ORIGINAL ARTICLE 10.1111/j.1469-0691.2008.02060.x

Prevalence of methicillin-resistant *Staphylococcus aureus* and factors associated with colonization among residents in community long-term-care facilities in Spain

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ABSTRACT

Hospital-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) strains are no longer limited to acute-care hospitals but have now spread to other healthcare settings such as long-term-care facilities (LTCFs), in most of which they are endemic. In Europe, few studies have addressed the MRSA situation in LTCFs. A cross-sectional study to determine MRSA prevalence and factors associated with *S. aureus* carriage in community LTCF residents is reported here. Nasal and decubitus ulcer cultures were performed for residents of nine community LTCFs. Residents were classified as MRSA carriers, methicillin-susceptible *S. aureus* carriers and non-carriers. Overall, 1377 nasal swabs and 82 decubitus ulcer cultures were performed. MRSA was isolated from 15.5% and 59.0% of the former and latter, respectively. The prevalence of MRSA colonization was 16.8% (95% CI 14.9–18.8), varying from 6.7% to 35.8% ($p < 0.001$) among LTCFs. Several independent variables were related to MRSA colonization. It is noteworthy that residents in an LTCF with fewer than 150 beds had at least a two-fold higher probability of being MRSA carriers. Modifiable factors were medical devices, decubitus ulcers and previous antibiotic treatment. An age of 85 years or older, a Charlson index ≥2 and transfer from an acute-care facility were non-modifiable factors also related to MRSA colonization. A high MRSA prevalence among residents in community LTCFs in Spain, with great variability among facilities, was found. The factors identified as being associated with MRSA colonization could be prevented by the implementation of several measures. Control strategies need to be coordinated between LTCFs and acute-care hospitals.

Keywords Epidemiology, geriatrics, long-term care, methicillin-resistant *Staphylococcus aureus*, MRSA

Original Submission: 1 October 2007; **Revised Submission:** 5 December 2007; **Accepted:** 4 April 2008

Edited by J. Van Eldere

Clin Microbiol Infect 2008; **14:** 867–872

INTRODUCTION

The introduction and successful dissemination of methicillin-resistant *Staphylococcus aureus* (MRSA) in acute-care hospitals in Spain was reported two decades ago [1,2], and it has become the major problem related to multiresistant microorganisms in the healthcare system. Furthermore, MRSA strains have spread into facilities related to the healthcare setting, such as long-term-care facilities (LTCFs), and are endemic in the majority of them [3,4]. Control measures to limit MRSA spread in LTCFs are controversial [5]. Most studies on the prevalence of MRSA colonization in LTCFs have been performed in Veterans' Affairs facilities in the USA; however, the epidemiology of MRSA in community LTCFs should be differentiated from those facilities [6]. In Europe, some studies have

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recently evaluated the prevalence of MRSA colonization in these facilities [7–10]. In Spain, only a few studies have addressed the interaction of MRSA strains between hospitals and other healthcare facilities [11–14]. An interesting finding is that patients with *S. aureus* bloodstream infection diagnosed at hospital admission following referral from an LTCF were associated with the presence of methicillin resistance [14]. Patients in whom MRSA carriage acquired during a previous hospital admission or stay in a LTCF was persistent were found to be at high risk of MRSA infection, although a low prevalence of these infections has been reported in LTCF residents [15,16]. Transfer of patients from acute-care hospitals to LTCFs is often delayed because of MRSA carriage. To determine the extent of this situation, a cross-sectional study was conducted in a large number of residents in community LTCFs for the elderly. The aims were to determine the prevalence of MRSA colonization and to define factors associated with *S. aureus* carriage in this population.

MATERIALS AND METHODS

Study design

This was a cross-sectional prevalence survey.

Study population and characteristics of community LTCFs

The study was performed in November 2005, in residents of community LTCFs for the elderly, located in two communities in Spain (Catalonia and the Balearic Islands).

Nine LTCFs with a total of 1586 beds (median 120; range 72–552 beds) were included in the study. Five of these are allocated to the geographical area of influence of a 900-bed acute-care hospital (Hospital Universitari de Bellvitge), three to that of a 490-bed hospital (Corporació Sanitària Parc Taulí) and one to that of an 800-bed acute-care hospital (Hospital Universitari Son Dureta). These facilities provide care for elderly permanent residents who may be disabled or infirm. All of these facilities have their own medical services, and most include a dementia ward. Residents are accommodated in rooms with one, two or three beds.

These LTCFs do not use active surveillance cultures to detect MRSA carriage, and decolonization procedures are not routinely performed. All facilities take standard precautions for patient care, and contact precautionary measures are occasionally applied for those patients colonized or infected by MRSA. A common policy of all the facilities is that known MRSA carriers are not denied admission.

Data collected

Medical charts were reviewed for basic clinical and epidemiological information. The following data were obtained for all residents: age, sex, facility and date of admission, underlying diseases (Charlson index) [17], functional status (Barthel index) [18], prior MRSA isolation, presence of decubitus ulcers, previous antibiotic treatment in the last 3 months, use of invasive devices (peripheral venous catheter, nasogastric tube and urinary catheter) in the last 7 days, and the presence of current infections.

Microbiological methods

To assess MRSA colonization, samples for cultures were obtained from anterior nares and third-degree or higher-degree decubitus ulcers, when applicable. These areas were swabbed with sterile cotton-tipped applicator sticks, which were immediately placed into Stuart transport medium. Nasal and decubitus ulcer swabs were first plated onto coagulase–mannitol agar plates and selective MRSA agar medium (MRSA Select; Bio-Rad Laboratories, Madrid, Spain). Swabs were then inoculated into staphylococcal enrichment broth composed of brain–heart infusion plus 7% NaCl. After 24 h of incubation at 35°C, the broth was subcultured onto coagulase–mannitol and MRSA Select plates. All plates were incubated for 48 h and inspected daily. Suspected *S. aureus* colonies were identified by the latex agglutination test (Pastorex® Staph-plus; Bio-Rad Laboratories) and DNase production (DNase Test Agar; Biomedics, Madrid, Spain). Methicillin resistance was determined by the cefoxitin disk diffusion method following CLSI recommendations. Testing for antimicrobial susceptibility to penicillin, oxacillin, cefoxitin, erythromycin, clindamycin, gentamicin, tobramicin, rifampin, tetracycline, trimethoprim–sulphamethoxazole, chloramphenicol, ciprofloxacin, vancomycin, teicoplanin, mupirocine, fusidic acid, quinupristin–dalfopristin and linezolid was performed by the disk diffusion method. [19].

Statistical analysis

For the purpose of this study and on the basis of the results, residents were classified as MRSA carriers, methicillin-susceptible *S. aureus* (MSSA) carriers and non-carriers. Following the methodology suggested by Harris *et al.* [20], two separate analyses were performed to compare, first, MSSA carriers with non-carriers, and second, MRSA carriers with non-carriers. Results were interpreted as follows: significant variables in the former analysis were considered to represent unique factors associated with MSSA colonization, and those in the second were considered to be factors associated with MRSA colonization. Variables with statistical significance in both analyses were considered to be factors related to *S. aureus* carriage.

Categorical variables were analyzed with chi-square tests or Fisher's exact test, as appropriate. Continuous variables were analyzed with Student's *t*-test or non-parametric tests. Variables associated with MRSA carriage with a probability equal to or less than 0.1 were further examined using advanced multivariable logistic regression modelling. All statistical tests were two-tailed, and p-values <0.05 were considered to be significant. SPSS package version 12.0 was used.

Approval for the study was obtained from the Research Ethics Committee of the Hospital Universitari Bellvitge. No written informed consent was obtained, because the study met the criteria for a waiver of this requirement.

Table 1. Prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization and clinical characteristics of residents in different community long-term-care facilities included in the study

	Centres (number of beds)									
	1 (220)	2 (120)	3 (552)	4 (72)	5 (101)	6 (94)	7 (121)	8 (124)	9 (182)	Total (1586)
Residents, *n*	195	115	466	72	95	89	109	73	163	1377
Male sex (%)	35.4	21.7	31.8	18.1	22.1	15.7	39.4	26.0	25.8	28.6
Mean age (years)	76.1	82.9	82.2	83.9	83.2	83.9	77.2	83.0	81.3	81.2
Charlson index ≥2%	73.1	47.0	35.2	47.2	67.4	58.0	70.4	40.3	66.7	52.8
Barthel index <30%	55.4	23.5	22.2	27.8	44.2	40.9	75.2	19.4	14.2	33.4
Decubitus ulcers (%)	12.3	6.1	5.8	2.8	8.4	8.0	30.2	1.4	1.8	8.1
Invasive devices use (%)	9.2	2.6	1.7	1.4	3.2	2.3	27.6	5.6	0	5.0
Prior antibiotic treatment (%)	29.7	22.6	10.3	12.5	23.2	18.2	44.0	40.8	36.2	22.5
Prior MRSA carriage (%)	21.8	1.7	1.3	6.9	6.3	0	2.8	0	8.0	5.6
Stay ≥6 months (%)	72.4	92.2	91.8	93.1	90.4	93.0	60.2	54.9	94.4	85.1
MSSA colonization (%)	16.9	8.7	24.3	16.7	15.8	24.7	29.4	27.4	11.8	16.7
MRSA colonization (%)	22.6	24.3	8.4	15.3	28.4	6.7	35.8	27.4	10.4	16.8

MSSA, methicillin-susceptible *Staphylococcus aureus*.

RESULTS

Characteristics of patients

All residents present on the day of the study (1377) were included in the analyses. Characteristics of residents as ascribed by community LTCFs are shown in Table 1. Among them, 71.4% were women; the mean age was 81.2 years (SD 9.9 years). Underlying conditions were present in 1138 (82.6%) residents. The most frequent of these conditions were dementia in 548 (39.8%) residents, diabetes mellitus in 321 (23.3%), chronic obstructive pulmonary disease in 206 (15%), solid tumours in 194 (14.1%), and hemiplegia in 169 (12.3%). The median Charlson index was 2 (interquartile range: 1–3) points, and the mean Barthel index was 54.16 (SD 38.3) points.

Prevalence of MRSA colonization

Cultures were performed from a total of 1377 nasal swabs and 82 decubitus ulcer swabs. *S. aureus* carriage was observed in 33.5% of the residents; 50.0% showed methicillin resistance. Overall, 231 (16.8%) residents were colonized by MRSA, 230 (16.7%) were colonized by MSSA, and the remaining 916 (66.5%) were non-carriers. The prevalence of MRSA colonization among residents was 16.8% (95% CI 14.9–18.8), varying from 6.7% to 35.8% ($p < 0.001$) among the LTCFs (Table 1). MRSA was isolated from 213 (15.5%) nasal swabs and from 49 (59.0%) decubitus ulcers. Eighteen residents with decubitus ulcers colonized by MRSA had a concomitant negative nasal swab, and in 31 residents both sites were colonized. Prior MRSA carriage was known in 77 (33.3% of the residents colonized by MRSA). No MRSA infection was recorded during the cross-sectional study.

Factors associated with *S. aureus* colonization in community LTCF residents

Table 2 shows bivariate and multivariate analysis comparing MRSA carriers with non-MRSA carriers. MSSA carriers had a higher Charlson index, more often had invasive devices, and more often had been transferred from hospitals and resided in facilities with <150 beds, as compared with non-carriers (data not shown). Variables associated with MRSA colonization were age of 85 years or more, existence of decubitus ulcers, previous antibiotic treatment, presence of invasive devices, comorbidity, transfer from an acute-care hospital, and residence in facilities with <150 beds. Multivariate analysis to identify independent factors associated with MSSA and MRSA colonization are shown in Tables 3 and 4, respectively. A comparison of the two models showed that for MSSA carriers, a Charlson index ≥2 points and residence in a facility with <150 beds remained independent factors. On the other hand, several independent variables were related to MRSA colonization. It is noteworthy that residents of a facility with <150 beds had at least a two-fold higher probability of being MRSA carriers (OR 2.10; 95% CI 1.52–2.92). Other modifiable factors were medical devices, presence of decubitus ulcers, and previous antibiotic treatment. Age of 85 years or more, a Charlson index ≥2 points and transfer from an acute-care hospital were non-modifiable factors also related to MRSA colonization.

Table 2. Bivariate and multivariate analysis of associated factors for methicillin-resistant *Staphylococcus aureus* (MRSA) colonization

	MRSA carriers, n = 231 n (%)	Non-MRSA carriers, n = 1146 n (%)	Univariate OR MRSA/non-MRSA carriers (95% CI)	Multivariate OR MRSA/non-MRSA carriers (95% CI)
Sex (male)	72 (31.2)	322 (28.1)	1.15 (0.85–1.57)	
Age ≥85 years	95 (41.3)	380 (33.4)	1.41 (1.05–1.88)	1.60 (1.16–2.21)
Charlson index ≥2 [17]	148 (64.6)	567 (50.4)	1.79 (1.33–2.41)	1.50 (1.09–2.08)
Barthel index <30 [18]	98 (43.0)	344 (31.4)	1.65 (1.23–2.21)	1.02 (0.72–1.43)
Decubitus ulcers	46 (20.1)	65 (5.7)	4.17 (2.77–6.28)	2.56 (1.58–4.17)
Previous antibiotic	97 (42.9)	207 (18.4)	3.33 (2.13–4.42)	2.44 (1.75–3.39)
Medical devices	31 (13.5)	37 (3.2)	4.67 (2.83–7.71)	2.47 (1.35–4.52)
Transferral from acute-care centre	55 (24.1)	103 (9.4)	3.07 (2.13–4.42)	2.15 (1.39–3.31)
Stay ≥6 months	176 (77.9)	943 (86.6)	0.54 (0.38–0.78)	0.80 (0.53–1.22)
Centre with <150 beds	131 (56.7)	422 (36.8)	2.25 (1.69–2.99)	1.77 (1.29–2.41)

Comparison of patients colonized by MRSA with a control group of non-MRSA carriers.

Table 3. Associated factors for methicillin-susceptible *Staphylococcus aureus* carriage vs. no *S. aureus* carriage

	OR	95% CI	p
Age ≥85 years	0.84	0.61–1.17	0.31
Charlson index ≥2	1.95	1.31–2.90	0.001
Barthel index <30	1.07	0.76–1.50	0.70
Decubitus ulcers	1.24	0.65–2.36	0.51
Previous antibiotic use	0.77	0.52–1.15	0.20
Medical devices	1.50	0.66–3.39	0.33
Transferral from acute-care centre	1.45	0.88–2.40	0.14
Stay ≥6 months	0.73	0.48–1.12	0.16
Centre with <150 beds	1.69	1.24–2.31	0.001

Logistic regression model.

Table 4. Associated factors for methicillin-resistant *Staphylococcus aureus* carriage vs. no *S. aureus* carriage

	OR	95% CI	p
Age ≥85 years	1.56	1.13–2.19	0.009
Charlson index ≥2	2.36	1.57–3.55	<0.001
Barthel index <30	1.08	0.76–1.55	0.64
Decubitus ulcers	2.92	1.73–4.93	<0.001
Previous antibiotic	2.20	1.56–3.13	<0.001
Medical devices	3.05	1.56–5.97	0.001
Transferral from acute-care centre	2.52	1.59–4.02	<0.001
Stay ≥6 months	0.80	0.51–1.26	0.34
Centre with <150 beds	2.10	1.52–2.92	<0.001

Logistic regression model.

DISCUSSION

In Europe, there is little information on the prevalence of MRSA colonization among LTCF residents. Recent studies have reported prevalences of 22% in the UK [7], 9.3% in Slovenia [8], 8.6% in Ireland [10] and 1.1% in Germany [9]. These figures are lower than those reported in studies of Veterans' Affairs facilities in the USA, where the colonization rate can reach 45% [6,21]. To our knowledge, this is the first report on the prevalence of MRSA colonization in community LTCFs in Spain.

In a previous study, the clinical epidemiology of patients with *S. aureus* bloodstream infections upon hospital admission was analyzed, and the major risk factors for methicillin resistance were prior MRSA isolation and having been transferred from an LTCF [14]. Given the increasing rate of exchange of patients between facilities in the healthcare setting and acute-care hospitals, it seems pertinent to determine the magnitude of MRSA colonization in LTCFs, as the extent of this problem could influence the infection control practices implemented by hospitals [22]. In Spain, guidelines for the prevention of MRSA transmission in acute-care hospitals are well established [23], even though there is a lack of such recommendations for LTCFs. The policy of most facilities is to admit MRSA carriers, although transfer of these patients from acute-care centres is often limited. This is because healthcare personnel have not been instructed on the measures for handling MRSA-colonized patients, and contact precaution measures are costly.

We analyzed a large number of patients from a homogeneous type of LTCF, i.e. community LTCFs, and performed cultures from nasal swabs and decubitus ulcers, which has been reported to be a valid and efficient method for the detection of MRSA carriage [24,25]. It is worthy of note that 18 residents in this study had decubitus ulcers colonized by MRSA and a concomitant negative nasal swab. No prior decolonization was recorded in their medical records, and intestinal MRSA carriage was not ruled out [26]. A high prevalence of MRSA colonization was found among patients within these institutions. This study allows an appreciation with further detail of the MRSA situation in the healthcare system. However, it is important to emphasize that active surveillance within LTCFs is not recommended in the absence of surveillance of suspected outbreaks of infection; thus, this study is not reproducible in daily clinical practice. In LTCFs, clinical samples and medical

records from hospitals should be considered, to define the baseline rate of MRSA colonization within a facility [21]. In the present study, approximately one-third of the residents colonized by MRSA were previously recognized as MRSA carriers by the facility; this indicates irregular application of the aforementioned recommendations. An outstanding finding is the wide variation in the prevalence of MRSA colonization among facilities, something that has been pointed out in other reports [21]. Differences in colonization rates may depend on several factors, such as the prevalence of MRSA in the referral hospital and infection control practices at the LTCF.

To determine factors associated with MRSA colonization, two separate models using multivariate analysis were built. This is an effective method for identifying factors associated with resistant pathogens, particularly for studies on infection control [20,27]. In this analysis, only the size of facilities was considered as a specific factor related to MRSA colonization; thus, it is difficult to interpret the differences found in the prevalence of MRSA colonization among LTCFs. A limitation of this point-prevalence study is the absence of a second sample to confirm the residents' carrier status; consequently, it was not possible to detect intermittent MRSA carriage. In LTCFs, the rate of intermittent carriage of MRSA is approximately 15% [26]. The study design makes it difficult to determine the exact risk of MRSA colonization; therefore, only associated factors are referred to. Independent factors associated with *S. aureus* carriage in community LTCF residents were comorbidity and the size of the facilities. Independent factors associated with MRSA colonization among this population were presence of decubitus ulcers, previous antibiotic treatment, age of 85 years or more, use of invasive devices, and transfer from an acute-care hospital. Limited data are available concerning risk factors for MRSA colonization in LTCFs in Europe. Vovko *et al.* [28] found previous antibiotic treatment and hospital admission to be risk factors in an LTCF with a low number of MRSA carriers. Interestingly, in other studies, care facility-specific risk factors for MRSA colonization, e.g. low ratio of nurses to beds, have been associated with MRSA carriage [7,29]. In our model, there is no variable that could explain why centres with <150 beds constitute an independent factor associated with *S. aureus* colonization, but we have observed that some of these facilities are deficient in application of standard measures to limit cross-transmission. A stay of more than 6 months in an LTCF has been found to be associated with the rate of MRSA colonization [29], in contrast to the findings of other authors [9,10]. In the present study, a stay of fewer than 6 months in an LTCF was associated with MRSA colonization only in the bivariate analysis; this should be interpreted as a survival bias due to the study design.

These observations show that factors related to methicillin resistance among residents in community LTCFs are similar to those described in hospitalized patients [30]. It is noteworthy that modifiable factors could be prevented by the introduction of only a few infection control measures. Appropriate, individualized and easy-to-implement infection control precautions, together with the promotion of a healthy lifestyle for residents, should be observed in LTCFs. Hand washing (alcohol-based gel) protocols, educational programmes for healthcare personnel, guidelines for antibiotic use and enhanced efforts to prevent the development of decubitus ulcers would all be suitable measures for community LTCFs.

To conclude, this study reports a large reservoir of MRSA among community LTCFs in Spain. The results indicate that restriction of referral of MRSA carriers from acute-care hospitals to community LTCFs would not be effective, because there is a high prevalence of silent carriers. Patients transferred from LTCFs to hospitals should be considered at high risk for MRSA colonization and should be included in a screening programme at admission. We therefore recommend that control strategies be coordinated between LTCFs and acute-care hospitals. Further studies are necessary to define the clinical impact of MRSA colonization among residents in community LTCFs.

TRANSPARENCY DECLARATION

This study was supported by the Ministerio de Sanidad y Consumo, Instituto de Salud Carlos III, Spanish Network for the Research in Infectious Diseases (REIPI RD06/0008). The authors declare no conflict of interest with respect to this article.

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