Simplified screening in an emergency department detected methicillin-resistant Staphylococcus aureus

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Christian Backer Mogensen[1], Poul Kjældgaard[2], Charlotte Jensen[1] & Ming Chen[2]

ABSTRACT

INTRODUCTION: All patients admitted to Danish hospitals are screened for methicillin-resistant *Staphylococcus aureus* (MRSA) by a questionnaire consisting of 19 questions issued by the Danish Health and Medicines Authority (DHMA). This study aimed to evaluate which of the questions were most useful. Furthermore, we assessed if other questions were more adequate and if a simplified screening model would perform equal to or better than the one presently used.

METHODS: Swabs were obtained for MRSA culture from patients who were more than ten years old and who had been admitted to an emergency department (ED). All DHMA questions together with a range of additional questions were answered.

RESULTS: Among the 1,220 patients who participated, 0.9% were MRSA carriers. Only three DHMA questions were associated with a significant risk of MRSA carriage. The additional questions associated with MRSA were "stayed with a non-Danish family within the past three years" and "daily contact with children at a nursery or kindergarten". A new model with only five questions increased the sensitivity insignificantly from 18-55% to 73% in the revised model, whereas no changes were seen for specificity, predictive values or likelihood ratios.

CONCLUSIONS: The DHMA's targeted screening for MRSA detection contained only few questions with significant association to MRSA carrier stage. A model based on only five questions seems to insignificantly improve the MRSA screening in this population. In order to develop a more simple and effective screening model, we recommend that our findings be tested in another ED patient population.

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TRIAL REGISTRATION: not relevant.

The burden of methicillin-resistant *Staphylococcus aureus* (MRSA) varies between countries. In Denmark, the prevalence has increased in the past decade [1]. New MRSA strains have been identified which are associated with pig farming [2], but many other strains have been isolated as well, suggesting that there are multiple sources of community-acquired MRSA [3].

Since the majority of patients who are admitted to hospital pass through the emergency departments (ED), the EDs play a crucial role in early identification of MRSA carriers. All patients admitted to Danish hospitals are screened for exposure to MRSA by a questionnaire issued by the Danish Health and Medicines Authority (DHMA) [4]. The questionnaire consists of a mandatory section to be used for all admissions with four main questions and five sub-questions addressing common risk situations, a section used in special risk situations (five questions) and five individual risk factors; a total of 19 variables are to be checked if the full screening procedure is followed. The procedure is quite complex, it requires some instruction and is time-consuming.

In a recent ED study, we used this questionnaire approach and found a 0.9% MRSA prevalence, and we were able to identify 18-27% of the MRSA carriers if the mandatory general risk questions were answered, and up to 55% of the MRSA carriers if all the general risk, specific risk and individual risk questions were answered. Only 9% of the MRSA carriers would be isolated using the DHMA isolation recommendations. The ED study also revealed that the majority of MRSA clones originated from pigs and Northern Germany, which reflects the fact that the ED was situated only 25 km from the Danish-German in a rural area with several pig farms [5].

The DHMA screening questionnaire was based on the knowledge of an established range of known risk factors for MRSA acquisition, such as contacts to local outbreaks or other MRSA carriers, travelling and non-Danish origin, or skin diseases [6, 7]. Acknowledging that the majority of MRSA cases in our study derived from pigs and Northern Germany, we hypothesised that a minor part of the DHMA questions together with other additional questions more targeted to these risk factors for MRSA would detect the MRSA carriers to the same or at a higher extent than the currently used DHMA screening.

The aim of the present study was: first, to evaluate which of the 19 questions in the DHMA screening were most useful for detecting MRSA; second, to analyse if other questions regarding MRSA exposure would perform better than the ones currently included in the screening; and third, if a more simplified screening model combining the most accurate questions for detection of MRSA risk would perform equally to or better than the presently used DHMA MRSA screening in this area of Denmark.

Questions tested for usefulness as risk markers for methicillin-resistant *Staphylococcus aureus*.

Origin
Which country are you from?
Which country are your parents from?

Contacts to children
Do you have daily close contact with children:
Who are adopted from a non-Nordic country within the past 6 months?
Who are at a day care or kindergarten?

Antibiotics
Have you been treated with antibiotics the past 2 years?
If yes, which kind of infection was treated?

Relation to Germany
Do you live in Germany?
Does anyone in your household work in Germany?
Does anyone in your household work at a German hospital?

Relation to farms
Do you live less than 500 m from a farm?
Do you visit a farm more than once a month?
Does anyone from your household visit a farm more than once a week?

Living place
Do you receive home care?
Have you been living in a nursing home within the past 6 months?
Have you been admitted to hospital within the past 6 months?
Have you been living with a foreign family within the past 3 years?
Have you been living in a boarding school within the past 3 years?
Have you been in prison within the past 6 months?
Have you been in the military/civil defence within the past 6 months?

Foreign countries apart from Germany
Have you stayed outside of Denmark for more than 3 days in the past 3 years?
If yes, in which countries?

Patients with high suspicion of methicillin-resistant *Staphylococcus aureus* colonisation require isolation, but are difficult to identify.

lysed in Stata 13. Odds ratios (OR) and 95% confidence interval were calculated for each question using univariate logistic regression. A screening model was suggested using a combination of the questions that had a significant association with MRSA.

The study was registered with the Danish Data Protection Agency (number 2008-58-0035) and ethical clearance was obtained from the regional ethical committee (mail 2 September 2013), which considered the study to be a quality assurance study. Only patients who freely consented to participate were included in the study.

Trial registration: not relevant.

RESULTS

Among 1,945 admitted patients, 1,220 consented (73% of all invited) to participate in the study. A total of 11 patients (0.9%) were found to be MRSA carriers.

Table 2 shows the OR for the currently used DHMA questions. The questions concerning previous MRSA, contact with living pigs and daily stay in an assisted living facility were all associated with a significantly increased risk of MRSA carriage, but the remaining DHMA questions were not. For the following risk indicators, no MRSA patients were identified: "treatment outside Nordic countries within the past six months", "worked at hospitals with MRSA outbreaks within the past six months", "worked at hospitals or similar institutions outside the Nordic countries within the past six months", "worked at Nordic hospital with MRSA out-

METHODS

The method has been described in details elsewhere [5]. In brief, all patients aged ten years or more, who were admitted to the ED, were invited to participate in the study. If they accepted, a nasal and pharyngeal swap was obtained for MRSA culture. At the same time, the patients were invited to answer all the DHMA questions concerning general and specific risk situations and individual risk factors for MRSA exposure. Furthermore, in the search for other questions concerning MRSA exposure, the patients were asked a range of additional questions, based on a literature search, local experience and specialist considerations (**Table 1**).

The nurse who cared for the patient asked all the questions immediately after the patient's arrival and recorded the answers in a structured electronic questionnaire which transferred the answers to a secure data environment. The results from the questionnaires were linked to the results from the MRSA cultures and ana-

break within the past six months", "stayed in poor sanitary facilities (refugee camps, war zones) or asylum centre within the past six months", "household contacts to persons living outside the Nordic countries", "signs of or exposure to MRSA in foreign countries", "recurrent skin abscesses" and "intravenous drug abuse".

Table 3 shows the analysis of the examined alternative questions for detection of MRSA carriage. A significant association with MRSA was found for the questions "stayed with a non-Danish family within the past three years", "daily contact with children at a nursery or kindergarten" and "imprisoned within the past six months". An association with MRSA was shown for no questions concerning relation to pig farming, antibiotic treatment, adoptions, living with people working in Germany or at nursing home, being a soldier, staying outside of Europe and relation to other countries or institutions apart from the above-mentioned.

Since the number of patients with MRSA was low, we were unable to identify screening questions associated with MRSA at the multivariate level. However, we selected those DHMA questions and alternative questions that had the highest significant OR in order to be able to present a revised model for identification of MRSA. The following five questions were included: "Any information concerning previous MRSA", "contacts with living pigs within the past six months", "daily stay in an assisted living facility", "daily contact with children at a nursery or kindergarten" or "stayed with non-Danish family within the past three years". We did not include imprisonment despite a high OR for MRSA, since the total number of patients with this exposure was very low.

If any of these five questions indicated exposure to MRSA, the screening test was positive. The screening measures were calculated and compared with the basic DHMA screening model where only the four mandatory questions for all patients were included, and also with the full DHMA model in which all the 19 questions including those relating to special risk situations and individual risk factors were included. The results are reported in **Table 4**. The new model increased the sensitivity insignificantly from 18-55% in the DHMA models to 73% in the revised model, while no major changes were seen in the specificity, predictive values or likelihood ratios.

DISCUSSION

We found that among the 19 DHMA questions, only three questions were associated with an increased risk of MRSA carriage: "previous MRSA", "daily contact with living pigs" and "daily stay in assisted living facilities". In a range of alternative questions designed to detect MRSA, only "staying with a non-Danish family within the past three years", "daily contact with children at a nur-

📋 **TABLE 2**

Danish Health and Medicines Authority risk situations and individual risk factors for methicillin-resistant *Staphylococcus aureus* carriage.

	MRSA status, n (%)		Univariate analysis,
	no MRSA	MRSA	OR (95% CI)
General risk situations			
Previous MRSA?			
No	1,157 (99)	9 (1)	1
Yes	39 (95)	2 (5)	6.6 (1.4-32)
MRSA-free after previous MRSA?			
Yes	16 (94)	1 (6)	1
No	23 (96)	1 (4)	0.7 (0.04-12)
MRSA contacts within the past 6 months?			
No	1,176 (99)	10 (1)	1
Yes	20 (95)	1 (5)	5.8 (0.7-48)
Long-term MRSA contacts if MRSA contacts within the past 6 months?			
No	15 (100)	0 (0)	NC
Yes	4 (80)	1 (20)	
Contacts with living pigs within the past 6 months?			
No	1,139 (99)	8 (1)	1
Yes	53 (95)	3 (5)	8.1 (2.0-31)
Daily contact with pigs if contact within the past 6 months?			
No	28 (93)	2 (7)	1
Yes	24 (96)	1 (4)	0.8 (0.2-2.7)
Special risk situations within past 6 months			
Daily stay in assisted living facility?			
No	1,199 (99)	10 (1)	1
Yes	10 (91)	1 (9)	12 (1.2-103)
Individual risk factors			
Wounds?			
No	1,110 (99)	10 (1)	1
Yes	99 (99)	1 (1)	1.1 (0.1-8.9)
Abscesses?			
No	1,154 (99)	10 (1)	1
Yes	55 (98)	1 (2)	2.1 (0.3-17)
Chronic respiratory tract infections (including sinusitis and obstructive lung disease)?			
No	1,084 (99)	10 (1)	1
Yes	125 (99)	1 (1)	0.9 (0.1-6.8)
Indwelling catheters or tubes?			
No	1,081 (99)	10 (1)	1
Yes	128 (99)	1 (1)	0.8 (0.1-6.6)

CI = confidence interval; MRSA = methicillin-resistant *Staphylococcus aureus*; NC = not calculated; OR = odds ratio.

sery or kindergarten" and "imprisonment within the past six months" were associated with an increased risk of MRSA. Combining five of these questions into a new screening model did improve, though insignificantly so, the MRSA detection rate compared with the currently used DHMA screening model, yielding a sensitivity increase from 18-55% to 73%.

Other studies from EDs concerning risk factors have recently been published. In Northern Germany, the com-

TABLE 3

Alternative risk indicator questions for methicillin-resistant *Staphylococcus aureus*.

	MRSA status, n (%)		Univariate analysis, OR (95% CI)
	no MRSA	MRSA	
Relation to other countries			
Danish citizen?			
Yes	1,114 (99)	10 (1)	1
No	48 (98)	1 (2)	2.3 (0.3-19)
Parents from Denmark?			
Yes	1,059 (99)	9 (1)	1
No	101 (98)	2 (2)	2.3 (0.5-11)
Household contacts working in Germany?			
No	1,168 (99)	10 (1)	1
Yes	41 (98)	1 (2)	2.8 (0.4-23)
Stayed for more than 3 days outside Denmark within the past 3 years?			
No	603 (99.5)	3 (0.5)	1
Yes	606 (99)	8 (1)	2.6 (0.7-10)
Stayed for more than 3 days in Germany within the past 3 years?			
No	943 (99)	8 (1)	1
Yes	266 (99)	3 (1)	1.3 (0.4-5)
Stayed for more than 3 days in other European countries (excluding the Nordic countries)?			
No	793 (99.4)	5 (0.6)	1
Yes	416 (99)	6 (1)	2.3 (0.7-7.5)
Stayed with a non-Danish family within the last 3 years?			
No	1,012 (99)	6 (1)	1
Yes	197 (97)	5 (3)	4.3 (1.3-14)
Relation to institutions			
Daily contact with children at nursery or kindergarten?			
No	1,044 (99)	6 (1)	1
Yes	165 (97)	5 (3)	5.3 (1.6-17)
Local authority home help?			
No	1,034 (99)	9 (1)	1
Yes	175 (99)	2 (1)	1.3 (0.3-6)
Admitted to hospital within the past 6 months?			
No	806 (99)	7 (1)	1
Yes	403 (99)	4 (1)	1.1 (0.3-3.9)
Living at a boarding school?			
No	1,189 (99)	10 (1)	1
Yes	20 (95)	1 (5)	5.9 (0.7-47)
Imprisoned within the past 6 months?			
No	1,202 (99)	10 (1)	1
Yes	7 (88)	1 (13)	17 (1.9-52)
Relation to farming and antibiotics			
Living less than 500 m from pig farm?			
No	883 (99)	9 (1)	1
Yes	326 (99)	2 (1)	0.6 (0.1-2.8)
Visiting a pig farm more than once a month?			
No	1,054 (99)	8 (1)	1
Yes	155 (98)	3 (2)	2.6 (0.7-9.7)
Household member visits pig farms more than once a week?			
No	1,093 (99)	10 (1)	1
Yes	116 (99)	1 (1)	0.9 (0.1-7.4)
Received antibiotic treatment within the past 2 years?			
No	428 (99)	5 (1)	1
Yes	624 (99)	6 (1)	0.8 (0.2-2.7)

CI = confidence interval; MRSA = methicillin-resistant *Staphylococcus aureus*; OR = odds ratio.

munity carriage was 1.3% and male sex and allergies were associated [8]. In Saarland, Germany, the prevalence on admission was 2.2%; and former MRSA, skin conditions and indwelling catheters were risk factors [9]. In Sweden, being born in a foreign country, receiving healthcare abroad and foreign travel were strongly associated with MRSA [10]. In Belgium, known MRSA history and stay in a care facility were associated with MRSA, and more than 90% of MRSA belonged to five health-care-associated strains [11]. In Scotland, a 2% MRSA prevalence in ED was associated with the number of admissions, specialty of admission, age, and hospital or care home [12]. This wide geographical variation in risk factors reflects the heterogeneity of the MRSA problem and makes it difficult to extrapolate knowledge about risk factors from one country to another.

Other countries have experienced similar difficulties in detecting MRSA by targeted screening as those ascertained in the present study. In London, where the MRSA prevalence is around 2%, the previous target policy would have detected 55% of MRSA cases upon admission [13], in Scotland 50-53% [14], and in Switzerland 22% [15] by using question-based targeted MRSA screening strategies; all of these are quite similar to our results.

Our findings have clinical implications. The clinical importance of not isolating a majority of MRSA carriers, while other patients are isolated unnecessarily, has been discussed elsewhere [5].The study suggests that the rather comprehensive DHMA screening model with 19 variables may be simplified to a five-questions model and still maintain the same or a higher sensitivity. This is in accordance with more simple, targeted strategies used in other countries [14-16].

The study also reveals that it may be difficult to develop a highly accurate question-based, targeted screening model for MRSA. Further development of targeted MRSA screening is difficult and requires large patient groups since the occurrence of MRSA carriage is low among the admitted patients. Furthermore, since the prevalence of MRSA in any ED depends on the population exposure to MRSA, e.g. contact to pig farms and other countries, the value of an MRSA screening questionnaire varies from one area to another, and it may not apply to an entire nation.

Controversy exists as to whether universal screening, which is costly but simple and may detect more MRSA carriers, should replace exposure-based targeted screening, which might be both complex, time-consuming and may lead to missed carriers [14]. In England, universal screening has replaced targeted screening [13], but the strategy is challenged by studies finding that a screening strategy based on clinical risk is more pragmatic and more cost-effective [17]. In Scotland, targeted

TABLE 4

Comparison of the Danish Health and Medicines Authority s' model and an alternative screening model for methicillin resistant *Staphylococcus aureus*.

	Basic DHMA model, 4 questions	Full DHMA model, 19 questions	New model, 5 questions
Patients, n			
Screening question positive	76	507	390
True MRSA	11	11	11
True positive	2	6	8
True negative	1,135	708	827
False positive	74	501	382
False negative	9	5	3
Total	1,220	1,220	1,220
Screening values			
Sensitivity, median (95% CI)	18 (2-52)	55 (23-83)	73 (39-94)
Specificity, median (95% CI)	94 (92-95)	59 (56-61)	68 (67-71)
Positive predictive value, median (95% CI)	3 (0-9)	1 (0-2)	2 (0-4)
Negative predictive value, median (95% CI)	99 (98-100)	99 (98-100)	99 (99-100)
Likelihood ratios			
Likelihood ratio of positive test, median (95% CI)	3.0 (0.8-11)	1.3 (0.8-2.3)	2.3 (1.6-3.3)
Likelihood ratio of negative test, median (95% CI)	0.9 (0.7-1.2)	0.8 (0.4-1.5)	0.4 (0.1-1.05)

CI = confidence interval; DHMA = Danish Health and Medicines Authority; MRSA = methicillin-resistant *Staphylococcus aureus*.

screening for patients based on three questions achieved detection rates of 50-53%, similar to universal screening, and targeted screening has now been implemented [14]. In Ireland, evaluation of universal versus targeted MRSA screening strategies concluded that targeted screening of at-risk patients on admission remains the most efficient strategy for early identification of MRSA-positive patients, and only few additional patients would be identified using a universal screening approach [18].

In Denmark, where the prevalence of MRSA remains low, the in-hospital transmission of community-acquired MRSA is nine times lower than hospital-acquired MRSA [19]. Rather than aiming at a general MRSA screening at hospital level, this finding encourages continued use of targeted screening and it emphasises the importance of standard precautions for the prevention of MRSA transmission, which has been shown to significantly reduce in-hospital MRSA transmission [15, 20].

The present study has some limitations. Despite a three-month inclusion period, only 11 MRSA patients were identified, which precluded multivariate analyses and resulted in inability to prove a better performance of a new screening model based on fewer questions than the currently used DHMA screening. Furthermore, since the new model for detection of MRSA was developed in the present study population, another population is required to evaluate the reproducibility of the results. Finally, the study group only represents two thirds

of all the admitted patients, which in some respects differed from the non-participating patients; and this might have affected the validity of the results. This aspect has been discussed elsewhere [5].

CONCLUSIONS

We found that the DHMA-targeted screening for MRSA detection contained only few questions with a significant association with MRSA carrier stage. A model based on only five questions seems to improve, though not significantly so, the MRSA screening in this population. In order to develop a simple and more effective screening model, we recommend that our findings be tested in another ED patient population.

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