

Patients with Rheumatic Diseases do not have an Increased Risk of MRSA Carrier Status

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ABSTRACT

Introduction: The aim of this study was to determine the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) both in rheumatologic and non-rheumatologic rehabilitation centers. In addition, we sought to evaluate the practice value of existing screening recommendations of the German Commission for Hospital Hygiene and Infection Prevention (KRINKO).

Methods: The analysis was performed in four rehabilitation clinics (rheumatology, psychosomatic medicine, oncology, and cardiology) with at least 200 patients per clinic tested for MRSA.

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Results: Nine (1.1%) of the 842 patients were colonized with MRSA. Only five of them should have been tested according to the commission's recommendations. The prevalence was 0.5% ($n = 207$) in rheumatologic, 0.9% ($n = 224$) in psychosomatic, 1.4% ($n = 209$) in oncologic and 1.5% ($n = 202$) in cardiologic patients. We found a greater exposure to risk factors in cardiologic and oncologic patients. Among patients with carrier status, a higher percentage was exposed to three potential risk factors not applied by the commission.

Conclusions: The prevalence of MRSA in our cohort correlates with data from previous studies. The low percentage among rheumatologic patients suggests that they are not more likely to reveal MRSA carrier status than other patient groups and that long-term immunosuppression does not necessarily represent a risk factor for MRSA colonization. Since only five out of nine patients with carrier status would have been detected following the recommendations of the KRINKO, further studies on potential risk factors are warranted.

Keywords: Bacterial infections; Methicillin-resistant *Staphylococcus aureus*; Prevalence; Rehabilitation centers; Risk factors

INTRODUCTION

MRSA colonization is known to entail a high risk for subsequent MRSA morbidity and mortality, especially among critically and chronically ill carriers, as shown by Huang et al. [1]. Thus, it is an important aim to reduce the percentage of MRSA carriers in medical establishments. Nevertheless, it would be very expensive and time consuming to perform MRSA screening on every new hospitalized patient in every medical establishment, as shown by Roth et al. [2]. Criteria for an effective MRSA screening of patients with high risk for colonization are therefore indispensable to detect economically, in terms of both time and money, the major part of patients with MRSA carrier status. The implementation of such a screening was proved cost saving by Chowers et al. [3]. Based on studies about risk factors for MRSA colonization, there are official recommendations for such a screening from the German Commission for Hospital Hygiene and Infection Prevention (KRINKO) [4]. According to available data, they consider patients with one of the following risk factors as patients with a high risk for MRSA carriage and consequently recommend screening patients presenting one of these risk factors: previous history of MRSA, the stay in a region with elevated prevalence of MRSA, dependence on dialysis, hospital stay of more than 3 days within the previous 12 months, contact with MRSA in a work setting (e.g., contact with farm animals), contact with patients with MRSA carrier status during a hospital stay, chronic skin lesions, and long-term care dependency. However, long-term care dependency only represents a risk factor if one of the following two factors occurs simultaneously: antibiotic treatment within 6 months or catheterization. We compared risk factors in patients with carrier status with these recommendations in order to obtain the percentage of patients with carrier status we would have detected by following the recommendations.

The main aim of this investigation was to compare the prevalence of MRSA between rheumatologic and non-rheumatologic rehabilitation centers. Therefore, we determined and

compared the prevalence of MRSA in patients of four medical rehabilitation centers of the Rehabilitation competence center in Bad Kreuznach (Germany). Similar studies on MRSA prevalence in rehabilitation centers have been led in other regions in Germany by Heudorf et al. [5], Rollnik et al. [6], Gieffers et al. [7] and Köck et al. [8]. However, in these studies, rheumatologic patients have only been investigated as a subgroup. There is a high rate of MRSA carrier status in immunosuppressed patients (up to 12%) [9]. Even if immune suppression in rheumatologic patients is not comparable to chemotherapy-induced immunosuppression, rheumatologic patients mostly receive immunosuppressive therapy for a long time and have generally a higher risk of infection. A potential infection with MRSA could progress to a more severe form than in immunocompetent patients.

Consequently, we investigated whether the risk of MRSA colonization is elevated in rheumatologic patients.

METHODS

Study Period and Participating Hospitals

From 4/2016 to 8/2016, 842 patients were tested on MRSA by throat and nasal swabs during their first 24 h in the medical rehabilitation center. In each of the four rehabilitation centers, about 200 patients were tested. More precisely, 207 patients of a center for rheumatologic and orthopedic rehabilitation (Karl-Aschoff-Klinik, Bad Kreuznach), 224 psychosomatic patients (St. Franziska-Stift, Bad Kreuznach), 209 oncologic patients (Nahetal-Klinik, Bad Kreuznach), and 202 patients of a center for cardiologic and orthopedic rehabilitation (Drei-Burgen-Klinik, Bad Kreuznach) were tested on MRSA. Therefore, during several weeks in each of these rehabilitation centers, every incoming patient was asked to participate. Refusals to participate in this internal quality control were rarely reported (< 0.1%).

Compliance with Ethics Guidelines

The study was conducted within an internal quality control exploration following the statement of the local ethics committee (Rhineland-Palatinate).

Study Population

The mean age was 54.0 ± 11.3 years, standard deviation (SD). More precisely, it was 53.6 ± 9.8 years (SD) for patients of the center for rheumatologic and orthopedic rehabilitation, 47.4 ± 10.2 years (SD) for psychosomatic patients, 62.2 ± 11.4 years (SD) for oncologic patients, and 53.3 ± 7.9 years (SD) for those of the center for cardiologic and orthopedic rehabilitation. The mean age of patients with carrier status was 48.6 ± 10.6 years (SD).

Forty-nine percent of the patients were male and 51% were female. Among the patients of the center for rheumatologic and orthopedic rehabilitation, 43% were male and 58% female. Among psychosomatic patients, 44% were male and 56% were female, and among oncologic patients, 32% were male and 68% female; 81% of the patients of the center for cardiologic and orthopedic rehabilitation were male and only 19% female. We detected five male and four female patients among those with MRSA carrier status.

Statistical Methods

All statistical evaluations were done using IBM SPSS Version 23.0. Gender distribution was determined using a cross table and the average age by performing an explorative data analysis and by creation of histograms. The frequency of the presence of risk factors was determined using frequency tables. The percentages both of all patients and of patients with MRSA carrier status, who should have been screened according to the recommendations of the KRINKO, were calculated using cross tables. The MRSA prevalence and the analysis of risk factors in patients with MRSA carrier status were also performed using cross tables. *P* values were

calculated using RStudio version 1.1.442 and a permutation test.

Questionnaire

In addition to the above-described risk factors of the recommendations of the KRINKO, we collected and analyzed further risk factors for MRSA colonization using a questionnaire (any surgery? immunosuppressive therapy? living with a pet and regular contact with people working in direct patient care?). Thus, our questionnaire contained 15 questions: ten about all risk factors included in the screening recommendations of the KRINKO and five additional questions about putative risk factors reported in the literature. Complete medication lists were collected to unravel immunosuppressive therapy. Following informed consent, every incoming patient was consecutively tested and interviewed. The questionnaires were delivered to the patient at the beginning of their stay in the rehabilitation center. If patients did not answer one or more questions, the study personnel interviewed them personally about the missing data to obtain complete questionnaires from all participating patients.

Microbiological Analyses

Swabs were carried out using the Copan Liquid Amies Elution Swab Collection and Transport System (eSwab, Art. No.: 490 CE.A; COPAN Flock Technologies srl. Via F. Perotti 16/18 in 25125 Brescia, Italy). Two swabs per patient were carried out by the staff of each medical rehabilitation center, one of the nasal vestibule of both nares and another one of the pharyngeal site. Both were directly transferred into transport medium and, following the instructions of eSwab (Copan), stored in a fridge. If the processing in the laboratory could not be performed within 6 days, the swabs were frozen and processed at a later point in time, always respecting the instructions of eSwab (Copan). The samples were processed at the Department for Hygiene and Infection Prevention of the University Medical Center of the Johannes Gutenberg University Mainz. During processing

of the samples, specimens were directly plated on blood agar (PB5039A, Oxoid) and MRSA detecting CHROM agar (CHROMagar™MRSA, 201402, Mast Diagnostica Laboratoriumspräparate GmbH) and incubated for 24–48 h at 37 °C. Since not every bacterial culture on the MRSA CHROM agar can be considered as MRSA culture, all potentially MRSA-positive culture isolates were further confirmed as *Staphylococcus aureus* by coagulase test (Pastorex Staph plus, Bio-Rad Laboratories GmbH) and a method for biochemical identification (BBL™ Crystal™ Gram-Positive ID Kit; BD). After confirmation, a cefoxitin disk diffusion test, whose accuracy was evaluated by Jain et al. [10] was performed. Therefore, the culture isolates were plated on Müller-Hinton agar (254032, BD) and a cefoxitin disk (MAST-DISC cefoxitin, 30 µg, 113133, Mast Diagnostica Laboratoriumspräparate GmbH) was added in the middle of each smear. After incubating for 24 h at 37 °C, the inhibition zone around the cefoxitin disk was measured. If it was lower than 22 mm, the culture isolate was confirmed as MRSA due to its resistance to the antibiotic cefoxitin according to EUCAST guidelines.

RESULTS

MRSA Prevalence

Of the 842 patients tested, nine patients (1.1%) were colonized with MRSA. The lowest prevalence of MRSA was found in patients of the center for rheumatologic and orthopedic rehabilitation (0.5% of $n = 207$). In patients of the center for psychosomatic rehabilitation, the prevalence was 0.9% (of $n = 224$) and in those of the center for oncologic rehabilitation it was 1.4% (of $n = 209$). The highest prevalence of MRSA was found in patients of the center for cardiologic and orthopedic rehabilitation (1.5% of $n = 202$).

Risk Factor Analysis

The relative presence of risk factors both in each rehabilitation center and for all patients

participating in the screening is shown in Table 1, whereas Table 2 shows the number and percentage of MRSA positive and negative patients within the different risk factor groups.

Overall, 4.3% of the 842 patients revealed a previous history of MRSA. In oncologic patients and patients of the center for cardiologic and orthopedic rehabilitation, the percentage was more than twice as high as in patients of the two other rehabilitation centers, which correlates with the higher percentage of MRSA in the two first named rehabilitation centers. Of the patients, 6.7% had stayed abroad in a risk region for more than 4 weeks within the past 12 months or were living in a risk region in Germany. Countries and regions considered as risk regions abroad were Portugal, Italy, Romania, Slovakia, Greece, Turkey, Cyprus, Malta, Israel, North Africa, Japan, Russia, the USA, countries in Central, East, Southeast and Southwest Asia, as well as war and crisis zones. Places considered as risk regions in Germany were establishments such as long-term care facilities. Chronic skin lesions were rarely reported (3.3%). Recently operated patients with wounds (hip, knee replacement) in the cardiologic and orthopedic rehabilitation center were tested on demand (in case of wound-healing problems). All tests were negative for MRSA. Of the 842 patients, 50.8% had been hospitalized for more than 3 days during the previous months, predominantly among both oncologic patients and those of the center for cardiologic and orthopedic rehabilitation. On the other hand, contact with MRSA in a work setting, for example due to work with livestock or in direct patient care, was reported in 8.1% of the cases, but more often among psychosomatic patients and those of the center for rheumatologic and orthopedic rehabilitation. Contact with people with carrier status and dependence on renal dialysis were rarely reported for all investigated rehabilitation indications ($\leq 1.5\%$). Long-term care dependency was often seen among oncologic patients, but was in general rare (1.8%). Twenty-three percent of the patients had received an antibiotic treatment within the previous 6 months and only 1.8% was wearing a catheter, a port, or another medical tool injuring the skin barrier, in both

Table 1 Risk factors in patients of the different medical rehabilitation centers

Risk factor	Rheumatology/ orthopedy, <i>n</i> = 207	Oncology, <i>n</i> = 209	Psychosomatics, <i>n</i> = 224	Cardiology/ orthopedy, <i>n</i> = 202	Overall, <i>n</i> = 842
MRSA carrier status	0.5%	1.4%	0.9%	1.5%	1.1%
Previous history of MRSA	2.9%	6.2%	2.2%	5.9%	4.3%
Stay in risk region	5.3%	5.7%	8.9%	6.4%	6.7%
Stay in hospital for > 3 days during the past months	50.2%	72.2%	25.4%	57.4%	50.8%
Contact to person with carrier status	0.0%	1.0%	0.4%	0.5%	0.5%
Dependence on renal dialysis	0.0%	1.0%	0.4%	1.5%	0.7%
Contact with MRSA at work setting	10.6%	5.3%	12.1%	4.0%	8.1%
Chronical skin lesions	2.4%	2.4%	5.8%	2.5%	3.3%
Chronical care dependency	0.5%	5.3%	0.0%	1.5%	1.8%
Antibiotic treatment within 6 months	17.9%	36.8%	16.5%	21.3%	23.0%
Catheter or other medical tools injuring the skin barrier	1.9%	3.3%	0.0%	2.0%	1.8%
Screening recommended	57.0%	76.6%	41.5%	61.4%	58.8%
Current immune suppression	26.6%	11.0%	0.9%	3.0%	10.2%
Immune suppression within 12 months	28.0%	30.6%	2.7%	6.9%	16.9%
Surgery within 12 months	37.2%	76.6%	15.2%	46.5%	43.3%
Contact to persons working in direct patient care	29.0%	45.0%	33.0%	29.7%	34.2%
Pet within 12 months	39.1%	28.2%	52.2%	44.6%	41.2%

cases especially oncologic patients. A current immunosuppressive therapy was reported in 10.2% of the cases, mainly among patients of the center for rheumatologic and orthopedic rehabilitation (26.6%). Patients admitted to this rehabilitation center exclusively had rheumatic diseases and were under DMARD therapy (predominantly methotrexate and low-dose corticosteroids). Among the patients who had received immunosuppressive therapy within

the previous year (16.9%), we encountered especially rheumatologic (28%) and oncologic patients (30.6%), since rheumatologic patients often take immunosuppressive medication and most of the oncologic patients have received chemotherapy within the months before their rehabilitation. Of the patients, 43.3% had undergone surgery within the previous year. Again, the percentage was the highest among oncologic patients and patients of the center for

Table 2 Number and percentage of MRSA-positive and -negative patients within the different risk factor groups

Risk factor	MRSA-positive	MRSA-negative	Overall, <i>n</i> = 842
Previous history of MRSA	0.0% (0/36)	25.0% (9/36)	4.3% (36/842)
Stay in risk region	0.0% (0/56)	16.1% (9/56)	6.7% (56/842)
Stay in hospital for > 3 days during the past months	0.9% (4/428)	1.2% (5/428)	50.8% (428/842)
Contact to person with carrier status	0.0% (0/4)	100.0% (4/4)	0.5% (4/842)
Dependence on renal dialysis	0.0% (0/6)	100.0% (6/6)	0.7% (6/842)
Contact with MRSA at work setting	1.5% (1/68)	11.8% (8/68)	8.1% (68/842)
Chronical skin lesions	0.0% (0/28)	32.1% (9/28)	3.3% (28/842)
Chronical care dependency	6.7% (1/15)	53.3% (8/15)	1.8% (15/842)
Antibiotic treatment within 6 months	2.1% (4/194)	2.6% (5/194)	23.0% (194/842)
Catheter or other medical tools injuring the skin barrier	0.0% (0/15)	60.0% (9/15)	1.8% (15/842)
Screening recommended	1.0% (5/495)	0.8% (4/495)	58.8% (495/842)
Current immune suppression	0.0% (0/86)	10.5% (9/86)	10.2% (86/842)
Immune suppression within 12 months	2.1% (3/142)	4.2% (6/142)	16.9% (142/842)
Surgery within 12 months	0.8% (3/366)	1.6% (6/366)	43.3% (366/842)
Contact to persons working in direct patient care	1.7% (5/288)	1.4% (4/288)	34.2% (288/842)
Pet within 12 months	1.4% (5/346)	1.2% (4/346)	41.2% (346/842)

cardiologic and orthopedic rehabilitation. Frequent contact with people working in direct patient care was reported in 34.2% of the cases. Frequent contact caused by illness was taken into account as well as private contact with people working in this sector (e.g., friends or family members). Furthermore, we investigated the number of patients having a pet, since there are reports suggesting that animals play a role in MRSA transmission, even if so far the importance of animals as reservoir for MRSA is poorly understood, as shown by Bramble et al. [11] and Weese [12]; 41.2% of the 842 patients have had a pet within the previous year or had one at the moment of the investigation, especially patients with psychosomatic rehabilitation indication (52.2%). Contact with livestock was covered by the question about contact with MRSA in a work setting, which is already listed as a risk factor in the recommendations of the KRINKO. In addition, we determined that patients

admitted to the non-rheumatologic rehabilitation centers did not suffer from rheumatic diseases that required immunosuppressive treatment or DMARD therapy.

In total, a greater exposure to risk factors for MRSA colonization was encountered in patients of the center for cardiologic and orthopedic rehabilitation and in patients with oncologic rehabilitation. However, based on the overall low number of positive MRSA carriers in our cohort, further statistical analysis was not significant. This is illustrated in Table 3, which shows *p* values for the statistical relationship between risk factors and actual MRSA status. Furthermore, the *p* value for the association between the MRSA prevalence in rheumatologic patients and non-rheumatologic patients is *p* = 0.53.

Table 3 *p* values for the statistical relationship between risk factors and actual MRSA status

Risk factor	MRSA positive	<i>p</i> value (risk factor <−> MRSA status)
Previous history of MRSA	0.0% (0/36)	1.00
Stay in risk region	0.0% (0/56)	0.66
Stay in hospital for > 3 days during the past months	0.9% (4/428)	0.82
Contact to person with carrier status	0.0% (0/4)	1.00
Dependence on renal dialysis	0.0% (0/6)	0.94
Contact with MRSA at work setting	1.5% (1/68)	1.00
Chronical skin lesions	0.0% (0/28)	1.00
Chronical care dependency	6.7% (1/15)	0.15
Antibiotic treatment within 6 months	2.1% (4/194)	0.28
Catheter or other medical tools injuring the skin barrier	0.0% (0/15)	1.00
Screening recommended	1.0% (5/495)	1.00
Current immune suppression	0.0% (0/86)	0.63
Immune suppression within 12 months	2.1% (3/142)	0.41
Surgery within 12 months	0.8% (3/366)	0.65
Contact to persons working in direct patient care	1.7% (5/288)	0.39
Pet within 12 months	1.4% (5/346)	0.60

Comparison of the Results with the KRINKO Recommendations

According to the recommendations of the KRINKO, 58.8% of the patients should have been tested, with the highest percentage among oncologic patients (76.6%), who were revealing the highest rate of risk factors. However, among the patients with MRSA carrier status, only five out of nine (55.6%) would have been tested according to the recommendations. Thus, four out of nine (44.4%) colonized patients would not have been detected according to the recommendations of the KRINKO.

Analysis of Risk Factors in Patients with Carrier Status

The absolute presence of risk factors in the nine patients with MRSA colonization is shown in Table 4. Three of these nine patients did not

present any of the risk factors of the screening recommendations of the KRINKO. Most frequent risk factors in these patients were hospital stays for more than 3 days and an antibiotic treatment, both in the previous months (both 44.4%); 33.3% had undergone immunosuppressive therapy or surgery, both within 12 months. Also, 55.6% of the patients currently had a pet or had had one within the previous year and/or had frequent contact with people working in direct patient care. Among patients with carrier status, 55.6% were male and 44.4% female patients.

DISCUSSION

The prevalence of MRSA among rheumatologic patients was found to be lower than among non-rheumatologic patients, with an overall prevalence of MRSA of 1.1%. In addition, only five out of nine colonized patients would have

Table 4 Risk factors in the nine MRSA-positive patients

Risk factor	R	O1	O2	O3	P1	P2	C1	C2	C3
Previous history of MRSA	-	-	-	-	-	-	-	-	-
Stay in risk region	-	-	-	-	-	-	-	-	-
Stay in hospital for > 3 days during the past months	-	✓	✓	✓	-	-	✓	-	-
Contact to person with carrier status	-	-	-	-	-	-	-	-	-
Dependence on renal dialysis	-	-	-	-	-	-	-	-	-
Contact with MRSA at work setting	-	-	-	-	-	✓	-	-	-
Chronical skin lesions	-	-	-	-	-	-	-	-	-
Chronical care dependency	-	-	✓	-	-	-	-	-	-
Antibiotic treatment within 6 months	✓	✓	✓	✓	✓	✓	-	-	-
Catheter or other medical tools injuring the skin barrier	-	-	-	-	-	-	-	-	-
Screening recommended	-	✓	✓	✓	-	✓	✓	-	-
Current immune suppression	-	-	-	-	-	-	-	-	-
Immune suppression within 12 months	-	✓	✓	✓	-	-	-	-	-
Surgery within 12 months	✓	✓	-	✓	-	-	-	-	-
Contact to persons working in direct patient care	✓	✓	-	-	✓	✓	✓	-	-
Pet within 12 months	✓	✓	-	-	-	✓	✓	✓	-

R rheumatologic patient, O1-3 oncologic patients, P1-2 psychosomatic patients, C1-3 cardiologic patients

been tested according to the recommendations of the KRINKO.

The finding of a rather high percentage among patients of the center for rheumatologic and orthopedic rehabilitation, who had undergone immunosuppressive therapy (26.6% under current immune suppression and 28% within the previous year), in comparison with the low percentage of MRSA colonization among the same patients (0.5%), suggests that long-term immunosuppression does not inevitably constitute a risk factor for MRSA colonization. This is a reassuring result, since it is an important aim to avoid MRSA colonization in patients with long-term immunosuppression because of their higher risk of progression to a more severe form in case of an MRSA infection.

The higher prevalence among patients of the center for cardiologic and orthopedic rehabilitation and those with oncologic rehabilitation

in comparison to patients of the center for rheumatologic and orthopedic rehabilitation and those with psychosomatic rehabilitation could be caused by several factors. Patients of the two rehabilitation centers previously mentioned were more often hospitalized, had undergone surgery more often and/or had more often been under antimicrobial therapy in the previous months. Furthermore, a higher number of them is in long-term care dependency, is depending on renal dialysis, has a previous history of MRSA and/or is wearing a catheter, a port, or similar. Consequently, a higher percentage of these patients were exposed to known risk factors for MRSA colonization. This may explain the higher prevalence of MRSA among these patients and may thus confirm the respective risk factors named in the recommendations of the KRINKO.

The overall prevalence of MRSA of 1.1% in our study correlates with the prevalence for the German general population (0.5–2%), estimated by the German Commission for Hospital Hygiene and Infection Prevention [4] and the German Federal Institute for Risk Assessment [13]. Compared to similar studies mentioned above, this prevalence is quite similar to that found by Köck et al. (1.2%) [8]. It is higher than the prevalence (0.7%) found by Heudorf et al. [5], whereas it is lower than the one found by Gieffers et al. (2.1%) [7] and much lower than the prevalence found in a study in neurologic rehabilitation (11.4%) by Rollnik et al. [6]. Again, our study shows that the MRSA carrier status in a rehabilitation center specialized for patients with rheumatic diseases is not increased compared to the prevalence of MRSA in the general population.

Among the nine patients colonized with MRSA, only five should definitely have been tested according to the recommendations of the KRINKO. The remaining four patients would not have been detected, since they did not fulfill the criteria. Therefore, the question arises of whether these recommendations should be expanded, particularly with the three patients not presenting any of these risk factors at all. On the other hand, the collected data are not sufficient to make a clear statement and would demand further investigation to verify this hypothesis. In any case, it is questionable whether there are more risk factors that should constantly be taken into account for the choice of patients to be screened by default when hospitalized.

We therefore additionally explored some more potential risk factors, which are currently not included in the recommendations of the KRINKO. From the above described data, we can see that overall 16.9% of the patients had undergone immunosuppressive treatment within the previous year, while among the patients with carrier status we encounter 33.3% instead. Overall, 34.2% of the patients had regular contact with people working in direct patient care, either privately, within their everyday lives, or in a healthcare environment, whereas this was the case for 55.6% of the colonized patients. In addition, only 41.2% of all

participating patients have had a pet (currently or within 12 months), while the percentage was 55.6% among patients with carrier status. This trend is applicable for neither current immunosuppressive therapy, nor surgery within the previous year. The latter is in line with the fact that operations are considered as a risk factor for MRSA infection, but not for MRSA colonization according to the Commission for Hospital Hygiene and Infection Prevention [4].

Nevertheless, the three first mentioned risk factors might have an impact on MRSA colonization, suggesting that further investigation is required. If further investigation allowed to determine risk factors that accurately identify colonized patients, we would suggest including them in the official screening recommendations of the KRINKO.

To date, there are no clear recommendations for rehabilitation clinics regarding the test of the MRSA status in their patients. The present study served as an internal quality control showing that currently there is no increased risk. However, this study has potential limitations. In the first place, the number of 842 screened patients might not be sufficient enough to unravel a statistically significant difference between the groups. The p value for the association between the MRSA prevalence in rheumatologic and non-rheumatologic patients is $p = 0.53$. This demonstrates that there is no statistically significant difference between the MRSA prevalence among rheumatologic patients and the MRSA prevalence among non-rheumatologic patients. Due to our found prevalence of 0.5% among rheumatologic patients, we would have had to screen a total number of almost 4800 instead of 842 patients to yield a p value of < 0.05 for this association.

In the second place, refusals to participate were rare, but they occurred. Furthermore, some of the patients did not speak German very well, so that they had difficulties in answering the questions. Based on conversations with these same patients, we guess that there might be a small number of patients who were not sure about the answers they gave, even if we tried to formulate them as simply as possible. However, this small number of patients might have

influenced the questionnaire but not the results of the MRSA carrier status. In addition, the nine patients identified as MRSA carriers were native speakers and therefore, did not have any problems with the language.

Besides, only swabs from the nasal vestibule and from the pharyngeal site were taken, but not from chronic wounds or other body areas (e.g., the inguinal region). This was done on purpose, since MRSA is mainly found in the nasal vestibule and colonizes on this basis especially the pharyngeal site, as shown by the Commission for Hospital Hygiene and Infection Prevention [4]. It could have been interesting to screen these two other sites as well, though it might have reduced the number of patients willing to participate. Furthermore, we could have tried to cover more potential risk factors in the questionnaire. However, we tried to keep the questionnaire manageable for both the patients and the clinical personnel.

CONCLUSIONS

In conclusion, the low MRSA prevalence in patients of the center for rheumatologic and orthopedic rehabilitation (0.5%) despite the frequent long-term immunosuppression in this patient group suggests that rheumatologic patients are not more likely to reveal MRSA carrier status than other patient groups and that long-term immunosuppression does not necessarily represent a risk factor for MRSA colonization. The higher prevalence in patients of the center for cardiologic and orthopedic rehabilitation and in patients with oncologic rehabilitation may be explained by greater exposure to several risk factors for MRSA colonization compared to the patients of the two other rehabilitation centers. The overall prevalence of MRSA (1.1%) correlates with what we suspected from previous studies.

Since only five out of nine patients with carrier status would have been detected by following the recommendations of the KRINKO and since we detected a higher percentage of other potential risk factors in colonized patients compared to the entirety of the patients, we suggest a further investigation of the exact

impact of these and other potential factors on MRSA carriage.

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Compliance with Ethics Guidelines. The study was conducted within an internal quality control exploration following the statement of the local ethics committee (Rhineland-Palatinate).

Data Availability. The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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