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Air and surface contamination patterns of meticillin-resistant *Staphylococcus aureus* on eight acute hospital wards

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SUMMARY

Background: Meticillin-resistant *Staphylococcus aureus* (MRSA) can be recovered from hospital air and from environmental surfaces. This poses a potential risk of transmission to patients.

Aim: To investigate associations between MRSA isolates recovered from air and environmental surfaces with those from patients when undertaking extensive patient and environmental sampling.

Methods: This was a prospective observational study of patients and their environment in eight wards of a 700-bed tertiary care hospital during 2010 and 2011. Sampling of patients, air and surfaces was carried out on all ward bays, with more extended environmental sampling in ward high-dependency bays and at particular times of the day. The genetic relatedness of isolates was determined by DNA microarray profiling and *spa* typing.

Findings: MRSA was recovered from 30/706 (4.3%) patients and from 19/132 (14.4%) air samples. On 9/132 (6.8%) occasions both patient and air samples yielded MRSA. In 32 high-dependency bays, MRSA was recovered from 12/161 (7.4%) patients, 8/32 (25%) air samples, and 21/644 (3.3%) environmental surface samples. On 10/132 (7.6%) occasions, MRSA was isolated from air in the absence of MRSA-positive patients. Patient demographic data combined with *spa* typing and DNA microarray profiling revealed four likely transmission clusters, where patient and environmental isolates were deemed to be very closely related.

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Conclusion: Air sampling yielded MRSA on frequent occasions, especially in high-dependency bays. Environmental and air sampling combined with patient demographic data, *spa* typing and DNA microarray profiling indicated the presence of clusters that were not otherwise apparent.

Introduction

Numerous studies have shown that the hospital environment is frequently contaminated with potential pathogens that pose a risk of cross-transmission to patients.[1,2] Meticillin-resistant *Staphylococcus aureus* (MRSA) can survive for long periods on environmental surfaces, and may be transmitted to patients via healthcare workers' hands or the environment.[3,4] Studies on MRSA in the environment have mostly related to outbreaks, intensive care units (ICUs), or isolation rooms with MRSA patients, rather than in routine ward areas over a period of time.[5–9] There is relatively little information on the dispersal of airborne MRSA and this may be an often underestimated method of transmission that results in clusters or outbreaks. It is not clear what impact MRSA in the environment and in air may have on patient acquisition and cross-transmission, and many studies involving the sampling of air in the vicinity of patients have been once-off investigations. Previous studies have strongly suggested or confirmed the transmission of bacteria by air, especially when carriers of *S. aureus* have viral infection.[10,11] However, the extent to which MRSA may be recovered from the air and how commonly this occurs in an acute hospital outside of an outbreak are unclear.

The current study describes the pattern of MRSA recovered from air and surfaces on a number of wards where MRSA is endemic over a period of time, and investigates patient and environmental links using *spa* typing and DNA microarray profiling of isolates.

Methods

Patients

The study was conducted on patients and their environment on eight wards, four general surgical and four general medical, in a 700-bed tertiary referral acute care hospital during 2010–2011. The study was undertaken as part of a larger study of MRSA that was approved by the Hospital Ethics (Medical Research) Committee. Patient and environmental sampling were conducted on a scheduled basis, and were not in response to an outbreak investigation. Bed occupancy was ~100%.

Sampling was carried out accordingly in three ways. First, sampling was conducted on 132 occasions on eight wards between March 2010 and February 2011. From March to June 2010, eight wards were sampled successively; three wards were sampled once, and five were sampled twice. From September 2010 to February 2011, the patients and the environment of four wards were each sampled for 4 weeks consecutively. Patient screening involved the taking of swabs from the nose, groin and non-intact skin/wound if available ($n = 706$), with one air sample taken in each ward bay.

Second, on 32 occasions, extended environmental sampling was conducted in the immediate area of patients in two high-dependency bays (HDBs) on eight wards, where more vulnerable and sicker patients are cared for. Patients were screened for MRSA on study wards as previously described.[12,13] At-risk patients were those as defined in national guidelines, i.e. patients known to be previously MRSA positive, patients transferred from another hospital or a long-term care facility, patients with chronic ulcers or urinary catheters, and patients who had been hospitalized within the last 18 months.[1] Environmental sampling involved surface sampling of each patient's mattress, pillow, bed rail or bed frame and locker. In addition, a settle-plate was placed on each patient's locker and one air sample was collected at the window-ledge of each ward bay.

Third, air sampling was conducted on HDBs at different times over a 24 h period: 07:30–09:00, 09:30–11:30, 14:00–16:00, 17:00–19:00, and 20:00–22:00 h, but without simultaneous patient sampling. However, during this study phase, routine ward screening revealed no MRSA-positive patients in the HDBs during these periods of sampling. No area sampled had any form of artificial ventilation. Cleaning was performed daily by the cleaning services, using water and detergent. A hypochlorite, 1000 ppm available chlorine, was used for MRSA and other infected/contaminated patients. Terminal decontamination of the bed and bed area after a patient's discharge of the bed and bed area was performed by a designated cleaning team.

Air and environmental surface sampling

Samples of air (1000 L) were taken using an impact air sampler (AES Chemunex Air Sampler, Department SAV, Rue Maryse Bastié–Ker Lann, 35172 BRUZ cedex, France) with MRSA*Select* chromogenic agar (CA) plates (Bio-Rad Life Science Group, Marnes La Coquette, France) which was placed on the ledges of outer wall windows in ward bays. CA settle plates were also placed on patients' lockers for 1 h. Neutralizing buffer swabs (Technical Services Consultants, Heywood, UK) were used to sample mattresses, pillows, bed rail or bed frames and patient lockers. An area, 10 × 10 cm, of each surface was sampled. In addition, mattresses were assessed by sweeping a CA plate over the surface of the mattress. Most wards consisted of 35 beds, each with one four-bedded and one six-bedded HDB, three other six-bedded bays, one two-bedded bay and five single rooms (Figure 1a). HDBs mainly comprised of four-bedded (wards A) or six-bedded (wards B) ward bays, but one ward had a five-bedded bay. The environmental sampling sites were those immediately associated with the patient's bed area and are shown in Figure 1b. All environmental swabs were enriched in tryptone soy broth with 6% (w/v) NaCl (TB05S-100, Cruinn Diagnostics, Dublin, Ireland) and incubated at 37 °C for 18 h. These were subsequently subcultured on to CA and incubated along with settle plates and sweep plates for 24 h at 37 °C. Presumptive MRSA was confirmed by coagulase and clumping factor production using Staphaurex Plus (Remel, Dartford, UK) and meticillin resistance determination using