Cost–benefit of infection control interventions targeting methicillin-resistant *Staphylococcus aureus* in hospitals: systematic review

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Abstract

Infections caused by methicillin-resistant *Staphylococcus aureus* (MRSA) incur significant costs. We aimed to examine the cost and cost–benefit of infection control interventions against MRSA and to examine factors affecting economic estimates. We performed a systematic review of studies assessing infection control interventions aimed at preventing spread of MRSA in hospitals and reporting intervention costs, savings, cost–benefit or cost-effectiveness. We searched PubMed and references of included studies with no language restrictions up to January 2012. We used the Quality of Health Economic Studies tool to assess study quality. We report cost and savings per month in 2011 US$. We calculated the median save/cost ratio and the save–cost difference with interquartile range (IQR) range. We examined the effects of MRSA endemicity, intervention duration and hospital size on results. Thirty-six studies published between 1987 and 2011 fulfilled inclusion criteria. Fifteen of the 18 studies reporting both costs and savings reported a save/cost ratio >1. The median save/cost ratio across all 18 studies was 7.16 (IQR 1.37–16). The median cost across all studies reporting intervention costs (n = 31) was 8648 (IQR 2025–19 170) US$ per month; median savings were 38 751 (IQR 14 206–75 842) US$ per month (23 studies). Higher save/cost ratios were observed in the intermediate to high endemicity setting compared with the low endemicity setting, in hospitals with <500-beds and with interventions of >6 months. Infection control intervention to reduce spread of MRSA in acute-care hospitals showed a favourable cost/benefit ratio. This was true also for high MRSA endemicity settings. Unresolved economic issues include rapid screening using molecular techniques and universal versus targeted screening.

Keywords: Contact isolation, cost-benefit, decolonization, economic analysis, MRSA, screening
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Background

Infections caused by methicillin-resistant *Staphylococcus aureus* (MRSA) incur significant morbidity, mortality and costs [1–3]. The adjusted odds ratio for death following MRSA bacteraemia compared with methicillin-sensitive *S. aureus* (MSSA) bacteraemia was estimated at 1.88 (95% CI 1.33–2.69) [4]. In the Netherlands, the additional length of stay for a patient with MRSA bacteraemia compared with MSSA bacteraemia was estimated at 10 days, with additional costs of €6372 (2011 US $9688) per patient [5]. An attributable in-hospital cost of €380 million was estimated for MRSA infections in EU healthcare systems [6]. In a review of the economic consequences of MRSA, the average cost of an MRSA-infected patient in Canada was estimated at US$12 216, with hospitalization being the major cost driver (81%), followed by barrier precautions (13%), antimicrobial therapy and laboratory investigations [7].

Intensive efforts to decrease MRSA infections in some European countries have resulted in significant reductions in MRSA incidence [8]. According to the European Antimicrobial

Resistance Surveillance System annual report in 2012, 22.8%% of all *S. aureus* bacteraemias reported in 2012 were methicillin-resistant, a significant decrease from 41.9% reported in 2006. In the UK, there was a 56% reduction in the number of reported MRSA bacteraemias between 2004 and 2008 [9].

Such intensive efforts are costly and the cost-effectiveness of these efforts at the hospital or national level has not been defined [10]. The main infection control interventions used against MRSA include screening, contact isolation, cohorting and decolonization in addition to standard precautions. Contact isolation requires personal protective equipment; screening programmes incur laboratory costs (especially if rapid molecular techniques are used), consumables costs, clinical staff costs and decolonization costs; patient cohorting requires dedicated nursing staff. Costs more complicated to account for include those related to initial building and construction, restriction of number of beds in an intensive care unit, closure of a unit, closure of an operating room or cancellation of an operation.

We performed a systematic review of primary studies reporting on the cost-effectiveness, cost–benefit or costs alone of infection control interventions aimed at preventing spread of MRSA. We aimed to provide an overview of empirical studies, to obtain a cost–benefit estimate and to examine factors affecting economic estimates.

Methods

We included studies assessing infection control interventions aimed at preventing spread of MRSA in hospitals. Interventions included implementation of surveillance for MRSA, screening with or without decolonization, contact isolation, droplet isolation, environmental control and antibiotic stewardship. Studies were included if they reported at least one of the following economic analyses: costs of the intervention (intervention cost), costs related to benefit/gain following the intervention (savings), cost–benefit or cost-effectiveness. Any unit of effectiveness could be assessed in cost-effectiveness analyses, including life-years, quality-adjusted life years or infections prevented. We included studies in which cost assessment was based on primary study data; we excluded decision analytic models where the input to the model was based solely on literature review. We excluded studies evaluating costs of laboratory tests or equipment only and studies assessing only benefit by considering a single class of antibiotics.

We searched PubMed until January 2012 using a structured search clause (Appendix 1) and the reference lists of all included articles. We imposed no date or language restrictions. Conference proceedings were not sought because we expected that the level of information provided in an abstract would be insufficient. Two reviewers independently applied inclusion criteria and extracted the data from included studies. Differences in the data extracted were resolved by discussion with a third review author. Justification for excluding studies from the review was documented.

We primarily aimed to extract the costs of the intervention and the economic gain following the intervention. When economic consequences of the intervention were reported at several time points, we extracted all time points and used the longest follow up in the primary analysis. When sensitivity analyses were performed, we extracted base-case figures. We extracted not only the total sum of costs and savings, but also the individual components including personnel (separating nurse, physician and laboratory technician time), materials, antimicrobials, laboratory costs, building and refurbishment. We attempted to extract data on indirect costs, including intangible and productivity losses qualitatively. In addition, we extracted data on the components of the infection control intervention, baseline MRSA endemicity and the effects of the intervention on clinical infections and colonization with MRSA. We based MRSA endemicity rates on the percentage of methicillin-resistant isolates out of all *S. aureus* clinical isolates (usually bacteraemia): <1% low, 1–10% moderate and >10% high [11].

We used the Quality of Health Economic Studies (QHES) tool, adapted for our review, to assess the studies' quality (Appendix 2). The original QHES instrument contains 16 criteria, each with a weighted point value and the maximal score is 100 [12]. As we assessed primary studies rather than economic models, some of the QHES criteria were not relevant. Hence, in the adapted tool, the maximal score was 86 for studies providing cost–benefit or cost-effectiveness analyses and 50 for studies reporting on costs alone. We examined the effect of the revised QHES score on results through subgroup analysis.

We expressed costs per month considering the intervention duration for intervention costs and the duration of follow-up for the save costs. We calculated the save/cost ratio (values >1 indicating savings larger than costs) and the save–cost difference (positive values indicating net saving), adjusted to 2011 US$. All costs reported are in 2011 US$ per month. Since cost values were not normally distributed, highly heterogeneous and reported without a dispersion measure, no formal meta-analysis was performed. We calculated summary median cost, save, ratio and difference values with range (minimum–maximum) or interquartile range (IQR) (25–75% centile). When a range of cost values was reported, we used the median of the range for the summary estimate. We