Risk Factors for Methicillin-Resistant
Staphylococcus aureus Colonization in a
Geriatric Rehabilitation Hospital

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Background. Knowledge of the prevalence of methicillin-resistant Staphylococcus aureus (MRSA) colonization, and
the frequency of transmission is vital for the implementation of MRSA infection control measures in hospitals. We
assessed risk factors for and rates of colonization of MRSA upon admission to a geriatric rehabilitation hospital, and
studied the contribution of the colonization on hospital mortality.

Methods. This was a prospective study conducted over a 6-month period. All patients were screened at admission,
using nasal and throat swabs. Whenever necessary, blood, sputum, urine, or wound cultures were obtained. Data collected
on admission included age, sex, functional status, reasons for admission to the rehabilitation unit, previous
hospitalizations, known carriage or infection with MRSA in previous hospitalizations, underlying diseases, prescribed
antibiotics in previous hospitalization, serum albumin, creatinine clearance, and patient management data. Risk factors for
MRSA carriage on admission were estimated by using multivariate analysis.

Results. Of the 337 patients admitted during the study period, 24 (7.1%) had a MRSA isolate, and 87.4% of these were
detected through screening specimens only. Of the 24 positive admissions with MRSA, 28 (95.8%) were newly identified MRSA
carriers. In the multivariate analysis, the following variables were highly associated with MRSA carriage: presence of tra-
cheotomy (p = .0001), hospitalization for deconditioning (p = .007), renal failure (p = .039), and quinolone use prior to hos-
pitalization (p = .037). The morbidity associated with MRSA was very low, and length of stay was not influenced by carriage.

Conclusion. The prevalence of MRSA carriage on admission to geriatric rehabilitation hospitals is high. Screening on
admission is probably useful, as it detects almost all MRSA carriers. However, given the low morbidity associated with
MRSA observed in this study, eradication of the MRSA carrier state is questionable. Further studies are needed to
determine the usefulness and cost/benefit ratio of screening.

METHICillin-resistant Staphylococcus aureus
(MRSA) infection carries a considerable rate of mor-
bidity and mortality in older patients. This pathogen is the
second most common cause of nosocomial infections
among hospitalized older adults (1). Only recently has the
magnitude of asymptomatic colonization and symptomatic
infection with MRSA in older patients been recognized and
explored (2). Among the principal factors that have been
shown to increase a patient’s risk of colonization with
MRSA, one may find prior hospitalization, recent use of
broad-spectrum antimicrobials, impaired functional status,
use of medical devices (urinary catheter, nasogastric tube, or
IV catheter), and chronic diseases leading to wounds or skin
breakdown (3–5). Once colonized, older patients often carry
the same strain of MRSA for 3 month to 3 years (3).

Asymptomatic colonization with MRSA is an important
risk factor for development of MRSA infection (4). The
issues concerning what control measures are necessary and
reasonable to prevent the introduction and spread of MRSA
are controversial. In contrast to acute-care hospitals, where
30%–60% of colonized patients will develop a nosocomial
MRSA infection, only 5%–15% of colonized residents in
long-term care facilities (LTCF) will develop infection (4,6).

In 1994, the MRSA Task Force of the American Hospital
Association published recommendations for the control of
MRSA in acute care hospitals and in LTCFs (7). The
recommendations further stressed the need for each in-
dividual facility to develop an MRSA control plan based on
prevalence of MRSA in the facility and referring insti-
tutions, frequency of MRSA transmission, and availability
of resources.

No group had prospectively investigated MRSA coloni-
ization and infection in a geriatric rehabilitation hospital.
Knowledge of the prevalence of MRSA colonization and
infection and the frequency of transmission is vital for the
implementation of MRSA infection control measures in such
hospitals. We assume that modes of MRSA transmission in
such hospitals are different from those in LTCFs and in
acute-care hospitals. We aimed to assess the prevalence and
incidence of MRSA colonization over a 6-month period in
a geriatric rehabilitation hospital. Patterns of MRSA acquisi-
tion within the facility were assessed, and the risk for
infection in patients colonized with MRSA was studied.

METHODS

Setting and Patients
The study was conducted over a 6-month period at the
Fliman Rehabilitation Geriatric Hospital (a public geriatric
facility affiliated with the Technion University Medical School and located in Haifa, Israel). This 150-bed geriatric rehabilitation and subacute care center offers two services: the subacute wards (50 beds) and the geriatric rehabilitation wards (100 beds). The center admits approximately 1750 patients per year. Over the past year, approximately 75% of the patients were admitted from wards in other hospitals, 15% were admitted from general hospital emergency rooms, 7% were admitted directly from nursing homes, and only 3% were admitted from home. All patients admitted to the hospital during the study period were included in the study.

Sampling
The screening program included collection of nasal, throat, and urine samples from each patient admitted to the rehabilitation wards. Samples were taken within 48 hours of admission. In addition, all skin wounds and gastrostomy and tracheotomy sites were swabbed at admission. Clinical diagnostic samples from the patients were submitted to the microbiology laboratory whenever a clinical site was suspected of infection.

Microbiological Methods
Swabs were inoculated onto selective blood agar containing phenyl ethyl alcohol (PD 042; HY Labs, Rehovot, Israel). Plates were examined for Staphylococci after 24 and 48 hours. Microbiological methods for identification of S. aureus included Gram stain, growth on sheep blood agar, and Staphylase Test (Oxoid, Basingstoke, Hampshire, U.K.). The antibiotic susceptibility pattern was determined using Mueller–Hinton agar plates supplemented with oxacillin incubated for 24 hours at 30°C–35°C. S. aureus strains with oxacillin inhibition corresponding to minimum inhibitory concentration (MIC) > 2 mg/L were classified as MRSA. All MRSA isolates were recorded, together with date of sampling, sample type, name, location of the patient, and antibiotic susceptibility results.

Definitions
A carrier was defined as a patient from whom MRSA was recovered from any screening sample, in the absence of MRSA from a clinical diagnostic sample. Colonization was defined as recovery of MRSA from a clinical diagnostic sample without systemic signs of sepsis or local overt infection (8). For the purpose of this analysis, carriers and colonized patients were grouped together (MRSA cases). Infection was defined as recovery of MRSA from a clinical diagnostic sample with the presence of systemic signs of sepsis or local infection.

Data Collection
Data collection was coordinated by a physician and the epidemiological nurse of the hospital. The physician completed standardized forms for each included patient.

Data were recorded for the following variables: age, sex, functional status [the Katz Index of Activities of Daily Living was used as the functional status staging tool (9), and the cutoff value used was dependence in at least two functions], previous hospitalizations, carriage and colonization or infection with MRSA in previous hospitalization, dates of admission and discharge, underlying diseases, prescribed antibiotics, albumin, creatinine clearance (CCr; calculated using the Cockroft–Gault formula), patient management data at admission and during hospitalization, and reasons for admission to the rehabilitation unit. Reasons for rehabilitation were grouped into one of four subgroups: (i) stroke rehabilitation, (ii) rehabilitation after an orthopedic surgery, (iii) other postoperative rehabilitation (e.g., abdominal, neurosurgery), and (iv) physical deconditioning (decline in functional status usually after prolonged hospital stay).

Statistical Analysis
Statistical analysis was performed by using parametric or nonparametric tests where appropriate. Logistic regression analysis was used to identify independent predictors of colonization with MRSA at the time of admission to the rehabilitation unit as well as clinical conditions associated with the development of symptomatic MRSA infection. Data were analyzed using SPSS (Statistical Package for the Social Sciences, version 12.0; Faculty of Medicine, Technion, Haifa, Israel). Association between factors and MRSA colonization was analyzed using the chi-square test or Fisher’s exact test as appropriate. Two-tailed p values of $\leq 0.05$ were considered as statistically significant.

RESULTS
During the 6-month study period, 337 admissions were recorded in the four rehabilitation wards: 136 patients (40.4%) were hospitalized for stroke rehabilitation, 120 (35.6%) for rehabilitation after an orthopedic surgery, 26 (7.7%) were other postoperative (abdominal and neurosurgery) rehabilitation patients, and 55 (16.3%) were hospitalized due to physical deconditioning. Of the 337 admissions, 329 were admitted directly from other hospitals, 7 from home, and only 1 patient was admitted from a nursing home. The mean age of the 169 men and 168 women was 74.3 $\pm$ 10.9 years. Mean duration of stay at our institution was 31.3 $\pm$ 15.9 days; most patients (262) were discharged home, 25 were discharged to a nursing home, 45 were transferred to a general hospital, and 5 patients (1.5%) died.

Of the 337 admissions, 24 (7.12%) had positive test results for MRSA. This prevalence of MRSA carriage varied across subgroups of patients: It was 16.3% among patients hospitalized due to physical deconditioning, 11.5% among other postoperative rehabilitation patients, 6.6% among patients hospitalized for rehabilitation after an orthopedic surgery, and 2.9% among stroke rehabilitation patients. In only one patient (4.2%) of the 24 admissions with positive screening test results, MRSA carriage had also been detected before admission. Therefore, in 23 admissions (95.8%), MRSA carriage was newly identified by screening at admission. As shown in Table 1, nasal swabs were the most efficient way to diagnose carriage (positive in 58.3% of the 24 MRSA-positive admissions, compared to only 29.1% of throat swabs and 29.1% of swabs from clinical specimens).
Variables Associated With MRSA Carriage

Of the 337 admissions, 314 (93.2%) were from four neighboring general hospitals. The prevalence of MRSA carriage was significantly different between patients transferred from different hospitals. The prevalence of MRSA carriage varied across hospitals from 3.9% to 15.6%. The prevalence of MRSA carriage was significantly higher in patients admitted from one hospital (Hospital N) (5/32 or 15.6%) \((p = .0447)\).

In addition, the univariate analysis revealed that MRSA carriage was associated with the presence of pressure ulcer on admission, presence of tracheotomy on admission, hypoalbuminemia, renal failure (CCr \(< 60\)), and deconditioning as a reason of hospitalization. Among antibiotics, quinolones were the only group associated with MRSA carriage (Table 2). Logistic regression modeling identified the presence of tracheotomy at admission, renal failure, hospitalization for deconditioning, and quinolone use to be highly and independently associated with MRSA carriage (Table 3).

Definition of MRSA strains isolated in our study as community-associated (CA-MRSA) or health care–associated MRSA (HA-MRSA) was not done. Definition cannot be done only by microbiological characterization of the two types of MRSA. HA-MRSA is usually defined as a cultured MRSA infection documented more than 48 hours after admission to a hospital. According to the antibiogram obtained (Table 4), MRSA isolates were probably HA-MRSA.

### DISCUSSION

Our results confirm a high prevalence of MRSA carriage at geriatric rehabilitation admission. The 7.1% prevalence found in this study is slightly lower than that in an earlier report by Manian and colleagues (10), who looked at routine screening for MRSA on admission to a general acute rehabilitation unit and reported a 12% isolation rate. We found substantial variations, however, across subgroups of rehabilitation patients. The highest isolation rate in our study was in postoperative (abdominal and neurosurgery) rehabilitation patients (11.5%) and in elderly patients hospitalized due to physical deconditioning (16.3%). We assume that this finding is related to the different incidence of MRSA colonization in the wards from which patients were transferred to the rehabilitation wards. Epidemiological data suggested that intensive care units and surgical wards are the places where most patients became colonized with MRSA. In these wards, prevalence of MRSA at discharge may reach 27% (11,12).

Our data suggest that combining nasal samples, clinical specimens, and routine throat samples ensures detection of most MRSA carriers. We found that cultures of the nares were positive in 58.3% of admissions with MRSA carriage, and that combining nasal and throat cultures allowed the detection of 87.4% of admissions with MRSA carriage.

### Table 1. Frequency of Specimens Positive for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Carriage at Admission to Rehabilitation Ward

<table>
<thead>
<tr>
<th>Sampling Site</th>
<th>No. (%) of Patients ((N = 24))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal</td>
<td>14 (58.3)</td>
</tr>
<tr>
<td>Throat</td>
<td>7 (29.1)</td>
</tr>
<tr>
<td>Wound</td>
<td>5 (20.8)</td>
</tr>
<tr>
<td>Urine</td>
<td>2 (8.3)</td>
</tr>
<tr>
<td>Patients with two MRSA samples (N = 4)</td>
<td></td>
</tr>
<tr>
<td>Nasal and throat</td>
<td>2 (8.3)</td>
</tr>
<tr>
<td>Nasal and wound</td>
<td>1 (4.2)</td>
</tr>
<tr>
<td>Throat and wound</td>
<td>1 (4.2)</td>
</tr>
</tbody>
</table>

*Note:* Each patient was cultured from at least three sites (nose, throat, urine).

### Table 2. Variables Associated in Univariate Analysis With Methicillin-Resistant *Staphylococcus aureus* (MRSA) Carriage in 337 Admitted Patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>MRSA Carriers ([N = 24]) (%)</th>
<th>Noncarriers ([N = 313]) (%)</th>
<th>RR (95% Confidence Interval)</th>
<th>(p) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>10 (41.7)</td>
<td>158 (50.5)</td>
<td>0.7 (0.32–1.57)</td>
<td>.5</td>
</tr>
<tr>
<td>Age</td>
<td>74.63 ± 12.1</td>
<td>74.31 ± 10.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reason of hospitalization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>4 (16.7)</td>
<td>132 (42.2)</td>
<td>0.59 (0.36–1.30)</td>
<td>.229</td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td>8 (28.6)</td>
<td>112 (36.2)</td>
<td>0.72 (0.32–1.59)</td>
<td>.537</td>
</tr>
<tr>
<td>Postoperative</td>
<td>3 (10.7)</td>
<td>23 (7.4)</td>
<td>1.43 (0.46–4.43)</td>
<td>.464</td>
</tr>
<tr>
<td>Deconditioning</td>
<td>9 (37.5)</td>
<td>46 (14.7)</td>
<td>2.429 (1.16–5.08)</td>
<td>.0292</td>
</tr>
<tr>
<td>Pressure ulcers</td>
<td>9 (37.5)</td>
<td>35 (11.2)</td>
<td>3.99 (1.86–8.57)</td>
<td>.001</td>
</tr>
<tr>
<td>Heart failure</td>
<td>9 (32.1)</td>
<td>67 (21.75)</td>
<td>1.62 (0.76–3.44)</td>
<td>.236</td>
</tr>
<tr>
<td>Renal failure</td>
<td>10 (41.7)</td>
<td>51 (16.3)</td>
<td>3.23 (1.51–6.92)</td>
<td>.004</td>
</tr>
<tr>
<td>Hypoalbuminemia</td>
<td>12 (50)</td>
<td>74 (23.6)</td>
<td>2.92 (1.36–6.25)</td>
<td>.007</td>
</tr>
<tr>
<td>Tracheotomy</td>
<td>5 (20.8)</td>
<td>4 (1.3)</td>
<td>9.56 (4.63–19.89)</td>
<td>.0001</td>
</tr>
<tr>
<td>Urinary catheter</td>
<td>7 (29.2)</td>
<td>62 (19.8)</td>
<td>1.6 (0.69–3.7)</td>
<td>.29</td>
</tr>
<tr>
<td>Postoperative wound</td>
<td>12 (50)</td>
<td>154 (49.2)</td>
<td>1.03 (0.48–2.22)</td>
<td>1</td>
</tr>
<tr>
<td>Functional dependence</td>
<td>17 (70.8)</td>
<td>161 (51.4)</td>
<td>2.17 (0.92–5.01)</td>
<td>.09</td>
</tr>
<tr>
<td>Antibiotic use</td>
<td>14 (58.3)</td>
<td>93 (29.7)</td>
<td>3.01 (1.38–6.55)</td>
<td>.006</td>
</tr>
<tr>
<td>Quinolones</td>
<td>4 (16.7)</td>
<td>15 (4.8)</td>
<td>3.34 (1.27–8.82)</td>
<td>.037</td>
</tr>
<tr>
<td>Cephalosporins</td>
<td>3 (14.3)</td>
<td>39 (12.6)</td>
<td>1.143(0.35–3.71)</td>
<td>.74</td>
</tr>
<tr>
<td>Penicillins</td>
<td>3 (14.3)</td>
<td>28 (9.1)</td>
<td>1.6 (0.5–5.15)</td>
<td>.43</td>
</tr>
</tbody>
</table>
Nasal, throat, and clinical samples in combination allowed the detection of 91.7%.

We, as others investigators who looked for risk factors for MRSA carriage in hospitals (13,14), found that the presence of pressure ulcers was significantly associated with MRSA carriage in patients admitted to our geriatric rehabilitation wards. This result is not surprising, as presence of pressure ulcers is probably a marker for intensive prolonged medical care and, consequently, for frequent opportunities for MRSA acquisition. There is a well-established association between presence of pressure ulcers and persistent MRSA carriage in hospitals (13,14), found that the presence of MRSA, we may assume that this finding is related to a high transfer of MRSA, because there are only nine tracheotomy patients (3,5). We believe that the high rate of MRSA colonization on admission to our hospital but rather sought to determine the prevalence of screening identified all positive MRSA carriers on admission to our hospital. Despite these plausible figures, most recommendations for controlling the spread of MRSA do not include MRSA screening at admission, as this strategy might be expensive and has not been proven in controlled studies to decrease the incidence of MRSA (22). In our study, only 4.2% of cases of MRSA carriage at rehabilitation ward admission were known previously, and none of the cases were associated with positive clinical samples during the stay in the ward. Therefore, screening tests at admission elicited all positive test results for MRSA carriers. This very high proportion can be ascribed to restriction of screening of patients considered at high risk of MRSA carriage in the wards from which patients were transferred to the rehabilitation wards before discharge.

We did not attempt to eradicate MRSA colonization in our hospital but rather sought to determine the prevalence of colonization and the risk of infection in colonized patients. On the basis of our results, we should be able to design appropriate control measures for a geriatric rehabilitation hospital. Screening identified all positive MRSA carriers on admission to our hospital. Despite these plausible figures, the direct effect of MRSA carriage in our hospital appears to be limited, given the low rate of associated morbidity. We believe that, given that patients are continuously transferred between rehabilitation hospitals and acute-care facilities, it is reasonable to consider rehabilitation units together with all other care units and to measure the effect of MRSA on a regional health care network, rather than on a given ward or hospital. The relationship between rates of MRSA carriage and the difference in patients and facility profile is demonstrated by the high rate (15.6%) of admissions positive for MRSA among patients coming from a specific hospital (hospital N). Hospital N is a 609-bed general hospital. The spectrum of patients sent to rehabilitation from other hospitals. Although we found no publication from this hospital regarding higher rates of MRSA or outbreaks of MRSA, we may assume that this finding is related to a high percentage of MRSA carriage in this institution. Transfer of

Table 3. Variables Associated With Methicillin-Resistant Staphylococcus aureus Carriage on Admission to Rehabilitation, in Multivariate Analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>Odds Ratio (95% Confidence Interval)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracheotomy</td>
<td>25.25 (5.22–122.08)</td>
<td>.0001</td>
</tr>
<tr>
<td>Hospitalization for deconditioning</td>
<td>4.29 (1.50–12.28)</td>
<td>.007</td>
</tr>
<tr>
<td>Renal failure</td>
<td>2.81 (1.05–7.54)</td>
<td>.039</td>
</tr>
<tr>
<td>Quinolone use</td>
<td>5.02 (1.95–12.96)</td>
<td>.045</td>
</tr>
</tbody>
</table>

Table 4. Antibiotic Sensitivity of 28 Clinical Isolates of Methicillin-Resistant Staphylococcus aureus

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>No. Sensitive (%) (N = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancomycin</td>
<td>28 (100)</td>
</tr>
<tr>
<td>Rifampin</td>
<td>27 (96.4)</td>
</tr>
<tr>
<td>Fusidic acid</td>
<td>26 (92.8)</td>
</tr>
<tr>
<td>Cotrimoxazole</td>
<td>23 (82.1)</td>
</tr>
<tr>
<td>Mupirocin</td>
<td>20 (71.4)</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>1 (3.6)</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>1 (3.6)</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>1 (3.6)</td>
</tr>
</tbody>
</table>
patients between hospitals is the second most important way of increasing the risk of MRSA in a given hospital (23).

The identification of all reservoirs (colonized or infected patients and simple carriers) within wards is considered to be a major component of all control programs (7, 13), and isolation strategies recommended to prevent cross-transmission may be hindered if carriers are not identified upon admission. The usefulness and cost/benefit ratio of the collection of samples for screening remain open to debate (7, 15). Whether the eradication of the MRSA carrier state in patients in a geriatric rehabilitation facility will lead to a decreased rate of MRSA infection in the hospital has yet to be documented. In contrast to general hospitals, where MRSA colonization on admission to the hospital increases the risk for later MRSA infection, we found no such increase in our geriatric rehabilitation hospital. Given the low morbidity associated with MRSA observed in our hospital, this examination is questionable. Perhaps only the patients at greater risk for infection, if identified, should be treated.

Conclusion

Screening for MRSA at geriatric rehabilitation admission is probably useful, as it detects almost all MRSA carriers. Screening at admission should include nasal swabs and sampling of the throat, in addition to collection of clinical specimens. Factors associated with MRSA carriage at geriatric rehabilitation admission are presence of pressure ulcer, presence of tracheotomy, hypoalbuminemia, renal failure, antibiotic use prior to hospitalization, and hospitalization for deconditioning. Further studies are needed to determine the usefulness and cost/benefit ratio of the collection of samples for screening.

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