MRSA screening in emergency department detects a minority of MRSA carriers

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ABSTRACT

INTRODUCTION: Methicillin-resistant *Staphylococcus areus* (MRSA) is an emerging problem. The Danish Health and Medicines Authority (HMA) has developed a question-based screening tool to identify patients with MRSA. The tool has three parts: questions on general risk situations, special risk situations and individual risk factors. The emergency departments (ED) play a key role in the prevention of in-hospital spreading of MRSA. The aim of the present study was to estimate the prevalence of MRSA among all admitted ED patients to assess how many patients should be swab-tested for MRSA and isolated and to evaluate the ability of the HMA screening tool to detect MRSA.

METHODS: Patients who were more than ten years old answered all the HMA questions on general and specific risk situations and individual risk factors for MRSA, and a swab was obtained for MRSA culture.

RESULTS: A total of 1,945 patients were admitted and 73% participated. Indications for swab testing for MRSA were present in 8%. The general risk situation questions identified 3% for isolation due to suspicion of MRSA. A total of 11 patients had a positive MRSA swab culture (0.9%). Among the isolated patients, 3% had MRSA, 97% would have been isolated unnecessarily, while 91% of the MRSA patients would not have been isolated. The general risk situation questions had a sensitivity of 18-27% and the whole questionnaire had a sensitivity of 55% for the detection of MRSA patients.

CONCLUSIONS: The majority of MRSA carriers who are acutely admitted to the ED will remain undetected.

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Methicillin-resistant *Staphylococcus areus* (MRSA) is an emerging problem [1-3]. In Denmark, the prevalence of MRSA increased approx. ten years ago [4, 5]. New MRSA clones have been identified like MRSA CC398, which is closely associated to pig farming, but many other clones have been described as well, which suggests multiple sources for community-associated MRSA [5]. A range of risk factors for acquisition of MRSA have been identified [1, 6].

In 2012, The Danish Health and Medicines Authority (HMA) issued a revised guideline for the handling of MRSA [7]. The guideline aims to maintain the MRSA morbidity at its present, low level. The HMA has developed a question-based screening tool, which should be used for all patients admitted to hospital. This tool consists of three parts concerning general risk situations (see **Table 1**), special risk situations and individual risk factors (see **Table 2**). All patients must answer the general risk situation questions, the special risk questions on indication, i.e. if the health professional or the patient has knowledge of certain risk situations. The individual risk factors include conditions like chronic skin or respiratory tract diseases. If a risk situation is identified, the patient should be tested for MRSA colonisation and in special situations be isolated with barrier protection.

Since the majority of all acute patients are currently admitted through the emergency departments (ED) in Denmark, the ED plays a key role in the prevention of in-hospital spreading of MRSA. However, little is known about the prevalence of MRSA in an ED patient population, and no study has revealed how many acute patients fulfill the HMA criteria for MRSA testing or isolation or determined how efficient these criteria are for identifying acutely admitted patients who are colonised with MRSA.

Hospital of Southern Jutland is one of the 20 acute hospitals which are currently established in Denmark. It covers a catchment area of around 230,000 citizens and is situated only 25 km from Germany, where the prevalence of MRSA is significantly higher than in Denmark. Furthermore, the major part of the catchment area is rural with numerous pig farms.

The aim of the present study was, firstly, to estimate the prevalence of MRSA among all acutely admitted ED patients; secondly, to assess how many patients should be swab-tested for MRSA and isolated; and, thirdly, to evaluate the ability of the HMA screening tool to detect MRSA patients in an area that is believed to have a relatively high MRSA prevalence compared with other areas of Denmark.

METHODS

The study was performed at Hospital of Southern Jutland emergency department during a three-month period from September to November 2013. On average, the ED received 25 patients for admission daily with medical, surgical and orthopaedic complaints. All pa-

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TABLE 1

General risk situations for exposure to *Staphylococcus areus* (MRSA) and indications for swab testing and isolation for MRSA among acutely admitted patients in an emergency department in Southern Denmark.

Question	Patients, n (% of total) (N = 1,220)	MRSA-positive patients, n (% of group)
1a. Has MRSA previously been detected in this patient?		
Yes	41 (3)	2 (5)
No	1,166 (96)	9 (1)
Do not know	13 (1)	0
1b. And if "yes" in 1a: Is the patient declared MRSA-free now?		
Yes	17 (41)	1 (6)
No	11 (27)	1 (9)
Do not know	13 (32)	0
2a. Has the patient had contact with an MRSA patient within the last 6 months?		
Yes	21 (2)	1 (5)
No	1,186 (97)	10 (1)
Do not know	13 (1)	–
2b. And if "yes" in 2a: Has the contact with an MRSA patient been a long-term contact?		
Yes	5 (24)	1 (20)
No	15 (71)	0
Do not know	1 (5)	0
3a. Has the patient received treatment in hospital or clinic outside the Nordic countries within the last 6 months?		
Yes	39 (3)	0
No	1,166 (96)	11 (1)
Do not know	15 (1)	0
3b. And if "yes" in 3a: Did the patient stay longer than 24 h in the clinic/hospital or had invasive procedures performed (apart from needle procedures)?		
Yes	27 (69)	0
No	12 (31)	0
Do not know	0	–
4a. Has the patient had contact with living pigs within the last 6 months?		
Yes	56 (5)	3 (5)
No	1,147 (94)	8 (1)
Do not know	17 (1)	0
4b. And if "yes" in 4a: Did the patient or somebody else in the household have daily contact with living pigs?		
Yes	25 (45)	1 (4)
No	30 (53)	2 (7)
Do not know	1 (2)	0
Indication for MRSA swab testing: ≥ 1 positive answer in question 1a, 2b, 3b or 4b		
Yes	92 (8)	3 (3)
No	1,128 (92)	8 (1)
Indication for isolation of the patient: not declared MRSA-free in question 1b or ex-Nordic hospital stay lasting > 24 h in question 3b or both		
Yes	34 (3)	1 (3)
No	1,186 (97)	10 (1)

tients who were more than ten years old and who were admitted were invited to participate in the study and requested to answer all the HMA questions concerning general and specific risk situations and the individual risk factors for MRSA exposure. The nurse who cared for the patient asked the questions when receiving the patient after securing privacy and following a structured electronic questionnaire. Answers were recorded immediately using an iPad, which transferred the answers to a data environment fulfilling the requirements of the Danish Data Protection Agency.

After the interview, nasal and pharyngeal swabs were obtained for MRSA culture. The swabs were inoculated into an enrichment broth (6.5% NaCl, SSI) and incubated directly at 37 °C for a minimum of 16-18 hours before being spread onto an MRSA-Select plate (Beckton-Dickinton (BD)) and a Columbia blood agar plate (BD). The media were incubated overnight at 35 °C, and characteristic colonies were further identified by standard routine methods. In all MRSA-positive samples established, all staphylococci were further isolated and identified (Bruker Maldi-Tof) in order to demonstrate other PBP2-positive staphylococci (i.e. *S. epidermidis*). The results from the questionnaires and from the MRSA cultures were merged in STATA 13. Statistical differences in continuous variables were analysed using the non-parametric Kruskall-Wallis test and all categorical variables by Fisher's exact test. For the screening measures, a 95% confidence interval (CI) was calculated.

A sample size estimation was performed prior to the study. We expected the prevalence of MRSA to be 2% in the ED population of 9,000 annual admissions with an acceptable deviation from this of ± 1. To achieve a representative sample size with 95% CI, 695 patients had to be included. In the present cohort study with exposure to MRSA as a risk factor and MRSA carriage as the outcome, we estimated that 5% of the population had been exposed to a risk situation, that 10% of this population had MRSA and that only 1% had MRSA without a risk situation exposure. We calculated a sample size consisting of 60 patients exposed and 1,183 non-exposed to risk situations, totally 1,243 patients with a power of 90% and a two-sided confidence level of 95%.

Ethical clearance was obtained from the regional ethics committee, which considered the study to be a quality assurance project (mail September 2, 2013). The study was registered with the Danish Data Protection Agency (no. 2008-58-0035).

Trial registration: not relevant.

RESULTS

A total of 1,945 patients above ten years of age were admitted during the study period; 1,660 patients (85%) were invited to participate of whom 1,220 accepted (73% of all invited patients). The included patients had a median age of 59 years (p25-p75: 41-73 years) and 52% were female patients. The 37% of patients who did not

participate were MRSA screened according to the HMA criteria, but the results were not recorded for the study, and no swabs were taken unless indicated according to the HMA recommendations. They were significantly older (median age 69 years, p25-p75: 45-82 years, p = 0.0001), had the same gender distribution with 56% female patients (p = 0.20), but arrived more frequently during the evening time (24% versus 17%, p = 0.001) than the participating patients.

Among the examined patients, indications for MRSA swab testing were present in 92 (8%). The general risk situation questions identified 34 patients (3%) for isolation due to suspicion of MRSA carrier state, and a total of 11 patients had a positive MRSA swab culture (0.9% of all patients), five with pig MRSA (CC398/t034), four with Northern Germany MRSA – 1 (CC22/t223) and Northern Germany MRSA – 2 (CC5/t002) and two with unknown strains (CC45/t015 and CC88/t5147).

In Table 1, the answers to the general risk situation questions are listed together with the current MRSA carrier state. Eight patients (73%) of the actual MRSA carriers would not have been detected by the general risk situation questions. Among the isolated patients, one (3%) had MRSA, indicating that 33/34 patients (97%) would have been isolated unnecessarily, while ten out of the 11 MRSA (91%) carriers would not have been isolated on admission if these questions were used.

In Table 2, the answers to the special risk situations and individual risk factors are reported together with the MRSA state. Overall, 5% of the patients had an individual risk situation, but the special risk situation questions only identified one MRSA patient. Among the examined patients, 407 patients (33%) had an individual risk factor for MRSA, but only three of these had MRSA (1%).

Table 3 presents the results of the analysis of the general risk situations, the specific risk situations and the individual risk factors as a screening test for identification of MRSA carrier state. The general risk situation questions had a sensitivity of 18-27% (95% CI: 6-61%) for identifying an MRSA-positive patient, depending on whether the former MRSA carriers who were later documented to be MRSA-free were excluded or not, while the whole screening questionnaire including both general, specific and individual factors would identify 55% (95% CI: 23-83%) of the patients with MRSA. The defined isolation criteria in the general risk situations would isolate 9% (95% CI: 0-41%) of the patients with MRSA. The likelihood ratios for positive test are low for all models. Likewise, the likelihood ratios for a negative test are close to one, indicating a minimal change in the likelihood of disease with these screening models.

The median time for the nurses to inquire all the general, specific situation and individual risk factor questions was seven minutes (p25-p75: 5-10 minutes).

TABLE 2

Special and individual risk situations for *Staphylococcus areus* (MRSA) carrier state in an emergency department in Southern Denmark.

	Patients, n (% of total) (N = 1,220)	MRSA-positive patients, n (% of group)
Special risk situations within the last 6 months[a]		
Daily stay in assisted living facilities or similar institutions	11 (1)	1 (9)
Worked at hospital departments with MRSA outbreak	5 (0.4)	0
Worked at hospital, assisted living facilities or similar institutions outside the Nordic countries	3 (0.3)	0
Worked at an institution in the Nordic countries with MRSA outbreak	2 (0.2)	0
Stayed or worked in places with poor sanitary standards (warzones, refugee camps) or refugee centre	3 (0.3)	0
Household contact to persons who have been living outside the Nordic countries	36 (3)	0
Been in foreign countries and had signs of *Staphylococcus* infection (especially if the patient acquired a tattoo, piercing, practiced contact sport, shared equipment or had been to prison)	21 (2)	0
Patients with any of the special risk situations	67 (5)	1 (1)
Individual risk factors		
Wounds	100 (8)	1 (1)
Recurrent abscesses	56 (5)	1 (2)
Chronic skin diseases	126 (10)	0
Chronic respiratory tract infections (including sinusitis and obstructive lung disease)	126 (10)	1 (1)
Indwelling catheters or tubes	129 (11)	1 (1)
Intravenous drug abuse	1 (0.1)	0
Patients with any of the individual risk factors	407 (33)	3 (1)

a) These questions are only asked, if the health professional identifies a special reason for the question.

DISCUSSION

We found that the prevalence of MRSA carriers in this ED population was 0.9%, that 8% should have a swab culture performed and that 3% should be isolated according to the HMA general risk factor criteria for isolation. This resulted in 97% of the patients being isolated unnecessarily, while 91% of the MRSA carriers were not isolated. As a screening tool, the general risk situation questions would identify 18-27% of the MRSA carriers; and if all the general risk, specific risk and individual risk questions were used, up to 55% of the MRSA carriers would be identified.

The finding of 0.9% MRSA carriers among acute patients admitted in an area of Denmark where the population has close contact to Germany and to pig farms was lower than the study group anticipated and suggests that the spreading of MRSA within the community is still at a low level, resembling the prevalence that has been found in Denmark for many years; the prevalence is also similar to that of other neighbouring countries like UK and the Netherlands [2, 6, 8].

The HMA criteria for identification of patients who should be tested for MRSA were of limited use. If all criteria were used, 55% of MRSA carriers would have been

TABLE 3

General and specific risk situations and individual risk factors as a screening test for methicillin-resistant *Staphylococcus areus* (MRSA) carrier state in an emergency department in Southern Denmark.

	Models for identification of patients for MRSA swab culture					
	general risk situations 1[a]	general risk situations 2[b]	specific risk situations	individual risk factors	combined general, specific and individual risk situations	Model for isolation: isolation required[c]
Patients, n						
Screening question-positive	76	92	67	407	507	47
True MRSA	11	11	11	11	11	11
True positive	2	3	1	3	6	1
True negative	1,135	1,120	1,143	805	708	1,163
False positive	74	89	66	404	501	46
False negative	9	8	10	8	5	10
Total	1,220	1,220	1,220	1,220	1,220	1,220
Screening values, % (95% CI)						
Sensitivity	18 (2-52)	27 (6-61)	9 (0-41)	27 (6-61)	55 (23-83)	9 (0-41)
Specificity	94 (92-95)	93 (91-94)	95 (93-96)	67 (64-69)	59 (56-61)	96 (95-97)
Positive predictive value	3 (0-9)	3 (1-9)	1 (0-11)	1 (0-2)	1 (0-2)	2 (0-11)
Negative predictive value	99 (98-100)	99 (98-100)	99 (98-100)	99 (98-100)	99 (98-100)	99 (98-100)
Likelihood ratios (95% CI)						
Of positive test	3.0 (0.8-11)	3.7 (1.4-10)	1.7 (0.3-11)	0.8 (0.3-2.2)	1.3 (0.8-2.3)	2.4 (0.4-16)
Of negative test	0.9 (0.7-1.2)	0.8 (0.5-1.1)	1 (0.8-1.2)	1 (0.8-1.6)	0.8 (0.4-1.5)	0.9 (0.8-1.1)

CI = confidence interval.
a) All patients with "no" or " do not know" in question 1b or "yes" in question 2b or "yes" in question 3b or "yes" in question 4b in Table 1.
b) All patients with "yes" in question 1a or "yes" in question 2b or "yes" in question 3b or "yes" in question 4b in Table 1.
c) Only patients who fulfilled criteria in general situations: all patients with "no" in question 1b or who had stayed > 24 h in hospital/clinic outside the Nordic countries.

identified, and only 18-27% would have been identified if the general risk situation questions were used within a well-supervised efficacy study design. Outside a study design, the effectiveness of MRSA screening questions may perform even poorer. We believe that the majority of MRSA carriers will pass unidentified through the ED. Although others have studied risk factors for MRSA carriage in Denmark, no studies have presently been performed on the ED population and the HMA screening tool [8].

There are several explanations why the question-based screening is not working better. On the patient side, the questions are based on past events and require a certain level of recall ability. It is surprising that a third of the patients who declare to have had MRSA did not know if they had tested MRSA-negative afterwards. Furthermore, some patients may be reluctant to report answers, indicating that they are potential MRSA carries, which results in isolation, additional treatments and possibly stigmatisation. This is reflected in the fact that 27% refused to participate in the study. On the health professional side, the MRSA screening implies spending seven minutes on this single task only, which may be regarded as a rather time-consuming procedure in a busy ED. Furthermore, the time limit also limits how detailed the screening can be. It is remarkable that even in this study period with daily surveillance of the screening, it was only possible to screen 85% of the admissions.

The findings of this study have clinical implications. The unfortunate consequences of the low ability to detect MRSA carriers are that MRSA carriers are not isolated and that non-carriers are isolated unnecessarily. While the former imply that MRSA might spread to vulnerable patients with serious consequences for their morbidity and treatment, it also means that other patients may experience the negative consequences of isolation, including delayed examinations and treatment.

Swab for methicillin-resistant *Staphylococcus areus* culture.

The study also revealed that the MRSA screening is quite time-consuming; the time needed in this ED amounts to half a man-year, raising a cost-benefit issue.

How may the identification of MRSA carriers in the ED be improved? There are some alternatives to consider. The MRSA screening questions could be posed more rigorously. This might improve the MRSA detection rate, but would be very difficult in a busy ED. The screening questions might be more targeted towards the population at risk. Future research is encouraged on this matter. A general swab-and-culture of all acutely admitted patients for MRSA is possible, but should be carefully considered and such consideration should include a cost-benefit analysis. Finally, rather than identifying the MRSA carriers, another strategy would be to assume that all patients are potential MRSA carriers and to raise the general hygiene level in-hospital in order to avoid transfer of MRSA.

The strength of the present study is that it was the first Danish study performed in an emergency department situated in a presumed MRSA-prevalent area of Denmark and under normal working conditions. The study is weakened, however, by some factors. Even though it was performed in a three-month period, we only found 11 MRSA carriers which results in some uncertainty as reflected in the wide confidence intervals. Furthermore, only two thirds of all the admissions were finally included in the study; and it seems that the non-participating patients differ on some aspects, including age and admission time. Whether this non-participating group has a higher or lower frequency of MRSA is unknown. Finally, we did not follow the full HMA recommendation to include the perineal area in the swab test due to inconvenience for the patients. Including this area may have increased the sensitivity of the swab test to detect MRSA from around 82% to 89% equal to one patient more in this study [9]. Despite these limitations, we still believe that our results reflect a real situation of the MRSA challenges in many Danish emergency departments and calls for additional considerations of how to detect and handle this challenge.

CONCLUSIONS

In this ED, 0.9% of the patients had MRSA. Less than every fifth will be detected by the general screening questions, and only half of the MRSA carriers will be detected if all general, specific and individual questions are used. We conclude that the majority of MRSA carriers who are acutely admitted to the ED will remain undetected.

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