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Screening and characterization of *Staphylococcus aureus* from ophthalmology clinic surfaces: a proposed surveillance tool

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Abstract

Purpose—To screen environmental surfaces of an outpatient ophthalmic clinic for methicillin-susceptible and methicillin-resistant *Staphylococcus aureus* (MSSA and MRSA); to identify the most commonly contaminated surfaces; and to phenotype and genotype all collected isolates

Design—A single institution, one-year prospective environmental study

Methods—Commonly touched surfaces from examination rooms and common areas were targeted and sampled on a quarterly basis for one year. Samples were collected using electrostatic cloths and swabs. *S. aureus* was isolated using non-selective and selective media. Morphological characteristics and standard biological testing were used to confirm staphylococcal species. *S. aureus* isolates were phenotypically (Kirby-Bauer method) and genotypically characterized (*mecA* confirmation, SCC*mec* typing and pulsed-field gel electrophoresis). Dendrogram analysis was used to establish genetic relatedness between the isolates.

Results—Of 112 total samples, 27 (24%) and 5 (4%) were MSSA- and MRSA-positive, respectively. Both community-associated (SCC*mec* IV, USA300) and hospital-associated (SCC*mec* II, USA100) MRSA isolates were found. No single surface remained consistently positive with the same isolate over time and molecular analysis demonstrated high levels of diversity among isolates. Doorknobs, slit-lamp head/chinrests, and computer keyboards were frequently contaminated.

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Conclusions—The proposed surveillance protocol successfully allowed the detection of both MSSA and MRSA contaminating important high-touch surfaces in a representative ophthalmology clinic. Frequently contaminated surfaces must be targeted for routine cleaning and disinfection as there is a constant introduction of clones over time. Hence, other clinics may consider implementing and adapting surveillance tools, as the one here described, to help them control these important nosocomial pathogens.

INTRODUCTION

Methicillin-susceptible and -resistant *Staphylococcus aureus* (MSSA and MRSA) are pathogens of growing concern to clinicians.¹ In the past 2 decades, an increase in MRSA colonization has been observed in the U.S.^{1,2} This is especially true of community-associated MRSA, which is increasing in the general population and is known for causing severe skin and pulmonary infections in individuals without traditional risk factors.^{1,3}

In ophthalmology, manifestations of MSSA and MRSA infection include preseptal cellulitis, dacryocystitis, and blepharoconjunctivitis, orbital cellulitis, blebitis, keratitis/corneal ulcer, and endophthalmitis.^{4,5} Among these infections, community-associated MRSA has been reported as one of the emerging etiological agents involved.^{6,7} Thus, as the prevalence of community-associated MRSA increases in the general population, infection control measures, which are critical to the inpatient environment, could be adapted for outpatient settings to evaluate for *S. aureus* surface contamination and to evaluate and improve the effectiveness of clinic cleaning and disinfection practices.

Studies in hospital settings have shown that commonly-touched surfaces, such as computer keyboards⁸ and blood pressure cuffs,⁹ among others, could be potential sources of *S. aureus* colonization/infection for patients. MSSA and MRSA can survive for days to months on inanimate surfaces.^{10,11,12} In light of this, the widespread presence of hospital-associated MRSA, and the increasing prevalence of community-associated MRSA, one must question whether surfaces in the outpatient setting also pose transmission risks for patients and/or employees.

To effectively identify the surfaces most commonly contaminated with pathogens like MSSA/MRSA and allow for molecular typing, an economical, standardized sampling protocol has been developed.^{13,14} This tool is valuable to evaluate the effectiveness of cleaning and disinfection practices and could contribute to a surveillance program with the goal of minimizing potential patient and personnel exposure to MSSA/MRSA strains, as well as other nosocomial pathogens.

The purpose of this study was to use a standardized sampling protocol to screen ophthalmic clinic equipment and commonly touched surfaces for MSSA and MRSA; to identify the most commonly contaminated clinic surfaces; and to further phenotype and genotype such isolates. This study could provide valuable information to develop surveillance programs which evaluate and improve future cleaning and disinfection protocols for outpatient clinical settings.

METHODS

Experimental design

This study was carried out in a large academic ophthalmology setting. A standardized method (described below) was used to sample twelve randomly selected examination rooms, and shared imaging rooms, from 2 ophthalmology clinic buildings belonging to the same system (one freestanding outpatient clinic, Clinic 1; one hospital-adjointing, Clinic 2). To be

able to cover as many locations as possible from the clinic, the same surface in three different examination rooms was sampled as a pool. For example, all tonometer tips from each set of 3 rooms were pooled into 1 sample. Each group of rooms was denoted Group A, Group B, etc. (Table 1) Items sampled in each exam room included patient contact surfaces such as slit lamp head/chinrests and tonometer tips; employee contact surfaces such as computer keyboards and hand sanitizer dispensers; and general contact surfaces such as doorknobs. Excluding shared imaging areas, 12 examination rooms out of 43 (28%) were sampled (Table 1).

Shared imaging equipment and imaging room contact surfaces (doorknobs, keyboards, head/chinrests, A- and B-scan ultrasound probes) in both clinic buildings were also tested. In these areas, there were not always a total of 3 surfaces available, so the number of samples included in each pool can be found in Table 1. The sampled surfaces were identical on all subsequent samplings. Overall, a total of 28 pooled samples from both exam and imaging rooms were collected on each date, representing a total of 76 individual surfaces.

Sampling was performed quarterly for 1 year. For the initial survey, rooms were selected randomly, and the same cadre of rooms/surfaces was screened for each subsequent survey. In each case, sampling was conducted at the end of the workday, after the clinics had closed and before daily cleaning/disinfection procedures were performed by the housekeeping staff.

Sample Collection and Processing

Samples were systematically collected from commonly touched surfaces with either cotton-tipped swabs (for smaller surface areas) which were pre-moistened to enhance sensitivity¹⁵ or 10.4 × 8.0 inch (26.5 × 20.3cm) dry electrostatic cloths (for larger surface areas). The electrostatic nature of the cloth enhances sensitivity of bacterial collection.¹⁶ For doorknob samples, the area immediately surrounding the doorknob was also sampled, up to about 1 foot from the knob, on both sides of the door. Slit lamp head/chinrests were sampled at both forehead and chin points of contact. Sampling was conducted by trained personnel wearing clean clothing covers and gloves, which were changed between each sample collected. After each sample was collected, swabs were immediately placed in tubes containing sterile Trypticase Soy Broth (TSB, BD BBL™_ Trypticase Soy Broth, Becton, Dickinson and Company) with 2.5% NaCl, while cloths were placed in sterile empty transportation bags (Nasco Whril-Pak®, Fort Atkinson, WI). All samples were taken immediately to the Diagnostic and Research Laboratory on Infectious Diseases, and processed as previously described with a few modifications.^{13,14,15} Briefly, a pre-enriched media (TSB with 2.5% NaCl) was added to each bag containing the dry cloths. Tubes with swabs as well as bags with cloths were incubated for 24 hours at 35° C, then grown on Mannitol Salt Agar plates (BD BBL_ Mannitol Salt Agar, Dickinson and Company). Finally, 3 colonies with typical Mannitol reaction were plated on 5% Sheep Blood plates (Remel, Blood Agar [trypticase soy agar, TSA, with 5% sheep blood], Lenexa, KS) to be further characterized. Typical morphological colonies of *S. aureus* were confirmed with standard biological testing. MRSA phenotype was confirmed by growth on Oxacillin Screen Agar plates (OSA, BD BBL™, Becton Dickinson and Company) containing 6 µg/mL of oxacillin supplemented with NaCl following the Clinical Laboratory Standards Institute protocols.¹⁷

Phenotyping and Genotyping

Antimicrobial resistance of all *S. aureus* isolates was established by the Kirby Bauer method using an array of 15 antibiotics (ampicillin 10 µg, amoxicillin/clavulanate 30 µg, oxacillin 1 µg, cephalothin 30 µg, cefpodoxime 10 µg, ciprofloxacin 2 µg, erythromycin 15 µg, gentamicin 1 µg, amikacin 30 µg, clindamycin 2 µg, tetracycline 30 µg, doxycycline 30 µg, trimethoprim/sulfamethoxazole 25 µg, moxifloxacin 5µg, and chloramphenicol 30 µg).

Resistance to vancomycin was tested using Vancomycin Screen Agar plates (BD BBL Vancomycin Screen Agar, Dickinson and Company). For quality control purposes, the following strains were included: *S. aureus* (ATCC 43300), *S. aureus* (ATCC 29213), *S. aureus* (ATCC 25923), *Enterococcus faecalis* (ATCC 23212), *Escherichia coli* (ATCC 25922), and *Pseudomonas aeruginosa* (ATCC 27853).

Molecular characterization of *S. aureus* isolates was performed as previously described.¹⁴ Briefly, Pulsed-Field Gel Electrophoresis (PFGE) was performed in a CHEF mapper system (Bio-Rad Laboratories, Nazareth, Belgium) to separated restriction fragments obtained from the digestion of chromosomal DNA with *Sma*I. *Salmonella* serotype Branderup strain H9812 was digested with *Xba*I and used as a molecular size marker. Relatedness between isolates was evaluated by dendrogram analysis of the PFGE resulting band patterns using commercial software (BioNumerics® version 6.6, Applied Maths, Ghent, Belgium). The dendrogram was generated using Dice coefficient and Unweighted Pair Group Method using Arithmetic averages (UPGMA), with a 1% band position tolerance. Based on percentage of similarity, band patterns were classified as clones or the same pulsotype (≥ 98%) and grouped in clusters (≥ 80%). To establish USA types, all *S. aureus* isolates obtained in this study were compared against a CDC database containing 100 *S. aureus* strains with the most typical band patterns for each USA type, using ≥ 80% similarity as the cutoff point. For MRSA isolates, *mecA* gene confirmation and SCC*mec* typing was performed as well.

RESULTS

Over the year, *S. aureus* was detected on 30 of 112 (28% overall; prevalence 14–39% over time) total samples. 25 of these were MSSA, and 5 were MRSA (Table 2). MSSA prevalence ranged from 14–29%, and MRSA 0–11%. One surface tested positive for both MRSA and MSSA simultaneously.

Three surfaces also tested positive for either methicillin-susceptible or –resistant (2 susceptible, 1 resistant) *Staphylococcus pseudintermedius*, an opportunistic pathogen commonly found in dogs which rarely, if ever, plays a pathogenic role in humans.^{18,19}

MSSA was found in the clinic environment on all four sampling dates, while MRSA was found on 3 out of 4 sampling dates (Table 1, Table 2). In November 2010, MSSA-positive samples included computer keyboards and doorknobs from both clinics' shared imaging areas, as well as the doorknobs of one exam room pool. In addition, a single MRSA-positive sample came from slit lamp head/chinrests in Group C (Table 1; Isolate 012a in Figure).

Three months later, in February 2011, the same head/chinrest pool from Group C was again MRSA-positive (Isolate 040a, Figure): although these isolates were from the same cluster, they were not the same clone. MRSA was also found on 2 other surfaces: imaging area head/chinrests and computer keyboards (Isolates 031a and 053a, Figure). MSSA was found on several other surfaces, but the same clone was not found on more than one surface on this date.

In May 2011, MRSA was detected on slit lamp head/chinrests in Group D (Isolate 073b, Figure). In addition, MSSA was found on the doorknobs, hand sanitizer dispensers, and computer keyboards of Group D; all these isolates (074a, 075a, 076a) were the same pulsotype, suggesting a common source and possible cross contamination.

At the final sampling in August 2011, no surfaces were MRSA-positive. However, the same MSSA clone was found on the slit lamp head/chinrests of Group A and the hand sanitizer dispensers of Group B. All other MSSA isolates from this date were non-clonally related.

While many surfaces tested positive at some point for MSSA or MRSA (Table 3), no surfaces directly contacting the eye (tonometer tips or A- and B-scan ultrasound probes) yielded a positive result at any point. The most commonly contaminated surfaces were doorknobs, with 11/24 (46%), and slit lamp head/chinrests, with 10/24 (42%) sampled surfaces testing positive either for MSSA or MRSA over the course of the year. The third most contaminated surface was computer keyboards, used only by clinic personnel, with 6/24 (25%) samples returning positive. MRSA, specifically, was most likely to be found on slit lamp head/chinrests (4/24; 17%) and computer keyboards (1/24; 4%).

Some of the 30 *S. aureus*-positive surfaces contained more than 1 unique isolate; thus, there was a total of 32 *S. aureus* isolates which were molecularly characterized. Of the 27 MSSA isolates, there were 20 individual pulsotypes, and of the 5 MRSA isolates, there were 4 unique pulsotypes.

Of the MSSA isolates, on two occasions the same clone was found in 2 separate exam room pools on the same sampling date (Figure, isolates 086 c, 093 a; isolates 061 a, 064 a). Another pulsotype was found in different exam rooms on different dates (Figure, isolates 010 a, 036 a). Finally, a third common pulsotype was found on multiple surfaces in a single pool of exam rooms on a single sampling date (Figure, isolates 074 a, 075 a, 076 b). No single MSSA or MRSA clone was found on the same surface on consecutive dates.

When considering the MRSA isolates, 3/5 (60%) were community-associated MRSA (SCCmec IV, USA300), and 2/5 (40%) were hospital-associated MRSA (SCCmec II, USA100)^{20–23}. Two of the three community-associated MRSA isolates were the same clone (Figure, isolates 031 a, 073 b); these were collected from 2 separate clinic buildings on 2 separate sampling dates. The two hospital-associated MRSA samples were different clones.

USA types for all samples (MSSA and MRSA) included USA100, USA200, USA300, USA500, USA600, USA700, and USA800. Nine of thirty *S. aureus*-positive samples did not match with 80% similarity when compared against the CDC database; thus they were classified as not typeable. As previously mentioned, all hospital-associated MRSA were USA100 clones, and all community-associated MRSA were USA300 clones.

Regarding antibiotic resistance profiles, of the 27 MSSA isolates, 3 were pan-susceptible and 13 were resistant only to ampicillin. An additional 2 were resistant to ampicillin and erythromycin alone, and a final cluster of 6 isolates was resistant to ampicillin, erythromycin, and clindamycin (though the clindamycin resistance was inducible).

Antibiotic resistance to multiple drugs was prevalent in the MRSA-positive samples. Four of five (80%) MRSA isolates were resistant to 3 or more classes of antibiotics (Table 4). The two hospital-acquired strains were resistant to beta-lactams, fluoroquinolones, macrolides, and lincosamides. One community-acquired strain was resistant to beta-lactams only; the other two added macrolides and either fluoroquinolones or lincosamides to their resistance profiles.

DISCUSSION

It remains unknown whether the presence of *S. aureus* on eye clinic instruments and surfaces presents a transmission or infection risk to patients. Our data confirm the presence of MSSA/MRSA on ophthalmology clinic surfaces which are both patient- and employee-contact items, the most common being doorknobs, slit lamp head/chinrests, and computer keyboards.

On all sampled surfaces over one year, MSSA was always present (14–29%), and MRSA contaminated up to 1 in 10 surfaces (0–11%). Of the MSSA/MRSA-positive surfaces, none contact the eye directly (ultrasound probes and tonometer tips). Although this result could be related to the fact that these items are smaller and have limited surface area from which to sample, it could also mean that these surfaces are simply more “clean” than the others sampled due to more diligent cleaning and disinfection practices (typically cleaned with alcohol swab between each patient). The fact that these surfaces did not carry *S. aureus* is encouraging, and appears to suggest that frequent disinfection can eliminate detectable *S. aureus* from equipment surfaces.

The majority of MRSA isolates found in our study were collected from slit lamp head/chinrests. In addition, after doorknobs, this was the second most commonly contaminated surface with *S. aureus*. Our results suggest that these surfaces may be hot-spots for this type of pathogen, and cleaning protocols may need to be tailored to impact its presence.

Molecular analysis of all 27 MSSA isolates demonstrated 20 unique pulsotypes – a high amount of diversity. Likewise, of the 5 MRSA isolates, 4 unique pulsotypes were demonstrated. This, coupled with the fact that we found the same clone in different clinic buildings on different sampling dates, would suggest a constant introduction of new *S. aureus* clones into the clinic. Additionally, no single pulsotype remained prevalent in the clinic over time, i.e. surfaces did not seem to have a single endemic strain of *S. aureus*. This suggests that current cleaning protocols are effective in preventing pathogens from spreading or becoming endemic to the outpatient environment.

As previously mentioned, several MSSA clones were detected on multiple surfaces on the same sampling date (Figure, isolates 074 a, 075 a, 076 b; isolates 086 c, 093 a; isolates 061 a, 064 a), or the same clone was detected on separate sampling dates (Figure, isolates 010 a, 036 a). The former situation could suggest cross-contamination of surfaces by clinic staff, and might be impacted with more diligent hand sanitization. The latter situation suggests a constant reintroduction of clones to the clinic environment, making continued vigilance with disinfection protocols essential.

Regarding antibiotic resistance profiles, of the 27 MSSA isolates, most were either resistant only to ampicillin, or pan-susceptible, as expected. However, several isolates displayed inducible clindamycin resistance, which may be particularly relevant to clinicians, as it demonstrates that though these samples show *in vitro* susceptibility to the drug, they nevertheless demonstrated higher likelihood of *in vivo* resistance. It is beneficial to know the policies of one’s microbiology laboratory, and whether inducible clindamycin resistance testing is part of routine testing.

Quinolone resistance amongst samples was also noted: one MSSA pulsotype from the August sampling date (found on slit lamp head/chinrests and hand sanitizer dispensers of 2 separate pools) demonstrated resistance to ciprofloxacin. Both hospital-associated MRSA strains showed resistance to this drug as well as moxifloxacin; however, the community-associated MRSA strains did not display quinolone-resistance. This is particularly relevant to clinicians, given that quinolone antibiotics are so commonly used in ophthalmology.²⁴ Quinolone resistance, while less common than resistance to other medications, has been shown to be prevalent among *S. aureus* and *epidermidis* species.^{25–27}

Furthermore, Hesje et al⁶ report that the proportion of community-associated MRSA strains demonstrating resistance to 3 or more classes of antibiotics is considerable (62.5% in their study), and this fact should also be considered when determining empiric treatment for ocular infections. Rutar et al²⁸ submit that community-associated MRSA is no longer

specific to high-risk populations, but is rather a much more widespread and virulent organism.

As recently suggested by Hsaio et al.²⁹, the portion of ocular MRSA infections that are community-associated is increasing, and community-associated MRSA may become more important in the ophthalmology outpatient environment. Despite small sampling numbers, our study may support this conclusion. In addition, the degree of antibiotic resistance in the studies by Hsaio et al.²⁹ and our group is greater than in the earlier report by Blomquist.¹ Whether this reflects a difference in endemic strains based on location, or an ever-widening resistance profile over time is uncertain.

Our study is limited in its scope and ability to determine whether the presence of MSSA/MRSA on inanimate clinic surfaces is a legitimate threat to patients. It does, however, indicate that office cleaning protocols are at least keeping these pathogens from becoming endemic to the outpatient environment. It also suggests a constant reintroduction of *S. aureus* clones to the clinic, increasing the chances of nosocomial infection if cleaning protocols are relaxed. Additionally, it may offer clinical guidance to ophthalmologists presented with patients who have ocular/periocular infections, given the range of antibiotic resistance found in our study. Clinicians may want to consider performing culture and susceptibility testing sooner rather than later, or changing their initial prescriptions for empiric or prophylactic antimicrobial therapy. Interestingly, a recent prospective study³⁰ of conjunctival bacterial isolates in patients undergoing cataract surgery showed that susceptibility of ocular surface flora was greatest for gentamicin (e.g., susceptibility for coagulase-negative staphylococci was 95% for gentamicin vs. 64.5% for ciprofloxacin).

In any case, antibiotic resistance in *S. aureus* appears to be an ever-increasing concern which demands further exploration. Our study provides valuable insight into the prevalence of a common pathogen in the ophthalmology clinic. The screening protocol herein could help identify potential hot spots for pathogen transmission/infection to patients and staff. Staff education and cleaning protocols can be directed/modified based on a regular surveillance program such as the one described in this study, and patients could benefit from the increased attention to preventing the spread of pathogens via commonly-touched clinic surfaces.

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Biographies

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Figure. Dendrogram analysis of *S. aureus* isolates collected from ophthalmology clinic surfaces
 This is a dendrogram analysis of *S. aureus* isolates from ophthalmology clinic surfaces over the course of one year: date collected, phenotypic profile (antibiotic resistance profile), SCC and USA typing, and description of surface. Abbreviations are as follows: Amp = ampicillin; Amc = amikacin; Oxa = oxacillin; Mxf = moxifloxacin; Cep = cephalothin; Cpd = cefpodoxime; Cip = ciprofloxacin; Ery = erythromycin; Cli = clindamycin; S = susceptible

Staphylococcus surveillance results: detection of methicillin-susceptible and methicillin-resistant *Staphylococcus aureus* on ophthalmology clinic surfaces over time

Table 1

LOCATION	SOURCE (number in pool) ^a	COLLECTION METHOD	TYPE OF CONTACT	RESULT 11/2010	RESULT 02/2011	RESULT 05/2011	RESULT 08/2011
CLINIC 1							
Group A	Tonometer tips (3)	Swab	P	-	-	-	-
Group A	Headrests/chinrests (3)	Cloth	P	-	MSSA	-	MSSA
Group A	Computer keyboards (3)	Cloth	S	-	MRSA	-	MRSP
Group A	Hand sanitizer dispensers (3)	Cloth	S	-	-	-	-
Group A	Doorknobs (3)	Cloth	G	-	MSSA	MSSA	-
Group B	Tonometer tips (3)	Swab	P	-	-	-	-
Group B	Headrests/chinrests (3)	Cloth	P	-	MSSA	MSSA	-
Group B	Computer keyboards (3)	Cloth	S	-	MSSA	MSSA	-
Group B	Hand sanitizer dispensers (3)	Cloth	S	-	MSSP	-	MSSA
Group B	Doorknobs (3)	Cloth	G	MSSA	MSSA	MSSA	-
Group C	Tonometer tips (3)	Swab	P	-	-	-	-
Group C	Headrests/chinrests (3)	Cloth	P	MRSA	MRSA	-	MSSA
Group C	Computer keyboards (3)	Cloth	S	-	-	-	-
Group C	Hand sanitizer dispensers (3)	Cloth	S	-	-	-	-
Group C	Doorknobs (3)	Cloth	G	-	MSSA	-	-
CLINIC 2							
Imaging A	Headrests/chinrests (2)	Cloth	P	-	-	-	-
Imaging A	B-scan & A-scan probes (2)	Swab	P	-	-	-	-
Imaging A	Computer keyboards (2)	Cloth	S	MSSA	-	-	-
Imaging A	Doorknobs (3)	Cloth	G	MSSA	-	MSSA	-
CLINIC 2							
Group D	Tonometer tips (3)	Swab	P	-	-	-	-
Group D	Headrests/chinrests (3)	Cloth	P	-	MSSA	MRSA	-
Group D	Computer keyboards (3)	Cloth	S	-	-	MSSA	-
Group D	Hand sanitizer dispensers (3)	Cloth	S	-	MSSA	MSSA	-
Group D	Doorknobs (3)	Cloth	G	-	-	MSSA	MSSA

LOCATION	SOURCE (number in pool) ^a	COLLECTION METHOD	TYPE OF CONTACT	RESULT 11/2010	RESULT 02/2011	RESULT 05/2011	RESULT 08/2011
Imaging B	Headrests/chinrests (2)	Cloth	P	-	MRSA	-	-
Imaging B	B-scan & A-scan probes (2)	Swab	P	-	-	-	-
Imaging B	Computer keyboards (2)	Cloth	S	MSSA	-	-	-
Imaging B	Doorknobs (3)	Cloth	G	MSSA	-	-	MSSP

MSSA = methicillin-susceptible *Staphylococcus aureus*; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSP = methicillin-susceptible *Staphylococcus pseudintermedius*; MRSP = methicillin-resistant *Staphylococcus pseudintermedius*; P = patient contact; S = staff contact; G = general contact; Group = group of pooled exam rooms; Imaging = pooled surfaces from shared imaging equipment.

^aThe same surfaces in each room were sampled in pools of 3 with either a pre-moistened cotton-tipped swab (Swab) or an electrostatic cloth (Cloth). Some imaging area samples had fewer surfaces from which to sample; number of surfaces included in the pool is denoted in column 2.

Table 2Prevalence of positive *S. aureus* surfaces in the ophthalmology clinic over time

Date	Total surfaces sampled	All <i>S. aureus</i>	MSSA	MRSA
11/2010	28	6/28 (21%)	5 (18%)	1 (4%)
2/2011	28	11/28 (39%)	8 ^a (29%)	3 (11%)
5/2011	28	9/28 (32%)	8 ^a (29%)	1 (4%)
8/2011	28	4/28 (14%)	4 (14%)	0 (0%)
TOTAL	112	30/112 (27%)	25 (22%)	5 (4%)

^a 1 sample from this group contained 2 individual isolates

Table 3Distribution of *S. aureus* positive samples in the ophthalmology clinic according to surface

Surface sampled	Total # sampled	<i>S. aureus</i> -positive	MSSA-positive	MRSA-positive
Doorknobs	24	11 (46%)	11 (46%)	0 (0%)
Slit lamp headrests	24	10 (42%)	6 (25%)	4 (17%)
Computer keyboards	24	7 (29%)	6 (25%)	1 (4%)
Hand sanitizers	16	3 (19%)	3 (19%)	0 (0%)

Table 4

Antimicrobial drug susceptibility profile of methicillin-resistant *S. aureus* isolates detected on surfaces in the outpatient ophthalmology clinic

Isolate number	SCCmec type	Antimicrobial susceptibility profile
031a	IV	Amp/Amc/Oxa/Cpd
073b	IV	Amp/Amc/Oxa/Cpd/Cip/Mxf/Ery
053a	IV	Amp/Amc/Oxa/Cpd/Ery/Cli
012a	II	Amp/Amc/Oxa/Cpd/Cip/Mxf/Ery/Cli
040a	II	Amp/Amc/Oxa/Cep/Cpd/Cip/Mxf/Ery/Cli

Amp = ampicillin; Amc = amikacin; Oxa = oxacillin; Cep = cephalothin; Cpd = cefpodoxime; Cip = ciprofloxacin; Mxf = moxifloxacin; Ery = erythromycin; Cli = clindamycin