American Journal of Infection Control 41 (2013) 214-20

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Patient-level factors associated with methicillin-resistant *Staphylococcus aureus* carriage at hospital admission: A systematic review

Alan J. Forster MD, MSc [a,b,c,d,e,*], Natalie Oake MSc [a,b], Virginia Roth MD [b,c,d], Kathryn N. Suh MD, MSc [d], Jake Majewski MD [d], Ciera Leeder BSc [a,b], Carl van Walraven MD, MSc [b,c,d,e]

[a] *Performance Measurement, The Ottawa Hospital, Ottawa, ON, Canada*
[b] *Clinical Epidemiology Program, The Ottawa Hospital Research Institute, Ottawa, ON, Canada*
[c] *Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, ON, Canada*
[d] *Department of Medicine, Faculty of Medicine, University of Ottawa, Ottawa, ON, Canada*
[e] *ICES@uOttawa, Ottawa, ON, Canada*

Key Words:
Hospital-acquired infection
Prevention
Infection control

Background: Selective methicillin-resistant *Staphylococcus aureus* (MRSA) screening programs target high-risk populations. To characterize high-risk populations, we conducted this systematic review to identify patient-level factors associated with MRSA carriage at hospital admission.

Methods: Studies were identified in the MEDLINE (1950-2011) and EMBASE (1980-2011) databases. English studies were included if they examined adult populations and used multivariable analyses to examine patient-level factors associated with MRSA carriage at hospital admission. From each study, we abstracted details of the population, the risk factors examined, and the association between the risk factors and MRSA carriage at hospital admission.

Results: Our electronic search identified 972 citations, from which we selected 27 studies meeting our inclusion criteria. The patient populations varied across the studies. Ten studies included all patients admitted to hospital, and the others were limited to specific hospital areas. MRSA detection methods also varied across studies. Ten studies obtained specimens from the nares only, whereas other studies also swabbed wounds, catheter sites, and the perianal region. Methods of MRSA diagnoses included polymerase chain reaction tests, cultures in various agar mediums, and latex agglutination tests. Patient age, gender, previous admission to hospital, and previous antibiotic use were the risk factors most commonly examined. The risk factor definition and study methods varied among studies to an extent that precluded meta-analysis.

Conclusion: The existing literature cannot be used to identify risk factors for MRSA colonization at the time of hospitalization. Future studies should be aware of the differences in the existing literature and aim to develop standardized risk factor definitions.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is an increasingly important organism in the hospital setting. MRSA colonization and infection are becoming more prevalent in many North American communities.[1] When patients with MRSA are admitted to hospital, the organism can be transmitted to other patients. This can be problematic because hospitalized patients may have increased susceptibility to infection. In addition, MRSA infections are associated with a significant increase in mortality, hospital readmission rates, and health care costs compared with methicillin-susceptible *Staphylococcus aureus* infections.[2-4]

A commonly used method to reduce hospital transmission is universal MRSA screening to identify MRSA carriers early in their hospitalization. This allows the prompt initiation of isolation measures to minimize MRSA transmission to other patients and health care providers.

Despite the increasing use of universal MRSA screening programs, published studies have yielded conflicting results. Harbarth et al,[5] Jeyaratnam et al,[6] and Nijssen et al[7] have each found that universal screening did not reduce the incidence of nosocomial MRSA infection, whereas Robicsek et al[8] and Shitrit et al[9] found that MRSA screening significantly reduced subsequent infections. Thus,

* Address correspondence to Alan J. Forster, MD, MSc, The Ottawa Hospital, Civic Campus, ASB 1-1053 Carling Avenue, Ottawa, ON K1Y 4E9, Canada.
E-mail address: aforster@ohri.ca (A.J. Forster).

Conflicts of interest: None to report.

0196-6553/$36.00 - Copyright © 2013 by the Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.
doi:10.1016/j.ajic.2012.03.026

the evidence supporting universal screening programs is inconclusive.

Although the benefit of universal MRSA screening programs is unclear, the absolute cost is not insignificant. One option to decrease the cost of MRSA control techniques is the use of selective MRSA screening. Selective MRSA screening programs target high-risk populations and may be cost-effective.[10]

To identify high-risk patients to select for screening, several investigators have tried to identify risk factors predicting MRSA colonization. These studies were performed in different settings and eras. We, therefore, conducted this systematic review to identify published studies in which patient-level risk factors for MRSA colonization at hospital admission were identified. We wanted to determine whether existing epidemiologic studies had sufficiently consistent results to allow us to select risk factors to develop a clinical algorithm supporting decision making for MRSA screening.

METHODS

Data sources

Potentially pertinent citations were identified in the MEDLINE (1950-2011) and EMBASE (1980-2011) databases using the search strategy in Appendix 1. The search strategy included Medical Subjects Headings and keywords related to MRSA, surveillance or screening, and risk factors. We supplemented our electronic database search by hand searching the reference list of included studies.

Study selection

The full text of articles identified by our electronic search was retrieved if either the title or abstract suggested that the study investigated factors associated with MRSA carriage. English studies were included in this systematic review if they included adult populations and used multivariable analyses to examine factors associated with MRSA carriage at hospital admission. Studies meeting these criteria were included irrespective of study setting or study design.

Data abstraction

From each study, we abstracted details of the population, the risk factors examined, the methods used to identify MRSA carriage, and the association between the risk factors and MRSA carriage at hospital admission. We captured all risk factors that were offered to the multivariate models and the risk factors that were statistically significant in the final multivariate models. Two reviewers (J.M. and N.O.) independently abstracted data from the included studies. Discrepancies were resolved by committee.

Study quality assessment

We assessed the quality of studies using 3 key study design components presented in the Newcastle-Ottawa scale, a tool for assessing the quality of nonrandomized studies.[11] This scale presents a set of quality criteria for both cohort studies and case control studies. We selected 3 components that were applicable to both types of studies to create a parsimonious set of criteria.

The 3 criteria we evaluated included representativeness of the cohort, ascertainment of exposure (ie, risk factors), and ascertainment of outcome (ie, positive for MRSA carriage). As in a previous study,[12] we classified study quality as "high" if all 3 criteria were met. Specifically, a high-quality study included patients who were representative of the target population (ie, all admissions to the hospital) and used an objective measure to ascertain the risk factors (eg, secure medical records) and the outcome (eg, microbiologic test). We classified study quality as "moderate" if 2 of the 3 criteria were satisfied. All other studies were classified as "low" quality.

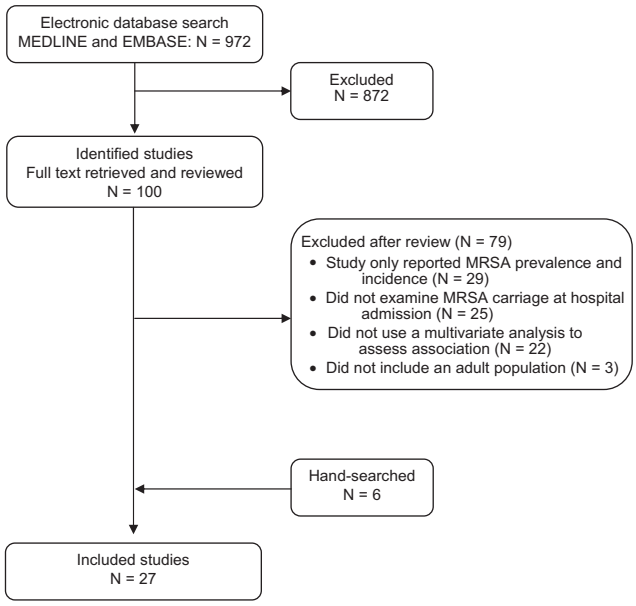

Fig 1. Results of search strategy.

Statistical analyses

Because of significant heterogeneity in the patient-level risk factor definitions across the included studies, we did not conduct formal meta-analyses of the data. Therefore, our analyses were primarily descriptive.

RESULTS

Study identification and description

The electronic database search yielded 972 citations. The full text of 100 articles were retrieved and assessed for study inclusion. The majority of studies were excluded because they only reported prevalence and incidence of MRSA carriage (n = 29), they did not examine MRSA carriage at hospital admission (n = 25), or they did not use a multivariable model to assess the association between risk factors and MRSA carriage (n = 22) (Fig 1). We identified an additional 6 studies through hand searching.

The 27 studies meeting inclusion criteria were published between 1994 and 2011 (Table 1).[13-39] Sixty-three percent (n = 17) of the included studies were prospective cohort studies[14-18,23-25,28-34,36,38] with the remaining using case control (n = 6)[13,20,26,27,35,39] cross-sectional (n = 2),[21,22] or retrospective designs (n = 2).[19,37] The patient populations varied across the included studies. Ten studies included *all* patients admitted to hospital,[13,20,22,25-27,30,35,37,38] whereas the other studies included patients admitted to intensive care units (n = 8),[15,19,21,23,29,32,34,39] geriatric wards (n = 5),[14,18,24,33,36] surgical departments (n = 2),[16,31] or other areas of the hospital (n = 2)[17,28] The majority of studies were conducted in the United States (n = 12). The 27 studies included a total of 68,877 participants with 2,928 cases of MRSA carriage at hospital admission. The prevalence of MRSA carriage on admission was significantly lower for studies that included all admissions to the