Cost-effectiveness of national mandatory screening of all admissions to English National Health Service hospitals for meticillin-resistant *Staphylococcus aureus*: a mathematical modelling study

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Lancet Infect Dis 2016; 16: 348–56

Published Online November 23, 2015 http://dx.doi.org/10.1016/S1473-3099(15)00417-X

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Summary

Background In December, 2010, National Health Service (NHS) England introduced national mandatory screening of all admissions for meticillin-resistant *Staphylococcus aureus* (MRSA). We aimed to assess the effectiveness and cost-effectiveness of this policy, from a regional or national health-care decision makers' perspective, compared with alternative screening strategies.

Methods We used an individual-based dynamic transmission model parameterised with national MRSA audit data to assess the effectiveness and cost-effectiveness of admission screening of patients in English NHS hospitals compared with five alternative strategies (including no screening, checklist-activated screening, and high-risk specialty-based screening), accompanied by patient isolation and decolonisation, over a 5 year time horizon. We evaluated strategies for different NHS hospital types (acute, teaching, and specialist), MRSA prevalence, and transmission potentials using probabilistic sensitivity analyses.

Findings Compared with no screening, mean cost per quality-adjusted life-year (QALY) of screening all admissions was £89 000–148 000 (range £68 000–222 000), and this strategy was consistently more costly and less effective than alternatives for all hospital types. At a £30 000/QALY willingness-to-pay threshold and current prevalence, only the no-screening strategy was cost effective. The next best strategies were, in acute and teaching hospitals, targeting of high-risk specialty admissions (30–40% chance of cost-effectiveness; mean incremental cost-effectiveness ratios [ICERs] £45 200 [range £35 300–61 400] and £48 000/QALY [£34 600–74 800], respectively) and, in specialist hospitals, screening these patients plus risk-factor-based screening of low-risk specialties (a roughly 20% chance of cost-effectiveness; mean ICER £62 600/QALY [£48 000–89 400]). As prevalence and transmission increased, targeting of high-risk specialties became the optimum strategy at the NHS willingness-to-pay threshold (£30 000/QALY). Switching from screening all admissions to only high-risk specialty admissions resulted in a mean reduction in total costs per year (not considering uncertainty) of £2·7 million per acute hospital, £2·9 million per teaching, and £474 000 per specialist hospital for a minimum rise in infections (about one infection per year per hospital).

Interpretation Our results show that screening all admissions for MRSA is unlikely to be cost effective in England at the current NHS willingness-to-pay threshold, and our findings informed modified guidance to NHS England in 2014. Screening admissions to high-risk specialties is likely to represent better resource use in terms of cost per QALY gained.

Funding UK Department of Health.

Introduction

On the basis of government and public concern about rates of meticillin-resistant *Staphylococcus aureus* (MRSA) infections between 2001 and 2004 in England and Wales,[1,2] various prevention and control interventions including legislation were introduced.[3,4] Annual rates of MRSA bacteraemia fell from 17·7 to 7·8 cases per 100 000 bed-days between April, 2005, and March, 2009,[5,6] in association with specific national interventions.[7]

Until April, 2009, national guidance[3] recommended targeted screening of patients admitted to high-risk specialties (nephrology, neurosurgery, orthopaedics and trauma, haematology and oncology, vascular surgery, and cardiothoracic surgery) or of patients with known risk factors for MRSA carriage. However, no randomised controlled trials were available to inform guidance of the most effective and cost-effective screening strategies, and clinical studies in the UK varied in both target population and reported effectiveness.[8–11]

In the absence of definitive clinical evidence, mathematical models are valuable tools by which to assess policy options. However, interpretation of existing model results to inform an evidence-based national screening policy is difficult: many models are specialty specific,[12–15] vary in strategy evaluated, and are often limited by insufficient data.[16–18] Results can also be country specific, dependent on health-care setting, and affected by MRSA prevalence.[12–14,17] A model developed in 2007,[18] which was parameterised using literature data, showed little long-term difference in hospital prevalence between screening

Research in context

Evidence before this study

In 2010, the English national policy changed from screening admissions to high-risk specialties to screening all hospital admissions for MRSA. However, there is no definitive clinical evidence supporting the effectiveness or cost-effectiveness of any one MRSA screening policy. We searched PubMed between Jan 1, 2000, and Oct 31, 2015, with the keywords "cost-effectiveness", "MRSA", "screening", and "England", and identified only three studies presenting cost-effectiveness outcomes. Each study focused on a particular specialty, which impeded their generalisability.

Added value of this study

When clinical evidence is scarce or contradictory and randomised controlled trials are infeasible or prohibitively expensive to undertake, model-based evaluations provide a method by which to rationally choose between intervention options. For this study we developed an individual-based dynamic transmission model, enabling population-level costs and health benefits associated with infectious disease prevention and control to be captured. Parameterisation used data from a national audit of MRSA screening, primary data sources, literature, and expert opinion. Importantly, the model therefore synthesised and incorporated all available evidence, and enabled strategies to be evaluated accounting for uncertainty. Our findings show that screening of all admissions is unlikely to be cost effective in any English NHS hospital type at current levels of MRSA prevalence. No screening strategy is likely to be cost effective at the current low prevalence levels. However, of all the screening options, targeting of patients admitted to high-risk specialties is likely to be the best option in most settings and was optimum in high-prevalence settings.

Implications of all the available evidence

This model-based study enabled the national policy of screening all admissions to be evaluated against alternatives, and showed that the existing policy was unlikely to be cost effective, thus informing a change in MRSA screening guidance to the NHS in 2014. As prevalence or transmissibility of circulating MRSA strains change over time, model outputs can continue to be used to guide policy decisions. Moreover, policy makers and clinicians in other countries might wish to consider the relevance of these findings to their health-care systems and settings.

strategies, but substantial variations in costs. This finding led to the Scottish Pathfinder project,[19] in which admission screening was piloted in three National Health Service (NHS) boards and a model-based evaluation undertaken; ensuing recommendations were to screen all high-risk admissions plus checklist-activated screening (ie, if patients had at least one risk factor for MRSA) of all other admissions. An additional recommendation was for future models to be individual-based to aid development of more complex, powerful tools to inform policy decisions.

On the basis of its own modelled impact assessment,[20] the English Department of Health introduced universal mandatory screening of all elective admissions (excluding paediatric, maternity, and some day-case admissions) from April, 2009, and of all emergency admissions from December, 2010, as part of the NHS Operating Framework 2010–11, in which reduction of MRSA to an unavoidable minimum was a major priority.[20]

The impact assessment committed the Department of Health to review the implemented policy. Here we present the cost-effectiveness evaluation from this review. We used an individual-based dynamic transmission model, populated by representative data (including those from our published national prevalence audit of MRSA screening[21,22]) to estimate the effectiveness and cost-effectiveness of six alternative screening strategies.

Methods

The model

We extended an individual-based, stochastic, dynamic transmission model[14,23] to evaluate the effects of screening, isolation, and decolonisation policies on MRSA transmission over a 5 year time horizon for patients in English NHS hospitals (defined as acute, teaching, and specialist[21,22]). Note that what we refer to as English hospitals throughout could more accurately be referred to as trusts—ie, a small number of jointly administered hospitals.

The model simulated the transmission of MRSA, control interventions, and associated patient outcomes. Patients were admitted via emergency or elective routes with a certain probability to high-risk (nephrology, neurosurgery, orthopaedics and trauma, haematology and oncology, vascular surgery, and cardiothoracic surgery) or low-risk (all remaining) specialties. The model incorporated specialty-specific infection, death and discharge rates, and realistic patient movements between specialty risk groups and the hospital and community populations (appendix p 4). We derived parameter estimates, including robust estimates of intervention effectiveness (and associated uncertainty), additional length of stay and mortality associated with clinical MRSA infections, from primary data sources, previous modelling studies, and the best available evidence from the literature. The appendix provides further details of the model and its assumptions.

See Online for appendix

Individual patients were classified as either MRSA susceptible (ie, negative), colonised, or infected, and could transition between these states on a daily basis (appendix p 2). The probability of MRSA infection or colonisation for each patient was updated daily and dependent on specialty, MRSA status of other patients in