Transmission of *Staphylococcus aureus* from maternity unit staff members to newborns disclosed through *spa* typing

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Background: We observed previously that newborn infants are colonized with *Staphylococcus aureus*, even if their mothers do not carry *S aureus*. This observation indicated a cross colonization, and, thus, a risk for nosocomial infection, although the infants are roomed in with their mothers.
Methods: The *S aureus* colonization of infants, their parents, and staff members was measured at 3 maternity units. Possible transmission routes were determined using *spa* typing of *S aureus* isolates.
Results: Infants had the highest *S aureus* carriage (45%) compared with fathers (39%), mothers (27%), and staff members (27%). In 13 out of 44 colonized infants, transmission from staff members was indicated. This transmission was more frequent than was transmission from their own parents (11 cases), and occurred even in cases when parents were colonized with *S aureus* of other *spa* types.
Conclusions: We confirm a high level of transmission of *S aureus* from staff members to infants, indicating a risk for patient safety, which necessitates continuing work with implementing scientific evidence for infection control. The *spa* typing is a rapid and valuable epidemiological tool, and it can be used in improving hospital hygiene control programs. (Am J Infect Control 2007;35:122-5.)

Colonization of the newborn with potentially pathogenic bacteria poses a risk for neonatal infection. A relationship between infection with *Staphylococcus aureus* and umbilical colonization has been suggested,[1] and nasal carriage of *S aureus* often is a prelude to infection with the same strain.[2,3] The main transmission route of *S aureus* to infants is the hands of health care workers, and hand washing reduces this transmission markedly.[4,5] In a recent patient safety project at 3 maternity units in the County of Jönköping, Sweden, we observed a 30% *S aureus* colonization of infants who were delivered by mothers without *S aureus* carriage. This indicated a nosocomial cross colonization, despite the fact that the infants are roomed in with their mothers, and that health care workers are supposed to follow accurate hand disinfection routines in their care. Ideally, infants should receive their normal flora from their parents. Many hospital-acquired infections result from patient colonization with hospital flora, which may be acquired rapidly.[6] Therefore, control of methicillin-sensible *S aureus* represents an important challenge as colonization is expected and endemic infections occur; however, surveillance efforts generally focus on methicillin-resistant *S aureus* (MRSA).[7]

Objective molecular epidemiology typing methods for *S aureus* (eg, *spa* typing) are documented as valuable for the tracking of epidemic isolates, elucidation of sporadically occurring clones, and to disprove person-to-person transmission in hospitals.[8-10]

In this study, *S aureus* colonization of infants, their parents, and staff members at 3 maternity units was measured. Samples also were obtained from the environment. By using *spa* typing of *S aureus* isolates, we could show that transmission from staff members to infants is still of major concern.

METHODS

Study population and samples

S aureus colonization of infants, their parents, and staff members was measured at 3 maternity units in the County of Jönköping (Sweden). Infants were routinely roomed in with their mothers, in rooms with 2 to 4 beds, and they shared diaper-changing tables. Participants gave their informed consent. Newborn infants and their parents were sampled on 6 occasions during one year (2003-2004). Members of the staff (99% women) were sampled at the first and sixth occasion. Samples were obtained from parents (n = 463) when entering the ward, with swabs from the nostrils, ears, and fingers. From infants (n = 218;

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99 girls, 119 boys), samples were collected from the nostrils, ears, and umbilical cord just before leaving the ward. Samples from staff members (n = 212, 210 women) were obtained in the same manner as from the parents at start of duty. Environmental samples (n = 151) were collected on the sixth occasion from strategic locations, such as beds, bathtubs, telephones, keyboards, door handles, stethoscopes, otoscopes, and diaper-changing tables. Air samples were obtained on 3 different occasions from each ward (1 × 100 L, 2 × 1000 L), using a surface air sampler (air IDEAL, bioMérieux AB, Gothenburg, Sweden).

Staphylococcus aureus culture and antibiotic susceptibility testing

Initially, swabs were plated onto standard blood agar plates and incubated for 24 hours at 37°C. For environmental surveillance, blood agar contact plates were pressed against the object of interest. One to 3 colonies of presumed *S aureus* were selected from primary culture plates, and replated onto blood agar plates. *S aureus* identification was performed by culture on DNase agar plates. Antibiotic susceptibility testing was performed at 37°C on Iso-Sensitest Agar (Oxoid Ltd., Basingstoke, UK) by use of disk diffusion technique, according to the Swedish Reference Group of Antibiotics.[11] Susceptibility testing was performed against the following antibiotics: cefadroxil, clindamycin, erythromycin, fusidic acid, and cefoxitin (Oxoid Ltd.). Cefoxitin was used as screening for MRSA.[12]

Isolates were stored at −80°C in skimmed milk.

spa typing of *Staphylococcus aureus*

The x-region of the *spa* gene was amplified by polymerase chain reaction with primers *spa*-1113f (5′-TAA AGACGATCCTTCGGTGAGC-3′) and *spa*-1514r (5′-CAGC AGTAGTGCCGTTTGCTT-3′), according to Ridom GmbH (Würzburg, Germany). The DNA sequencing was performed on both strands using a CEQ 8800 capillary sequencer (Beckman Coulter, Fullerton, CA). The *spa* types were determined using the Ridom StaphType software (Ridom GmbH) described previously.[9]

Statistical analysis

The differences in prevalence of *S aureus* carriage were analyzed by χ^2 test.

RESULTS

Prevalence of *Staphylococcus aureus* carriage and recovery from the environment

By culturing samples from the nostrils, ears, and fingers of parents and staff members, the overall prevalence of *S aureus* carriage varied from 27% to 39%, with the highest figure for fathers, in each separate unit (Table 1). We observed significant differences of carriage between fathers and mothers ($P = .0067$) as well as between fathers and staff members ($P < .001$). The prevalence among children showed no significant differences relating to gender (48% girls, 42% boys) (Table 1). Hospital stay ranged from 1 to 8 days, with 85% leaving within 4 days (Fig 1). Infants had significantly higher *S aureus* carriage compared with mothers ($P < .001$) and staff members ($P < .001$). The difference between fathers and children was not significant ($P = .17$). Among colonized adults, *S aureus* was isolated most frequently from the nostrils (70%), followed by ears (30%) and fingers (20%). Among infants, *S aureus* was isolated most frequently from the umbilical cord (85%), followed by the nostrils (40%) and ears (15%). Adults and infants were colonized at 2 sites in 20% and 40% of the cases, respectively.

Table 1. Number of *S aureus*–colonized individuals and the corresponding prevalence (%)

	Children				
Maternity unit	**Female**	**Male**	**Mothers**	**Fathers**	**Staff**
Hospital A	11 (46)	19 (40)	23 (32)	26 (36)	21 (33)
Hospital B	23 (59)	18 (49)	24 (29)	31 (37)	20 (30)
Hospital C	14 (39)	13 (38)	15 (20)	32 (43)	16 (30)
Total	48 (48)	50 (42)	62 (27)	89 (39)	57 (27)

In 151 samples that were collected from the environment, *S aureus* was found in only 7 cases. These 7 samples were obtained from a door handle, a telephone, a keyboard, a stethoscope, a bathtub, an otoscope, and a diaper-changing table. The *S aureus* was not found in any of the samples that were collected from the air.

Resistance

The routinely performed antibiotic susceptibility testing revealed a low number of resistant strains; only 8 of 315 isolates showed any resistance toward the 5 antimicrobial agents for which we tested. Of those, 6 isolates were resistant to clindamycin and erythromycin, and 2 were resistant to fusidic acid. No MRSA was found.

spa types and transmission routes

By *spa* typing all isolates from the first and sixth cultures, we found 74 different *spa* types among 160 isolated *S aureus* strains. The three most common *spa* types were t012 (20 isolates), t015 (10 isolates), and t021 (10 isolates), which were distributed equally between infants, parents, and staff members.

In 11 cases of infant *S aureus* colonization, we observed colonization of the mother or father by

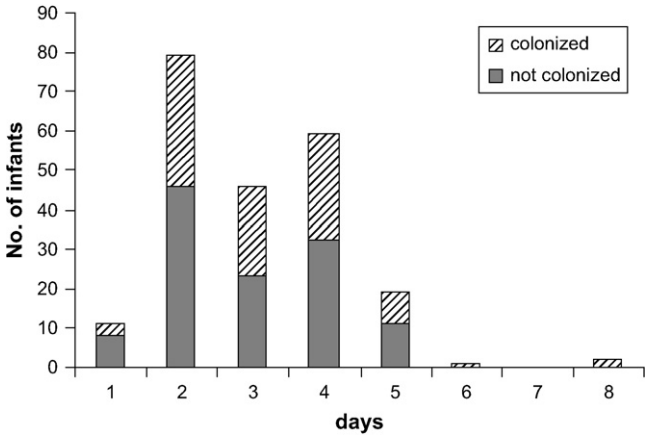

Fig 1. Length of hospital stay and colonization of *S aureus*.

the same *spa* type (Table 2). In 13 cases of infant colonization where a corresponding parent–child *spa* type was absent, we observed the same *spa* type among the staff members. In 4 cases, this occurred even when the parents were colonized with *S aureus* of other *spa* types. Additionally, in 5 cases of infant colonization the *spa* types were identified only among other infants or parents of other infants who were admitted during the same time period. For the remaining 15 cases of infant *S aureus* colonization, the *spa* types were not sampled from any other source.

DISCUSSION

The present study shows a rapid colonization of newborns with *S aureus*, and to a higher frequency than in parents and staff members; this is in agreement with previous data on intestinal colonization of infants.[13] Using *spa* typing, a diverse clonality of isolates was shown, and a major role of staff members in the spread of *S aureus* to infants was confirmed.[4]

The rate of *S aureus* carriage in adults was in accordance with previous observations as was the fact that males had a higher colonization rate than did females.[14] The highest colonization rate was observed for infants, however, although the difference between infants and fathers did not reach significance.

The *spa* typing was used to investigate the clonality of *S aureus* isolates from the first and sixth cultures. We demonstrated a large strain diversity, and no dominant institutional flora could be observed. The three most commonly isolated strains were distributed equally between the study groups, which indicates that the prevalence of various *spa* types are similar in the community and in staff members of the maternity wards. The fact that 15 neonatal strains were not found anywhere else indicates that commonly used methods for screening of *S aureus* have limitations, such as an insufficient number of locations for sampling. Other reasons for unexplained colonization of infants may be due to transmission from visitors and transient colonization of staff members or parents. To address this issue more extensive sampling would be required, including repeated sampling of individuals as well as the inclusion of additional sampling sites, such as throat, stool, and vagina.

Table 2. Number of probable transmissions of *S aureus* to infants according to *spa* typing data

Transmission source	Occasion 1	Occasion 6	Total
Own mother or father	8 (23 %)	3 (33 %)	11 (25 %)
Staff members	10 (29 %)	3 (33 %)	13 (30 %)[#]
Unknown or other infant/parent	17 (49 %)	3 (33 %)	20 (45 %)

[#]In one additional case, a *spa* type of an infant *S aureus* strain was isolated from the mother as well as a member of the staff.

The absence of an institutional flora may be due to a low antibiotic pressure, short hospital stays, and a low level of infections. The low prevalence of antibiotic resistance is in accordance with previous findings from Swedish hospitals.[15]

We found that among newborn infants who were colonized with an *S aureus* strain that was not recovered from their parents, the strain often could be isolated from staff members. This is in accordance with previous data showing that the main transmission route is via the hands of health care workers.[4,16] In our study, where the children were roomed in with their mothers, transmission from staff members occurred even in cases when the mother was colonized with *S aureus* of another *spa* type.

The most frequently transmitted strain to infants was t012, which also was the most prevalent strain *spa* typed in this study. These data might reflect an epidemic potential of this strain.[17]

The role of the inanimate environment in the spread of nosocomial infections is controversial.[15,18,19] The environment did not seem to be an important source for cross colonization, because we did not observe transmission of *S aureus* strains isolated from the environment to infants.

Prevention of cross colonization with *S aureus* is important because a correlation between infection and colonization rates has been documented,[20] and proper hand hygiene is considered the most important preventive procedure.[5,21-23] Improving and implementing the results of scientific evidence in hospital infection control and health care epidemiology are critical to enhance patient outcomes.[24]

In conclusion, cross colonization of newborn infants with *S aureus* from staff members continues to be a serious problem. We suggest that adherence to hand

disinfection routines is critical, and that parents should care for their infants. This should decrease cross colonization from staff members. By *spa* typing *S aureus*, this bacteria can be used as an indicator for bacterial spread in a hospital setting. Data generated in this manner can be used to improve patient safety work by reducing hospital infections.

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