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An outbreak of meticillin-resistant *Staphylococcus aureus* colonization in a neonatal intensive care unit: use of a case–control study to investigate and control it and lessons learnt

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SUMMARY

Aim: To describe the investigation and management of a meticillin-resistant *Staphylococcus aureus* (MRSA) outbreak on a neonatal intensive care unit (NICU) and the lessons learnt.

Methods: This was an outbreak report and case–control study conducted in a 40-cot NICU in a tertiary referral hospital and included all infants colonized/infected with gentamicin-resistant MRSA.

Intervention: Standard infection-control measures including segregation of infants, barrier precautions, enhanced cleaning, assessment of staff practice including hand hygiene, and increased MRSA screening of infants were implemented. Continued MRSA acquisitions led to screening of all NICU staff. A case–control study was performed to assess staff contact with colonized babies and inform the management of the outbreak.

Findings: Eight infants were colonized with MRSA (spa type t2068), one of whom subsequently developed an MRSA bacteraemia. MRSA colonization was significantly associated with lower gestational age; lower birthweight and with being a twin. Three nurses were MRSA colonized but only one nurse (45) was colonized with MRSA spa type t2068.

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Multivariable logistic regression analysis identified being cared for by nurse 45 as an independent risk factor for MRSA colonization.

Conclusions: Lack of accurate recording of which nurses looked after which infants (and when) made identification of the risk posed by being cared for by particular nurses difficult. If this had been clearer, it may have enabled earlier identification of the colonized nurse, avoiding subsequent cases. This study highlights the benefit of using a case–control study, which showed that most nurses had no association with colonized infants.

Introduction

Premature infants are vulnerable to methicillin-resistant *Staphylococcus aureus* (MRSA) colonization and infection due to immune immaturity and fragile skin. The risk of transmission is high, particularly for nurses who have close contact with infants. Outbreaks of MRSA have previously occurred in our neonatal intensive care unit (NICU) and were linked to nurses through staff screening and microbial whole-genome sequencing [1,2].

An outbreak and case–control study is described here involving a unique MRSA clone that occurred on our NICU in 2016 and the lessons learnt.

Methods

Study design

This was an outbreak report and case–control study.

Study setting and participants

The NICU is a 40-cot, tertiary unit providing level 3 care (i.e. providing access to neonatologists 24 h per day and capable of looking after infants of less than 27 weeks gestation). It opened in 2012 and cares for approximately 900 infants annually. It has eight rooms, each containing four to six cots (Figure 1). To give historical context, four MRSA-colonized infants were identified between 2010 and 2014. Seven infants were detected in 2015. Molecular typing indicated likely transmission between two infants; however, the remainder were genotypically distinct.

Microbiological investigation

All infants were screened for MRSA at multiple sites (nose, throat, groin) when admitted to NICU and weekly during their admission. Following the identification of MRSA-colonized infants, environmental screens were taken from incubators, computers, nursing stations, the sluice, milk room and extract vents. Swabs were plated on to Brilliance MRSA2 agar (Oxoid, Basingstoke, UK) and presumptive MRSA colonies were identified by mass spectrometry (MALDI-ToF; Bruker, Billerica, USA). Antimicrobial susceptibility testing was performed by disc diffusion (BSAC methodology). MRSA isolates were sent to the Healthcare Associated Infections and Antimicrobial Reference Unit (Public Health England, Colindale, London, UK) for characterization. MRSA outbreak isolates underwent DNA extraction in the Clinical Microbiology & Public Health Laboratory and microbial whole-genome sequencing in the Clinical Genetics Department using the MiSeq platform (illumina Inc, San Diego, CA, USA).

Bioinformatic analysis

The samples were aligned to the reference genome *S. aureus* TW20 using smalt (https://www.sanger.ac.uk/science/tools/smalt-0), single nucleotide polymorphisms (SNPs) differing from the reference were identified with a bespoke script. SNPs located closer than 10 base pairs apart were removed. The remaining SNPs were concatenated into a single string and used as the basis for the further analysis. Due to the limited number of samples clustal was used for generating the multiple alignment necessary for generating the phylogenetic tree.

Interventions

Following the detection of MRSA-colonized infants, the outbreak management was divided into two phases: phase 1 (immediate outbreak management) and phase 2 (when initial control measures failed to stop transmission).

In Phase 1, an incident-management team (IMT) meeting was convened after three MRSA-positive infants were identified. MRSA-colonized infants were nursed in cots using barrier precautions (gloves, aprons) and cohorted together in the same room. Senior NICU staff and the infection control team (ICT) performed observations of practice and hand hygiene audits. Additional training around the use of personal protective equipment (PPE) was provided. Mothers of affected infants were also screened. Topical MRSA decolonization was considered inappropriate by clinical staff because of the fragile nature of premature infants' skin. The frequency of MRSA screening of infants on NICU was increased to twice weekly to look for evidence of ongoing transmission. Enhanced cleaning was implemented involving more frequent cleaning, particularly of highly touched contact points, and the use of chlorine-based products and ultraviolet light irradiation. It was not possible to use hydrogen peroxide due to the nature of the ventilation on NICU.

In Phase 2, all NICU staff (approximately 200) were screened for MRSA at the start of their shift (nasal swab) following written informed consent. The MRSA screening process was overseen by Occupational Health and managed confidentially. Senior NICU staff members were not made aware of the results. MRSA-colonized staff received decolonization therapy with nasal mupirocin and octenisan for seven days and were excluded from work for the first two days of treatment. They were then screened three times (one week apart) to confirm MRSA clearance and monthly thereafter for

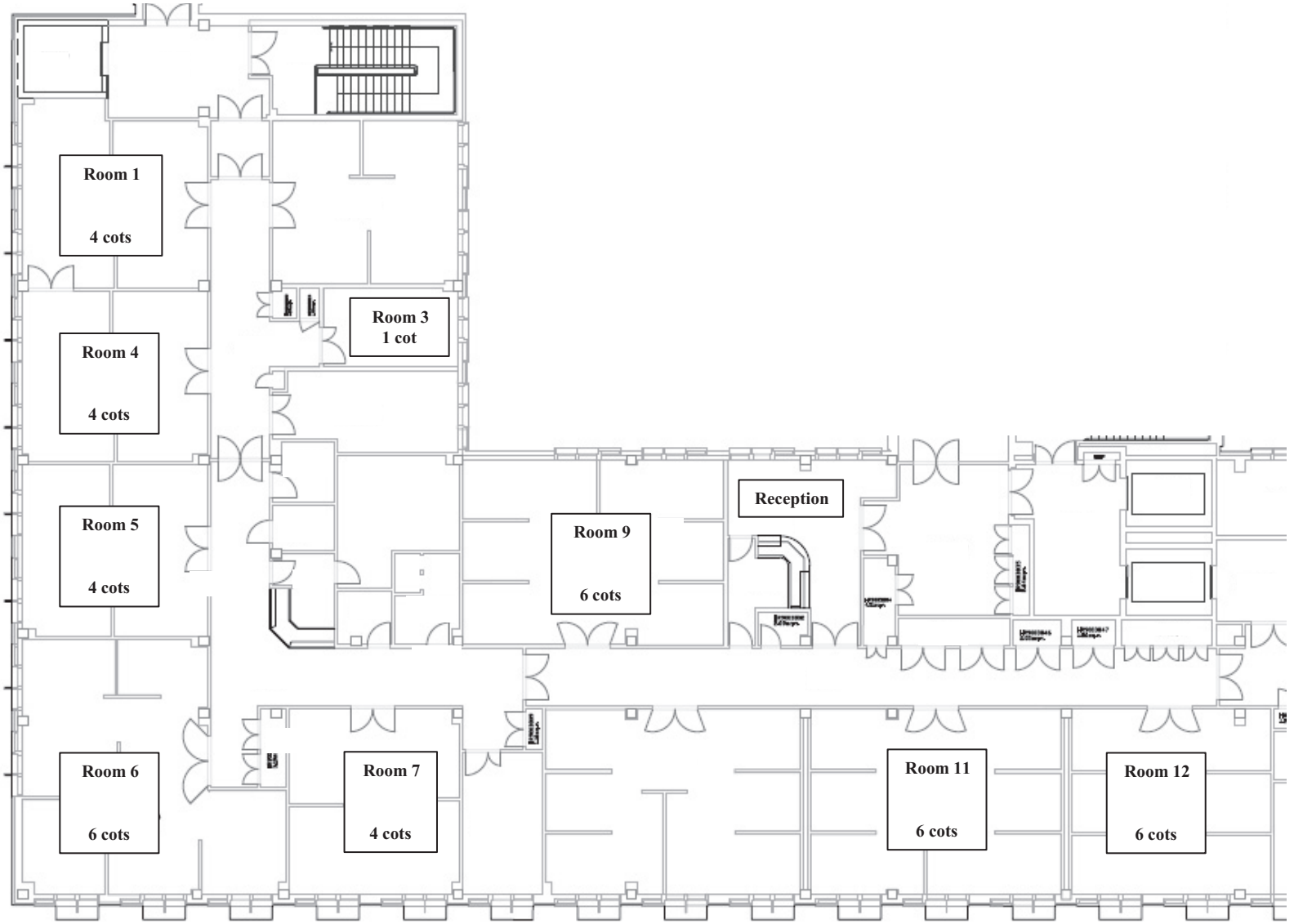

Figure 1. Neonatal intensive care ward layout.

12 months. MRSA-positive infants were nursed using gowns and gloves rather than aprons and gloves (day 51 onwards). A risk assessment performed to review the impact of closure of the NICU to new admissions determined that the risk to patient safety related to NICU closure outweighed the risk of possible MRSA infection, assuming appropriate precautions were being taken.

Case–control study

A case–control study was undertaken to test the hypothesis that there was no association between MRSA colonization in infants and allocation of individual nurses to the same room in which infants were admitted on $\geq$1 day in the interval of risk. Nurses were chosen because of their close contact with infants and previous studies also identified this group as the highest transmission risk [1,2]. The record of room in the NICU for each nurse for each day was determined by examining the patient records, rotas and daily records of infant/cot locations.

The population at risk for the case–control study was defined as all infants admitted to NICU between the admission date of the first MRSA colonized infant (day 0) and the date of the result of the last MRSA positive swab (day 54). Cases were defined as infants colonized or infected with gentamicin-resistant MRSA from the population at risk. Controls were chosen by removing cases from the population at risk list, ordering them alphabetically by name and then using random numbers to obtain three controls per case.

Clinical data were obtained from medical records and entered into an Excel database. Variables collected included case/control status, gender, admission date, gestational age, birthweight, twin/singleton, place of birth, Consultant name and date of discharge.

Daily printed records of infant cot/room allocation by date were collected from hospital records. Rotas of nursing allocations were reviewed by room and date to determine which nurse was allocated to the same room as each infant on the same day. Individual nurse to infant rota records were incomplete because nurses assisted each other in the care of other infants in the same bay on the same shift, for example on rest breaks, and these additional arrangements were not routinely recorded. In contrast nurse rotas at bay level were accurate and complete. These data were imported into an SQL database to calculate the number of days each of the nurses was allocated to the same room as the infant. These data were exported to STATA 13.1 and merged with the clinical data for each infant.

Data were analysed in STATA 14.1. The number of infants with $\geq$1 date of same room allocation with individual nurses was small so this was dichotomized to ever vs never being present in a room with each of the nurses. Single and multivariable logistic regression was conducted with likelihood ratio tests.

Explanatory variables with raised odds ratios (ORs) and *P*-values $<$0.2 in single variable analysis were considered by forward stepwise multivariable analysis. The initial multivariable model consisted of two potentially confounding continuous explanatory variables, gestational age and birth weight and the binary variables, ever same room of allocation infant and each nurse.

The suitability of the linearity of the continuous variables was examined, one at a time, while assuming linearity for the other continuous variable. Any infant–nurse same-room allocation for each of the nurses was added, one at a time in decreasing order of significance, grouped by *P*-value: $<$0.005, $\geq$0.005 to $<$0.05, $\geq$0.05 to $<$0.1, and $\geq$0.1. Within each category, the order of variable selection was done in order of decreasing number of cases exposed or decreasing OR. Infant–nurse same-room allocation were removed if $P>0.05$ and if its removal did not result in a change of the estimable ORs of the variables remaining in the model by 20% or more, otherwise the nurse was retained as a substantial confounder.

If there were too many variables in the resulting model, a significant one was removed and added after the variables which resulted in model non-convergence had been considered. Protective and substantial confounder variables were also removed, as were added variables which caused the model not to be able to be estimated because of non-convergence.

The process concluded when all variables for consideration in the multivariable model had been evaluated. This gave the final multivariable model with the remaining significant variables. As ORs for some of the variables could not be estimated, exact logistic regression was used on a simpler model omitting birth weight from the final model. Interaction was investigated in the final model between gestational weight, and any same room allocation of nurses.

Internal and external review

Feedback forms were sent to IMT members to reflect on the incident management and the effectiveness of the response. A formal feedback discussion was held at the final IMT meeting. NHS Improvement was invited to perform a review of the response.

Results

Description of the outbreak

There were 117 infant admissions between day 0 and day 54 with nine MRSA-positive infants initially identified. One was subsequently excluded following characterization of the MRSA. Eight infants were colonized with a gentamicin-resistant MRSA strain, t2068; indistinguishable by pulsed-field gel electrophoresis. This *spa* type has not been observed elsewhere in England (A Kearns, personal communication). Three healthcare workers (HCWs) were found to be MRSA colonized, one of whom (nurse 45) carried an isolate with the same spa type t2068 as the infants.

Eight MRSA samples were available for sequencing – seven from infants and one from nurse 45. Phylogenetic analysis showed that seven of eight of the isolates were closely related with a maximum of 66 SNP differences in the core genome between them. Furthermore, the sample from nurse 45 was closely related to seven of the infants' MRSA isolates, suggesting that transmission events had occurred.

Phase 1 (days 30–48)

Infant 1 was detected following a routine MRSA screen taken 12 days after admission to the Unit (day 12). Infants 2 and 3 were detected on day 30 from screens taken on days 26 and 27, respectively. Two of these infants were born in Cambridge.

Infant 3 subsequently developed an MRSA bacteraemia. Root cause analysis suggested the cause of the bacteraemia was poor skin integrity.

The occurrence of three positive MRSA screens within a two-week period was considered unusual and a discussion was held on day 30 between the ICT and NICU staff. Enhanced environmental cleaning and increased MRSA screening of infants (to twice weekly) was implemented. Observations of practice and hand hygiene audits demonstrated a wide variation in the use of PPE and poor understanding among staff of when to change PPE (e.g., when to change gloves). The ICT attended a NICU senior team meeting on day 34 where the actions already implemented the week before were ratified and an IMT was instituted. The first IMT meeting was held on day 41. An epidemiological timeline was developed (Figure 2) and showed that infants 2 and 3 had shared the same room for two days.

The MRSA outbreak isolates were resistant to meticillin, erythromycin, ciprofloxacin and gentamicin. The resistance to gentamicin was unusual in local MRSA isolates and was therefore a useful laboratory marker for the outbreak strain. Environmental samples were negative for MRSA. Infant 4 was identified on day 46 from a swab taken on day 41.

Phase 2 (days 48–85)

Two infants were identified from screens taken on day 44 (infants 5 and 6). Screens taken on day 47 to day 48 identified two more infants (infants 7 and 8). Infant 8 was identified on day 54.

The outbreak was declared over at the IMT meeting on day 85, when no further transmission had occurred for a month.

Retrospective review of isolates previously referred for characterization suggested the outbreak strain had been identified previously on NICU in 2015. Since transmission appeared to be ongoing despite enhanced precautions, MRSA screening of NICU staff was initiated.

Case–control study

Twenty-seven unmatched controls were enumerated based on their initially being nine cases. All 27 controls were retained despite excluding one case.

Single variable analysis

MRSA colonization was associated with gestational age (median 188 vs 232 days, P=0.001); lower birthweight (median 892.5 g vs 1750 g, P<0.001); and with being a twin (OR 7.50, range 1.30–41.0, P= 0.02). MRSA colonization was not associated with gender, hospital of birth, or admitting Consultant (Table I). MRSA colonization was significantly associated (P<0.05) with same-room rostering of 19 of the 135 nurses for ≥1 day to the same room with an MRSA positive infant. Of these, only one nurse (nurse 45) had same room rostering with all eight cases (OR inestimable P<0.001). Three nurses had the same room allocation with seven of eight infants. There was also some evidence of association with nurse 35, though they had same room allocation with only three of eight infants.

Multivariable analysis

The initial model included gestational age, birthweight and nurse 45. The final exact logistic regression model (Table II) comprised gestational age, nurse 45 (adjusted OR 6.30 (0.64, ∞) P=0.02); and nurse 35 (OR 15.60 (1.34, 182) P=0.045).

Routine MRSA screening was maintained. Three HCWs were found to be colonized with MRSA on days 43, 45 and 48, respectively. Only nurse 45 was colonized with MRSA t2068. HCWs were decolonized and subsequently allowed to return to work. No further cases were detected in infants following exclusion of colonized HCWs.

The results of the feedback are provided in Table III.

Further cases of MRSA t2068 developed after closure of the outbreak from samples taken on day 149, day 175 and day 223, respectively. MRSA was again detected from nurse 45 as part of the routine monthly screening. This nurse had looked after these three infants. They were decolonized again and remain MRSA negative; no further acquisitions have occurred since.

Extra resources spent dealing with the outbreak included 20 IMT meetings (each lasting one hour, with 10–20 attendees), enhanced environmental cleaning, increased MRSA screening of infants and staff (10–15 min per screen) and the work performed for the case–control study (16 person weeks).

Discussion

This study describes the investigation and management of an MRSA outbreak on a NICU and the challenges faced. Routine MRSA screening permitted early identification of increased MRSA colonization. However, the absence of accurate record keeping of which individual nurses cared for which individual infant on each day hampered the outbreak investigation. The case–control study had to use the less direct measure of allocation to the same room of each nurse and infant on the

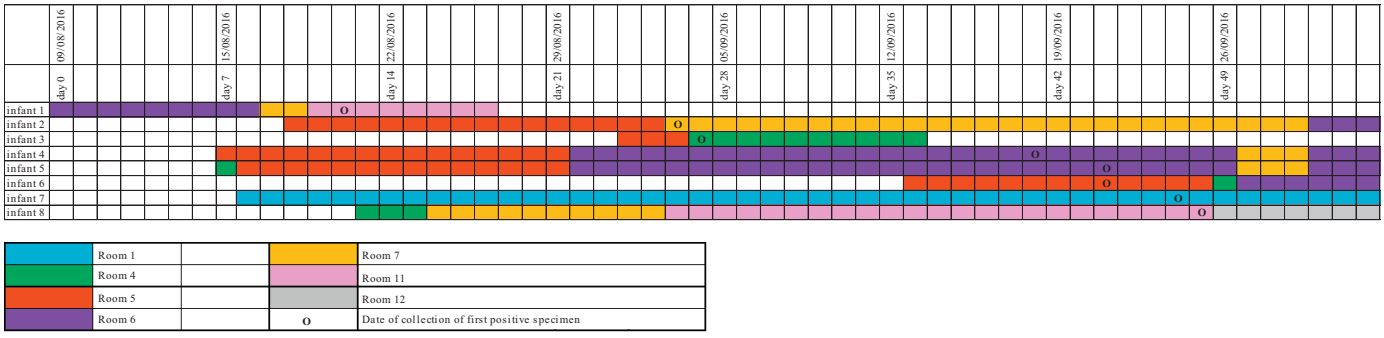

Figure 2. Epidemiological timeline of the outbreak.

Table I
Single variable analysis of clinical characteristics and nurses with significant ($P<0.05$) same ward allocation association with meticillin-resistant *Staphylococcus aureus* carriage infants

Variable		Cases $N = 8$	Controls $N = 27$	Odds ratio	95% confidence interval	P
Gestational age (days)	Minimum	168	173	0.95 per day	0.91–0.99	0.001
	25th centile	177	205			
	Median	188	232			
	75th centile	210.5	273			
	Maximum	222	295			
Birthweight (g)	Minimum	520	500	0.997 per g	0.994–0.9997	<0.001
	25th centile	617.5	1150			
	Median	892.5	1750			
	75th centile	987.5	2960			
	Maximum	1360	4920			
Twin birth	Yes	5	5	7.30	1.30–41	0.02
	No	3	22	1.00		
Gender	Female	5	9	3.33	0.65–17	0.14
	Male	3	18	1.00		
Infant born in Rosie	Yes	4	10	1.70	0.35–8.34	0.5
	No	4	17	1.00		
Admitting consultant	D005	0	1	0.00	n.e.	0.6
	D012	0	1	0.00	n.e.	
	D022	1	5	0.27	0.02–3.65	
	D063	3	4	1.00		
	D122	1	1	1.33	0.06–31	
	D157	0	1	0.00	n.e.	
	D166	0	3	0.00	n.e.	
	D172	1	5	0.27	0.02–3.65	
	D196	1	2	0.67	0.04–11	
	D197	1	0	n.e.	n.e.	
	D212	0	2	0.00	n.e.	
	D214	0	1	0.00	n.e.	
	D217	0	1	0.00	n.e.	
Infant ever exposed to nurse no. 007	Yes	5	5	7.33	1.30–41	0.02
	No	3	22	1.00		
Infant ever exposed to nurse no. 033	Yes	4	4	5.75	1.00–33	0.049
	No	4	23	1.00		
Infant ever exposed to nurse no. 035	Yes	3	1	15.60	1.34–182	0.02
	No	5	26	1.00		
Infant ever exposed to nurse no. 045	Yes	8	9	n.e.	n.e.	<0.001
	No	0	18	1.00		
Infant ever exposed to nurse no. 046	Yes	4	3	8.00	1.28–50	0.02
	No	4	24	1.00		
Infant ever exposed to nurse no. 049	Yes	6	8	7.13	1.17–43	0.02
	No	2	19	1.00		
Infant ever exposed to nurse no. 052	Yes	6	5	13.20	2.03–86	0.003
	No	2	22	1.00		
Infant ever exposed to nurse no. 053	Yes	5	4	9.58	1.61–57	0.01
	No	3	23	1.00		
Infant ever exposed to nurse no. 068	Yes	5	2	20.83	2.73–159	0.001
	No	3	25	1.00		
Infant ever exposed to nurse no. 107	Yes	5	5	7.33	1.30–41	0.02
	No	3	22	1.00		
Infant ever exposed to nurse no. 116	Yes	6	7	8.57	1.39–53	0.01
	No	2	20	1.00		
Infant ever exposed to nurse no. 118	Yes	5	6	5.83	1.07–32	0.04
	No	3	21	1.00		
Infant ever exposed to nurse no. 137	Yes	7	4	40.25	3.84–421	<0.001
	No	1	23	1.00		
Infant ever exposed to nurse no. 148	Yes	4	4	5.75	1.00–33	0.048
	No	4	23	1.00		

Table I (*continued*)

Variable		Cases $N = 8$	Controls $N = 27$	Odds ratio	95% confidence interval	P
Infant ever exposed to nurse no. 164	Yes	7	8	16.25	1.75–158	0.003
	No	1	19	1.00		
Infant ever exposed to nurse no. 177	Yes	1	0	n.e.	n.e.	0.08
	No	7	27	1.00		
Infant ever exposed to nurse no. 178	Yes	7	6	24.50	2.50–240	<0.001
	No	1	21	1.00		
Infant ever exposed to nurse no. 180	Yes	4	2	12.50	1.69–92	0.01
	No	4	25	1.00		
Infant ever exposed to nurse no. 192	Yes	5	6	5.83	1.07–32	0.04
	No	3	21	1.00		

n.e., not estimable.

same day. This required assembly of a same room–day diary for nurses and infants derived from handwritten ward notes. This took time, delaying recognition of the risk posed by nurse 45.

This study highlights the benefit of using a case–control study which showed that most nurses had no association with colonized infants. The synergy of the case–control study and typing and sequencing results gave greater confidence in identifying nurse 45 and provided some assurance of the absence of risk from other sources. The exclusion and decolonization of the nurse was followed by an interval with no new cases.

A recent meta-analysis found that MRSA colonization in infants was associated with gestational age <32 weeks (P=0.01) and birth weight <1500 g (P=0.01) [3] which is consistent with our analysis. An association with twin birth was also found. In the final multivariable model, gestational age and co-location with two nurses was associated with MRSA colonization (Table II). Infant gender (P=0.21), inborn status (P=0.09), and delivery type (P=0.24) were not significantly associated with colonization.

Hocevar *et al.* describe great variability in practice on NICUs, underscoring the need for further research to define optimal strategies for prevention [4]. Contributing factors previously described included inadequate staffing levels, cluttered units, inadequate sterilization of communal milk-expressing equipment and inappropriate follow-up of MRSA results [5]. One qualitative study found that many HCWs also reported challenges to following consistent hand hygiene and use of PPE, which was discovered in our NICU [6]. Barriers included patient care demands, equipment and environmental issues (e.g., availability of sinks), time pressures, the practices of other HCWs, and the need for additional signs indicating which patients require contact precautions. They reported a need for improved clarity of isolation protocols, additional rooms and staff for isolated patients, improved education/communication and an emphasis on involving all HCWs in reducing contamination.

Table II
Multivariable, adjusting for linear association of gestational age with illness, using exact logistic regression

Variable		Odds ratio	95% confidence interval	P
Infant ever exposed to nurse no. 35	Yes	2.64*	0.20–157	0.045
	No	1.00		
Infant ever exposed to nurse no. 45	Yes	6.30†	0.64–∞	0.02
	No	1.00		

* Conditional estimate.
† Median unbiased estimate.

Several studies have found HCWs to be responsible for outbreaks [1,2,7]. One study found that HCW-assisted transmission was implicated in five of six outbreaks [5]. MRSA carriage rates in neonatal nurses ranged from 0.6% to 8% [1,2,8,9], with an average of 1% [10,11]. Risk factors for MRSA in HCWs have previously been described in terms of colonization, persistence despite decolonization and relapse after decolonization [12].

Most studies suggest decolonizing affected HCWs; however, no studies offer suggestions on how to effectively manage persistently positive or intermittently positive HCWs. It was necessary to decolonize the individuals, but to avoid victimizing them or 'exposing' them to their peers a confidential system was used. Affected HCWs were offered psychological support in addition to education; the role of family members of HCWs was not considered, although intra-familial spread is described [13–15]. The positive HCWs continue to be screened monthly in case they relapse. Screening, enhanced cleaning, isolation, barrier nursing, staff movement restrictions, hand hygiene audits, household contact screening and environmental sampling have been used previously [16]. Iacobelli *et al.* provided HCW education and screening [17]. All of these interventions were instituted to stop this outbreak. Aprons and gloves continued to be used until day 51 when gowns were introduced for use with positive infants in an attempt to control the outbreak.

MRSA decolonization of infants has been shown to prevent transmission [18]. However, this study does not describe how to decolonize infants <35 weeks' gestational age [19]. Some of our babies were 24 weeks and octenisan/chlorhexidine were considered unsuitable.

The increased resources needed to deal with an outbreak are described. Occupational Health appointed an additional nurse to facilitate staff screening, decolonization and rescreening.

A number of issues were identified on review of the outbreak. Recording duty nurse allocations to care for infants was not carried out. It was not possible to measure individual doctors' exposure to individual infants for the case–control study because no systematic record of their contact with infants was available. The post-outbreak and external reviews were found to be very useful in terms of learning and we were

Table III
Results from the internal and external reviews

Internal incident review
Feedback was received from the majority of IMT members, representing NICU, Public Health England and the infection control team. Below is a summary of feedback, structured using the headings from the feedback form.
A. Overview of management of the incident
Feedback was positive, with comments including 'good proactive management' and 'good working relationships'.
B. What went well
Feedback identified the good working relationship between different teams, staff engagement, communications, staff swabbing, the outbreak investigation, and support from the cleaning contractor as areas that worked well.
C. Difficulties encountered
One difficulty encountered was the number of staff involved in the IMT and a lack of clarity of the terms of reference and membership of the group. There was a lack of senior input early on. Administration of meetings was considered informal as there was no dedicated secretarial support and as a result minute taking was performed by staff trying to chair meetings at the same time. Others related to the need to update Trust policies in a range of different areas to reflect the changing epidemiology of MRSA and also reconsider triggers for the declaration of an outbreak.
There was a lack of clear recording of which staff cared for which babies.
There was lack of clarity as to who should lead on screening staff for MRSA, and whether it should be infection control or occupational health. Occupational health led on it but did not have the resources initially
D. Areas for improvement/implications for future arrangements
Feedback discussion relating to areas with potential applicability to the rest of the Trust: • Recognition of the outbreak – differentiation of the abnormal when there is a background rate. • Generic outbreak policy – procedure for escalation, how and when does the minor issue become more significant? • Formation and function of the IMT – somewhat informal currently, need to clarify roles, administration, formality (e.g., roles, case definitions, recording of formal risk assessment, lack of senior attendance and defined secretarial support). • Staff screening – clear process, consent, defined actions as a result of findings, with extra resources required • On-going issue with staff screening in the future – 'knee jerk' response vs need to address staff movement and risk
External incident review
Following the notification of the outbreak to the Trust's regulators, NHS Improvement, was invited to perform a 'critical friend review' of the IMT and the unit response. This was done on day 71 of the outbreak. At this point, there were still five MRSA-positive babies on the Unit.
The main comments are summarized as follows: • The initial escalation of the outbreak and instigation of the IMT could have been more prompt. The IMT meetings should have been more formal in terms of membership, roles, case definitions and administration. • There was a lack of continuity in the IMT in that the membership was not defined and staff attended when they were able. As a result, actions recorded did not always have documented ownership or completion. Audit data or other information should have been obtained to give the IMT assurance that actions had been completed. • There appeared to be delays in getting some issues resolved. For example, additional alcohol dispensers for hand hygiene were required and should have been obtained immediately. • There was inconsistency of practice in some areas across the unit. For example, relating to the use of personal protective equipment (e.g., which product to use for hand washing, inappropriate use of gloves) and staff understanding of the different levels of cleaning (deep clean, rolling clean, enhanced clean).
The IMT found the external review a very helpful and constructive exercise. It agreed with the view the outbreak meetings need to be more formal and appropriately supported. This is a Trust-wide issue, not one specifically related to this outbreak. It was thought that appropriate interventions to control the outbreak had been implemented in a timely manner, but that the documentation of discussions and agreed actions could have been improved. Initial discussions were held and documented on day 30 and day 34, but these had not been labelled as formal IMT meetings.

IMT, incident-management team; MRSA, meticillin-resistant *Staphylococcus aureus*; NHS, national Health Service; NICU, neonatal intensive care unit.

able to apply some of these lessons to other areas of the hospital. This study also raised areas of uncertainty and suggestions for future research, namely: how should premature babies with MRSA be decolonized (if at all)? Should gowns have been introduced earlier instead of aprons? How do you identify and screen the highest risk staff and subsequently deal with positive staff?

Data on resource requirements needed to deal with the outbreak or formally monitor the psychological impact of being a HCW colonized with MRSA were not collected. However, the time required for IMT meetings and the case–control study alone were significant.

This study presented an outbreak of a single strain of MRSA affecting eight infants on our NICU and how screening

permitted identification before infection. A case—control study was conducted using a case definition of MRSA colonization, with subsequent corroboration of case status and colonization of the outbreak strain in the implicated nurse by characterization of the MRSA isolates.

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