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Major Article

Screening test recommendations for methicillin-resistant *Staphylococcus aureus* surveillance practices: A cost-minimization analysis

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Background: To mitigate methicillin-resistant *Staphylococcus aureus* (MRSA) infections, intensive care units (ICUs) conduct surveillance through screening patients upon admission followed by adhering to isolation precautions. Two surveillance approaches commonly implemented are universal preemptive isolation and targeted isolation of only MRSA-positive patients.

Methods: Decision analysis was used to calculate the total cost of universal preemptive isolation and targeted isolation. The screening test used as part of the surveillance practice was varied to identify which screening test minimized inappropriate and total costs. A probabilistic sensitivity analysis was conducted to evaluate the range of total costs resulting from variation in inputs.

Results: The total cost of the universal preemptive isolation surveillance practice was minimized when a polymerase chain reaction screening test was used ($82.51 per patient). Costs were $207.60 more per patient when a conventional culture was used due to the longer turnaround time and thus higher isolation costs. The total cost of the targeted isolation surveillance practice was minimized when chromogenic agar 24-hour testing was used ($8.54 per patient). Costs were $22.41 more per patient when polymerase chain reaction was used.

Conclusions: For ICUs that preemptively isolate all patients, the use of a polymerase chain reaction screening test is recommended because it can minimize total costs by reducing inappropriate isolation costs. For ICUs that only isolate MRSA-positive patients, the use of chromogenic agar 24-hour testing is recommended to minimize total costs.

Health care-associated infections (HAIs) are among the most common complications associated with hospital care[1] and among the leading causes of preventable death in the United States.[2] Despite being largely preventable, these infections negatively affect 1 out of every 25 hospitalized patients[3] and are associated with an economic burden of more than $40 billion each year.[4] Methicillin-resistant *Staphylococcus aureus* (MRSA) is a well-established cause of HAIs that includes the extra designation of being a drug-resistant organism.[3] In addition to causing increased morbidity and mortality for those infected, MRSA infections are associated with a large economic burden because they nearly double the cost of a hospitalization.[5]

Patients in intensive care units (ICUs) are at the greatest risk of contracting these infections because severe illness, immunosuppression, and extended lengths of stay are common patient-related risk factors associated with HAIs like MRSA.[6] To mitigate MRSA infections, ICUs conduct MRSA surveillance through screening of the nares upon patient admission followed by isolation precautions.[7] Two approaches to MRSA surveillance in the ICU are universal preemptive isolation and targeted isolation of only MRSA-positive patients.[8]

Under the universal preemptive isolation surveillance practice, all patients are screened upon admission and are immediately isolated until the absence of MRSA carriage has been shown.[8]

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Preemptively isolating all patients is effective in reducing the transmission of MRSA; however, noncolonized patients are unnecessarily isolated, leading to unnecessary resource use (eg, contact precautions and disinfectant)[9] and thus excess cost.[8] Therefore, some ICUs wait to isolate patients until the screening test results come back and then only isolate those who test positive for MRSA. This strategy of targeted isolation reduces the number of patients unnecessarily isolated, but delays the initiation of isolation for colonized individuals, which could lead to the transmission of MRSA between patients. When colonized patients are not isolated, susceptible patients are at risk of acquiring MRSA at a rate of approximately 1% per day.[10]

Universal preemptive isolation and targeted isolation differ in when isolation precautions are implemented, but both include universal screening upon admission to the ICU. MRSA screening has historically relied on the growth and identification of the bacterial species on culture. Culture methods are inexpensive but can take multiple days to detect MRSA.[8,11] An increasingly common alternative is to use more rapid screening tests, such as chromogenic agar or polymerase chain reaction.[11,12] Although costlier, these tests generate results in a few hours.[11-13] These more rapid and expensive screening tests also tend to have a higher sensitivity in detecting the bacterial species.[11]

Both universal and targeted surveillance practices could be enhanced if coupled with screening tests that produce results quicker. With universal preemptive isolation, a quicker result would allow noncolonized patients to be removed from isolation sooner and thus reduce the total isolation costs. Similarly, with targeted isolation, a quicker result allows earlier implementation of isolation precautions and thus reduces the number of open days, or the days a MRSA-positive patient is not isolated and could transmit the pathogen to other patients.[14] Therefore, although these rapid screening tests are more costly, they could result in cost offsets. The objective of this study was to calculate the cost of universal preemptive isolation and targeted isolation to identify the MRSA screening test that minimizes costs for each surveillance practice.

MATERIALS AND METHODS

Study design

A cost-minimization analysis from the hospital perspective was conducted to calculate the total cost of MRSA surveillance practices for a hypothetical cohort of patients admitted to an ICU. Two surveillance practices were assessed: universal preemptive isolation upon admission and targeted isolation of only MRSA-positive patients. For the universal preemptive isolation surveillance practice, cost categories included costs associated with the screening test, including the cost per test and personnel time to administer and read the test, and costs associated with isolation, including the cost of contact precautions and disinfectant. Isolation costs were separated into appropriate and inappropriate isolation costs. Appropriate isolation costs were those isolation costs spent on patients who were colonized with MRSA. Inappropriate isolation costs were those isolation costs spent on patients who were unnecessarily preemptively isolated because they were not colonized with MRSA. For the targeted isolation surveillance practice, cost categories included costs associated with the screening test, including the cost per test and personnel time, and costs associated with leaving a person open (not isolated). Open costs were separated into appropriate and inappropriate. Appropriate open costs were the resources associated with not isolating a noncolonized patient. Inappropriate open costs were assigned to those patients who were colonized with MRSA and not isolated and included the monetized risk of MRSA transmission.

This analysis is from the hospital perspective because hospitals are responsible for covering the cost of surveillance. Although hospitals are currently paying for the implementation of these surveillance practices, resources could be used more efficiently if inappropriate and total costs were minimized. Because hospitals can choose among several screening tests to be used in their surveillance practice, the screening test cost, turnaround time, sensitivity, and specificity were varied in the model to align with each commonly used MRSA screening test. Four MRSA screening tests were assessed, including conventional culture and chromogenic agar 48-hour test that generate results in a few days and chromogenic agar 24-hour and polymerase chain reaction tests that can produce results in 24 hours or less. This analysis calculated the cost of universal preemptive isolation under the 4 different screening test options to determine which screening test minimized inappropriate and total costs. This analysis also calculated the cost of targeted isolation under the 4 different screening test options, and the results of each of the four targeted isolation scenarios were compared to determine which minimized cost. Because the comparisons were within the same intervention, the outcomes were equivalent and thus a cost-minimization analysis was used to determine which screening test minimized total costs. The screening test that minimized total costs was recommended as the most efficient screening test for each surveillance practice.

Model design

The analysis was modeled using a decision tree that accounted for the diagnostic accuracy and turnaround time of the different MRSA screening tests. The decision tree modeled pathways to represent patients who were appropriately and inappropriately preemptively isolated for the universal preemptive isolation surveillance practice and pathways to stratify patients who were appropriately and inappropriately left open (unisolated) for the targeted isolation surveillance practice. For the universal preemptive isolation decision tree, a hypothetical patient was screened and isolated upon admission. The patient was removed from isolation if his or her screening test came back negative. For the targeted isolation decision tree, a hypothetical patient was screened upon admission, but only isolated if he or she tested positive for MRSA.

Model inputs

Published infection control literature was reviewed to retrieve clinical and cost inputs. Clinical inputs included the colonization rate, sensitivity, and specificity for each screening test, and the turnaround time for each screening test. Cost inputs included the cost of each screening test (including the cost of materials and laboratory personnel time), the cost per isolation day, and the cost per open day. All cost inputs were inflated to 2015 US dollars using the medical-cost inflation rate.[15] Model inputs are detailed in Table 1.

Sensitivity analyses

To assess the influence of variation in the inputs on the results and conclusions, sensitivity analyses were conducted. A univariate sensitivity analysis using the lower and upper bounds of the input range in Table 1 determined parameters with influence over the cost of each surveillance practice. Additionally, a probabilistic sensitivity analysis of 1,000 Monte Carlo simulations varied all of the inputs over their plausible range simultaneously to create a distribution of each cost component and the total cost of the surveillance practice. Input ranges in Table 1 represent the 95% confidence interval where available. When 95% confidence intervals were unavailable