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Prevalence and factors associated with meticillin-resistant *Staphylococcus aureus* colonization on admission to geriatric care units: impact on screening practices

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SUMMARY

Objectives: Universal screening for meticillin-resistant *Staphylococcus aureus* (MRSA) entails additional costs, and there is no consensus for targeted screening for high-risk units. The aims of this study were to determine the prevalence of MRSA in geriatric care units, and to identify the factors associated with MRSA colonization on admission.

Methods: This retrospective case–control study (1:1) in the geriatric care unit of six Belgian hospitals covered the period from 1st January 2021 to 31st December 2022. Cases were patients with a positive MRSA screening result within 48 h of admission to the geriatric care unit, and controls were patients with a negative screening result.

Results: In total, 556 patients were included in this study (278 in each group). Prevalence per 100 admissions for the total sample was 2.3 [95% confidence interval (CI) 2.2–2.6]. Significant multi-variate factors associated with MRSA carriage on admission were: history of MRSA, nursing home origin, and chronic skin lesions. Applying these three factors would give an area under the receiver operating characteristic (ROC) curve of 0.73 (95% CI 0.71–0.77), and would allow screening to be carried out in only 55.4% of cases (95% CI 51.2–59.6%).

Conclusions: Using these factors as screening criteria in geriatric care units could significantly reduce the number of patients screened for MRSA, while maintaining satisfactory sensitivity and specificity.

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Introduction

Meticillin-resistant *Staphylococcus aureus* (MRSA) infections are associated with a significant rate of morbidity and mortality [1,2]. In fact, 15% of healthcare-associated infections (HAIs) in

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intensive care units (ICUs) are caused by *S. aureus* and, in one-third of these, MRSA is the bacterium responsible for the infection [3,4]. This results in significant costs for hospitals and social security [5]. This increase in costs is due to increases in the length of stay, more frequent readmissions, and a higher financial burden associated with antibiotic therapy for patients infected with MRSA [6—8].

In the general population, a large proportion of patients are asymptomatic carriers of MRSA, and it is estimated that 9—33% of these carriers will develop MRSA infection at some point [3]. Screening for MRSA is common practice in hospitals in many countries, and some do require this prevention strategy. The aim of this practice is to limit the risk of cross-contamination, but it also plays a role in antimicrobial stewardship by allowing decolonization prior to any antibiotic treatment of an MRSA infection or prophylaxis tailored to the MRSA carrier. The use of vancomycin would, therefore, be more limited [9].

Acquisition of MRSA, as well as MRSA bacteraemia, is more common in patients aged ≥75 years. There is also a higher mortality rate following MRSA bacteraemia in patients in this age group compared with younger patients [10]. In addition, residents of geriatric long-term care facilities are frequently hospitalized in geriatric units, and have a reported high rate of MRSA colonization. This population, with its specific characteristics, therefore deserves special attention, particularly in terms of MRSA screening [11].

From a theoretical point of view, identification of every patient with MRSA on admission would be ideal for managing the transmission of this micro-organism. However, universal screening entails significant costs for social security and hospitals [5,12]. Reducing the number of screenings without reducing the quality of care would, therefore, be beneficial for patients, hospitals and the social security system. A study published in *Nature* in 2020 established three MRSA screening criteria that enable only 25% of admitted patients to be screened, while maintaining high sensitivity and specificity [13]. This study was carried out on patients admitted to emergency departments, without discriminating between them on the basis of age.

At the time of writing, there is no international consensus on screening patients for MRSA upon admission. A recent study indicated that some acute care facilities have reported no negative consequences associated with discontinuing contact precautions for patients colonized with MRSA [14]. In addition, screening recommendations do not take into account the specificities of the geriatric population, despite the documented increased risk of infection and carriage in these patients [3,15,16].

This study aimed to determine the prevalence of MRSA in geriatric care units, and to identify the factors associated with MRSA colonization upon admission in order to develop screening criteria.

Methods

Study design and setting

This retrospective case—control study (1:1) was undertaken in the geriatric care units of six Belgian hospitals in the same province (representing approximately 10—15% of acute care beds) between 1st January 2021 and 31st December 2022. All six hospitals had geriatric wards, with half having 48 beds and the other half having approximately 75 beds each. The admission criteria included patients aged ≥75 years. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies were followed for this case—control study [17].

Participants

To calculate the prevalence by year and by hospital, all admissions to geriatric care units (N=11,754) were taken into account (see Appendix 1 for samples by hospital).

Cases were patients with a positive MRSA screening result within 48 h of admission to the geriatric care unit, and controls were patients with a negative screening result. For matching, one control per case was selected at random from among potential controls hospitalized at the same hospital site and year. For the randomization of controls, all patients admitted to geriatrics during the study period were assigned a number chronologically by the researchers, according to the date of admission. A random drawing was then performed, using Excel (Microsoft Corp., Redmond, WA, USA), to choose the controls. Patients who had not been screened for MRSA carriage on admission to the geriatric ward or for whom the data sought were not available were excluded. Based on laboratory data and geriatric admissions, the compliance rate for MRSA screening within 48 h was approximately 90% over the study period for all patients admitted to the geriatric care units.

Variables and data sources

Data were collected retrospectively by analysing patient records. Data on the site of carriage and factors influencing the risk of MRSA carriage were collected [12,13,18,19]. To identify MRSA carrier status, data for combined nasopharyngeal and perineal swabs and an additional swab of clinical site (i.e. wound, respiratory or urine sample) were collected for the period within 48 h after admission.

For laboratory analysis, MRSA was detected routinely by microbiological culture and antibiotic susceptibility testing. Three swabs from the nose, throat and perineum were pooled in an MRSA-specific enrichment liquid (Copan tryptic soy broth media supplemented with 2.5% NaCl). The tryptic soy broth media were incubated overnight in an aerobic atmosphere at 37 °C. They were then inoculated on to ChromiD-MRSA chromogenic medium from bioMérieux (Marcy l'Etoile, France). These culture media were then incubated for 16—24 h under the same atmospheric conditions. The growth of MRSA can be detected immediately after 24 h in the form of green colonies on Chromid MRSA medium due to the alpha-glucosidase activity produced in the presence of cefoxitin. These colonies were identified by matrix-assisted laser desorption ionization-time of flight mass spectrometry (Bruker Daltonics, Bremen, Germany) equipped with MALDI Biotyper Compass IVD Version 4.2.90 to confirm their identification as *S. aureus*. An automated microdilution antibiotic susceptibility test was performed on the Phoenix M50 automated system from Bexton Dickinson (Franklin Lakes, NJ, USA) to confirm resistance to oxacillin and cefoxitin. The antibiogram was interpreted in accordance with the 2021 and 2022 recommendations of the European Committee on Antimicrobial Susceptibility Testing.

Abbott's PBP2A rapid antigenic diagnostic test was also used to confirm meticillin resistance in *S. aureus* isolates.

Statistical methods

The prevalence of MRSA was estimated from all admissions to geriatric care units, by hospital site and by year, and is expressed as prevalence per 100 admissions. A cumulative prevalence was obtained for hospital sites and is expressed as a 95% confidence interval (CI).

Qualitative variables have been presented as absolute and relative frequency [*N* (%)]. Quantitative variables have been presented as median and interquartile range (IQR). The Mann–Whitney test was used for comparisons of quantitative variables, and Chi-squared test or Fisher's exact test was used for symmetric variables for proportion comparisons. The Kolmogorov–Smirnov test was used to analyse the symmetry of the quantitative variables. Univariate logistic linear regression models were performed in order to test the association between different independent variables and for both groups. Following the Hosmer–Lemeshow suggestion, variables with $P<0.05$ on univariate analysis were included in the multiple logistic regression. For the final model, a probability cut-off for an optimal balance of sensitivity and specificity was determined with the Youden index. The corresponding area under the receiver operating characteristic (AUROC) curve was calculated. Subsequently, sensitivity, specificity, and positive and negative predictive values were calculated. Odds ratios (OR) with 95% CI and *P*-values have been used to describe the results. $P<0.05$ was considered to indicate significance.

Statistical analyses were performed using STATA Version 14.0 (Stata Corp, College Station, TX, USA) and R Version 4.1.2.

Ethical considerations

The agreement of the ethics committee for each hospital site was obtained for collection and publication of the data.

Results

In total, 556 patients were included in the study (278 cases and 278 controls). Values for age [median 85 (IQR 80–90) years], transfer from a hospital, hospitalization within preceding 12 months, treatment with antacids, oncological treatment, and use of medical device (tracheostomy, urinary catheter and gastronomy) did not vary significantly between the groups. However, there were significantly more patients in the case group with a history of MRSA (20.9% vs 2.2%), from nursing homes (54.0% vs 28.1%), who had received antibiotic therapy within preceding 3 months (19.8% vs 12.9%), and with chronic wound care (30.2% vs 12.2%), compared with the control group. Conversely, there were fewer patients with home care by allied health professionals (28.7% vs 37.1%) in the case group compared with the control group (Table I).

The prevalence per 100 admissions for the total sample was 2.1 (95% CI 1.8–2.4) for 2021 and 2.6 (95% CI 2.2–3.0) for 2022. There were significant variations in prevalence by hospital and by year, ranging from 1.0 (95% CI 0.5–1.5) for one hospital (H1) in 2022 to 6.9 (95% CI 6.7–7.2) for another hospital (H5) in 2022 (Figure 1). The vast majority of MRSA carriage came from nose–throat–perineum screening (81.7%), followed by 11.5% from a combination of screening and clinical site, and the remainder (6.8%) from clinical site alone (Figure 2).

The significant multi-variate factors associated with MRSA carriage on admission were history of MRSA (OR 8.96, 95% CI 3.71–21.60), coming from a nursing home (OR 2.82, 95% CI 1.78–4.48), and presence of chronic skin lesions (OR 2.65, 95% CI 1.64–4.30). Applying these three factors as screening criteria would give an AUROC curve of 0.73 (95% CI 0.71–0.77), sensitivity of 72.3% (95% CI 69.8–75.7%) and specificity of 62.6% (95% CI 68.2–66.4%) (Figure 3, Table II). Finally, the screening criteria with three factors meant that it was only possible to perform an MRSA smear in 55.4% (95% CI 51.2–59.6%) of the sample (Table III).

Table I
Sociodemographic characteristics of the patients at admission

Variables	Case (*N*=278)	Control (*N*=278)	*P*-value	Total (*N*=556)
Age	85 [79–90]	85 [81–90]	0.2528	85 [80–90]
History of MRSA	57 (20.9)	6 (2.2)	<0.0001	63 (11.3)
From nursing home	150 (54.0)	78 (28.1)	<0.0001	228 (41.0)
Transfer from another hospital	1 (0.4)	2 (0.7)	0.478	3 (0.5)
Hospitalization within preceding 12 months	96 (34.5)	92 (33.1)	0.745	188 (33.8)
Home care by a nurse	77 (27.7)	103 (37.1)	0.010	180 (32.4)
Stomach antacid treatment	132 (47.5)	125 (45.0)	0.569	257 (46.2)
Antibiotic therapy within preceding 3 months	55 (19.8)	36 (12.9)	0.033	91 (16.4)
Chronic skin lesion	84 (30.2)	34 (12.2)	<0.0001	118 (21.2)
Tracheotomy	2 (0.8)	1 (0.4)	0.522	3 (0.5)
Urinary catheter	11 (4.0)	5 (1.8)	0.125	16 (2.9)
Gastrostomy	3 (1.1)	4 (1.4)	0.467	7 (1.3)
Oncology treatment	11 (4.0)	11 (4.0)	0.556	22 (4.0)

MRSA, meticillin-resistant *Staphylococcus aureus*.
Data are shown as absolute frequency (relative frequency) or median [interquartile range].

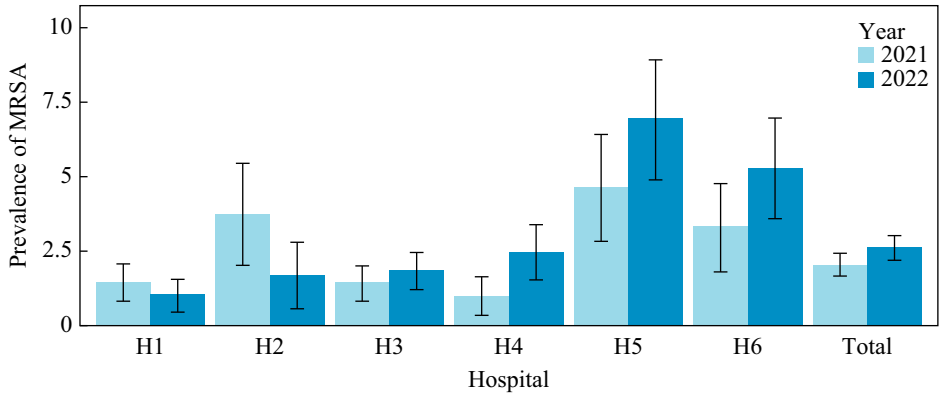

Figure 1. Prevalence of meticillin-resistant *Staphylococcus aureus* (MRSA)-positive patients per 100 admissions by hospital. Error bars show 95% uncertainty intervals.

Discussion

This study assessed the prevalence of MRSA and the factors associated with its carriage on admission to geriatric care units. Based on the study findings, some important observations can be made.

First, with regard to the prevalence of colonization with MRSA at admission, the present results show low overall prevalence in comparison with studies carried out in acute hospital wards (1–24%) [12,20,21]. Compared with studies conducted in geriatric care units alone (4.6–14.6%), the prevalence observed in this study was also low overall [20,22,23]. According to Belgian national data, a substantial decrease has been noted in MRSA carriage in acute hospitals (1.1 in 2007 to 0.4 per 100 admissions) and nursing homes (19.0% in 2005 to 9.0% in 2015) in recent years, and this decrease also seems to be reflected in the present study sample [19,24,25]. However, even in this sample from a single province in Belgium, there was significant variation in the prevalence of MRSA on admission depending on the hospital (1.1–6.9%). There are several possible explanations for this variance, with the most likely being higher prevalence in nursing homes close to hospitals with high prevalence [26]. Indeed, after a secondary analysis, many MRSA-positive patients were found to have come from two specific nursing homes. Extensive MRSA screening of residents and healthcare professionals would be necessary to confirm this hypothesis [27].

Second, the significant risk factors (history of MRSA, coming from a nursing home, and chronic skin lesions) identified in this study appear to be similar to other studies on the same subject [13,28–30]. Anticancer treatment was not found to be significant in this study, but this may be because such treatment is rarely used in the elderly. Age was not a significant factor either. This could be explained by a high mean age that did not differ between cases and controls. In comparison with a study carried out solely in geriatric care units in 2005, identical risk factors were not identified (recent antibiotic treatment and intrahospital transfer) [23]. However, this study had a higher prevalence of MRSA and was published >20 years ago [23]. In any case, information on the three risk factors identified in this study is generally readily available at the time of admission in patient records, and easily accessible in clinical practice. It is, therefore, not necessary to access additional sources of data,

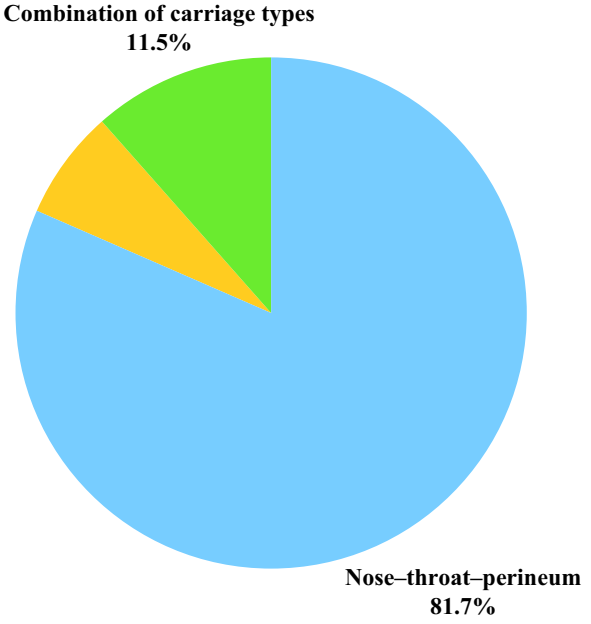

Figure 2. Meticillin-resistant *Staphylococcus aureus* carriage site.

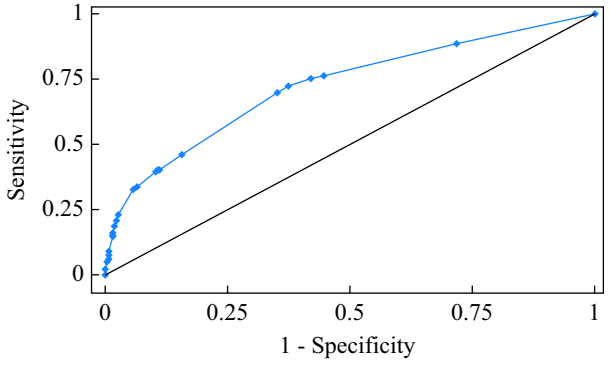

Figure 3. Area under the receiver operating characteristic (ROC) curve analysis based on multi-variate analysis factors. CI, confidence interval. Area under ROC curve = 0.71 (95% confidence interval 0.71–0.77).

Table II
Factors associated with meticillin-resistant *Staphylococcus aureus* (MRSA) colonization on multi-variate analysis

Variables	Adjusted odds ratio (95% CI)	*P*-value
History of MRSA	8.96 (3.71–21.60)	<0.0001
From nursing home	2.82 (1.78–4.48)	<0.0001
Home care by a nurse	1.09 (0.68–1.75)	0.730
Antibiotic therapy within preceding 3 months	1.31 (0.79–2.20)	0.294
Chronic skin lesion	2.65 (1.64–4.30)	<0.0001

CI, confidence interval.

Table III
Characteristics of screening criteria based on the model in the multi-variate analysis

Variables	Results (95% CI)
Sensitivity	72.3% (69.8–75.7%)
Specificity	62.6% (58.2–66.4%)
Positive predictive value	67.2% (64.5–71.1%)
Negative predictive value	68.0% (64.5–72.7%)
Patients screened with the model	55.4% (51.2–59.6%)

CI, confidence interval.

as is the case for the predictive models developed in other studies [23,31].

Third, regarding the accuracy of the factors identified here, this model has some strengths compared with other scores with more predictors and larger sample sizes that demonstrated better sensitivities and specificities [23,30,32]. As with all tests, the risk–benefit balance is very important. On the one hand, the proportion of patients in this study was lower compared with other studies, and this was an important factor in terms of associated costs, reduced workload for carers, and patient comfort. In addition, according to other studies, targeted screening is more cost-effective than universal screening [13,33,34]. On the other hand, there is a need to remain vigilant about a possible increase in MRSA colonization, which could have a negative impact on the outcomes of hospitalized patients and nursing home residents [3,34]. However, according to a Canadian study, although universal screening on admission improved the detection of MRSA three-fold compared with selective screening based on risk factors, universal screening was no more effective for detecting MRSA than selective screening based on risk factors, and no more effective in limiting nosocomial transmission of MRSA within hospitals [12]. Moreover, the biggest spreaders of MRSA are patients with chronic wounds colonized by this micro-organism [35,36]. With the screening criteria identified in this study, these patients are automatically screened and the risk of MRSA cross-contamination via wounds is limited in healthcare institutions. Universal screening could increase contact precautions for MRSA; however, the drawbacks of contact precautions are significant and their effectiveness remains a concern [37], particularly the environmental impact of the increased use of gowns and gloves, the effectiveness of which has yet to be demonstrated for MRSA [14]. According to the recommendations of the Society for Healthcare Epidemiology of America/Centers for Disease Control and Prevention, active surveillance of MRSA on a hospital-wide scale can be used in conjunction with contact precautions to reduce the incidence of MRSA infection with moderate-quality evidence [3]. However, the reduction of MRSA transmission to other patients on the ward depends on a set of measures that must be taken into account to assess the benefits and drawbacks of a targeted screening protocol with decreased loss of sensitivity and specificity. Furthermore, it is challenging to detect all carrier patients in a ward unit, making the goal of MRSA-free units less achievable, even with universal screening. The sensitivity and specificity of MRSA screening can, therefore, be considered satisfactory, depending on its prevalence in the hospital.

Finally, in hospitals with a low prevalence of MRSA on admission, the factors identified in this study could lead to more targeted screening, even in geriatric care units. Nevertheless, universal screening may be intermittently necessary in the event of a substantial rise in the number of admissions of patients with MRSA. However, this hypothesis would require confirmation through larger studies, including assessments of MRSA transmission rates.

Limitations

This study has several limitations associated with the quality of data collection in routine clinical practice. First, no weighted risk factors according to the importance of the factors were developed and tested in this study. However, having one of these screening criteria makes it easier to use in clinical practice than a weighted score. Second, the sample size could be considered limited compared with other studies. Nevertheless, this study was a multi-centre study and was conducted over 2 years. Third, the factors analysed were selected from the literature, but other factors could have been included in the multi-variate model. Fourth, this study was observational, with the possibility of selection and observational bias. In addition, the analyses were carried out on the basis of medical records, and some information may have been missing. Finally, the rate of patients tested for MRSA on admission could not be extracted for this study, which may be considered a selection bias.

In conclusion, the prevalence of MRSA on admission to geriatric care units was low in this study; however, significant variation was observed between hospitals. Three risk factors were identified: history of MRSA, history of chronic skin lesions, and coming from a nursing home. The use of these factors as screening criteria in geriatric care units would make it possible to significantly reduce the number of patients screened for MRSA, while maintaining satisfactory sensitivity and specificity.

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Author contributions
IM: conceptualization, visualization, writing – review and editing. AB: methodology, software, data curation, formal analysis. DM: validation. CDY: validation. AS: validation, supervision, writing – review and editing.

Conflict of interest statement
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Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Google translate for initial translation of the manuscript from French to English. After using this tool, the authors and a medical writer who is a native English language speaker reviewed and edited the content as needed, and take full responsibility for the content of the publication.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2024.01.014.

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