The economic value of screening haemodialysis patients for methicillin-resistant *Staphylococcus aureus* in the USA

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Abstract

Methicillin-resistant *Staphylococcus aureus* (MRSA) can cause severe infections in patients undergoing haemodialysis. Routine periodic testing of haemodialysis patients and attempting to decolonize those who test positive may be a strategy to prevent MRSA infections. The economic value of such a strategy has not yet been estimated. We constructed a Markov computer simulation model to evaluate the economic value of employing routine testing (agar-based or PCR) at different MRSA prevalence, spontaneous clearance, costs of decolonization and decolonization success rates, performed every 3, 6 or 12 months. The model showed periodic MRSA surveillance with either test to be cost-effective (incremental cost-effectiveness ratio ≤$50 000/quality-adjusted life-year) for all conditions tested. Agar surveillance was dominant (i.e. less costly and more effective) at an MRSA prevalence ≥10% and a decolonization success rate ≥25% for all decolonization treatment costs tested with no spontaneous clearance. PCR surveillance was dominant when the MRSA prevalence was ≥20% and decolonization success rate was ≥75% with no spontaneous clearance. Routine periodic testing and decolonization of haemodialysis patients for MRSA may be a cost-effective strategy over a wide range of MRSA prevalences, decolonization success rates, and testing intervals.

Keywords: Cost-effectiveness, economics, haemodialysis, methicillin-resistant *Staphylococcus aureus*, surveillance
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Introduction

Haemodialysis (HD) patients may be at increased risk for methicillin-resistant *Staphylococcus aureus* (MRSA) colonization and infections [1]. A recent Active Bacterial Core surveillance study found the incidence of invasive MRSA infections among dialysis patients to be 100-fold that in the general population [2]. This is not surprising, as HD patients have a multitude of risk factors, including regular contact with healthcare facilities, healthcare workers, and invasive medical devices [3]. Chronic renal failure can lead to immune system abnormalities and even greater susceptibility to invasive MRSA infections and poorer outcomes. In fact, infections are the second leading cause of mortality among patients with end-stage renal disease [4].

One potential strategy to prevent MRSA infections among HD patients is routine periodic testing for MRSA colonization and decolonizing (i.e. the use of antimicrobials to remove MRSA colonization) patients who test positive. Whereas some institutions may have implemented this, others have not, as surveillance programmes can be costly.

Although a previous study, published in 1996, evaluated the cost-effectiveness of employing routine screening and mupirocin decolonization for *S. aureus* in the dialysis population, additional questions and data have emerged over the last decade [5]. The Bloom *et al.* study provided important information but focused on agar-based surveillance, a 1-year

time horizon, one type of vascular access (shunt), shunt infections (vs. other possible outcomes), and a single decolonization method (mupirocin). The emergence of alternative testing techniques (i.e. PCR) and decolonization regimens, such as those involving rifampin and chlorhexidine, raises questions regarding their role and economic value [6,7]. We developed a Markov computer simulation model to evaluate the economic value of routine periodic testing and decolonization of HD patients for MRSA. Key model parameters were varied in sensitivity analyses, and allowed us to delineate how the cost-effectiveness of such a strategy may vary by MRSA prevalence, decolonization cost, and decolonization success rate. The results of our model may help guide policy-making and the design of future epidemiological and clinical studies.

Methods

Model structure

Using TreeAge Pro Suite 2009 (TreeAge Software, Williamstown, MA, USA), we constructed an individual-based Markov computer model that simulated the decision of whether to test an HD patient routinely and periodically for MRSA from the third-party payer perspective. The model evaluated two surveillance methods: a single anterior nares culture (agar-based surveillance), and nucleic acid detection with an amplified probe technique (PCR-based surveillance). Fig. 1a depicts the flow of the model, which includes five discrete Markov states: (i) not MRSA-colonized; (ii) MRSA-colonized without active infection; (iii) active MRSA infection with outpatient treatment; (iv) active MRSA infection with inpatient treatment; and (v) death (absorptive). Each patient entered the model on the assumption of a three times weekly schedule of dialysis treatment [8]. Each patient entering the model had a probability of a certain type of access (tunnelled dialysis catheter vs. arteriovenous fistula vs. arteriovenous graft). At the beginning of each simulation, the patient had a probability of being already colonized based on the MRSA prevalence. During each cycle, a non-colonized patient could remain non-colonized or become colonized, based on MRSA prevalence. A colonized patient could remain colonized, lose colonization by spontaneous clearance, develop a clinically apparent MRSA infection and be medically decolonized, or die. The probability of MRSA colonization was time-dependent and based on local prevalence. All probabilities were annual and adjusted for the different cycle lengths. At the end of each cycle length, modelled as the time between surveillance intervals, a patient could stay in the same state or move to another. The MRSA status of each patient was determined at the end of each cycle, and they transitioned accordingly. Each patient continued to cycle in the model until reaching the death state, either from not surviving an infection or from reaching the end of his or her life-expectancy (median: 4.8 years) [4].

Testing occurred once every cycle (i.e. 3, 6 or 12 months) in the routine testing branch. These chosen intervals correspond to the timing of other routine tests of HD patient monitoring, such as adequacy of treatment and nutritional evaluation [9,10]. Each test had a probability of identifying MRSA colonization based on its sensitivity. Patients who tested positive (regardless of their actual colonization status) underwent an MRSA decolonization regimen, which had a probability of successfully decolonizing the patient. By contrast, patients who tested negative (even those who were actually MRSA-colonized) did not receive MRSA decolonization. Colonized patients could experience spontaneous clearance of MRSA. All patients with an active MRSA infection underwent decolonization. In the no-testing branch, only patients with an active MRSA infection underwent decolonization. Patients undergoing decolonization could experience side effects. Successfully decolonized patients moved to the not MRSA colonized state, whereas unsuccessful decolonization placed the patients in the MRSA colonized without active infection state. Successfully decolonized patients could become recolonized in subsequent cycles.

An agar-based test of a clinical isolate identified infection. Patients with MRSA infection had probabilities of developing an invasive infection and receiving inpatient treatment for any combination of the following conditions: wound infection (e.g. skin and soft tissue infection), line infection (i.e. infection of the access site), bacteraemia, endocarditis, pneumonia, and osteomyelitis (Fig. 1b). Those patients requiring inpatient treatment for these conditions entered the active MRSA infection with inpatient treatment state. The cost of hospitalization for each condition came from age-dependent data from the Healthcare Cost and Utilization Project, and was based on the mean length of stay for a patient with that condition. We used length of stay to determine quality-adjusted life-year (QALY) decrements. The infection attributable costs depended on the type of access; bacteraemia was associated with access site removal, temporary catheter insertion, and new access site insertion. All other patients with active MRSA infection entered the active MRSA infection with outpatient treatment state.

For each simulation run, we determined the incremental cost-effectiveness ratio (ICER) of MRSA testing, defined as:

$$= \frac{\text{Cost}_{\text{MRSA testing}} - \text{Cost}_{\text{No testing}}}{\text{Effectiveness}_{\text{MRSA testing}} - \text{Effectiveness}_{\text{No testing}}}$$

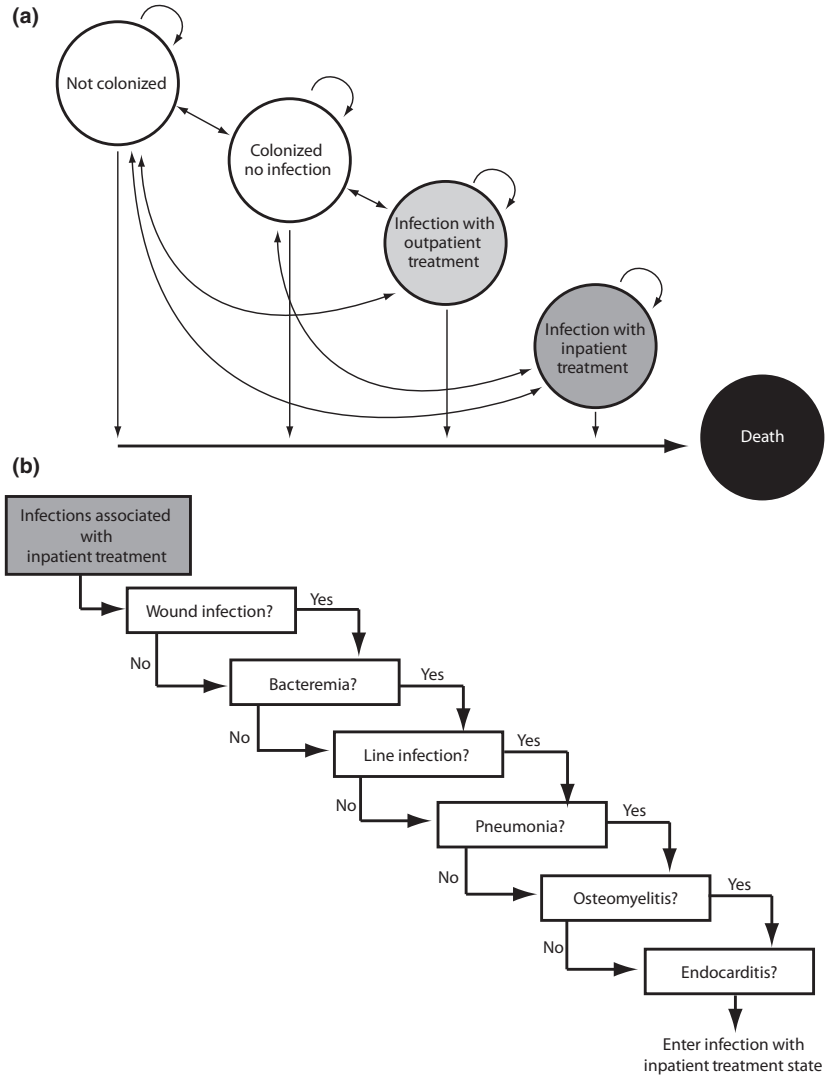

FIG. 1. (a) Markov model structure. (b) Infections associated with inpatient treatment subtree.

where effectiveness is the resulting impact of a given strategy on a patient's health, measured in QALYs.

Data inputs

Table 1 shows the probability, cost, QALY and time input variables for our model. All data came from the published literature where available, and sources are listed in Table 2. Probabilities were pulled from triangular or beta distributions. All costs were converted to 2010 figures (US$), using a 3% discount rate, and were either flat values or pulled from triangular or gamma distributions. All numbers of antimicrobial administrations were either point values or assumed a uniform distribution. These numbers were based on treatment administration at each dialysis event. All durations of hospitalization represented national medians. The distribution types chosen depended on available data and the anticipated bounds of a given parameter. Beta distributions approximate normal distributions and continuous variables that are bounded by 0 and 1 [11]. Gamma distributions frequently represent continuous variables that are always positive and have a skewed distribution, with long upper tails that represent small fractions of the variability [12]. Triangular distributions are used when only the lower limit, likeliest value and upper limit are known. Uniform distributions depict parameters for which all values within a range have an equal likelihood. Where multiple sources are listed in Table 1, the parameter value represents the mean and standard deviation of all included studies. Expert opinion came from detailed interviews and consultations with both an infectious disease physician and a nephrologist.

Each clinical condition resulted in QALY decrements as listed in Table 1 and that persisted throughout the expected duration of the clinical condition (also listed in Table 1). Net QALYs were given by a patient's age-dependent dialysis

TABLE 1. Data inputs for variables in our model

Description (units)	Distribution type	Mean	Standard deviation	Range	Source (Table 2[a])
Costs (US$)					
Vancomycin, 1-g dose	Gamma	10.79	4.73		A
Vancomycin, 500-mg dose	Gamma	6.35	3.63		A
Decolonization regimens					
Mupirocin, 300-mg dose		15.45			B
Rifampin, twice daily for 10 days		59.56			A
Chlorhexidine, 4% cholorhexidine gluconate		29.56			A
Death	Triangular	6720		(5040–8762)	C
Infection outcomes					
Bacteraemia (45–64-year-olds)	Gamma	13 474.57	716.53		D
Bacteraemia (65–84-year-olds)	Gamma	12 983.25	466.79		D
Endocarditis (45–64-year-olds)	Gamma	27 637.15	6246.79		D
Endocarditis (65–84-year-olds)	Gamma	29 600.74	5405.44		D
Line infection (45–64-year-olds)	Gamma	18 740.94	428.43		D
Line infection (65–84-year-olds)	Gamma	19 876.59	539.04		D
Osteomyelitis (45–64-year-olds)	Gamma	11 048.62	1620.37		D
Osteomyelitis (65–84-year-olds)	Gamma	10 495.13	1164.66		D
Pneumonia (45–64-year-olds)	Gamma	23 568.24	884.236		D
Pneumonia (65–84-year-olds)	Gamma	20 801.53	520.168		D
Wound infection (45–64-year-olds)	Gamma	6019.388	655.616		D
Wound infection (65–84-year-olds)	Gamma	6590.229	665.627		D
Clinical procedures					
Transthoracic echocardiogram	Gamma	161.75	44.44		E
Tunnelled dialysis catheter insertion		284.71			E
Tunnelled dialysis catheter removal		140.37			E
Arteriovenous graft insertion		767.88			E
Arteriovenous graft removal		588.18			E
Temporary catheter		121.97			E
Physician consultation	Triangular	89.53		(59.09–119.97)	E
Agar-based surveillance		12.34			F
PCR-based surveillance		50.27			F
QALY values					
Dialysis patients, ages 60–64 years		0.601			G
Dialysis patients, ages 65–84 years		0.549			G
Bacteraemia		0.61			H
Endocarditis		0.615			I
Line infection		0.683			J
Osteomyelitis		0.59			K
Pneumonia		0.87			L
Wound infection		0.683			J
Side effects		0.995			Z
Probabilities					
Test characteristics					
Sensitivity of agar test	Triangular	0.926		(0.63–0.97)	M
Specificity of agar test	Triangular	0.971		(0.922–0.995)	N
Sensitivity of PCR test	Triangular	0.984		(0.91–0.997)	O
Specificity of PCR test	Triangular	0.977		(0.956–0.987)	O
Access site type					
Arteriovenous fistula		0.244			P
Arteriovenous graft		0.051			P
Tunnelled dialysis catheter		0.705			P
MRSA outcomes					
Infection if colonized	Triangular	0.2692		(0.1777–0.3607)	Q
Invasive infection if infected		0.17			R
Inpatient treatment if invasive infection		0.90			R
Clinical conditions of haemodialysis patient hospitalized for invasive MRSA infection					
Bacteraemia		0.7813			S
Bacteraemia secondary to line infection		0.4706			T
Endocarditis		0.0955			U
Line infection		0.0313			S
Osteomyelitis		0.0625			V
Pneumonia	Beta	0.1976	0.0579		W
Wound infection		0.1563			S
Mortality					
Mortality, ages 60–64 years		0.174			P
Mortality, ages 65–69 years		0.205			P
Mortality, ages 70–79 years		0.262			P
Mortality from bacteraemia	Beta	0.2913	0.0604		X
Mortality from endocarditis	Beta	0.4394	0.15		Y
Mortality from pneumonia	Beta	0.3053	0.0807		Z
Side effects from treatment		0.57			AA
Number of antimicrobial treatments					
Bacteraemia	Uniform			(12–18)	Expert opinion
Endocarditis	Uniform			(12–18)	Expert opinion
Line infection	Uniform			(6–12)	Expert opinion
Osteomyelitis		18			Expert opinion
Pneumonia		6			Expert opinion
Wound infection	Uniform			(4.29–6)	Expert opinion

TABLE 1. *Continued*

Description (units)	Distribution type	Mean	Standard deviation	Range	Source (Table 2[a])
Duration of hospitalization (days)[b]					
Wound infection		3			D
Line infection		7			D
Bacteraemia		5.5			D
Endocarditis		7			D
Pneumonia		9			D
Osteomyelitis		5			D

MRSA, methicillin-resistant *Staphylococcus aureus*; QALY, quality-adjusted life-year.
[a]Letters correspond to the sources in Table 2.
[b]Duration of hospitalization used for QALY decrements.

QALY (adjusted by cycle length) multiplied by the QALY of a clinical condition. If patients developed multiple clinical conditions, they were assigned only the greatest QALY decrement and the maximum cost of treatment and hospitalization among their given conditions. Patients had the probability of side effects from treatment and received QALY decrements when appropriate. To assess whether the surveillance strategy was cost-effective, the threshold used in our model was $50 000/QALY [13]. Our model also assumed a mean age of 61 years for all dialysis patients [4].

Decolonization regimen scenarios

Separate scenarios examined the use of the following four different decolonization regimens: (i) mupirocin (300 mg) only; (ii) mupirocin plus rifampin (twice daily for 10 days); (iii) mupirocin and rifampin plus chlorhexidine (4% chlorhexidine gluconate); and (iv) a regimen costing $200, to determine whether an even greater cost of treatment would affect our results. The cost of decolonization varied with treatment regimen (Table 1).

Sensitivity analyses

Sensitivity analyses examined the impact of varying the values of key variables in the model. As the prevalence of MRSA colonization among HD patients is not clearly established and the efficacies of decolonization methods are unknown, we varied these parameters over a range of values [1,6,7,14]. We systematically varied the MRSA prevalence from 0.5% to 20%, the probability of spontaneous clearance from 0% to 25%, and the decolonization success rate from 10% to 100%. Each set of conditions was tested for each decolonization regimen. Cost of infection was varied from half the baseline costs (Table 1) to 1.5 times the baseline costs. Testing frequency was simulated for 3-month, 6-month and 12-month periods. For each simulation run, we conducted probabilistic sensitivity analyses, which simultaneously varied all input parameters over the ranges indicated in Table 1.

Results

Each simulation run consisted of 2000 HD patients passing through the model 2000 times (i.e. 4 000 000 total trials). Tables 3 and 4 show how the ICER varied with MRSA prevalence, decolonization cost, and decolonization success rate, for agar and PCR testing every 3 months. 'Dominant' means that testing dominated, i.e. was less costly and more effective than no testing. Routine agar-based surveillance was cost-effective for all MRSA colonization rates (0.5–20%), decolonization costs ($15.45–$200), and probabilities of decolonization success (10–100%) and spontaneous clearance (0–25%) at all testing intervals. Testing at 3-month intervals resulted in ICERs ≤$1701/QALY (0% spontaneous clearance, decolonization cost $200) and ≤$1683/QALY (≥25% spontaneous clearance, decolonization cost $200). For decolonization costs ≤$104.57, agar surveillance dominated, with an MRSA colonization rate ≥5% and a decolonization success rate ≥25%; increasing the cost of decolonization to $200 resulted in dominance with an MRSA colonization rate ≥10% and the same decolonization success rate (≥25%). Cost-effectiveness increased when the frequency of testing was decreased to 6 and 12 months. Agar testing every 6 months resulted in ICERs ≤$424/QALY for all decolonization costs and success rates with a 0% probability of spontaneous clearance. Agar surveillance remained cost-effective with a 25% spontaneous clearance probability (ICERs ≤$434/QALY with decolonization success ≥25%). Testing dominated the no-testing strategy for scenarios when MRSA colonization was ≥5%. Performing agar surveillance every 12 months was even more cost-effective (ICERs ≤$114/QALY for all scenarios tested with no spontaneous clearance, and ≤$114/QALY for all scenarios with spontaneous clearance of 25% and a decolonization success ≥25%).

Table 4 shows results for PCR surveillance at 3-month intervals. PCR testing was cost-effective; ICERs were

TABLE 2. Sources for model inputs

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TABLE 3. Mean incremental cost-effectiveness ratio (ICER) (95% confidence interval) of performing routine agar surveillance at 3-month intervals with varying methicillin-resistant *Staphylococcus aureus* (MRSA) prevalence and decolonization success rates with a 0% probability of spontaneous clearance

	Decolonization success (%)				
Probability of MRSA colonization (%)	**10**	**25**	**50**	**75**	**100**
Decolonization with mupirocin ($15.45)					
0.5	**1086** (D, 2958)	**1047** (D, 2999)	**1027** (D, 2930)	**1044** (D, 2920)	**1047** (D, 2973)
1	**988** (D, 2913)	**855** (D, 2673)	**818** (D, 2565)	**858** (D, 2577)	**881** (D, 2628)
2.5	**632** (D, 2700)	**307** (D, 2086)	**305** (D, 2052)	**367** (D, 2016)	**503** (D, 2274)
Decolonization with mupirocin and rifampin ($75.01)					
0.5	**1279** (D, 3189)	**1203** (D, 2957)	**1170** (D, 3119)	**1201** (D, 2992)	**1259** (D, 3115)
1	**1184** (D, 3204)	**1048** (D, 2947)	**1036** (D, 2918)	**1048** (D, 2862)	**1098** (D, 2961)
2.5	**898** (D, 2807)	**525** (D, 2382)	**481** (D, 2171)	**564** (D, 2354)	**649** (D, 2408)
Decolonization with mupirocin, rifampin, and chlorhexidine ($104.57)					
0.5	**1372** (57, 3338)	**1297** (D, 3226)	**1273** (D, 3278)	**1327** (D, 3129)	**1309** (40, 3331)
1	**1286** (D, 3464)	**1147** (D, 2975)	**1117** (D, 2876)	**1116** (D, 2933)	**1178** (D, 3070)
2.5	**1039** (D, 3115)	**640** (D, 2530)	**596** (D, 2497)	**665** (D, 2386)	**738** (D, 2485)

Bold: surveillance is cost-effective (ICER ≤$50 000/quality-adjusted life-year).
Dominant (D): surveillance is less costly and more effective than no surveillance.
Results for decolonization cost of $200 are included in the text but not shown in the table.
Results for higher colonization rates (5%, 10%, and 20%) are not shown, as surveillance remains cost-effective.

≤$4833/QALY for all scenarios evaluated. Performing MRSA surveillance was the dominant strategy at MRSA prevalence ≥20% and decolonization success rate ≥50% for all decolonization costs when spontaneous clearance was 0%. Employing PCR-based surveillance was even more cost-effective when performed every 6 or 12 months. At a 6-month frequency, ICERs for PCR surveillance were ≤$1231/QALY for all scenarios evaluated. It became dominant under the same conditions as testing every 3 months. PCR surveillance every 12 months was cost-effective with ICERs ≤$323/QALY. PCR testing was dominant at 20% MRSA prevalence and 75% decolonization success rate when spontaneous clearance was 0%.

Varying the cost of infection (from 0.5 to 1.5 of baseline) did not substantially change the results. Surveillance was still cost-effective for all MRSA colonization rates, spontaneous clearance rates, and decolonization cost and success rates. Decreasing the cost of infection resulted in marginally higher ICERs. Agar surveillance was dominant with ≥20% MRSA colonization rate and ≥50% decolonization success rate when the probability of spontaneous clearance was 0%. PCR surveillance was dominant with ≥20% MRSA colonization rate and ≥25% decolonization success rate when the probability of spontaneous clearance was 0%. Increasing the cost of infection resulted in more cost-effective ICERs.

TABLE 4. Mean incremental cost-effectiveness ratio (ICER) (95% confidence interval) of performing routine PCR surveillance at 3-month intervals with varying methicillin-resistant *Staphylococcus aureus* (MRSA) prevalence and decolonization success rates with a 0% probability of spontaneous clearance

	Decolonization success (%)				
Probability of MRSA colonization (%)	**10**	**25**	**50**	**75**	**100**
Decolonization with mupirocin ($15.45)					
0.5	**4349** (2343, 7473)	**4288** (2324,7239)	**4261** (2300, 6978)	**4309** (2392, 7516)	**4312** (2393, 7237)
1	**4204** (2200, 7369)	**4058** (2193, 7002)	**4079** (2113, 7054)	**4109** (2164, 7139)	**4204** (2221, 7226)
2.5	**3769** (1786, 6710)	**3535** (1582, 6456)	**3497** (1605, 6199)	**3557** (1821, 6317)	**3710** (1807, 6639)
5	**3166** (1214, 6012)	**2654** (826, 5370)	**2600** (875, 5220)	**2732** (1028, 5159)	**2951** (1244, 5390)
Decolonization with mupirocin and rifampin ($75.01)					
0.5	**4434** (2440, 7453)	**4439** (2389, 7529)	**4401** (2369, 7632)	**4427** (2364, 7669)	**4453** (2445, 7611)
1	**4418** (2451, 7417)	**4207** (2194, 7270)	**4223** (2312, 7166)	**4247** (2332, 7369)	**4339** (2425, 7395)
2.5	**4027** (2031, 6904)	**3675** (1720, 6554)	**3651** (1730, 6425)	**3709** (1811, 6473)	**3800** (1979, 6539)
5	**3523** (1417, 6822)	**2822** (929, 5621)	**2744** (1055, 5358)	**2907** (1173, 5561)	**3066** (1312, 5730)
Decolonization with mupirocin, rifampin, and chlorhexidine ($104.57)					
0.5	**4553** (2518, 7572)	**4494** (2450, 7576)	**4473** (2437, 7455)	**4533** (2523, 7612)	**4495** (2513, 7433)
1	**4478** (2426, 7643)	**4335** (2343, 7503)	**4285** (2306, 7575)	**4310** (2242, 7728)	**4409** (2407, 7398)
2.5	**4135** (2053, 7598)	**3815** (1794, 6923)	**3755** (1809, 6887)	**3859** (1952, 6833)	**3882** (1909, 6944)
5	**3665** (1545, 6746)	**2927** (1036, 5669)	**2791** (974, 5501)	**2955** (1216, 5575)	**3177** (1294, 5869)

Bold: surveillance is cost-effective (ICER ≤$50 000/quality-adjusted life-year).
Dominant (D): surveillance is less costly and more effective than no surveillance.
Results for decolonization cost of $200 are included in the text but not shown in the table.
Results for higher colonization rates (5%, 10%, and 20%) are not shown, as surveillance remains cost-effective.

Discussion

Our results suggest that routine periodic testing and decolonization of HD patients for MRSA colonization is cost-effective for a wide range of MRSA prevalence, decolonization cost and decolonization success rate values. This is consistent with the findings of Bloom *et al.* [5] that *S. aureus* screening and decolonization of dialysis patients is cost-saving. Routine agar surveillance had lower ICERs (i.e. had greater economic value) than PCR, suggesting that the marginal gains in sensitivity and specificity afforded by PCR are outweighed by the increased cost associated with PCR. The cost of surveillance appears to have a greater impact on the ultimate economic value of a surveillance strategy than the cost of the decolonization regimen. Accounting for potential spontaneous clearance somewhat decreased the economic value of surveillance but did not substantially change our results (i.e. active surveillance and decolonization remained cost-effective throughout all scenarios tested). The choice of drug regimen (among the available possibilities) also did not substantially affect the results, suggesting that surveillance remains cost-effective even when more expensive regimens are used. MRSA colonization rate was the largest driver of cost-effectiveness, followed by the probability of successful decolonization; both increased the cost-effectiveness of surveillance (i.e. lower ICERs). In fact, our results indicate that employing surveillance becomes economically dominant as MRSA prevalence increases, even at low decolonization success rates. Therefore, when deciding when, whether and how to implement a surveillance programme, decision-makers may want to focus on the risk of MRSA colonization and the efficacy of decolonization. In other words, they may want to choose the most efficacious decolonization regimen.

Our previous studies have evaluated the economic impact of routine surveillance and decolonization in vascular surgery, orthopaedic surgery and cardiac surgery patients, as well as screening and contact isolation of medical patients in acute-care hospitals [15–18]. These populations have unique patient-level risk factors for MRSA that suggest that decisions concerning the implementation of a surveillance programme ought to be made for each population. HD patients have a much higher incidence of invasive MRSA than the general population; however, the impact of decolonization in

HD populations may be different from that in surgical populations, where transient decolonization may decrease the risk of postoperative infection.

The long-term effectiveness of various decolonization regimens is unclear. Studies have not clearly established the efficacy of decolonization [19]. A double-blind trial of intranasal mupirocin reported a 25% eradication rate vs. 18% in the placebo group [20]. A systematic review of decolonization studies noted that many studies found much higher decolonization success rates, although variable follow-up times were used [6]. Short-term decolonization seems to be successful; however, long-term decolonization is harder to achieve. Many patients may become recolonized after returning home or entering other healthcare environments. Moreover, it is still debated whether decolonization is simply suppression of colonization for a finite length of time rather than the individual reverting fully to a non-colonized state. Future studies may clarify the longer-term success rates of different decolonization regimens. However, on the basis of our model, as long as decolonization is successful in 10% of attempts, implementing decolonization on MRSA-positive patients would be cost-effective.

Our study did not consider the possibility that decolonization may select for mupirocin resistance. Although several studies have documented resistance when mupirocin is widely used in the general population, and with routine mupirocin use in peritoneal dialysis patients when used both intranasally and at the exit site, resistance appears to be rare with routine intranasal application alone in HD patients [7,21].

Our results are conservative with regard to the benefits of MRSA testing, as our model used the lower end of infection procedure costs, while excluding rarer MRSA complications. Our model also did not factor in how testing may prevent MRSA spread by identifying and either decolonizing or isolating carriers before they can transmit MRSA to other patients. Finally, our study did not quantify how information from routine testing (e.g. MRSA colonization prevalence and infection incidence) may help public health officials, hospital administrators and researchers to monitor MRSA spread and the effectiveness of interventions.

Rather than make decisions, computer models provide information that may help individual nephrologists, HD centre administrators, hospital infection control personnel and policy-makers make informed decisions based on their local circumstances. Models can help elucidate relationships and factors that are not readily apparent and provide benchmarks for decision-making. Decision-makers can adapt model findings to their unique local circumstances and tailor their solutions accordingly.

Limitations

All computer simulation models are simplifications of real life and cannot completely represent every possible event and outcome that may result from MRSA colonization or infection in HD patients. Probabilities were individual-based, and did not depend on the states of other HD patients. We selected the more common clinical outcomes for which data were available. The data inputs for our model came from different studies of varying quality, and may not fully reflect the socio-demographic and clinical heterogeneity of HD patients. Also, our results may not be generalizable to younger HD patients, as our model only considered those patients ≥61 years of age.

Conclusions

Our model suggests that routine periodic MRSA testing of HD patients with either agar-based or PCR-based methods is cost-effective over a wide range of MRSA prevalence, decolonization cost and decolonization success rates. Testing may identify patients at risk for and prevent MRSA infections, yielding savings that may outweigh the costs of testing and decolonization. Individual nephrologists, HD centre administrators, hospital infection control personnel and policy-makers can compare their local circumstances with the assumptions and outlined thresholds of our model to make decisions about whether to implement routine MRSA testing. Future studies could help to delineate MRSA prevalence and decolonization success rates in different HD populations.

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Transparency Declaration

Conflicts of interest: nothing to declare.

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