ORIGINAL ARTICLE

MOLECULAR EPIDEMIOLOGY OF THE TRANSMISSION OF METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* IN KYIV ACUTE CARE HOSPITALS, UKRAINE

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ABSTRACT

The aim: To evaluate the potential of transmission of methicillin-resistance Staphylococcus aureus (MRSA) in Ukrainian acute care hospitals.

Materials and methods: We performed a multicenter cross-sectional study. Definitions of HAI were used from the CDC/ NHSN. The susceptibility to antibiotics was determined by disk diffusion method according to the EUCAST. The cefoxitin-resistant isolates S.aureus were analyzed for the presence of the mecA gene and femA endogenous control gene using PCR. The virulence factor encoding genes (lukS-PV and lukF-PV) were detected by PCR.

Results: Of 2,421 patients with HAIs caused *S.aureus* included in the study, 28.7% patients had MRSA. Prevalence of nasal carriage rate of MRSA among healthcare workers (HCWs) was 33.3%. MRSA contamination of hands and uniforms/gowns of HCW were 32.2% and 29.7%, respectively. MRSA contamination in the inanimate environment surfaces in near- and extended patients areas were 26.9%. The predominant MRSA contamination in hospital environment surfaces were: room inner door knob (32.8%), bed rails (28.9%), room light switch (28.9%), chair (27.9%), bedside table handle (20.6%), bedside table (20.5%), and tray table (13.7%). The PVL gene was present in 38.7% of MRSA strains, isolated from patients with HAIs and in 55.7% of MRSA, isolated from environment surfaces in patient area. In addition, the PVL genes were detected in over 56.3% of MRSA isolated from HCWs carrier.

Conclusions: The majority of MRSA is acquired during hospitalization. Environmental surfaces may serve as potential reservoirs for nosocomial MRSA and facilitate transmissions via contact.

KEY WORDS: Healthcare infections, MRSA, mecA, Panton Valentine Leukocidine, nosocomial transmission, hospital environmental contamination

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INTRODUCTION

The emergence and spread of Healthcare-associated infections (HAIs) caused by methicillin-resistant Staphylococcus aureus (MRSA) has become a serious public health threat worldwide. MRSA is currently the most commonly identified antibiotic-resistant pathogen in hospitals in many parts of the world, including Europe, the Americas, North Africa and the Middle and Far East. HAIs caused by are MRSA pathogens reported to be causing enormous damage to patients and public healthcare, resulting in increased morbidity and mortality and healthcare costs. The incidence of HAIs caused by MRSA remains high. The estimated that almost 150,000 MRSA infections occur every year in countries of the European Union (EU) and the European Economic Area (EEA), resulting in >7,000 attributable deaths [1]. The burden from infections caused MRSA in the European Union/European Economic Area (EU/EEA) has increased in recent years, especially in the higher prevalence southern and eastern countries [2]. According to the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) and the European Antimicrobial Resistance Surveillance Network (EARS-Net) data, in 2020, nine (23%) of 40 countries reporting data on S. aureus had the lowest MRSA percentages (below 5%). MRSA percentages equal to or above 25% were found in 10 (25%) of 40 countries [3]. The incidence of HAI caused by MRSA in Ukraine ranged from 13.2% [4] to 35.7% [5, 6]. Incidence of MRSA nasal carriage among Ukrainian HCWs was 17-34% [7,8].

For the prevention of HAIs, knowledge about transmission routes is essential. There are multiple transmission routes by which patients may acquire MRSA or other infectious agents that are capable of surviving in the environment. Environmental surfaces may serve as potential reservoirs for nosocomial pathogens and facilitate transmissions via contact depending on its tenacity [9].

Hospital disinfection policies have a major role to play in the control of MRSA. Currently, in Ukraine used the healthcare environment, up to five hundred biocides, mainly for the disinfection of hospital surfaces. However, the effectiveness of most of these biocides is not known. The usage of these biocides in the hospital environment may not be justified and

is detrimental in the long term, for example, by promoting the emergence of bacterial resistance to specific antimicrobials.

Literature data show that anyone patients or healthcare personnel can get MRSA. The risk transmission of MRSA increases with skin-to-skin contact, and shared equipment or supplies in hospitals [10]. Asymptomatic carriers of MRSA are important sources of nosocomial transmission. However, the route of transmission of MRSA in hospitals is not completely understood. In Ukraine, there are no studies examining the transmission of MRSA in hospitals.

THE AIM

To evaluate the potential of transmission of methicillin-resistance *Staphylococcus aureus* (MRSA) in Ukrainian acute care hospitals.

MATERIALS AND METHODS

STUDY DESIGN AND SETTING

We performed a multicenter cross-sectional study was conducted from January 2021 to December 2021 in eight acute care hospitals in Kyiv, Ukraine. We have included hospitals that are similar in terms of medical equipment, personnel, and laboratory facilities, and number of beds. All participating hospitals were required to have at least 1 infection control professional, a clinical microbiology laboratory with the capacity to process cultures.

DEFINITIONS

Major and specific HAI site definitions were adapted from the Centers for Disease Control and Prevention's (CDC's) / National Healthcare Safety Network (NHSN) Surveillance Definitions for Specific Types of Infections [11]. Institution of antimicrobial treatment by a physician without microbiological confirmation was not considered to be sufficient for diagnosis of an HAI in any other circumstance. Serologic and antigen test results were not included in case definitions because laboratories in participating hospitals did not have the capability to perform these tests. Cases were described as community-acquired (CA) if MRSA was isolated from patients within on either of the first two days of hospital admission were categorized as isolates from community-acquired (CA) infections, while isolates collected on day three in hospital or later were categorized as isolates of MRSA from hospital-acquired (HA) infections [12].

DATA COLLECTION

Surveillance data of MRSA strains isolated from patients (colonized/infected), healthcare workers and from inanimate surfaces, were collected on a form specifically designed by the investigators. We analyzed data collected during a 12-month period. As part of this analysis, basic patient data were collected, including age (≥1 yr old), sex, and specimen type. Hospitals also provided consecutive, nonduplicate isolates for molecular typing. All patients admitted to acute care hospitals in study period were analyzed. Data from clinical medical records and microbial reports were reviewed. The follow-up of each patient was continued until discharge or death. Contact precautions were implemented over standard precautions for patients with HAIs.

SAMPLING STRATEGY

Samples for were collected from patients with HAIs and other patients at the time of admission to hospitals that participated in this study, and on the day of discharge. Additionally, we took samples from near- and extended patient (colonized or infected) areas, also from healthcare personnel (nares/hands/uniforms/gowns).

NOSOCOMIAL TRANSMISSION OF MRSA

Nosocomial transmission events in the hospital were defined as the transfer of MRSA from a colonized patient to another patient who was previously negative, hospital stays that overlapped with the stay of a colonized patient, and instances of epidemiological linkage. The linkage was defined as either being a roommate of the index patient in a multibed room or being treated by the same attending doctors.

MICROBIAL METHODS

Bacterial identification and antimicrobial susceptibility testing in this study were carried out with a VITEK 2 system (bioMe´rieux, Marcy l'Etoile, France) and confirmed by the detection of mecA through PCR analysis. Some further antimicrobial susceptibility testing was performed with the disc diffusion method according to the EUCAST guidelines. S. aureus ATCC 29213 was used as a quality control strain for the determination of minimum inhibitory concentrations (MICs). Isolates with either a resistant or an intermediate phenotype were considered non-susceptible for comparison purposes.

POLYMERASE CHAIN REACTION (PCR)

DNA was extracted from a single colony of each isolate with a QIAamp DNA Mini Kit (Qiagen Gmbh, Germany) according to the manufacturer's guidelines. In this study the cefoxitin-resistant isolates were analyzed for the presence of the mecA gene and femA endogenous control gene using PCR, as previously described. Positive and negative controls were added in each run, we used reference strains that are mecA positive and negative. PCR amplification for Panton-Valentine leukocidin (PVL)-encoding genes (lukS-PV and lukF-PV) was performed on representative isolates, as previously described [13]. Known AMR determinants and the Panton-Valentine leukocidin (PVL) lukF-PV and lukS-PV genes were identified from raw sequence reads [14].

ETHICS

The study was approved by the Ethics Committee of the Shupyk National Healthcare University of Ukraine. Written informed consent was obtained from all healthcare personnel and of the patients enrolled or the patient's next to kin.

Table I. Demographics and clinical characteristics of HAIs caused by MRSA in acute care hospitals in Kyiv, Ukraine

Characteristic	No. of HAI[a] caused by *S.aureus*	No. of isolates MRSA[b]		Specimen origin				Prevalence of HAI caused by MRSA
				CA-MRSA[c]		HA-MRSA[d]		
		n	%	n	%	n	%	
All patients	928	296	31.9	64	21.6	232	78.4	30.4 – 33.4
Sex								
Male	528	160	30.3	37	23.1	123	76.9	28.8 – 31.9
Female	400	136	34.0	27	19.9	109	80.1	32.4 – 35.6
Age (years)								
1–4	88	14	15.9	4	28.6	10	71.4	14.7 – 17.1
5–14	32	3	9.4	1	33.3	2	66.7	8.4 – 10.4
15–24	42	6	14.3	1	16.7	5	83.3	13.2 – 15.4
25–34	40	5	12.5	2	40.0	3	60.0	11.4 – 13.6
35–44	83	11	13.2	5	45.5	6	54.5	12.1 – 14.3
45–54	112	18	16.1	5	27.8	13	72.2	14.9 – 17.3
55–64	144	52	36.1	19	36.5	33	63.5	34.5 – 37.7
65–80	179	77	43.0	13	16.9	64	83.1	41.4 – 44.6
81≥	208	110	52.9	14	12.7	96	87.3	51.3 – 54.5
Patient type								
Internal	12	1	8.3	1	100	0	0	7.4 – 9.2
Pediatric	28	7	25.0	3	42.9	4	57.1	23.6 – 26.4
Orthopedic	176	56	31.8	7	12.5	49	87.5	30.3 – 33.3
Ear, nose and Throat surgery	192	68	35.4	17	25.0	51	75.0	33.8 – 36.9
Neurosurgical	97	26	26.8	5	19.2	21	80.8	25.4 – 28.2
General surgery	224	97	43.3	16	16.5	81	83.5	41.7 – 44.9
Colorectal surgery	76	18	23.7	7	38.9	11	61.1	22.3 – 25.1
Surgical intensive care	27	7	25.9	2	28.6	5	71.4	24.5 – 27.3
Gynecologic	64	11	17.2	4	36.4	7	63.6	16.1 – 18.4
Obstetrics	32	5	15.6	2	40.0	3	60.0	14.4 – 16.8
HAI type								
SSIs	576	197	34.2	29	14.7	168	85.3	32.6 – 35.8
PNEU	32	3	9.4	3	100	0	0	8.4 – 10.4
BSI	304	94	30.9	31	33.0	63	67.0	28.3 – 33.5
UTI	16	2	12.5	1	50.0	1	50.0	11.4 – 13.6

Note: [a]HAI, healthcare infection; [b]MRSA, methicillin-resistance *Staphylococcus aureus*, [c]CA-MRSA, community-acquired MRSA; [d]HA-MRSA, healthcare acquired MRSA

STATISTICAL ANALYSIS

The analysis of statistical data was performed using Excel (Microsoft Corp., Redmond, WA, USA). HAIs were analysed by type of infection, which were mutually exclusive. Results are expressed as median, mean ± standard deviation for continuous variables, and number and corresponding percentage for qualitative variables. The primary endpoint was the epidemiology of the methicillin-resistant *Staphylococcus aureus* (MRSA) isolated from patients and from health care personnel, their resistance to antibiotics. Comparisons were undertaken using Student's t-test and Pearson's chi-squared test or Fisher's exact test for categorical variables as appropriate. Statistical significance was defined as $p<0.05$.

RESULTS

PREVALENCE OF HAIs CAUSED BY MRSA

Of 2,421 patients with HAIs caused *S.aureus* included in the study, 696 patients had MRSA. The most frequently reported HAI types caused MRSA were Surgical Site Infections (66,6%), Bloodstream infections (31.8%), Pneumonia (1%), and Urinary Tract Infections (0.7%). The overall prevalence of HAIs caused by MRSA was 28.7% (95% confidence interval [CI], 27.8-29.6, $p<0.0001$), and the prevalence of the 4 most frequently recorded types of infections was the following: SSI, 34.2 % (95% confidence interval [CI], 32.6-35.8), BSI, 30.9% (95% CI, 28.3-33.5), PNEU, 9.4% (95% CI, 8.4-10.4), and UTI, 12.5% (95% CI, 11.4-13.6).

Table II. Frequencies of healthcare worker MRSA carriage from screening exercises in outbreak settings in acute care hospitals in Kyiv, Ukraine

Characteristic of departments	Staff screened	Screening method	Frequency of MRSA[a] isolates
Pediatric	Physicians	Nares	0
		Hands	0
		Uniforms/gowns	0
	Nurses	Nares	6.3%
		Hands	12.5%
		Uniforms/gowns	0
Orthopedic	Physicians	Nares	12.9%
		Hands	16.1%
		Uniforms/gowns	11.5%
	Nurses	Nares	31.9%
		Hands	24.7%
		Uniforms/gowns	25.8%
Ear, nose and throat	Physicians	Nares	14.2%
		Hands	11.7%
		Uniforms/gowns	15.1%
	Nurses	Nares	37.3%
		Hands	25.9%
		Uniforms/gowns	18.6%
Neurosurgical	Physicians	Nares	0
		Hands	0
		Uniforms/gowns	0
	Nurses	Nares	4.8%
		Hands	5.1%
		Uniforms/gowns	1.9%
General surgery	Physicians	Nares	24.8%
		Hands	18.9%
		Uniforms/gowns	9.6%
	Nurses	Nares	37.3%
		Hands	35.6%
		Uniforms/gowns	23.1
Surgical intensive care unit	Physicians	Nares	0
		Hands	0
		Uniforms/gowns	0
	Nurses	Nares	18.8%
		Hands	22.1%
		Uniforms/gowns	16.8%
Gynecologic	Physicians	Nares	0
		Hands	0
		Uniforms/gowns	0
	Nurses	Nares	11.2%
		Hands	12.8
		Uniforms/gowns	4.1%
Obstetrics	Physicians	Nares	2.7%
		Hands	2.1%
		Uniforms/gowns	0
	Nurses	Nares	7.1%
		Hands	9.8%
		Uniforms/gowns	2.1%

Note: [a]MRSA, methicillin-resistance *Staphylococcus aureus*

Table III. Frequencies of MRSA, isolated from near- and extended patient areas in outbreak settings in acute care hospitals in Kyiv, Ukraine (p<0.05).

Specimen origin	Number of samples	No. of isolates MRSA[a]		CI[b] 95%
		n	%	
Bed rails	211	61	28.9	27.6 – 30.2
Tray table	153	21	13.7	12.7 – 14.7
Bedside table handle	102	21	20.6	19.5 – 21.7
Bedside table	78	16	20.5	19.4 – 21.6
Chair	43	12	27.9	26.6 – 29.2
Room light switch	308	89	28.9	27.6 – 30.2
Room inner door knob	341	112	32.8	31.5 – 34.1
Total	1236	332	26.9	25.6 – 28.2

Note:
[a]MRSA, methicillin-resistance *Staphylococcus aureus*
[b]CI, confidence interval

Table IV. Distribution of the genes in MRSA, isolated from patients with HAI and from screening exercises in outbreak settings in acute care hospitals in Kyiv, Ukraine

Specimen origin	No. isolates of MRSA[b]	mecA		femA		PVL[c]	
		n	%	n	%	n	%
Patients (without HAI[a]) nares	13	10	76.9	10	76.9	4	30.8
HCW nares	16	15	93.7	15	93.7	9	56.3
HCW hand	28	25	89.3	25	89.3	18	64.3
HCW uniforms/gowns	11	10	90.9	10	90.9	8	72.7
Environment surfaces in patient area	332	315	94.9	315	94.9	185	55.7
bed rails	61	57	93.4	57	93.4	27	44.3
tray table	21	21	100	21	100	19	90.5
bedside table handle	21	19	90.5	19	90.5	15	71.4
bedside table	16	15	93.7	15	93.7	11	68.7
chair	12	11	91.7	11	91.7	8	66.7
room light switch	89	85	95.5	85	95.5	36	40.4
room inner door knob	112	107	95.5	107	95.5	69	61.6
Total	400	375	93.7	375	93.7	224	56.0

Note:
[a]HAI, healthcare-associated infection
[b]MRSA, methicillin-resistance *Staphylococcus aureus*
[c]PVL, Panton-Valentine leukocidin

Prevalence of HAIs caused by HA-MRSA and CA-MRSA was 79.2% and 20.8%, respectively. Patient characteristics and prevalence of HAIs caused by HA-MRSA and CA-MRSA are shown in Table I.

POTENTIAL FOR TRANSMISSION OF MRSA IN HOSPITALS

A total 1,493 strains of *S.aureus* were isolated from patients without HAIs at the time of admission and on the day of discharge, from healthcare workers (HCW), and samples from patient area surfaces in acute care hospitals. Of these isolates, 26.8% (400/1,493) were MRSA. During the hospital stay among patients without HAIs were identified 13 (15.3%, CI 95%, 13.4-17.2%) nasal carriers of MRSA. The number of positive results of screening for MRSA nasal carriage among patients without HAIs was lower (1 cases) at the time of admission than on the day of discharge (12 cases).

The prevalence of nasal carriage rate of MRSA among healthcare workers (HCWs) was 33.3% (CI 95%, 30.7-35.9%). MRSA carriage rate was highest among nurses 38.7%, (CI 95%, 36.0-41.4) whereas carriage among physicians was 23.5% (CI 95%, 21.3-25.7%). A frequency of HCW MRSA carriage from screening exercises in outbreak settings in acute care hospitals is shown in Table II.

We found high MRSA contamination of hands (32.2%) and uniforms/gowns (29.7%) of HCW. The MRSA contamination of hands and uniforms/gowns was higher in nurses than in physicians. We found significant of MRSA contamination in the inanimate environment surfaces in near- and extended patients with HAI areas. Of 1,236 S.aureus isolated from patient areas, 26.9% were MRSA. A frequency of MRSA, isolated from near- and extended patient areas in outbreak settings shown are Table III.

According to the results of antimicrobial susceptibility tests, all of the isolates were susceptible to vancomycin, linezolid, tigecycline, and teicoplanin (data not shown). For all MRSA isolates, it was found that 96.9% were resistant to penicillin, 68.9% of isolates were resistant to erythromycin, 41.3% were resistant to clindamycin, 63.8% were resistant to tetracycline, 44.3% were resistant to gentamicin, 33.7% were resistant to ciprofloxacin, 36.2% were resistant to levofloxacin, 45.8% were resistant to moxifloxacin, and 15.2% of isolates were resistant to trimethoprim-sulfamethoxazole.

PREVALENCE OF THE VIRULENCE GENES

In this study the cefoxitin-resistant isolates were analyzed for the presence of the mecA gene and femA endogenous control gene, and the virulence factor encoding genes (PVL-genes). The PVL gene was present in 38.7% of MRSA strains, isolated from patients with HAI. A total of 400 MRSA strains isolated during study period, representing patients without HAI, HCW (nares, hands and uniforms/gowns), and inanimate environment surfaces in near- and extended patient areas, were evaluated. All isolates were identified as MRSA using the oxacillin disc resistance. However, using PCR targeting the mecA gene in S. aureus, only 93.2% (375/400) isolates were confirmed as MRSA. MRSA was characterized by multiplex PCR amplification of the Panton-Valentine leukocidin (PVL) gene and the mecA, and femA gene. The femA gene was positive in all MRSA strains. A total of 56% (224/400) [95% CI 54.5%, 57.5%, p <0.001] MRSA strains were PVL gene positive. Distribution of genes in MRSA isolates arranged by different specimen origin categories shown are Table IV.

DISCUSSION

This is the first study in Ukraine were to evaluate the potential of transmission of MRSA in Ukrainian acute care hospitals. The overall prevalence of HAIs caused by MRSA in Kyiv acute care hospitals was 28.7%. In this study MRSA colonization/infected was evaluated in isolates obtained from patients both at the time of admission to and at the time of discharge from the acute care hospitals. In our study MRSA colonization was confirmed one patient at admission and 12 on the day of discharge. Many patients were treated by the same attending doctors. The rate of nasal carriage of MRSA among HCWs was 33.3%. We found high MRSA contamination of hands and uniforms/gowns of HCW, and significant of MRSA contamination in the inanimate environment surfaces in near- and extended patients areas. It can be a sign that hand hygiene and quality of cleaning and disinfection of surfaces in Ukrainian acute care hospitals is still in need of improvement. Our study suggesting that most cases of MRSA are acquired during hospitalization. We believe that there is sufficient evidence to state that inanimate surfaces likely play a role in the transmission of MRSA in Ukraine. Supportive evidence includes hospital environmental cultures demonstrating widespread surface contamination in rooms of many patients colonized or infected with MRSA (Table III and IV) and that hands can become colonized with MRSA (Table II) via patient or environmental surfaces. In addition, this study showed that nasal carriage of MRSA in source HCW and patients, which would increase environmental contamination, has been a risk factor for MRSA acquisition. In our previous study reported the prevalence of MRSA nasal carriage among HCWs in Kyiv, Ukraine was 17% [7]. The present study showed that the rate of nasal carriage of MRSA among HCWs in Kyiv acute care hospitals was 33.3%.

The results of our study showed that the Panton-Valentine leukocidin (PVL)-encoding genes (lukS-PV and lukF-PV) is common among Ukrainian hospital of the MRSA isolates. Our results indicated the PVL gene was present in 38.7% of MRSA strains, isolated from patients with HAIs. We found a high prevalence of the virulence factor encoding genes (PVL-gene) in MRSA, isolated from environment surfaces in patient area (55.7%). PVL-gene were most commonly co-present in MRSA strains, isolated from tray table (90.5%), bedside table handle (71.4%), bedside table (68.7%), chair (66.7%), room inner door knob (61.6%), bed rails (44.3%), and room light switch (40.4%). In addition, the PVL genes were detected in over 56.3% of MRSA isolated from HCWs carrier. This carrier state may also be an important risk factor for transmission MRSA from physicians and nurses to patients and vice-versa [7]. In the current study, the prevalence of MRSA isolates containing PVL genes was higher than in several previous studies in other countries [15-19]. There are increasing reports of MRSA harboring the PVL toxin, which increases strains pathogenicity and their ability to cause infections. Outbreaks of PVL-producing strains have recently been reported worldwide [18, 20]. Problems arise in the treatment of overt infections with MRSA because the antibiotic choice is very limited. In our study all of the MRSA isolates were susceptible (100%) only to vancomycin, linezolid, tigecycline, and teicoplanin.

The combination of the production of PVL, which is a potent toxin involved in severe HAI caused MRSA, with resistance to commonly used antibiotics and ability to spread easily in hospitals, and communities, possess a potential threat to public health. For the control and prevention of HAIs caused by MRSA, knowledge about transmission routes is essential. The transfer of MRSA via patient area surfaces plays a vital role for HAI in acute care hospitals. Therefore, information about the MRSA contamination on surfaces can have direct implications on clinical measures, including hand hygiene guidelines and disinfection strategies.

MRSA can colonize the skin and nares of an HCW without causing sickness (carriers), and in this way, it can be passed on to other susceptible individuals unknowingly. Therefore, in hospitals implementing contact precautions for MRSA carriers is essential for preventing HAIs. For implement effective precautions for avoiding MRSA infections, it is important to clarify when, how, and from whom MRSA is transmitted. It will be extremely difficult to disentangle the contributions of the animate and inanimate reservoirs of MRSA in leading to transient hand carriage of MRSA by HCW. Even though surface contamination may play a role in MRSA transmission, changes in routine disinfection only are unlikely to reduce disease transmission because recontamination of the patient environment area likely is rapid. Clearly, proper hand washing with an antimicrobial agent before and after each contact with patients or their immediate environment and additional contact precautions, ncluding wearing gloves when entering the rooms of patients with MRSA is crucial in preventing transmission of MRSA in hospitals. Nosocomial transmission of the MRSA may easily occur if no appropriate infection control measures are applied on a regular daily basis.

CONCLUSIONS

Healthcare infections caused MRSA presents a significant burden to the Ukraine hospital system. The majority of MRSA is acquired during hospitalization. There is a potential risk of nosocomial transmission of MRSA. Environmental surfaces may serve as potential reservoirs for nosocomial MRSA and facilitate transmissions via contact. This is due to high environmental contamination with MRSA in the hospital rooms of colonized or infected patients and high the rate of nasal carriage of MRSA among HCWs. Cleaning and disinfection processes must be improved so that there is a reduction in environmental contamination of frequent-contact surfaces. Thorough handwashing and use of recommended barrier precautions are indicated to prevent cross-transmission of MRSA.

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