

Age and Ageing 2005; 34: 456–462
doi:10.1093/ageing/afi135
Published electronically 11 July 2005

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Prevalence and prediction of previously unknown MRSA carriage on admission to a geriatric hospital

HUGO SAX¹, STEPHAN HARBARTH¹, GAETAN GAVAZZI², NICOLE HENRY¹, JACQUES SCHRENZEL³,
PETER ROHNER³, JEAN PIERRE MICHEL², DIDIER PITTET¹

¹Infection Control Program, ²Department of Geriatrics, and ³Microbiology Laboratory, Geneva University Hospitals, Geneva, Switzerland

Address correspondence to: S. Harbarth, Infection Control Program, Geneva University Hospitals, 24 rue Micheli-du-Crest, 1211 Geneva 14, Switzerland. Fax: (+41) 22 372 3987. Email: stephan.harbarth@hcuge.ch

Abstract

Objectives: to determine the prevalence and characteristics of previously unknown methicillin-resistant *Staphylococcus aureus* (MRSA) carriers at admission.

Design: two prospective case–control studies.

Subjects: 1,621 elderly patients were screened for MRSA carriage within 24 hours after admission to a geriatric hospital in Geneva, Switzerland.

Methods: risk factors associated with previously unknown MRSA carriage were determined in the derivation group, and the resulting risk score was evaluated in the validation cohort using logistic regression analysis.

Results: prevalence of MRSA carriage at admission increased from 7.3% (53/724 patients) in 2001 to 8.7% (78/897 patients) in 2003, with a corresponding prevalence of unknown MRSA carriers of 4.6 and 5.8%, respectively. Three variables were independently associated with previously unknown MRSA carriage: recent antibiotic treatment (adjusted OR (aOR) 2.3; 95% CI 1.0–5.1), intra-hospital transfer (aOR 2.5; 95% CI 1.2–5.3), and hospitalization in the past 2 years (aOR 2.7; 95% CI 1.1–6.7). In the validation cohort, the probability of MRSA carriage increased across risk scores: 0 point, 4% prevalence (6/146); 1 point, 15% (21/136); and ≥ 2 points, 31% (21/68; $P < 0.001$). The risk score showed good discrimination and calibration in both groups.

Conclusions: our risk score, which used a simple additive point system to estimate the likelihood of unknown MRSA carriage, had good accuracy and generalised well in an independent sample of patients. Once validated in a clinical trial, our risk score may be used as a tool to optimise MRSA control.

Keywords: MRSA, prevalence, infection control, carriage, prediction, aged, elderly

Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) represents an important burden on sub-acute and chronic care facilities [1]. Epidemiologic surveys indicate that rates of MRSA cross-infection are increasing in these settings [2–4]. Since MRSA carriers without symptomatic infection are an important reservoir and source of spread, risk profiles to identify elderly patients at high risk of MRSA carriage have been developed [5–8]. Despite the great merit of these studies, they were often limited to nursing home residents and did not attempt to develop practical tools to predict on-

admission MRSA carriage in elderly patients hospitalised in a geriatric hospital.

Between 1990 and 2000, the proportion of MRSA among all clinical *S. aureus* isolates at our geriatric university hospital substantially increased from <1 to $>50\%$ [9]. Therefore, in April 2001, a cross-sectional screening survey was performed. Among 260 screened patients, 48 MRSA carriers (18%) were detected. Only 15 out of 48 (31%) patients had previously been identified as MRSA carriers.

Therefore, we undertook two prospective case–control studies to determine the prevalence of newly identified MRSA carriage on admission and the proportion of unknown

MRSA carriers that would have been missed without admission screening. Moreover, the present study describes the derivation and the validation of a practical model to identify previously unknown MRSA carriers on admission to a geriatric hospital.

Methods

Setting and study population

The geriatric hospital of the Geneva University Hospitals is a university-based institution with 294 beds, which serves as the primary and tertiary geriatric care centre for the greater Geneva area. Two-thirds of patients are directly admitted from the community; one-third are transfers from the acute care setting or from nursing homes. During the study period, approximately 2,600 patients (mean age 83 years) were hospitalised each year, with a median length of stay of 36 days.

Study design

We undertook two prospective case-control studies: the first period (derivation cohort) extended from 1 July through 31 October 2001, the second period (validation cohort) from 1 March through 31 August 2003. During these time periods, all consecutive hospitalised patients were screened for MRSA carriage within 24 hours after admission. Patients were excluded if they refused screening or stayed <24 hours.

Screening procedure

Swabs were performed using a cotton stick moistened with sterile 0.9% saline solution. They were collected from both anterior nares and perineal region in all patients and, if present, from catheter insertion sites, skin lesions and urine in catheterised patients [9].

Microbiological procedure

All swabs were processed in the central laboratory within 24 hours. They were first streaked onto ORSA plates (Oxacillin Resistance Screening Agar, Oxoid, Basingstoke, UK) and then suspended in 2 ml of colistin-salt broth (brain-heart infusion with 10 µg of colistin/ml and 2.5% NaCl), as a back-up medium. Suspect colonies were confirmed by Pastorex agglutination (Bio-Rad, Reinach, Switzerland), positive reaction on DNase agar, and growth on Mueller-Hinton oxacillin agar (6 µg of oxacillin/ml) according to NCCLS standards [10]. The presence of MRSA was confirmed using the Vitek 2 identification and susceptibility testing cards for Gram-positive bacteria (bioMérieux, Marcy l'Etoile, France).

Data collection

From medical records, we extracted information on socio-demographic data, admission date, diabetes, McCabe and Jackson score of severity of underlying illness [11], Charlson comorbidity index [12], patient's prior location and transfer status, previous hospitalisation in the past 2 years (excluding the current hospital stay if the patient was transferred from acute care), previous surgery within 1 year, presence of

urinary catheter or skin lesions on admission, past history of MRSA carriage and recent antibiotic treatment within the last month.

Definitions

A known MRSA carrier was defined as any patient with at least one culture result positive for MRSA prior to the present admission (since 1994). A previously unknown MRSA case was a patient in whom MRSA was isolated for the first time on hospital admission.

Retrieval of previously known MRSA-positive patients

Since 1994, the names of all MRSA-positive patients have been kept in a secure, computerised database at our institution. An automatic alert is generated each time a previously identified MRSA carrier is re-admitted, in order to rapidly install contact precautions [9]. When no previous admission to our institution was found in new MRSA carriers, we interviewed the patient or his primary care physician to determine whether MRSA carriage had previously been identified in another institution or in the outpatient setting.

Statistical analysis

Results are expressed as mean values \pm SD. For contrasts of dimensional variables, the Student's *t* test and the Wilcoxon rank-sum test were used. To compare proportions, we used a χ^2 -test or Fisher's exact test, when indicated. Continuous variables were converted to categorical variables if they did not fulfil criteria of linearity.

The primary outcome of interest was previously unknown MRSA carriage on admission. If a patient was admitted more than once during the study period, only the first admission was included in the logistic regression analysis. Patients previously identified as MRSA carriers were excluded from the prediction model. Patient characteristics were computed separately for the derivation and validation set. For the derivation cohort, all 641 patients without past history of MRSA carriage served as controls. For the validation set, we randomly selected 302 control patients without history of MRSA carriage who were admitted during the same time period.

The association between independent variables and previously unknown MRSA carrier status was evaluated by logistic regression indicating the bivariate odds ratios (ORs) with their 95% confidence intervals (95% CI). Variables reaching ORs of ≥ 2 and *P* values ≤ 0.1 were entered in a forward stepwise logistic regression analysis, generating a prediction model of previously unknown MRSA carriage. The predictive accuracy and calibration of the models was assessed using area under the receiver operating curves (AUC) and Hosmer-Lemeshow goodness-of-fit tests [13, 14].

To facilitate the use of the model in clinical practice, the ORs associated with the identified predictors in the logistic regression model were transformed into point scores to obtain an aggregate score by adding up points. The beta coefficients of all independent risk factors were similar in

magnitude and, therefore, risk stratification was performed by a simple count of the number of predictors.

Statistics were run with the STATA 8.0 software package (STATA Corp., College Station, TX). *P* values <0.05 (two-tailed) were considered significant.

Results

Cohort assembly

During both study periods, 1,714 patients (derivation cohort 772; validation cohort 942) were admitted for >24 hours. The compliance with MRSA screening was excellent: 724 out of 772 patients (94%) and 897 out of 942 patients (95%) were screened, respectively.

MRSA carriage on admission

Prevalence of MRSA carriage at time of admission increased from 7.3% (53/724 patients) in 2001 to 8.7% (78/897 patients) in 2003. Of all MRSA carriers, 31 out of 53 (58%) and 48 out of 78 (62%) were not known for a past history of MRSA colonisation. After excluding 52 MRSA-positive patients and 64 formerly MRSA-positive patients who had successfully been decolonised and were MRSA-free on admission, the true prevalence of unknown MRSA carriers on admission was 4.6% (31/672) and 5.8% (48/833), respectively.

In both periods, four patients without previously identified MRSA carriage had an active MRSA infection on admission. Thus, using only clinical isolates of infected sites and targeted screening of previously known MRSA carriers, 51% (27/53) and 56% (44/78) of all MRSA carriers would have been missed without the general screening policy on admission.

Baseline features

Baseline features of the two study populations and characteristics of previously unknown MRSA carriers compared with MRSA-free patients are shown in Table 1. The derivation and validation cohorts were similar with respect to age, sex, Charlson comorbidity index, prior surgery, transfer from acute care or nursing home, recent antibiotic treatment, and presence of skin lesions. Significantly more patients in the derivation cohort than in the validation cohort had a rapidly or ultimately fatal disease ($P=0.004$) and had previously been hospitalised ($P=0.01$). The validation cohort had a greater proportion of patients with diabetes ($P<0.001$) or urinary catheters ($P<0.001$) than did the derivation cohort.

In both cohorts, newly identified MRSA carriers were more sick, had more previous hospitalisations, surgical interventions, antibiotic treatments and urinary catheters on admission than non-carriers.

Development and validation of the prediction model

Table 2 presents the results of the bivariate and multivariate logistic regression analysis for the derivation cohort. The final risk model to predict previously unknown MRSA carriage consisted of the following three variables: recent antibiotic treatment (adjusted OR 2.3; 95% CI 1.0–5.1;

$P=0.05$), intra-hospital transfer (adjusted OR 2.5; 95% CI 1.2–5.3; $P=0.02$), and hospitalisation within the last 2 years (adjusted OR 2.7; 95% CI 1.1–6.7; $P=0.03$). Four of the 31 cases had none of these risk factors (sensitivity 87%; specificity 30%; negative predictive value 95%). The model had a corresponding AUC-value of 0.71 (95% CI 0.61–0.80). In the validation cohort, 6 out of 48 cases had no characteristic included in the final prediction model (sensitivity 88%; specificity 46%; AUC-value 0.72; 95% CI 0.65–0.79).

Risk score

Using the three independently predictive variables from the logistic regression model, we created a risk score by stratifying patients who had 0, 1 or ≥ 2 of these risk factors. For example, an 82-year-old male patient with several hospitalisations due to prostate cancer who received ciprofloxacin 3 weeks prior to admission and spent 8 days in urology before transfer to the geriatric hospital had a risk score of $1+1+1=3$.

For the derivation cohort, the observed proportions of patients with newly identified MRSA carriage were 2% (4 out of 199) in patients with none of the risk factors, 3% (8 out of 311) in patients with 1 risk factor and 12% (19 out of 162) in patients with ≥ 2 risk factors ($P<0.001$). For the validation cohort, which was based on a case-control study of 350 patients, the observed proportions were 4% (6 out of 146) for score 0, 15% (21 out of 136) for score 1 and 31% (21 out of 68) for a score ≥ 2 ($P<0.001$). The Hosmer-Lemeshow test yielded a *P* value of 0.34 for the derivation cohort and a *P* value of 0.31 for the validation cohort, demonstrating good fit of the prediction model.

Operating characteristics

Table 3 presents the operating characteristics of the risk score for different cut points to predict previously unknown MRSA carriage on admission. Limiting screening at admission to patients with ≥ 1 risk factor would have reduced the screening volume by at least 30% and would have identified 87% (27/31) of all previously unknown carriers in the derivation cohort and 88% (42/48) in the validation cohort. Limiting on-admission screening to patients with ≥ 2 risk factors (24% and 19% of patients in the derivation and validation cohort, respectively) would have identified 19 (61%) and 21 (44%) MRSA carriers in both cohorts.

Discussion

In this study, we have derived and validated a model to predict previously unknown MRSA carriage on admission to a geriatric hospital. Three patient characteristics predicted MRSA carriage and stratified patients into risk groups. The derived risk score worked well in the validation cohort in terms of both calibration and discrimination.

Earlier work has demonstrated the challenge of estimating risk factors of MRSA carriage on admission to geriatric hospitals. For instance, Eveillard and colleagues performed a 5-week on-admission screening study in two geriatric wards in France [15]. Variables independently associated with MRSA carriage were hospitalisation within the last 6 months and open skin lesions, whereas hospital transfer and recent antibiotic therapy were not associated with MRSA

Table 1. Patient characteristics, by cohort and MRSA status at admission

Characteristic	Derivation cohort				Validation cohort				P value ^a
	New MRSA-positive case	MRSA negative	Total cohort		New MRSA-positive case	MRSA negative	Total cohort		
N	31	641	672		48	302	350		
Age, years (± SD)	84 (±7)	84 (±7)	84 (±7)		85 (±6)	84 (±7)	85 (±7)		>0.2
Male gender, n (%)	7 (23)	186 (29)	193 (29)		24 (50) ^b	89 (29)	113 (32)		>0.2
Previous hospitalisation, n (%)	23 (74) ^b	352 (55)	375 (56)		35 (73) ^b	132 (44)	167 (48)		0.01
Previous surgery, n (%)	11 (35) ^b	71 (11)	82 (12)		12 (25) ^b	29 (10)	41 (12)		>0.2
Intra-hospital transfer, n (%)	15 (48) ^b	146 (23)	161 (24)		16 (33) ^b	52 (17)	68 (19)		0.1
Nursing home transfer, n (%)	1 (3)	63 (10)	64 (9.5)		4 (8)	28 (9)	32 (9.1)		>0.2
Presence of diabetes, n (%)	5 (16)	60 (9)	65 (10)		10 (21)	54 (18)	64 (18)		<0.001
Charlson index (± SD)	2.6 (±2.1) ^b	2.0 (±1.8)	2.0 (±1.8)		2.5 (±1.9) ^b	1.8 (±1.8)	1.9 (±1.8)		>0.2
Rapidly or ultimately fatal disease, n (%) ^c	8 (26)	134 (21)	142 (21)		12 (25) ^b	36 (12)	48 (14)		0.004
Recent antibiotic therapy, n (%)	10 (32) ^b	92 (14)	102 (15)		16 (33) ^b	28 (9)	44 (13)		>0.2
On admission, presence of:									
Urinary catheter, n (%)	5 (16) ^b	35 (6)	40 (6.0)		16 (33) ^b	26 (9)	42 (12)		<0.001
Open skin lesion, n (%)	7 (23)	84 (13)	91 (14)		8 (17)	25 (8)	33 (9.4)		0.07

NB. Previously identified MRSA carriers have been excluded from this analysis.

^aIndicates P values for the comparison of the total cohorts (derivation versus validation dataset).

^bIndicates a P value <0.05 for comparison of patients who are MRSA-positive and MRSA-negative within each respective cohort.

^cAccording to the McCabe and Jackson Score [11].

Table 2. Risk factors associated with newly identified MRSA carriage at admission to a geriatric hospital, excluding formerly known MRSA carriers (bivariate and multivariate logistic regression analysis in the derivation cohort)

Risk factor	Odds ratio (95% CI)	
	Bivariate	Multivariate
Male sex	0.7 (0.3–1.7)	
Age \geq 80 years	1.2 (0.5–2.7)	
Previous hospitalisation (<2 years)	2.9 (1.2–7.3)	2.7 (1.1–6.7)
Prior surgery (past 12 months) ^a	4.4 (2.0–9.6)	
Charlson score (per 1-point increment)	1.2 (1.0–1.4)	
Ultimately or rapidly fatal disease	1.3 (0.6–3.0)	
Diabetes mellitus	1.8 (0.7–4.8)	
Recent antibiotic therapy (<1 month)	2.8 (1.3–6.2)	2.3 (1.0–5.1)
Origin of patient		
Home	0.6 (0.3–1.5)	
Nursing home	0.3 (0.1–2.3)	
Intra-hospital transfer	3.2 (1.5–6.6)	2.5 (1.2–5.3)
Presence at admission of		
Peripheral catheter	1.7 (0.7–3.8)	
Urinary catheter ^b	3.2 (1.2–8.8)	
Open skin lesions	1.9 (0.8–4.6)	

^aThis variable showed strong collinearity with the variable ‘previous hospitalisation’ and was therefore excluded from the multivariate analysis.

^bThis variable did not increase the accuracy of the multivariate model in the derivation set.

Table 3. Yield of the risk score for different screening cut points to predict previously unknown MRSA carriage at admission to a geriatric hospital

Score (number of risk factors)	Sensitivity	Patients to be screened
Derivation cohort		
\geq 0	100% (31/31)	100% (672/672)
\geq 1	87% (27/31)	70% (473/672)
\geq 2	61% (19/31)	24% (162/672)
Validation cohort		
\geq 0	100% (48/48)	100% (350/350)
\geq 1	88% (42/48)	58% (204/350)
\geq 2	44% (21/48)	19% (68/350)

carriage. Unfortunately, this study, like others [16, 17], did not discriminate between known and unknown MRSA carriers on admission.

Other studies have identified numerous risk factors for MRSA colonisation in elderly patients during hospitalisation, including length of stay, previous surgery, functional status, presence of skin lesions or invasive devices, prior antibiotic exposure, severe comorbidity, and proximity to an already infected or colonised patient [3, 5, 6, 8, 16, 18–20]. Elderly patients accumulate many of these risk factors due to frailty and frequent contact with the health care system. Although these studies were useful in identifying patients at risk of nosocomial MRSA colonisation or infection, none of them had been validated prospectively and targeted specifically previously unknown MRSA carriers on admission. Therefore, our risk score offers an improvement over existing studies, because it had a larger sample size, was validated on a prospectively collected database and developed a simple point score to stratify elderly patients into low- and high-risk groups for unidentified MRSA carriage.

The few investigations that have specifically evaluated the prevalence of MRSA carriage on admission to sub-acute or chronic care facilities differ from our study in important ways, so comparisons are limited. However, our study confirms that the prevalence of previously unknown MRSA carriage at admission to geriatric care is high [16, 21]. It increased from 4.6% in 2001 to 5.8% in 2003, reflecting endemic MRSA transmission in the Geneva health care setting [22, 23]. Previously reported prevalence of unknown MRSA carriage at admission ranged between 7.8 and 13.6% [2, 4, 24].

Screening for MRSA carriage in the geriatric setting remains a controversial issue, since the rates of MRSA infections and infection-related deaths are low [19, 25, 26]. Yet MRSA endemicity in any chronic care facility may result in adverse outcomes, increased use of glycopeptides and emergence of vancomycin resistance [27]. Although not supported by strong evidence, some anecdotal reports have demonstrated that programmes combining screening, cohorting, early implementation of contact isolation and topical decolonisation could reduce the rate of MRSA cross-infection in geriatric facilities [28, 29]. For instance, Talon *et al.* demonstrated the usefulness of systematic screening on admission, allowing early recognition of patients with MRSA [2]. Although MRSA carriage in a geriatric hospital has less dramatic clinical implications, these authors argued that it may act as a reservoir for the acute-care setting. Therefore, identification of this unknown reservoir may have an impact on the entire healthcare network [21]. Nevertheless, many authors consider screening only high-risk patients would be sufficient [21]. It would be more cost-effective, but requires readily available risk factors to be clearly established. Our risk score could be a starting point for further studies, investigating the clinical and financial implications of a targeted screening programme.

This study has some limitations that deserve comment. The prognostic model was derived and validated in one centre and may not reflect the epidemiology of MRSA in other settings. However, our risk score had good discrimination and calibration, making it likely that the score may be generalisable to other locations. Moreover, the prevalence of community-acquired MRSA was not investigated. Previous analyses have shown, however, that community-acquired MRSA remains negligible in the Swiss elderly population [30].

In summary, our risk score demonstrated good accuracy and provides a useful prediction tool to estimate the likelihood of unknown MRSA carriage on admission to a geriatric hospital. Assuming population characteristics similar to those of our cohort, the use of our score could decrease the volume of MRSA screening cultures by at least 30%. Once validated in a large intervention trial, it may be used as an instrument to optimise MRSA control in the sub-acute and chronic care setting.

Key points

- The prevalence of previously unknown MRSA carriage at admission to geriatric care is high.
- Three patient characteristics predicted unknown MRSA carriage on admission and stratified patients into risk groups.
- The derived risk score had good accuracy and generalised well in an independent sample of patients. It could decrease the volume of MRSA screening cultures by at least 30%.

Acknowledgements

The authors would like to acknowledge the financial support of The Geneva University Hospitals (CI 70897). We thank the personnel of the Department of Geriatrics for their full support and help.

Informed consent

The study protocol was approved by the institutional review board as a continuous quality improvement project. No informed consent was therefore required.

Conflicts of interest

None.

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Received 3 December 2004; accepted in revised form 24 May 2005

Age and Ageing 2005; 34: 462–466
doi:10.1093/ageing/afi139
Published electronically 25 July 2005

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Chronic pain as perceived by older people: a qualitative study

B. SOFAER¹, A. P. MOORE¹, I. HOLLOWAY², J. M. LAMBERTY³, T. A. S. THORP³, J. O'DWYER⁴

¹Clinical Research Centre for Health Professions, University of Brighton, Eastbourne, UK

²Institute of Health and Community Studies, Boumemouth University, UK

³Pain Management Unit, Brighton and Sussex University Hospital Trust, Brighton, UK

⁴Pain Clinic, Worthing and Southlands NHS Trust, Worthing, UK

Address correspondence to: B. Sofaer. Email: b.sofaer@bton.ac.uk

Abstract

Background: the practical issues confronting older people who suffer chronic pain may not be tackled in a pain clinic setting and little is known of their strategies for coping. They seem to have little or no information on how to improve the quality of their lives or on resources available to them.

Aim: the aim of this study was to ascertain from older people the practical, physical and psychosocial limitations they faced because of chronic pain, and the strategies they used to deal with them.

Method: a qualitative approach to generating data was chosen using a Grounded Theory approach and unstructured interviews. Sixty-three people ranging from 60 to 87 years of age participated in the study. Audio-tapes were transcribed verbatim. The material was coded and collapsed into themes.

Results: two main themes emerged: (i) the desire for independence and control; and (ii) adaptation to a life with chronic pain. The valuing of independence is in line with previous findings. With only three exceptions none of the participants were certain how or where to get help with practical issues and so they lived in fear of loss of their independence. Several sub-categories formed the theme of adaptation. These were acceptance and non-acceptance, pacing oneself, helping other people, the use of prayer and 'looking good and feeling good'. When independence and control is effective, older people may adapt better to chronic pain.