hours and then read for colony forming units. Colony forming unit values were reported as Colony Forming Units (CFU)/1000mm^2. All data recording was done in Microsoft Excel (Office365 version 22065). All data analysis was performed in Jamovi (version 2.2.5). Basic descriptive statistics were performed for each test site and for the data as a whole for both cultivable bacteria and fungi. An analysis of the distribution of the CFU/1000mm^2 values, graphically, and by using the Shapiro Wilk test for normality was performed (where a P value of less than 0.05 suggested a non-normal data distribution). The data were considered non-normally distributed and non-parametric tests were used for all statistical analysis. The data were presented as dotplot graphs and the difference between median values analysed using Kruskall Wallis (non-parametric one way ANOVA test). Pairwise comparisons were performed using the Dwass-Steel-Chritchlow-Fligner method. In all cases a P value of less than 0.05 was considered as significant.

(2) Air quality testing

Airbourne particulate matter (PM) is not a single pollutant, but rather is a mixture of various chemicals, compounds, organisms and inert products. It is a complex mixture of solids and aerosols composed of droplets of liquid, dry solid fragments and solids with liquid coatings. Particles are defined by their diameter for air quality regulatory purposes. Those with a diameter of 10 microns or less (PM10) are inhalable into the lungs and can induce adverse health effects. Fine particulate matter is defined as particles that are 2.5 microns or less in diameter (PM2.5). Therefore, PM2.5 compromises a portion of PM10.

Measurements of PM2.5, PM10, P (Particle count) and Carbon Dioxide (CO_2) were undertaken three times (within 10 minutes of each other) within the room using a M2000 air quality monitor (Temtop [Elitech Technology Inc.], Milpitas, United States of America). Samples were collected in triplicate in each space and average calculated per visit.

6. Results

The results section is organised into surface microbiological testing (1) and air quality testing (2). All installation and testing procedures were undertaken as detailed in the materials and methods section. All installations and test sites were agreed by the study team and project team in advance of study commencing. No changes were made during the conduct of the study.

(1) Surface microbiology testing

All procedures used to undertake the surface microbiology testing were as described in the materials and methods section.

Analysis of the whole dataset (including all test sites)

Bacterial analysis

Table 1: Descriptive statistics for total bacteria (CFU/1000mm^2)

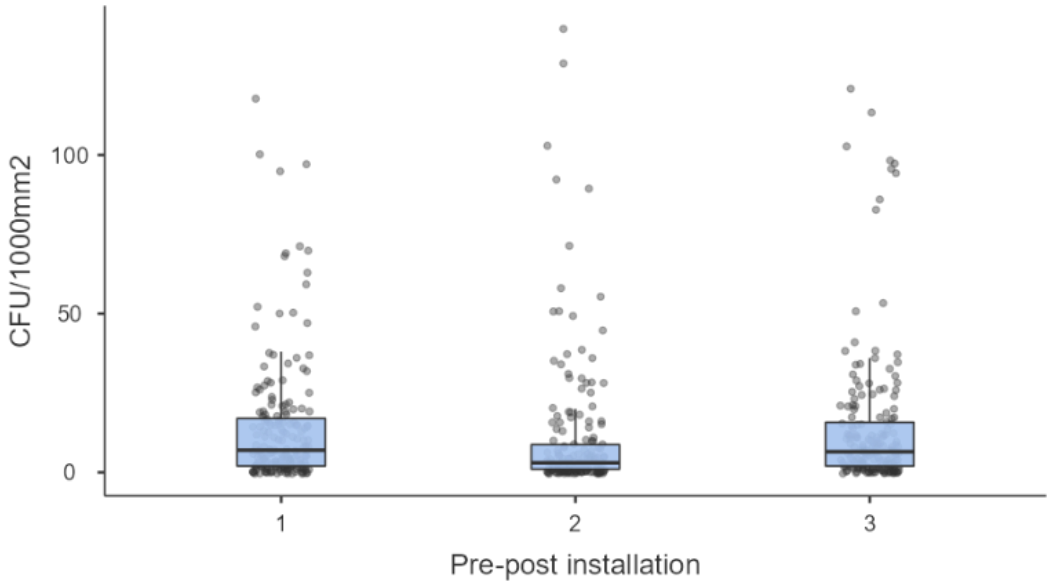
Descriptives

	Pre-post installation	CFU/1000mm2
N	1	189
	2	186
	3	182
Missing	1	3
	2	6
	3	10
Mean	1	14.0
	2	10.5
	3	14.2
Median	1	7
	2	3.00
	3	6.50
Standard deviation	1	19.9
	2	21.2
	3	22.3
IQR	1	15.0
	2	7.75
	3	13.8
Minimum	1	0
	2	0
	3	0
Maximum	1	118
	2	140
	3	121
Shapiro-Wilk W	1	0.675
	2	0.524
	3	0.613
Shapiro-Wilk p	1	< .001
	2	< .001
	3	< .001

Key: Descriptive data are presented for the dataset. Values are presented as CFU (Colony Forming Units)/1000mm^2. Details of the statistical tests used can be found in the methods section. The median CFU/1000mm^2 was highest in the pre-installation month (month 1) when compared to the two post installation months (months 2 and 3). Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

Boxplot analysis for total bacteria

Figure 2: Boxplot analysis for total bacteria (CFU/1000mm^2)



Key: The median CFU/1000mm^2 was highest in the pre-installation month (month 1) when compared to the two post installation months (months 2 and 3). Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

One-way ANOVA non-parametric for total bacteria

Table 2: One-way ANOVA non-parametric for total bacteria (CFU/1000mm^2)

Kruskal-Wallis

	χ^2	df	p
CFU/1000mm2	21.9	2	< .001

Key: The one-way ANOVA (non-parametric) test was performed to determine if there were significant differences between the median values for each month. A P value of <0.05 was considered as significant.

The results of the test statistic suggest that there was a significant difference between the median CFU/1000mm^2 values. A pairwise comparisons test was performed to indicate where the significant differences were (Table 3).

Table 3: Pairwise comparisons for total bacteria (CFU/1000mm^2)

Pairwise comparisons - CFU/1000mm2

		W	p
1	2	-5.939	< .001
1	3	-0.474	0.940
2	3	5.492	< .001

Key: The pair-wise comparison testing was performed to determine where there were significant differences between the median values. A P value of <0.05 was considered as significant. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

The pairwise comparisons test suggested that differences in the median CFU/1000mm^2 values were found between month 1 (pre-installation) and month 2 (first month post installation), and month 2 (first month post installation) and month 3 (second month post installation). These data suggest that there was a significant reduction in the median CFU/1000mm^2 value between month 1 (pre-installation) and month 2 (first month post installation) but that the median CFU/1000mm^2 value increased between month 2 (first month post installation) and month 3 (second month post-installation).

Fungal analysis

Table 4: Descriptive statistics for total fungi (CFU/1000mm^2)

Descriptives

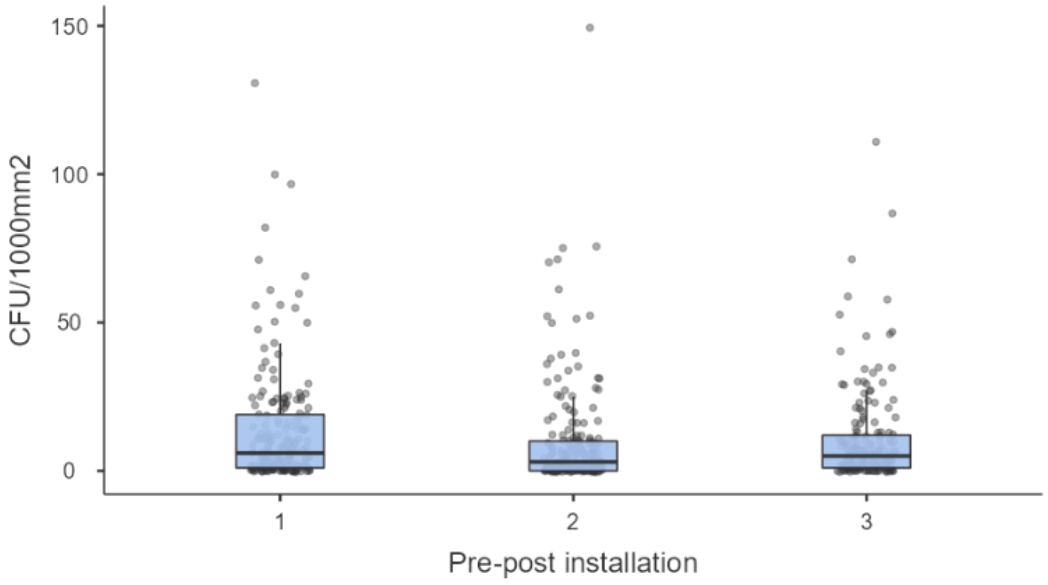
	Pre-post installation	CFU/1000mm2
N	1	187
	2	190
	3	180
Missing	1	5
	2	2
	3	12
Mean	1	13.7
	2	9.89
	3	10.4
Median	1	6
	2	3.00
	3	5.00
Standard deviation	1	19.9
	2	18.2
	3	15.9
IQR	1	18.0
	2	10.0
	3	11.0
Minimum	1	0
	2	0
	3	0
Maximum	1	131
	2	149
	3	111
Shapiro-Wilk W	1	0.683
	2	0.572
	3	0.646
Shapiro-Wilk p	1	< .001
	2	< .001
	3	< .001

Key: Descriptive data are presented for the dataset. Values are presented as CFU (Colony Forming Units)/1000mm^2. Details of the statistical tests used can be found in the methods section. The median CFU/1000mm^2 was highest in the pre-installation month

(month 1) when compared to the two post installation months (months 2 and 3). Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

Boxplot analysis for total fungi

Figure 3: Boxplot analysis for total fungi (CFU/1000mm^2)



Key: The median CFU/1000mm^2 was highest in the pre-installation month (month 1) when compared to the two post installation months (months 2 and 3). Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

One-way ANOVA non-parametric for total fungi

Table 5: One-way ANOVA non-parametric for total fungi (CFU/1000mm^2)

Kruskal-Wallis

	χ^2	df	p
CFU/1000mm2	10.7	2	0.005

Key: The one-way ANOVA (non-parametric) test was performed to determine if there were significant differences between the median values for each month. A P value of <0.05 was considered as significant.

The results of the test statistic suggest that there was a significant difference between the median CFU/1000mm^2 values. A pairwise comparisons test was performed to indicate where the significant differences were.

Table 6: Pairwise comparisons for total fungi (CFU/1000mm^2)

Pairwise comparisons - CFU/1000mm2

		W	p
1	2	-4.43	0.005
1	3	-1.83	0.397
2	3	3.01	0.084

Key: The pair-wise comparison testing was performed to determine where there were significant differences between the median values. A P value of <0.05 was considered as significant. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

The pairwise comparisons test suggested that differences in the median CFU/1000mm^2 values were found between month 1 (pre-installation) and month 2 (first month post installation).These data suggest that there was a significant reduction in the median CFU/1000mm^2 value between month 1 (pre-installation) and month 2 (first month post installation) but that the median CFU/1000mm^2 value increased between month 2 (first month post installation) and month 3 (second month post-installation).

Analysis of the individual test sites

Bacterial analysis

The following is a presentation of the bacterial data for the individual test sites. For the sake of space, the descriptive statistics are summarised for each test area along with the results of the statistical analysis in a single table (Table 7).

Table 7: Descriptive statistics for bacteria by test area (CFU/1000mm^2)

Month 1	AREA	1	2	3	4	5	6	7	8
	Mean	19.87	8.92	10.88	15.29	19.50	11.05	19.25	7.04
	Median	10.00	2.00	4.00	6.50	13.00	6.50	8.00	5.00
	Standard deviation	25.81	12.70	23.70	18.52	22.02	11.64	24.79	10.14
	IQR	20.50	13.00	7.75	20.50	11.00	16.80	27.00	6.00
	Minimum value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum value	100.00	47.00	118.00	68.00	95.00	46.00	97.00	50.00
Month 2	AREA	1	2	3	4	5	6	7	8
	Mean	7.78	14.17	4.77	8.54	19.32	2.29	25.61	2.21
	Median	3.00	2.50	2.50	4.00	5.00	0.00	10.00	1.50
	Standard deviation	10.85	30.38	6.24	13.14	33.64	5.29	28.83	2.78
	IQR	6.50	9.50	6.00	9.25	18.80	2.25	34.50	2.25
	Minimum value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum value	31.00	140.00	18.00	58.00	129.00	25.00	92.00	13.00
Month 3	AREA	1	2	3	4	5	6	7	8
	Mean	28.58	8.33	7.52	8.63	26.83	8.42	19.00	4.00
	Median	14.50	5.00	6.00	5.00	15.00	1.00	12.00	3.00
	Standard deviation	35.11	8.85	7.32	10.33	32.11	19.72	21.37	3.81
	IQR	31.30	7.75	8.00	8.00	15.00	4.25	20.50	5.00
	Minimum value	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
	Maximum value	113.00	34.00	27.00	37.00	121.00	83.00	97.00	12.00

Key: Descriptive data are presented for the datasets by test site. Values are presented as CFU (Colony Forming Units)/1000mm^2. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

The bacterial data for each test area are presented by the month of the test. In table 8, the differences in median bacterial CFU/1000mm^2 are presented where the median values in month 1 (pre-installation) were floored at zero (baseline), and the changes (+ or -) are presented compared to baseline.

Table 8: Bacteria by test area – change from baseline (CFU/1000mm^2)

Comparison of medians								
MONTH	1	2	3	4	5	6	7	8
Month 1	10.00	2.00	4.00	6.50	13.00	6.50	8.00	5.00
Month 2	3.00	2.50	2.50	4.00	5.00	0.00	10.00	1.50
Month 3	14.50	5.00	6.00	5.00	15.00	1.00	12.00	3.00
Significance*	P=0.015	P=0.529	P=0.164	P=0.329	P=0.072	P=0.003	P=0.643	P=0.020
Difference from baseline (medians)								
MONTH	1	2	3	4	5	6	7	8
Month 1	-	-	-	-	-	-	-	-
Month 2	-7.00	0.50	-1.50	-2.50	-8.00	-6.50	2.00	-3.50
Month 3	4.50	3.00	2.00	-1.50	2.00	-5.50	4.00	-2.00

Key: The bacterial data for each test area are presented by the month of the test. The differences in median bacterial CFU/1000mm^2 are presented where the median values in month 1 (pre-installation) were floored at zero (baseline), and the changes (+ or -) are presented compared to baseline. Month 1 (pre-installation), Month 2 (first month post installation), Month 3 (second month post installation).

For all but two of the test areas (areas 2 and 7) there was a reduction in median bacterial CFU/1000mm^2 in the first month post-installation. In the second month post installation the median CFU/1000mm^2 values increased compared to pre-installation except for areas 4, 6 and 8.

There was a statistically significant difference in the median CFU/1000mm^2 values from test areas 1, 6 and 8.

Table 9: Pairwise comparisons for area 1 bacteria (CFU/1000mm^2)

Pairwise comparisons - CFU/1000mm2			
		W	**p**
1	2	-2.963	0.091
1	3	0.964	0.774
2	3	3.941	0.015

Key: The pair-wise comparison test was performed to determine where there were significant differences between the median values. A P value of <0.05 was considered as significant. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

There was a significant difference in the median CFU/1000mm^2 values for month 2 (first month post-installation) and month 3 (second month post-installation).

Table 10: Pairwise comparisons for area 6 bacteria (CFU/1000mm^2)

Pairwise comparisons - CFU/1000mm2			
		W	**p**
1	2	-4.67	0.003
1	3	-3.19	0.062
2	3	1.35	0.606

Key: The pair-wise comparison testing was performed to determine where there were significant differences between the median values. A P value of <0.05 was considered as significant. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

There was a significant difference in the median CFU/1000mm^2 values for month 1 (pre-installation) and month 2 (first month post-installation).

Table 11: Pairwise comparisons for area 8 bacterial (CFU/1000mm^2)

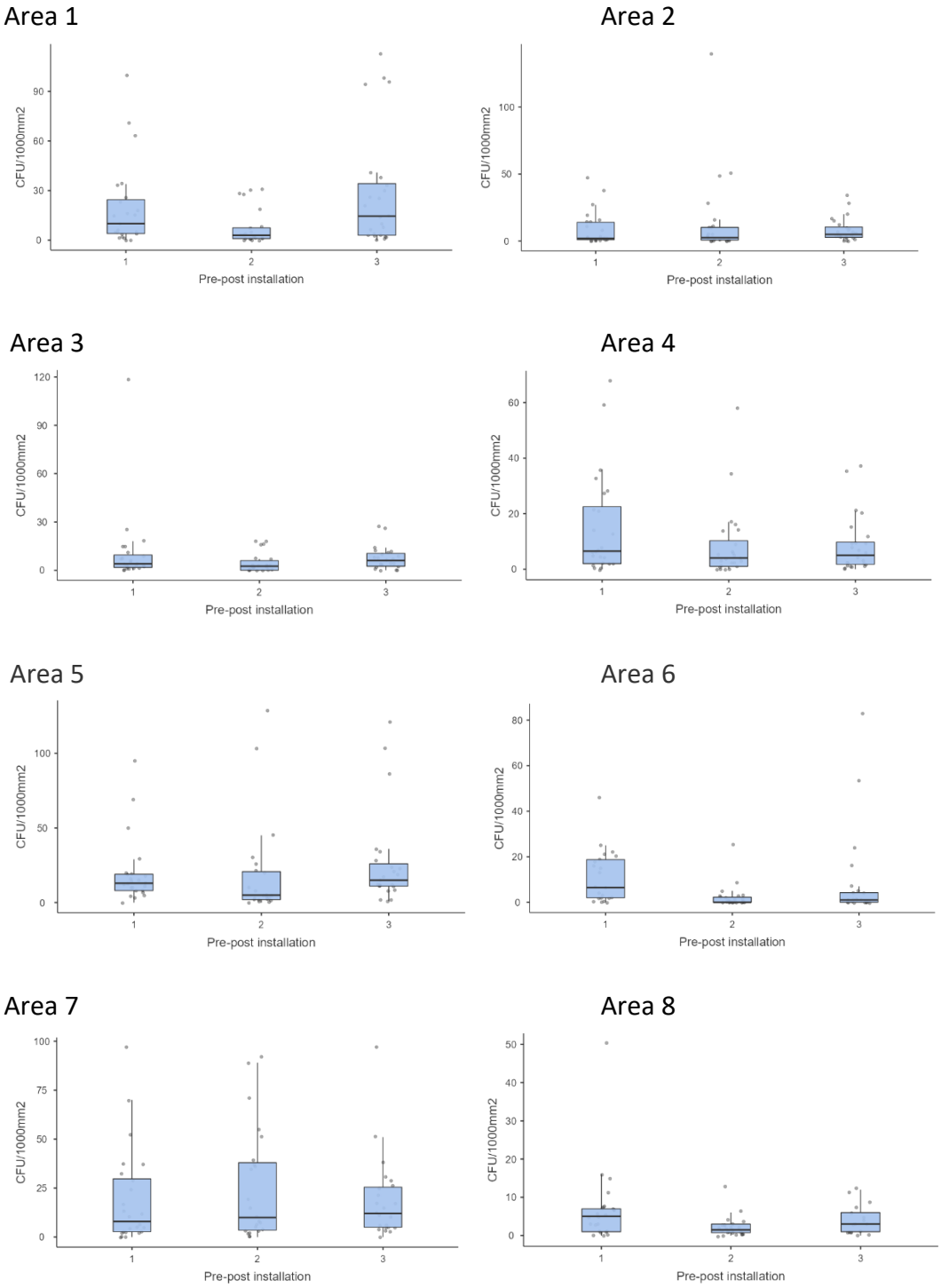
Pairwise comparisons - CFU/1000mm2			
		W	**p**
1	2	-3.90	0.016
1	3	-1.42	0.576
2	3	2.23	0.257

Key: The pair-wise comparison testing was performed to determine where there were significant differences between the median values. A P value of <0.05 was considered as significant. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

There was a significant difference in the median CFU/1000mm^2 values for month 1 (pre-installation) and month 2 (first month post-installation).

The following figure (Figure 3) provides a dashboard of the boxplots for each area (1 to 8).

Figure 4: Boxplots for bacteria in areas 1 to 8 (CFU/1000mm^2)



Key: For the bacterial analysis, the general trend in the data observed in the overall analysis was largely followed when individual test areas were analysed for CFU/1000mm2. Significant differences in the median values were observed for test areas 1 (P=0.015), 6 (P=0.003) and 8 (P=0.020). Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

Fungal analysis

The following is a presentation of the data for the individual test sites. For the sake of space, the descriptive statistics are summarised for each test area along with the results of the statistical analysis in a single table (Table 12).

Table 12: Descriptive statistics for fungi by test area (CFU/1000mm^2)

Month 1	AREA	1	2	3	4	5	6	7	8
	Mean	18.91	5.78	8.38	17.63	29.96	7.64	13.08	7.88
	Median	11.00	2.00	7.50	6.50	18.00	2.50	12.50	4.00
	Standard deviation	23.73	8.28	8.33	21.92	34.53	9.78	13.45	10.76
	IQR	17.00	6.50	9.75	26.00	39.50	9.75	21.50	8.25
	Minimum value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum value	100.00	35.00	31.00	71.00	131.00	29.00	56.00	43.00
Month 2	AREA	1	2	3	4	5	6	7	8
	Mean	11.25	6.09	9.29	15.29	16.42	1.46	14.87	4.54
	Median	7.00	1.00	4.00	5.00	9.00	0.00	3.00	2.00
	Standard deviation	14.82	8.71	17.55	19.91	21.87	2.47	31.61	7.49
	IQR	7.25	8.50	5.25	25.30	22.00	2.00	17.50	6.00
	Minimum value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum value	52.00	31.00	75.00	76.00	71.00	8.00	149.00	34.00
Month 3	AREA	1	2	3	4	5	6	7	8
	Mean	17.83	5.08	5.70	13.17	23.08	2.91	9.95	3.78
	Median	9.00	2.50	4.00	7.00	11.00	0.00	7.00	2.00
	Standard deviation	22.45	6.80	6.58	15.46	25.53	6.24	9.81	3.62
	IQR	20.50	3.75	5.50	13.50	23.80	2.50	10.00	4.75
	Minimum value	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
	Maximum value	87.00	29.00	29.00	53.00	111.00	27.00	35.00	11.00

Key: Descriptive data are presented for the datasets by test site. Values are presented as CFU (Colony Forming Units)/1000mm^2. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

The fungal data for each test area are presented by the month of the test. In table 13, the differences in median fungal CFU/1000mm^2 values are presented where the median CFU/1000mm^2 values in month 1 (pre-installation) were floored at zero (baseline), and the changes (+ or -) are presented compared to baseline.

Table 13: Fungi by test area – change from baseline (CFU/1000mm^2)

Comparison of medians								
AREA	1	2	3	4	5	6	7	8
Month 1	11.00	2.00	7.50	6.50	18.00	2.50	12.50	4.00
Month 2	7.00	1.00	4.00	5.00	9.00	0.00	3.00	2.00
Month 3	9.00	2.50	4.00	7.00	11.00	0.00	7.00	2.00
Significance*	P=0.322	P=0.921	P=0.473	P=0.853	P=0.198	P=0.015	P=0.633	P=0.422
Difference from baseline (medians)								
AREA	1	2	3	4	5	6	7	8
Month 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Month 2	-4.00	-1.00	-3.50	-1.50	-9.00	-2.50	-9.50	-2.00
Month 3	-2.00	0.50	-3.50	0.50	-7.00	-2.50	-5.50	-2.00

Key: The fungal data for each test area are presented by the month of the test. The differences in median fungal CFU/1000mm^2 are presented where the median values in month 1 (pre-installation) were floored at zero (baseline), and the changes (+ or -) are presented compared to baseline. Month 1 (pre-installation), Month 2 (first month post installation), Month 3 (second month post installation).

For all test areas there was a reduction in median fungal CFU/1000mm2 in the first month post-installation. In the second month post installation the median CFU/1000mm^2 values increased compared to pre-installation in areas 2 and 4. There was a statistically significant difference in the median CFU/1000mm^2 values from test area 6.

Table 14: Pairwise comparisons for area 6 fungi (CFU/1000mm^2)

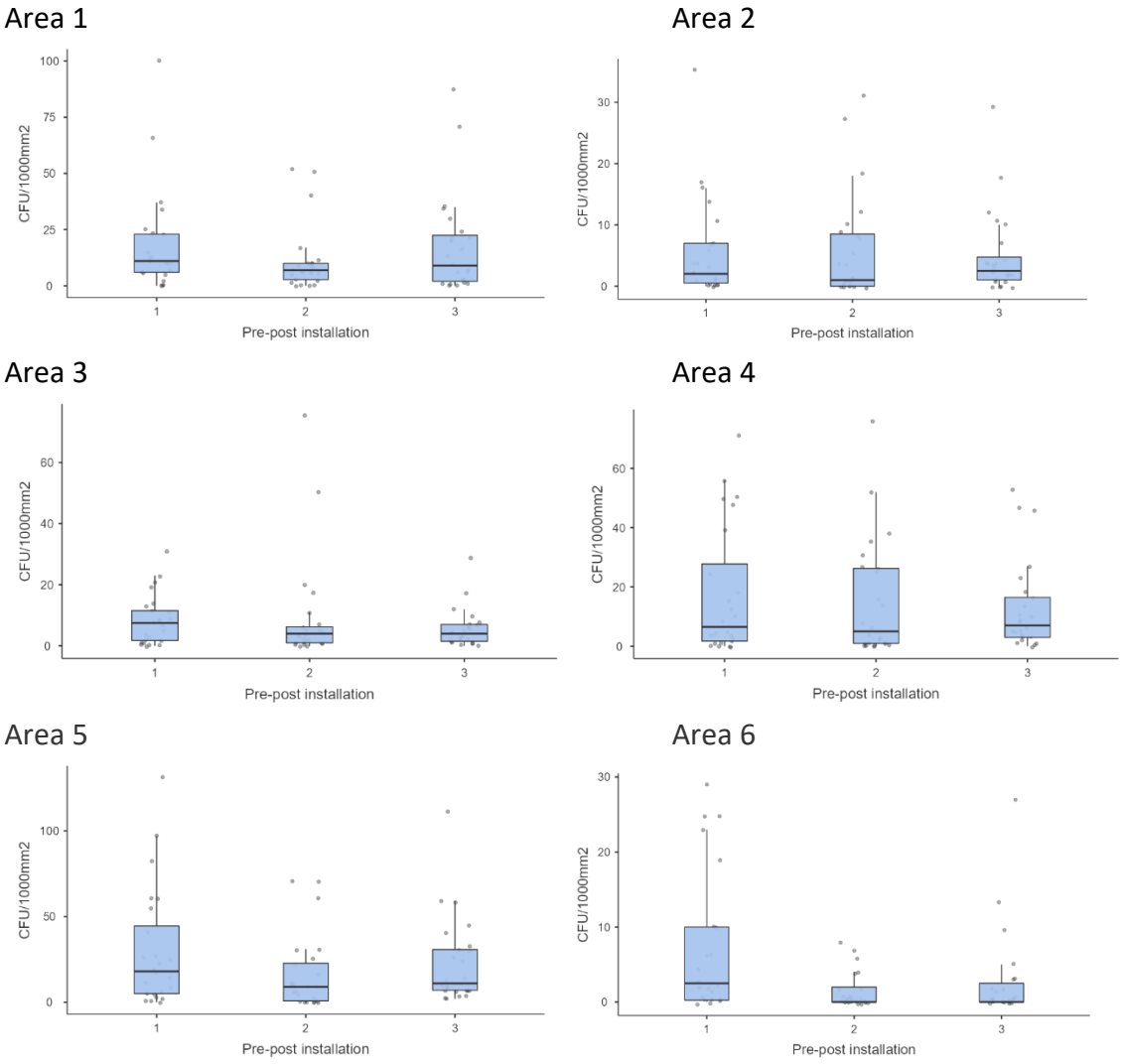
Pairwise comparisons - CFU/1000mm2			
		W	**p**
1	2	-3.830	0.019
1	3	-3.043	0.080
2	3	0.695	0.876

Key: The pair-wise comparison test was performed to determine where there were significant differences between the median values. A P value of <0.05 was considered as significant. Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

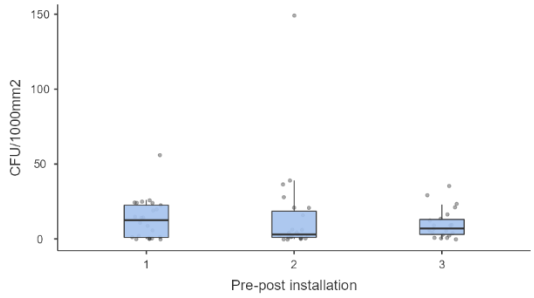
There was a significant difference in the median CFU/1000mm^2 values for month 1 (pre-installation) and month 2 (first month post-installation).

The following figure provides a dashboard of the boxplots for each area (1 to 8).

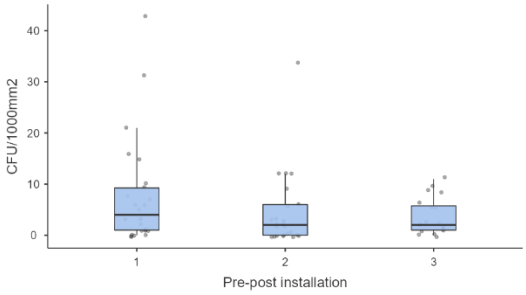
Figure 5: Boxplots for fungi in areas 1 to 8 (CFU/1000mm^2)



Area 7



Area 8

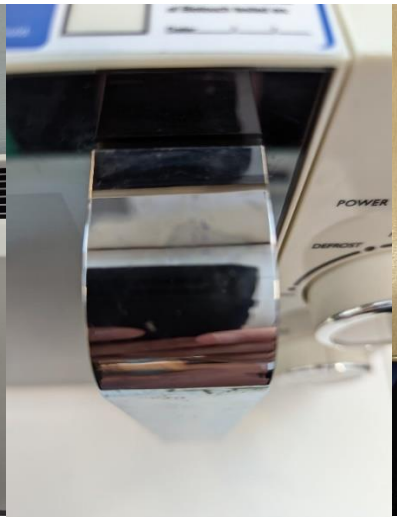


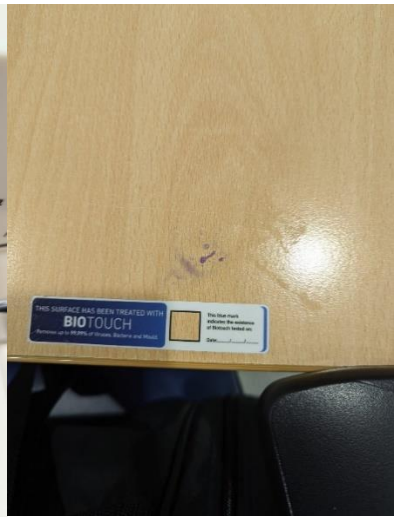
Key: For the fungal analysis, the general trend in the data observed in the overall analysis was largely followed when individual test areas were analysed for CFU/1000mm^2. A significant difference in the median values was observed for test area 6 (P=0.015). Month 1=pre-installation, Month 2=first month post installation, Month 3=second month post installation.

Area 4 – Staff Lifts did not have an Airsanifier in place as part of the 'Kill, Prevent, Protect' designed symbiotic system to generate the best possible results and whilst this is a clear advantage. This area also showed a reduction in levels and these results indicate that 'Biotouch' is capable of producing a reduction in contamination on its own. It should be noted that the reduction of airborne contamination would in turn result in an increase of surface contaminates and this is why the 'Biotouch' is essential to the system.

We had been made aware that the protocols for cleaning (and disinfection) were in the process of changing 'back' to pre pandemic practice and we are now aware when this was. At the outset of the research phase / Month 1 the protocol for cleaning and disinfection was using Actichlor + on all hard surfaces, however at the beginning of month 3 the pre pandemic protocol of liquid detergent was reverted to. Therefore, our data suggest that the cleaning and disinfection regimen of Actichlor + was comparable to detergent plus the BioTouch surface treatment and airsanifiers. Final stage testing does show the presence of Biotouch at the end of Month 3, see pictures and Bromophenol Blue markings below.

At the end of the 3-month study a surface test was undertaken to determine if the surface treatment was still associated with the surfaces. The images below demonstrate visual evidence of permanency.





(2) Air quality testing

All procedures used to undertake the air quality testing were as described in the materials and methods section.

Analysis of the whole dataset (including all test sites)

The pre-installation air quality testing highlighted area 5 as having the highest PM2.5, PM10, particle counts (P), and CO_2 levels. The pre-installation PM2.5 values ranged from an average by test site of 2.875 µg/m3 to 6.9167 µg/m3.The pre-installation PM10 values ranged from an average of 3.95 µg/m3 to 10.625 µg/m3. The pre-installation particle count values ranged from an average of 4084.4 µg/m3 to 10038 µg/m3. The pre-installation CO_2 values ranged from an average of 741.56 µg/m3 to 1348.6 µg/m3.

The post-installation PM2.5 values ranged from an average of 1.6417 µg/m3 to 4.925 µg/m3. The post-installation PM10 values ranged from an average of 2.1625 µg/m3 to 7.6417 µg/m3. The post-installation particle count values ranged from an average of 2212.8 µg/m3 to 4814.1 µg/m3The post-installation CO_2 values ranged from an average of 682.29 µg/m3 to 782.96 µg/m3

The overall reductions in post-installation values in comparison to pre-installation values for each of the measurands was as follows (expressed as a percentage). PM2.5 -43%, PM10 -42%, P -34%, CO_2 -13%.

Analysis of the individual test sites

Table 15: air quality per test site

Main Entrance

1	Pre					Post									
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	3.6667	5.6333	3.1	6.0667	4.6167	4.7	3.5	3.1667	2.1333	2.2667	3.1667	1.5667	5.2	3.2125	30%
PM10	6.2667	11.967	4.4667	9.6333	8.0833	5.3	6.1	4.9	3.6667	3.5667	4.9	1.8333	6.2	4.5583	44%
P	6138	6906.3	5097	8986	6781.8	4673	5489	5206	3803.3	3624.3	5206	1396.3	6867	4533.1	33%
CO2	717.33	839.67	904.67	768.67	807.58	900.67	721	829.33	795	780.67	829.33	623	784.67	782.96	3%

Phototherapy

2	Pre					Post									
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	3.5	1.8	0.9	5.3	2.875	1.9	4	1.6	1.9	1.9	1.6	0.4	1.2	1.8125	37%
PM10	4.3	2.6	1.3	7.6	3.95	2.8	7.1	1.7	2.7	2.5	1.7	0.7	1.6	2.6	34%
P	5090	3164	1416	7370	4260	2997	6393	2532	3372	2904	2532	1024	1886	2955	31%
CO2	657	847	852	788	786	663	731	779	766	688	779	690	758	731.75	7%

Just immediatley following cleaning

Dermatology Staff

3	Pre					Post									
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	3.2667	8.2667	0.9	3.3667	3.95	1.3	1.5667	3.4667	0.5667	1.4	3.4667	1.3333	1.9333	1.8792	52%
PM10	5.1	5.8333	1.7333	5.1	4.4417	2.1333	2.4	5.2667	0.9333	1.9667	5.2667	3.3	2.7	2.9958	33%
P	4673	4908	1734.7	5022	4084.4	2186.3	2521	5290.7	955	1385.3	5290.7	3133.7	2860	2952.8	28%
CO2	700	1430.7	868.33	753.67	938.17	742.67	639.67	693	768.67	591.33	693	657	673	682.29	27%

Lift Area (Biotouch Only)

4	Pre					Post									
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	4.7	4.3333	1.5	6.7667	4.325	1.9	5.5333	3.1667	2.1333	1.9333	3.1667	1.8333	1.9	2.6958	38%
PM10	7.2333	7.0667	2.5667	10.567	6.8583	3.4333	8.4333	4.6667	3.7	2.8	4.6667	3.9333	2.1333	4.2208	38%
P	6953	6659.7	2516.3	9789.3	6479.6	4072	7393.7	4953.7	3219.3	2765.7	4953.7	7913	3242	4814.1	26%
CO2	716.33	746	824.33	688.67	743.83	793.67	708.67	810	750.33	741.67	810	622.33	701	742.21	0%

Emergency Department Staff Room

5

	Pre					Post								
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	8.8667	9.9333	2.6	6.2667	6.9167	3.6667	3.6	6.9667	7.1333	8.5667	6.9667	0.9333	1.5667	4.925	29%
PM10	13.667	16.333	3.5	9	10.625	5.8333	5.4333	12.167	10.033	11.1	12.167	1.7667	2.6333	7.6417	28%
P	12799	14632	3765.7	8953.7	10038	5755.3	5333.3	20472	10118	11635	20472	1678.3	2129.7	9699.3	3%
CO2	1650.7	1334	1384.3	1025.3	1348.6	1110	965.33	1031.7	1193.3	789.67	1031.7	837	764	965.33	28%

Emergency Department Isolation Room

6

	Pre					Post								
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	2.8333	3.1	1.9333	4.8	3.1667	3.8667	0.9	2.5	0.4	0.5	2.5	0.5	1.9667	1.6417	48%
PM10	3.7667	4.0667	2.4	7.1333	4.3417	3.6667	1.3667	3.6333	0.5333	0.9667	3.6333	0.8667	2.6333	2.1625	50%
P	3623.7	4675.3	2887.7	7090.3	4569.3	2592	1335.3	3775	709.33	933	3775	1212	3370.7	2212.8	52%
CO2	967.33	629.67	1408.3	675.67	920.25	764	759	794.67	618.67	647.33	794.67	670	842.33	736.33	20%

Emergency Department Waiting Area

7

	Pre					Post								
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	4	5.9333	2.1	8.7333	5.1917	2.2333	5.3	2.8	2.2667	2.1667	2.8	0.9	2.5	2.6208	50%
PM10	5.2667	8.4	3.1667	13.867	7.675	3.6333	6.8667	4.2333	2.6667	2.8333	4.2333	1.3	3.9333	3.7125	52%
P	5886.3	5156.3	3194	19876	8528.3	4016	6590	4297	4064.7	2751	4297	1339	2226.2	3697.6	57%
CO2	969	926.67	804.33	723.33	855.83	766.67	667.67	744	769.67	617	744	690	873.33	734.04	14%

Exercise Tolerance Room

8

	Pre					Post								
	Wk 1	Wk 2	Wk 3	Wk 4	Avg	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Avg	%
PM2.5	7.2667	5.5333	0.8	6.4333	5.0083	1.4333	4.4	2.2333	0.8667	1.9667	2.2333	2.2333	0.7	2.0083	60%
PM10	9.4667	4.7667	0.9333	9.1	6.0667	2.2667	5.8	3.0667	0.9667	2.7	3.0667	3.0667	1.4667	2.8	54%
P	8436.7	4872	1170	6066.3	5136.3	2255.3	6752	3427.7	773.67	942.33	3427.7	3427.7	2696.3	2962.8	42%
CO2		689.33	828.33	707	741.56	728	717	707.67	870	765.67	707.67	707.67	665	733.58	1%

Key: Four measures of air quality were assessed. These were PM2.5, PM10, Particle counts (P), and CO_2. Tests were undertaken pre-installation and post-installation. Values were expressed as a percentage of 3 replicates for each result (per week). The average values were calculated for the pre-installation and post-installation phases of the study. For all measurands, there was a percentage decrease observed ranging from 43% reduction for PM2.5 to 13% reduction for CO_2.

Patient and Staff questionnaire.

The patient questionnaire identified that the 'KPP' system was inobtrusive / "Quiet" overall and that it was a positive intervention from patients. Staff that had replied to the questionnaire was generally along same lines as patients, however the negative comments regarding the 'smell' was addressed in the ED Staff Room as we had felt due to the high readings of CO2 in the 1st month of testing that a stronger Airsanifier be used. This was replaced immediately on receipt of feedback to a 'normal' sized Airsanifier. The noise level, smell and 'taste' within the Dermatology office space would be addressed using the smaller 'silent' equipment as used in area such as 'Exercise Tolerance' room. Feedback from Emergency Department Staff room following replacement was that there was no smell, unfortunately this was not recorded in the feedback document. The units used were chosen by Insite to suit the short term research and with minimal disruption. Therefore any 'noise' concerns are easily addressed. A concern raised regarding the toxicity of Biotouch should be addressed with education and awareness of its inert properties. The concern also mentioned exposure to chemicals when in fact this is what 'KPP' is intended to remove both short and long term.

7. Discussion

It is clear that the environment plays an important role in the spread of infection in the healthcare setting. Current approached to reducing the risk of environmental spread of infection have focused on regular cleaning and disinfection, yet it has been demonstrated in the intensive care unit setting that potentially pathogenic bacteria can still be isolated from surfaces despite cleaning and disinfection.[11] Infection control is a multifactorial process with multiple interventions working together to reduce the risk of infection. The results of the current study have demonstrated that in clinical areas where cleaning and disinfection is undertaken, additional treatment of surfaces with an antimicrobial coating can further reduce the bacterial and fungal colonisation of high touch surfaces. Such approaches to surface disinfection have been proposed by others but little or no independent in-use trials have been reported for the healthcare setting.[12,13] This current study therefore represents a valuable addition to the body of evidence.

(1) Surface microbiology testing

The dataset: The dataset for bacterial analysis consisted of results from 8 test areas. In all, there were 576 possible data points over the 3-month study. Of these 576 possible data points 19 were missing because a CFU/1000mm^2 value could not be generated from the dipslide or the sample was not taken on a given day. This represents a data availability rate of 96.7%. The dataset for fungal analysis consisted of results from 8 test areas. In all, there were 576 possible data points over the 3-month study. Of these 576 possible data points 19 were missing because a CFU/1000mm^2 value could not be generated from the dipslide or the sample was not taken on a given day. This represents a data availability rate of 96.7%. Different methods for dealing with missing values were considered. For data points where the culture analysis recorded >150 colonies we did not report a value as counting colony numbers greater than 150 leads to the risk of error because of counting inaccuracy. One possible approach in this instance would have been to replace these values with 150 (a ceiling value). However, this approach was discounted as it would have reduced the actual number for these data points, which may have influenced the analysis. For missing values because of bacteria and/or fungi spreading over the surface of the agar, a value could not be recorded because it was unclear how many CFUs were responsible for the growth. Estimating CFU values in these situations would have been inaccurate and may have influenced the analysis.

The overall analysis: For the bacterial analysis, the median CFU/1000mm^2 reduced from 7.00 in month 1 (pre-installation) to 3.00 in month 2 (first month post-installation) and then increased to 6.50 in month 3 (second month post installation). This represented a significant difference in median values ($P<0.001$). A pairwise comparison analysis demonstrated that there was a significant difference between months 1 and 2 ($P<0.001$) and months 2 and 3 ($P<0.001$). For the fungal analysis the median CFU/1000mm^2 reduced from 6.00 in month 1 (pre-installation) to 3.00 in month 2 (first month post-installation) and then increased to 5.00 in month 3 (second month post installation). This represented a significant difference in median values ($P=0.005$). A pairwise comparison analysis demonstrated that there was a significant difference between months 1 and 2 ($P=0.005$). These data suggest that there was a reduction in bacterial and fungal counts (CFU/1000mm^2) between the pre-installation testing (month one) and post installation testing but only in the first month post-installation (month 2). Thereafter the bacterial and fungal CFU/1000mm^2 values increased towards pre-installation values.

Analysis by test area: For the bacterial analysis, the general trend in the data observed in the overall analysis was largely followed when individual test areas were analysed for CFU/1000mm^2. Significant differences in the median values were observed for test areas 1 ($P=0.015$), 6 ($P=0.003$) and 8 ($P=0.020$). For the fungal analysis, the general trend in the data observed in the overall analysis was largely followed when individual test areas were analysed for CFU/1000mm^2. A significant difference in the median values was observed for test area 6 ($P=0.015$).

(2) Air quality testing

Particulate matter in the air is generally regarded as being an important indicator of internal air quality. PM2.5 and PM10 are therefore indicators of air quality and a reduction in such values represents an improvement. Particulate matter may contain infectious aerosols of respiratory origin that may contain pathogens, which are subject to the same physical laws as other particulate matter. Other particulate matter may contain dust, and contaminants from combustion engines. A reduction in particulate matter within the indoor air, irrespective of the origins of the particulate matter, therefore, represents an improvement in indoor air quality and potentially reduced airborne transmission risk.

We demonstrated a percentage reduction in all measures of air quality between the pre- and post-installation phases of this study.

8. Conclusion

We found that surface and airborne contamination were reduced post-treatment compared to pre-treatment.

For surfaces, the first month post-treatment exhibited the greatest reductive effect, with month 2 post-treatment tending towards pre-treatment values.

For air quality, there was a percentage reduction in all measures of air quality – PM2.5, PM10, particle counts (P) and CO_2.

The limitations of this study prevent long term follow up monitoring of staff & patient sickness/HAI to determine if disease transmission has been reduced. Instead, we acknowledge disease transmission happens through environmental surfaces and that pathogens may survive for several weeks contributing to HAI's. By demonstrating reductions in surface and air contamination in this study we suggest that ultimately this provides a positive weapon in the field of infection prevention.

9. Use of Funds

The funds awarded were in a number of areas.

1) To engage The University of the West of Scotland as a 'Sub-Contractor' to prepare the approriate Methodology / Protocols, assess microbiology and monitor the whole project from a Quality / Standards persepective. This included shadowing during the data collection period.

2) To Engage SJL Innovations, an independent company with experience in innovation and Healthcare Environments who carried out the air monitoring and collection of 'Dipslides' and delivery to The University of The West of Scotland.

3) To Provide enough equipment for each area in regards to Airsanifiers and Biotouch for the installation and later removal. All levels / engagement inclusive of travel and time expenses.

10. Future Works

We are of the opinion, which is backed up by private Industry that this product is now Market Ready and in particular proven within the Healthcare / Hospital environment.

Further work to investigate the impact of our antimicrobial surface coating Biotouch™ on HAI rate and environmental bioburden is underway. Using agreed denotations of HAI we suggest to compare Biotouch™ treated clinical environments across multiple sites against similar non treated control areas over a defined period. To account for cleaning practices, isolation policies and antimicrobial prescribing policies it would be preferable to conduct a study in one health board to mitigate bias then between health boards for observational discussion. We believe this research is the next logical step to progress our technology within the live health and social care arena. We are keen to evolve our clinical partnership to bring these technologies into routine practice to benefit patients and services alike.

As a commercial entity we are environmentally aware. Our vision is to reduce the use of environmentally challenging chemicals and prolong the lifespan of surfaces and textiles to promote sustainability and reduce the overall impact to the environment.

11. Describe any potential long-term collaborations / partnerships entered into

Insite Specialist Services have been commissioned, independent of this research by several companies within the care home sector nationally who have subsequently purchased and successfully to implement the KPP system.

12. Describe the potential for exploiting the work

The KPP system is immediately available for installation and easily scalable for customer specification. At present time of maximal hospital usage and unprecedented bed occupancy the KPP system is an immediately available solution to address stretched cleaning schedules and protocols, improve environmental bioburden and air quality minimal downtime and disruption. There is a demonstrable visual quality control system which is easily and reliably implemented. The system can be extended to fleet transport services to address needs of the ambulance service, improving vehicle decontamination time and thus positively impacting ambulance availability.

13. Please describe how your company has gained from this project

Insite Specialist Services thank the competition panel and the staff who have afforded us the opportunity to study the KPP system within the healthcare environment and allow the NHS staff to experience and understand our product. As a commercial entity we have developed our clinical and research team in order to better address the needs of the health and social care sector. Having access to clinical areas to test and forging an industry and clinical partnership lends credibility to our system and has promoted our company within healthcare sector. As a Scottish company we have a vested interest to deliver solutions to better the health and welfare of our population which are both financially and environmentally sound.

14. References

[1] Otter JA, Yezli S, Salkeld JA, French GL. Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and an overview of strategies to address contaminated surfaces in hospital settings. Am J Infect Control 2013; 41:S6–11.

[2] Boyce JM. Environmental contamination makes an important contribution to hospital infection. J Hosp Infect 2007; 65(Suppl 2):50–4.

[3]Dancer SJ. The role of environmental cleaning in the control of hospital-acquired infection. J Hosp Infect 2009; 73:378–85.

[4]Dancer SJ. Controlling hospital-acquired infection: focus on the role of the environment and new technologies for decontamination. Clin Microbiol Rev 2014; 27:665–90.

[5] Weber DJ, Rutala WA, Miller MB, Huslage K, Sickbert-Bennett E. 2010. Role of hospital surfaces in the transmission of emerging health care-associated pathogens: norovirus, *Clostridium difficile*, and *Acinetobacter* species. Am J Infect Control. 38(5):S25–S33.

[6] Russotto V, Cortegiani A, Raineri SM, Giarratano A. 2015. Bacterial contamination of inanimate surfaces and equipment in the intensive care unit. J Intensive Care. 3:54

[7] Adams CE, Dancer SJ. 2020. Dynamic transmission of *Staphylococcus aureus* in the intensive care unit. Int J Environ Res Public Health. 17:2109.

[8] Mitchell, B. G et al. Variation in hospital cleaning practice and process in Australian hospitals: A structured mapping exercise. Infection, Disease & Health. 2017. Vol 22. Issue 4. P 195-202

[9] Sarika Sharma et al. An overview on recent progress in photocatalytic air purification: Metal-based and metal-free photocatalysis. Environmental Research, Volume 214, Part 3,2022 https://doi.org/10.1016/j.envres.2022.113995

[10] Mamaghani et al Photocatalytic oxidation technology for indoor environment air purification: The state-of-the-art. Applied Catalysis B: Environmental Volume 203, April 2017, Pages 247-269

[11] Wille I, Mayr A, Kreidl P, Brühwasser C, Hinterberger G, Fritz A, et al. Cross-sectional point prevalence survey to study the environmental contamination of nosocomial pathogens in intensive care units under real-life conditions. J Hosp Infect. 2018 Jan 1;98(1):90–5

[12] Kaur R, Liu S. Antibacterial surface design – Contact kill. Prog Surf Sci. 2016 Aug 1;91(3):136–53.

[13] Li W, Thian ES, Wang M, Wang Z, Ren L. Surface Design for Antibacterial Materials: From Fundamentals to Advanced Strategies. Adv Sci. 2021 Oct 1;8(19):2100368

15. This report is work commissioned by the Authority. The views expressed in this publication are those of the author(s) and not necessarily those of the Authority.

Appendix 2

Test Sites for Haarsain SBRI – Insite

The cleaning of areas reverted to pre covid guidance from 11th July 2022. The use of chlorine-based products would still remain for infected areas and sanitary fittings only.

Test site location	Department using/responsible for the site and name of lead person	People who use the site (e.g. patients, staff, students, visitors)	Cleaning times by domestic services and cleaning agents
Phototherapy	Dermatology	Patients Staff	Between 6.15am-12.15pm Actichlor/Sanitiser
Dermatology staff offices	Dermatology	Staff	Between 6.15am-12.15pm Actichlor/Sanitiser
Reception area of main entrance	Estates	Staff Patients Visitors	Between 9pm-6am GP liquid for cleaning
Exercise tolerance room (treadmill room)	Cardiology	Patients Staff	Between 7.30am-2.30pm GP liquid or Actichlor as required
ED waiting area	Emergency Department.	Staff Patients Visitors	Between 6am-12am GP liquid or Actichlor as required
ED staff room	Emergency Department	Staff	Between 6am -1.30pm GP Liquid/Actichlor/Sanitiser
ED decontamination unit procedure room in the isolation corridor (room CE4 045)	Emergency Department	Staff Patients	Between 6am-12am GP Liquid/Actichlor/Sanitiser (cleaning in-between patients would be carried out by clinical staff, we have asked the staff again for details on what products they use).
Lift buttons Level 7, behind main reception - PB2012 and Biotouch only	Estates	Staff Patients Visitors	Cleaned at various times. GP liquid