Investigating the Variability of Airborne Bacteria in a Hospital Intensive Care Unit Over a 24 Hour Period

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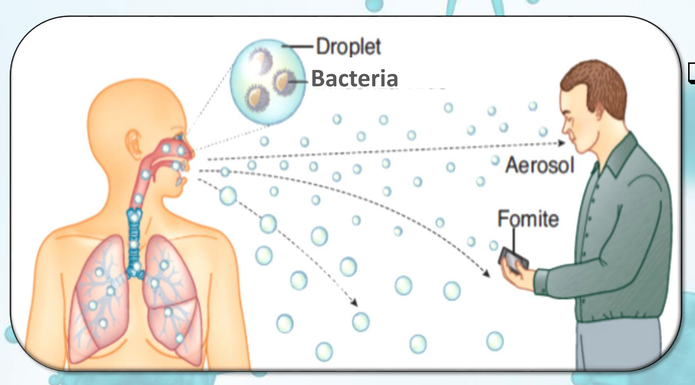
INTRODUCTION

- Airborne transmission of infectious microorganisms is a serious public health threat, accounting for ~10-33% of all nosocomial infections.
- The global antimicrobial resistance crisis has become a driving force for improved infection prevention and control strategies, including developing a greater understanding of the transmission routes of harmful microbes.
- Microorganisms originating from the human respiratory tract or skin can become airborne by coughing and sneezing, and by periods of increased activity such as bed changes, staff rounds and visiting hours.



- The objective of this study was to evaluate the variability of airborne contamination within a hospital ICU in order to establish an improved understanding of the extent to which airborne bioburden may contribute to cross-infection of patients.

METHODS

- Environmental monitoring of airborne contamination levels was conducted in Glasgow Royal Infirmary ICU, in both occupied and unoccupied patient isolation rooms.
- A sieve impactor air sampler was used to collect 500L air samples every 15 minutes over a 24 hour period (08:00 – 08:00h).
- Samples were collected on agar plates, and bacterial contamination levels recorded as CFU/m^3 of air.
- An activity log was collated over the sampling period to record activities that might contribute to spikes in contamination levels.

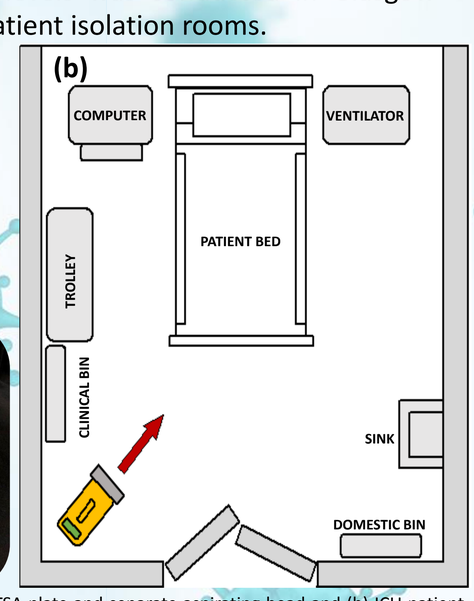
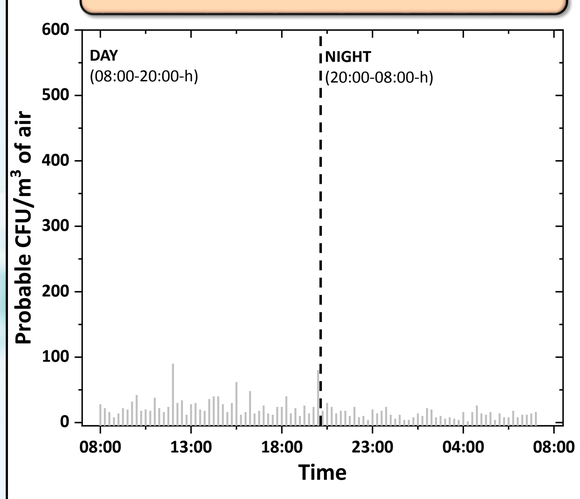


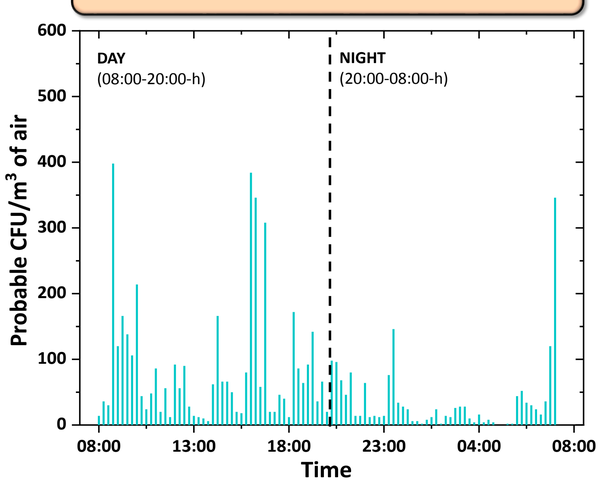
Fig 1. (a) SAS Super 180 Air Sampler with fitted TSA plate and separate aspirating head and (b) ICU patient isolation room layout showing position of air sampler.

RESULTS

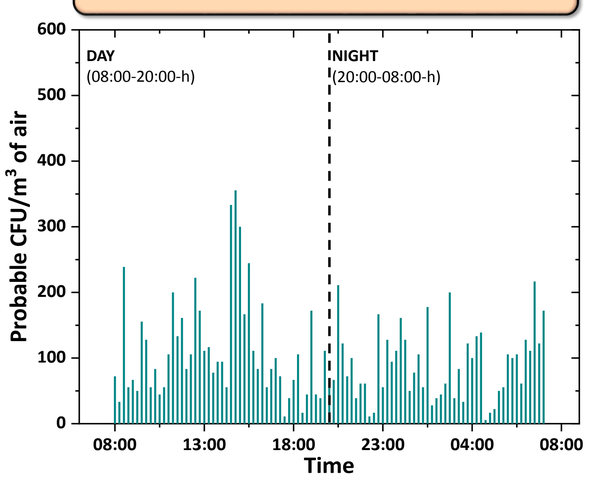
EMPTY ROOM



1 DAY OCCUPANCY



6 DAY OCCUPANCY



10 DAY OCCUPANCY

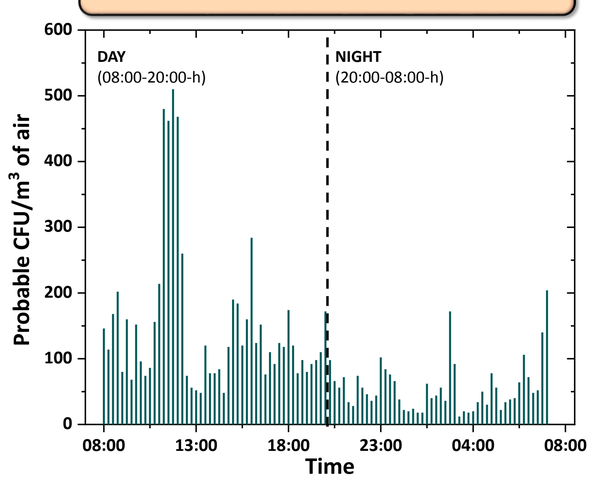


Fig 2. Air contamination levels (probable CFU/m^3) of air over a 24 hour period in an ICU isolation room during different patient/ room scenarios. n=97

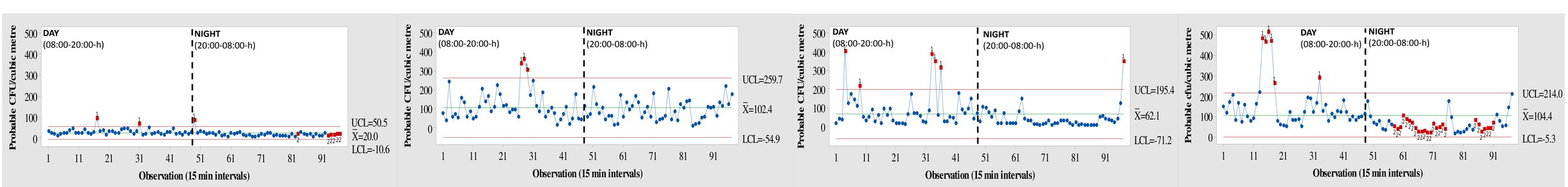


Fig 3. Statistical process control charts indicating upper and lower control limits and highlighting in red, data points that are termed 'out of control' in relation to the overall dataset.[1] refer to data points greater than 3 standard deviations above the centre point/mean value and [2] refer to 9 observations in a row on the same side of the centre line. n=97

[1] Room cleaning, door opened, handover

[2] Minimal room activity

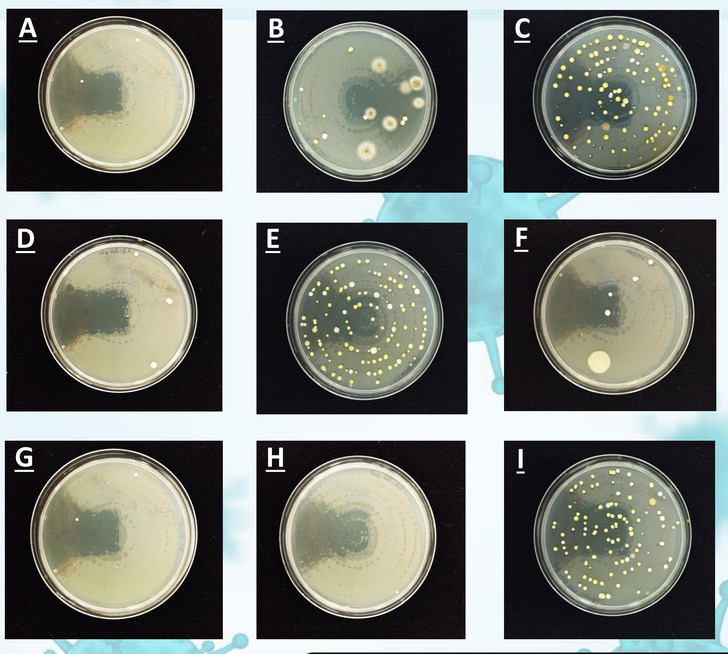
[1] High staff presence, ventilator change, patient taken for CT scan, patient turn

[1] Visitation

[1] Patient turn, physio, operation of mechanical hoist, high staff presence, visitation

[2] Minimal room activity and staff presence

MICROBIOLOGY



- Visual representation of airborne microorganisms collected onto TSA plates from a patient-occupied ICU Isolation room over 24 hours. Images highlight the variation in air contamination levels throughout the day.

Morning
A: 08:00 am
B: 08:30 am
C: 08:45 am

Afternoon/Evening
D: 13:30 pm
E: 16:00 pm
F: 22:30 pm

Overnight:
G: 01:30 am
H: 05:00 am
I: 08:00 am

Table 1. Summary of data analysed from 24 hour air studies within patient occupied isolation rooms. P-values represent the differences (at the 95% confidence level) between mean values obtained during the day (08:00-20:00-h) and night (20:00-08:00-h).

Room Occupancy (days)	Mean Total (CFU/m^3)	Mean Day (CFU/m^3)	Mean Night (CFU/m^3)	P Value (at 95% CI)
0	20.0	26.8	13.0	<0.001*
1	62.1	86.9	36.7	0.002*
6	102.4	113.6	90.9	0.080
10	104.4	151.2	56.6	<0.001*

CONCLUSIONS

- This study has demonstrated the high degree of variability in levels of airborne contamination over the course of a 24 hour period in a hospital ICU.
- Numerous factors contributed to microbial air contamination levels, including patient status, length of room occupation, time of day and room activity.
- Peaks in airborne contamination showed a direct relation to an increase in room activity at the time of activity and for some time after.
- Consideration should be given to potential improved infection control strategies and decontamination technologies which could be deployed within the clinical environment to reduce airborne contamination levels, with the ultimate aim of reducing healthcare-associated infections from environmental sources.

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