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Chapter 2.2

Costs and benefits of the MRSA Search and Destroy policy in a Dutch hospital

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Abstract

The objective of this study was to determine the costs and benefits of the MRSA Search & Destroy policy in a Dutch hospital during 2001 through 2006. Variable costs contained costs for isolation, contact tracing, treatment of carriers and closure of wards. Fixed costs were costs for building of isolation rooms and salary of one full-time infection control practitioner. To determine the benefits of the Search & Destroy policy, the transmission rate during the study period was calculated. Furthermore, the number of cases of MRSA bacteraemia prevented was estimated and its associated prevented costs and patient lives. The costs of the MRSA policy were estimated at 215,559 euro a year, which equals 5.54 euro per admission. The daily isolation costs for MRSA suspected and positive hospitalized patients were €95.59 and €436.62, respectively. Application of Search & Destroy resulted in a transmission rate of 0.30 and was estimated to prevent 36 cases of MRSA bacteraemia per year, resulting in annual savings of €427,356 euro for the hospital and 10 lives per year (95% CI 8-14). In conclusion, application of the MRSA Search & Destroy policy in a hospital in a country with a low endemic MRSA incidence saves money and lives.

Introduction

Meticillin-resistant *Staphylococcus aureus* (MRSA) has become an increasingly important pathogen in hospitals worldwide and recently also in the community.[1] In The Netherlands and in Scandinavian countries the percentage of *S. aureus* bacteraemia caused by MRSA is very low (≤1%), contrary to other European countries that have reached percentages up to 50 percent.[2] The low incidence in The Netherlands and Scandinavian countries is maintained by an active Search & Destroy (S&D) policy, outlined in the national guidelines of the Dutch Working Party on Infection Prevention (WIP).[3] The main aspects of the S&D policy are screening and isolation of patients considered at increased risk for carriage of MRSA. This policy mainly affected persons that have been treated in a hospital abroad. However, since July 2006 a new group has been added, i.e. patients with exposure to pigs or veal calves.[4,5] Isolation is performed in a room with an anteroom, where HCW must put on their personal protective equipment (PPE: mask, hat, gown and gloves). Because MRSA can be transmitted by air, an air pressure gradient (−15 Pascal in the room, −7.5 Pa in the anteroom and 0 Pa in the corridor) is required to prevent airflow (which may contain MRSA) from the room to the corridor. Carriers of MRSA (both patients and Health Care Workers (HCW)) are treated with antibiotics, which are described in the guidelines of the Dutch Working Party on Antibiotic Policy (SWAB).[6] Up till now few studies have estimated the costs and benefits of the S&D policy.[7,8] The objective of this study was to determine the costs and benefits of the S&D policy in a large teaching hospital, the Amphia hospital, in a country with a low MRSA prevalence. The S&D policy in the Amphia hospital is based entirely on the national MRSA guideline from the WIP.[3] The implementation of the guideline is controlled by the Inspection for Healthcare.

Materials and methods

Setting

This analysis was performed in the Amphia hospital, a teaching hospital with 1370 beds. All medical specialties are present. The hospital is located in the south-western part of the Netherlands and serves a population of ~440,000 inhabitants. During the study period, on average 38,943 patients were admitted annualy to this hospital with 282,585 patient days per year (mean numbers over 2001 through 2006).

MRSA screening and confirmation

Culture swabs were inoculated on a blood agar plate and in a broth enrichment. Culture plate and broth enrichment were incubated by 35-37°C overnight. After 1 day the

broth enrichment was inoculated on a blood culture plate and a mannitol salt agar plate with oxacillin (2 mg/l). Colonies, which were suspected for *S. aureus*, were tested by a latex agglutination test and the susceptibility for oxacillin was determined on a Mueller Hinton agar plate with 2% NaCL. All strains were confirmed to be MRSA by PCR for the Nuc-gene and the Mec-A gene. MRSA strains from all patients and HCW were typed by the Dutch National Reference Centre (RIVM, Bilthoven, The Netherlands). This method was unchanged during the study period.

Data collection

Data of all patients and health care workers (HCW) that were found to be carrying MRSA during the years 2001 through 2006 were prospectively recorded in a data base. The following items were recorded: patient identification number, date of birth, date of first MRSA positive culture, MRSA Pulsed-Field Gel Electrophoresis (PFGE) type, MRSA polymorphic X-region of the protein A gene (*Spa*) type, MRSA source, whether MRSA was found by targeted screening or by coincidence, number of screened contact patients and Health Care Workers (HCW) (both unprotected and protected contacts), number of secondary cases, number of days that MRSA positive HCW were suspended from work, whether MRSA treatment was given and if so, whether MRSA was eradicated.

Estimation of costs for the hospital

The costs of the MRSA S&D policy for the hospital over the years 2001 through 2006 were based on real data extracted from the above-mentioned data bank and other data (isolation database and registration forms) of the Infection Control department. First, costs were divided into variable and fixed costs. The method for the estimation of the variable costs is shown in figure 1. Cases were stratified based on the location of the initial finding (inpatient's or outpatient's clinic), if they were detected by targeted screening or as a coincidental finding and whether nosocomial spread had occurred. Costs for materials for personal protective equipment (PPE): gown, gloves, mask and hat, screening cultures, cleaning, salaries, missed patient days, MRSA eradication treatment, and building of pressure-controlled isolation rooms were asked to the financial department of the hospital. To calculate the costs for PPE the number of isolation days and outpatient visits of MRSA suspected and positive patients were extracted from the isolation data base of the infection control department. For inpatients, the mean number of HCW and visitors that entered the room daily were extracted from the contact lists of the archives of the Infection Control Department. Treatment costs were estimated based on the number of treatments given to the MRSA positive patients and HCW. The mean costs were €100 per treatment. Strain typing costs (€100/strain) were not included in the costs-analysis, because this is done in a reference laboratory which is reimbursed by the government and in this study the costs for the hospital were

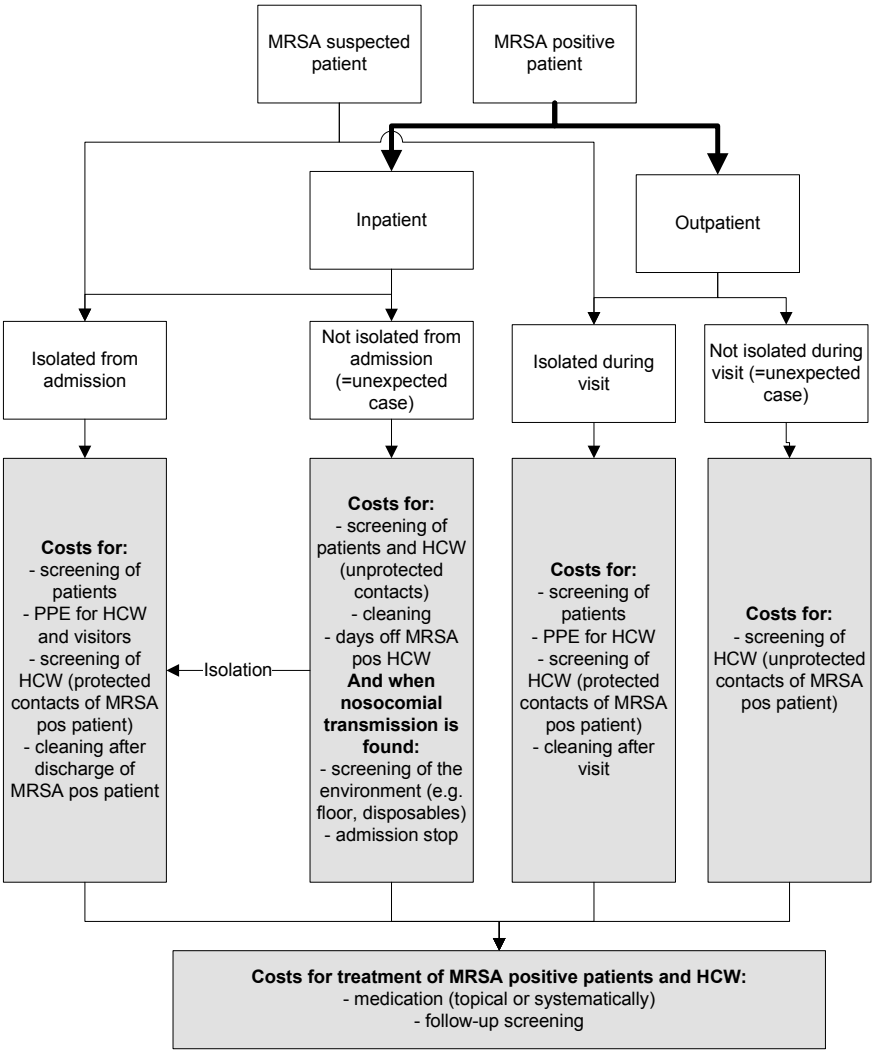

Figure 1. Estimation of the variable costs of the S&D policy.

estimated. The fixed costs were divided into costs for building of pressure controlled isolation rooms and the salary of one full-time infection control practitioner. The costs of the microbiologist, who acts as the infection control physician as well, were included in the culture costs. Ten percent was added to the total costs for overhead and for costs that could not be estimated, for example costs for disposables that had to be thrown away and for additional HCW that were asked to work when a MRSA positive patient was lying on their ward.

Furthermore, the additional daily isolation costs for isolated patients and additional costs for unexpected MRSA positive cases were estimated. Treatment costs were excluded in these analyses. To estimate the daily isolation costs for MRSA positive and

suspected patients the total variable isolation costs were divided by the total number of patients that had been appropriately isolated. The mean length of stay for MRSA positive and suspected patients was calculated and used to estimate the daily isolation costs. Fixed costs for building isolation rooms were divided by the total number of isolation days and added to the mean daily isolation costs. To estimate the additional costs that have to be made for patients and HCW that were unexpectedly found to carry MRSA, the total variable costs for unexpected MRSA cases were divided by the number of patients and HCW that were found to be MRSA positive by coincidence. These additional costs were estimated both for the cases with and without nosocomial transmission.

Estimation of benefits

To estimate the effect of the S&D policy in our hospital, the transmission rate (secondary cases / index cases) during the study period was calculated. Secondary cases were cases of patients and HCW who were colonised by MRSA due to nosocomial transmission. When a MRSA positive case found in the hospital could be linked in time (overlap in dates of patient days with a maximal interval of 30 days) and place (overlap in wards including adjacent wards) to an index patient or HCW and the MRSA strains was indistinguishable to the strain of the index, the source of the case was classified as nosocomial transmission. When no link in time and place could be found, the case was classified as index case.

Furthermore, the benefits of the situation under application of the S&D policy was compared to a situation in which the Netherlands would have never applied the S&D policy. Therefore, the mean annual number of patients with a nosocomial *S. aureus* bacteraemia that could be prevented and its associated saved costs and the number of patient lives that could be saved by application of the S&D policy was estimated. This was based on the annual number of patients with a nosocomial *S. aureus* bacteraemia found in the Amphia hospital. Patients suffering from a *S. aureus* bacteraemia were identified in the laboratory information system. Data were available for the years after the implementation of this information system, i.e 2004 through 2006. Each first *S. aureus* positive blood sample of a patient was included, further positive samples were excluded. Samples taken from patients at the dialysis department were excluded because in this patient population it is difficult to determine whether the bacteraemia was acquired in the hospital or in the community. Bacteraemia were defined to be nosocomial when the first positive blood culture was sampled more than two days after admission. To estimate the number of lives that could be saved, the mortality rate during hospital stay was determined in patients with a nosocomial *S. aureus* bactaeremia. The assumption was made that if no control measures would have been implemented 50% of the nosocomial *S. aureus* bacteraemias would have been caused by MRSA, as is the case in many countries that do not apply a MRSA S&D policy [2]. Introduction

of MRSA has been shown to increase the absolute number of cases of nosocomial *S. aureus* bacteraemia, as has been shown in the UK.[9,10] So instead of replacement, MRSA adds up to the existing burden of disease. Associated costs were based on the results of Cosgrove et al, who estimated the median hospital costs for patients with MRSA bacteraemia at €11,871 ($14,655).[11] This calculation was based on the mean dollar-euro exchange rate of 2005, the year that the study of Cosgrove et al was published.[11] In our estimation of benefits no difference in mortality between bacteraemia due to MRSA or MSSA was taken into account.

Results

Costs of the MRSA policy

The total costs of the MRSA policy over the years 2001 through 2006 were calculated at €1,293,353. This is on average €215,559 per year. The costs are specified in table 1.

Table 1: Costs of the MRSA Search and Destroy policy in 2001 through 2006

	Number	**Costs (€)**	**2001-2006 total costs (€)**
Variable costs:			
1. Isolation costs			
MRSA suspected patients (324 admissions)			
PPE (gown, gloves, mask, hat for HCW and visitors	6 (=mean contact list) + 5 / day	1.86/set	
	1,446 isolation days	20.46/day	29,585.16
Screening of patients	324 x 4 cultures = 1296	29/culture	37,584.00
Subtotal isolation costs MRSA suspected patients			**67,169.16**
MRSA positive patients (90 admissions)			
PPE for HCW and visitors	6 (=mean contact list) + 5 / day	1.86/set	
	644 isolation days	20.46/day	13,176.24
Screening of patients	90 x 4 cultures = 360	29/culture	10,440.00
Screening of HCW (protected contacts (=with PPE))	84 HCW (=mean contact list) x 90 admissions = 7,560	29/culture	219,240.00
Cleaning after discharge	90 hours	50/hour	4,500.00
Subtotal isolation costs MRSA positive patients			**247,356.24**
Costs outpatients' clinic visits (MRSA positive and suspected patients)	936/6 year		
PPE for HCW	1872	1,86/set	3,481.92
Screening of HCW (protected contacts)	1872	29/culture	54,288.00
Cleaning after visit	936	50/hour	46,800.00
Screening of patients	936 x 4 cultures = 3744	29/culture	108,576.00
Subtotal isolation costs outpatient's clinic			**213,145.92**
Subtotal isolation costs			**527,671.32**

Table 1 (continued)

	Number	Costs (€)	2001-2006 total costs (€)
2. Costs coincidental findings inpatient's clinic without nosocomial spreading.	27patients and 4 HCW		
Screening of patients (unprotected contacts)	1,264 cultures	29/culture	36,656.00
Screening of HCW (unprotected contacts)	1,226 cultures	29/culture	35,554.00
Cleaning	27 rooms	50/hour	1,350.00
Day offs of MRSA positive HCW (job taken into account)	133 days	90/day	11,970.00
Subtotal costs			**85,530.00**
3. Costs coincidental findings inpatient's clinic with nosocomial spreading.	2 outbreaks (14 patients and 9 HCW)		
Screening of patients (unprotected contacts)	360 cultures	29/culture	10,440.00
Screening of HCW (unprotected contacts)	777 cultures	29/culture	22,533.00
Screening of the environment (e.g. floor, disposables)	198 cultures	29/culture	5,742.00
Cleaning	257 hours	50/hour	12,850.00
Admission stop in outbreak situation	55 days	385/day at ward	21,175.00
Day offs of MRSA positive HCW (job taken into account)	215 days	90/day	19,350.00
Subtotal costs			**92,090.00**
4. Costs coincidental findings in outpatient's clinic	16 patients		
Screening of HCW (unprotected contacts)	211	29/culture	6,119.00
Screening of patients (when HCW is positive)	0		0
Cleaning	0		0
Subtotal costs			**6,119.00**
5. Treatment costs	12 HCW with 14 treatments 32 pat with 44 treatments		
Treatment (topical or systemically)	58 treatments	100/ treatment	5,800.00
Follow-up screening of treated patients and HCW	1,524 cultures	29/culture	44,196.00
Subtotal costs			**49,996.00**
Fixed costs:			
1. Salary ICP (1fte)	1 fte	51,661.5/ year	309,969.00
2. Building isolations rooms (debit from 20 year)	16 rooms	21,750/ room (debit of 20 years)	104,400.00
Subtotal costs			**414,369.00**
Calculated costs 2001 until 2006			**1,175,775.32**
Overhead: 10%			**117,577.53**
Total costs 2001 until 2006			**1,293,352.85**
Costs per year			**215,558.81**

HCW = Health Care Workers

Table 2: Mean additonal costs per MRSA case and additional costs per isolation day during 2001 through 2006

Inpatient's clinic	n	Isolation days	Mean total variable costs (€) / case	Mean length of stay	Mean variable costs (€) / isolation day	Mean fixed costs (€) / isolation day	Total costs (€) / isolation day
MRSA suspected patient in isolation	324	1446	207.31	4.5	46.07	49.52	95.59
MRSA positive patient in isolation	90	644	2748.40	7.1	387.10	49.52	436.62
Coincidental finding without nosocomial spread[1]	31	NA	2759.03	NA	NA	NA	NA
Outbreak situation (2 outbreaks)[1]	23	NA	4003.91	NA	NA	NA	NA
Outpatient's clinic							
MRSA positive/suspected patient in isolation[2]	936	NA	227.72	NA	NA	NA	NA
Coincidental finding without nosocomial spread	16	NA	382.44	NA	NA	NA	NA

n = number
NA = not applicable
[1]These costs are additional to the isolation costs.
[2]No data were available about the number of postive and suspected patients, so costs could not be estimated for separate groups.

The mean variable costs per MRSA positive or suspected case and costs per isolation day are shown in table 2. Figure 2 shows the costs for the separate items of the S&D policy. The main costs are caused by costs for screening and the salary of one full-time infection control practitioner.

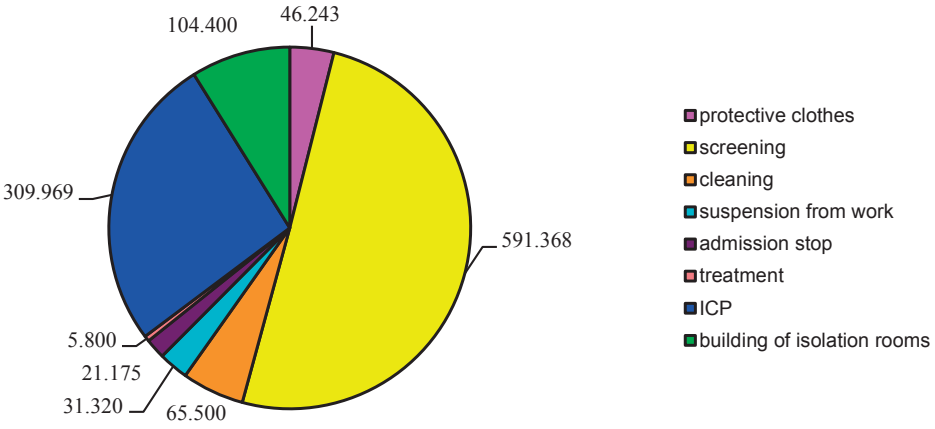

Figure 2. Costs of the different items of the MRSA Search and Destroy policy in 2001 through 2006.
ICP = Infection Control Practitioner

Benefits due to the MRSA policy

Two outbreaks occurred during the study period, both caused by the same MRSA type (PFGE 55, *Spa* t003). The first patient was a patient who had been transferred from a hospital in Turkey. Unfortunately, this patient was not asked whether he belonged to a MRSA risk category on admission and was therefore not isolated until MRSA was found in a clinical culture and spread had occurred. Thirteen patients and 9 HCW were colonised by nosocomial transmission during these two outbreaks. The transmission rate during the study period was 0.30 (22 secondary cases / 73 index cases).

In 2004 through 2006, the total number of patients that developed a nosocomial bacteraemia caused by *S. aureus* was 109 (mean 36 ± 10 per year), resulting in an incidence density of 1.3 / 10,000 patient days (109 / 833,716). All these *S. aureus* strains were susceptible for meticillin. Thirty-one of these patients (28.4%) died during their hospital stay (mean 10 per year). Based on the assumption of 50% MRSA prevalence caused entirely by addition, 36 additional nosocomial bacteraemia would have been caused by MRSA each year when no control measures had been taken. Based on Cosgrove et al, the hospital costs for these 36 MRSA bacteraemia would have been €427,356.[11] With comparable MRSA and MSSA mortality rates, this would have resulted in 10 additional deaths (95% CI 8-14).

Discussion

Estimated costs

The costs of the S&D policy were estimated at €215,559 per year, equivalent to €5.54 per admission or €0.76 per patient day. This equals 0.08% of the hospital budget. The estimated costs are comparable to the costs as estimated by Vriens et al.[7] The annual costs of the MRSA policy in the University Medical Centre Utrecht during the years 1991 through 2000 were estimated at €280,000. Recently, Nulens et al estimated the costs for pro-active searching for MRSA in the University Hospital Maastricht at €1,383,200 per year.[8] These higher estimate is mainly caused by more screening tests due to the extension of the risk period from 2 to 6 months and the higher costs per isolation day, i.e. costs for extra HCW, disposables and additional room cleaning. In our hospital, almost no additional HCW were asked to work, a stock of disposables for 24 hours only was used, and additional room cleaning was only required after discharge of the patient instead of every day. Apparently, this approach is effective as well and is associated with much lower costs. In general, the costs estimated for the Amphia hospital are representative for all other Dutch hospitals, because they all follow the S&D policy described in the WIP guideline.[3] Although there may be variations between hospitals in the implementation of the guideline these are minor.

This is the first study that estimated the additional costs per MRSA suspected or positive case (table 2). The daily incremental costs for hospitalized patients in isolation were relatively low, i.e. €436.62 for MRSA positive patients and €95.59 for MRSA suspected patients. This difference can be explained by the absence of screening of HWC after contact with MRSA suspected patients. However, relatively high additional costs have to be made for coincidental findings who were not in isolaton from the very start, i.e. €2759.03 for cases without nosocomial transmission and €4003.91 for cases with nosocomial transmission. It confirms the importance to identify persons at risk for MRSA carriage and take control measures as soon as possible.

In the Amphia hospital, the number of MRSA positive persons increased during this study-period due to the emergence of NT-MSRA.[4] This type is related to a reservoir in pigs and veal calves.[5] As this reservoir is now clearly established and will not likely to decrease in the future, this will result in higher costs for the MRSA policy, especially for the variable costs. In addition, the costs described in this article are costs for a MRSA S&D policy in a country with low endemic MRSA levels. Costs that have to be made in a high prevalence setting will be much higher, because in that setting it is impossible to designate patients to a specific MRSA risk category. This will require more extensive screening. Also, more isolation rooms, PPE and MRSA eradication treatment are needed. The best way to handle this is probably a stepwise implementation. For example, the mathematical model of Bootsma et al. showed that starting with a limited number of control measures (e.g. screening, precautionary isolation) will reduce the MRSA–rates in the hospital.[12] Based on this model it is estimated that application of the full S&D policy in a high-endemic setting will reduce endemic prevalence levels to <1% within 6 years. However, screening of contact patients (with precautionary isolation) of an index case will take, on average, 8 years to reach endemic levels <1%.

Estimated benefits

During the study period hardly any nosocomial transmission occurred (transmission rate of 0.30), which shows the effectiveness of the S&D policy in a country with a low endemic MRSA incidence. Furthermore, the saving in costs for the hospital and the number of patient lives saved based on the prevention of MRSA bacteraemia was calculated to estimate the benefits for the Amphia hospital. This is extremely difficult since it is not possible to determine accurately what would have happened happen if no control measures had been implemented in the Dutch situation. Therefore it has to be based upon assumptions that try to translate the observed situation in countries with high rates of MRSA to the countries with low rates. In countries that did not implement the S&D policy, the number of cases of bacteraemia caused by *S. aureus* increased when MRSA emerged.[10] So MRSA added to the existing burden of Staphylococcal disease. If no S&D policy had been implemented in our hospital, it was estimated that annually 36

cases of MRSA bacteraemia would be added to the present 36 cases of MSSA bacteraemia. The S&D approach prevents these events and this was estimated to result in an annual saving of €211,797 (saved costs based on prevented MRSA bacteraemia - costs for application of S&D policy = €427,356 - €215,559) for the hospital and of 10 (95% CI 8-14) patient lives. This is probably an underestimation because of two reasons. First, there are indications that there is a difference in mortality rate between bacteraemia caused by MRSA and MSSA.[10,13] The meta-analysis of Cosgrove et al showed a significant higher mortality rate due to MRSA bacteraemia than due to MSSA (OR 1.88, 95% CI 1.33-2.69). Because this increased mortality due to MRSA is under discussion, we did not take it into account for our estimation of the benefits. Second, this estimation focussed on bacteraemia only and not on other infections caused by *S. aureus*. In the USA, the mortality rate due to MRSA invasive infections was estimated at 6.3/100,000 inhabitants in 2005.[14] The Amphia serves a population of ~440,000 inhabitants. In accordance with the situation in the USA, when no S&D policy would had been applied in the Amphia, 27 deaths due to invasive MRSA infection would have occurred in 2005. This is higher than the upper range of the confidence interval that we estimated. Therefore we consider this to be a conservative estimate.

In conclusion, application of the MRSA S&D policy in a hospital in a country with a low endemic MRSA incidence saves money and lives.

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