Eur J Clin Microbiol Infect Dis (2002) 21:782–786
DOI 10.1007/s10096-002-0811-4

ARTICLE

M. Vriens · H. Blok · A. Fluit · A. Troelstra
C. van der Werken · J. Verhoef

Costs Associated with a Strict Policy to Eradicate Methicillin-Resistant *Staphylococcus aureus* in a Dutch University Medical Center: A 10-Year Survey

Published online: 8 November 2002

Abstract Although the Dutch policy to eradicate methicillin-resistant *Staphylococcus aureus* (MRSA) is very strict compared to policies employed in other countries, it has proven to be successful epidemiologically (incidence of MRSA in the Netherlands, <0.5%). The present study was performed to investigate both the financial and the logistical consequences of this strict, so-called "search and destroy" policy in the Netherlands. The data were based on a 10-year survey (1991–2000) of screening, surveillance, and outbreaks at the University Medical Center Utrecht. The consequences of the policy were determined by a panel comprising physicians from the Department of Surgery, the Department of Medical Microbiology, Subdivision Hospital Hygiene and Infection Prevention, the Department of Pharmacy, and Household Services. The costs associated with the policy were also calculated, including those for additional (disposable) material, cultures, specific medication, decontamination, and closing of the wards. Over the course of the 10 years, implementation of the MRSA policy resulted in more than 2,265 lost hospitalization days. In addition, the wards had to be closed 48 times, 29 healthcare workers had to temporarily discontinue working, and 78,000 additional cultures had to be performed. The total cost reached 6 million Dutch guilders (euro 2,800,000). The financial and logistical consequences were then compared to those in a hypothetical situation without the "search and destroy" policy. In such a situation, the hospital would be faced with an increased incidence of MRSA, vancomycin intermediate-susceptible *Staphylococcus aureus*, and vancomycin-resistant enterococci. The costs associated with the use of alternative antibiotics, required in a scenario of high endemic-level MRSA, would be at least twice as high as the costs expended in the actual situation, thus demonstrating that a strict MRSA policy is financially worthwhile.

M. Vriens · H. Blok (✉) · A. Fluit · A. Troelstra · J. Verhoef
Department of Hospital Hygiene and Infection Prevention,
Eijkman-Winkler Institute for Microbiology,
Infectious Disease and Inflammation,
University Medical Center Utrecht,
HP G 04.614, Heidelberglaan 100, 3584 CX Utrecht,
The Netherlands
e-mail: H.E.M.Blok@lab.azu.nl
Tel.: +31-30-2509091, Fax: +31-30-2541770

M. Vriens · C. van der Werken
Department of Surgery, University Medical Center Utrecht,
HP G 04.228, Heidelberglaan 100, 3584 CX Utrecht,
The Netherlands

Introduction

Absolute control of the spread of methicillin-resistant *Staphylococcus aureus* (MRSA) remains a major occupation of infection-control practitioners throughout the world [1]. The Dutch approach to controlling MRSA is based on the so-called "search and destroy" policy [2]. At the University Medical Center Utrecht (UMCU), this means isolating all patients suspected of being colonized or infected with MRSA. Suspect patients include all patients who were hospitalized in a foreign country during the previous year and all patients who have had contact with MRSA-positive patients. As soon as inventory cultures for MRSA are shown to be negative, isolation precautions are discontinued. MRSA-positive patients, in contrast, are hospitalized in strict isolation. If one or more risk factors for prolonged carriage (skin lesions, foreign bodies, chronic infections, and antibiotic usage) are present, even when cultures are negative, isolation is continued until the risk factors are no longer present.

All MRSA-positive patients at the UMCU are given eradication therapy for MRSA carriage as soon as the risk factors have disappeared; they are then monitored for a 6-month follow-up period. Only when risk factors remain absent and cultures for MRSA are negative during this 6-month follow-up period are MRSA isolation precautions discontinued. If MRSA is cultured unexpectedly from a clinical sample of a patient, all contact patients, e.g. roommates and healthcare workers (HCWs) are screened for MRSA. If a second MRSA-positive patient is found, the ward is closed to new admissions. An

intensive care unit (ICU) is closed immediately in the event that an MRSA-positive patient is detected unexpectedly, since all patients and HCWs involved are at risk of being colonized with MRSA. Temporary suspension from work and therapy to eradicate MRSA carriage are standard procedures when HCWs are found to be MRSA positive. The ICU reopens for admission only when screening cultures have proven that all patients and HCWs are MRSA negative.

Even though the UMCU has been successful in keeping the incidence of MRSA colonization/infection below 0.5%, 16 outbreaks occurred during the 10-year period of the survey [3, 4]. Two of the outbreaks were major and, although containable, had major financial and logistical consequences. For example, wards had to be closed temporarily, surgeries postponed, and elective admissions cancelled. High-risk units like surgical wards and ICUs were the most affected [5]. This retrospective, descriptive study provides data on the financial costs of a 10-year "search and destroy" policy.

Patients and Methods

To ascertain the magnitude of the investments that are involved in the Dutch MRSA policy, we studied the financial and logistical outcome of screening, surveillance, and outbreaks at the UMCU, a 1,042-bed university hospital, over a 10-year period (1991–2000). All costs, available retrospectively, were calculated, including (i) material costs, i.e. those associated with additional supplies (such as gloves, masks, and gowns), specific medication, and the cleaning of wards; (ii) costs associated with HCWs, such as temporary work exclusion and additional HCWs hired for cleaning and nursing; (iii) microbiological cultures; and (iv) lost income for departments resulting from the closure of wards during outbreaks, which meant a lower number of admissions and surgical procedures.

In cooperation with Household Services, we calculated both the number of wards that had to be cleaned and the number of extra cleaning personnel required. Order forms from all departments involved in the screening and outbreaks of MRSA were analyzed to investigate the amount of additional material needed (e.g. disposable gloves and gowns). Furthermore, the Department of Pharmacy provided data on antibiotic use during the 10-year period. On the basis of these data, a sound estimation could be made about the situation (empiric, prophylactic, or therapeutic) in which vancomycin would have to be given as a substitute or an addition if no "search and destroy" policy were in place. The number of HCW substitutions required during MRSA outbreaks was also noted per ward. Finally, the number of microbiological cultures was counted for all patients and HCWs involved in the screening, surveillance, or outbreaks of MRSA.

Besides the calculated costs, MRSA-positive patients face so-called intangible costs. These costs carry no price tag but are related to the physical and psychological costs of discomfort and other problems the patient would not have had to face if no MRSA carriage had occurred [6, 7].

Results

Patients subjected to the "search and destroy" policy were those who had been hospitalized abroad prior to admission to the UMCU and those who were known to carry MRSA during a previous admission. These patients were nursed in isolation and screened for MRSA by means of culture. Between January 1991 and December 2000, a total of 1,145 patients who had been previously hospitalized abroad were screened on admission for MRSA carriage (Table 1). Thirty-eight were MRSA positive, eight of whom eventually caused an outbreak despite isolation precautions. During the same period, 1,434 patients were screened at the outpatient clinic. Sixteen were MRSA positive and 1,418 MRSA negative. The overall number of admitted patients carrying MRSA

Table 1 Infection control policy on methicillin-resistant *Staphylococcus aureus* (MRSA) at the Universtity Medical Center Utrecht, 1991–2000

Year[a]	No. of index-patients (new MRSA-positive patients)	No. of patients with epidemic MRSA strain[b] (no. with non-Dutch strains)	No. of patients colonized with MRSA during an outbreak	No. of MRSA-positive healthcare workers	No. of suspected patients hospitalized abroad prior to admission
1991	6	2 (1)	6	0	115
1992	6	2 (2)	1	1	78
1993	3	0	0	0	144
1994	3	1 (1)	0	6	101
1995	9	3 (1)	3	4	115
1996	8	0	0	0	138
1996–1997	2	2 (0)	22[c]	14[c]	92
1997	5	2 (1)	2	0	108
1997–1998	1	1 (0)	2	1	139
1998	6	2 (2)	1	4	115
1999[d]	9	0	0	0	
1999–2000	1	1 (0)	1	1	
2000	1	0	0	0	

[a] When an index patient caused colonization of other patients in the following year, both years are given
[b] Defined as a strain of MRSA that spread to patients and/or staff
[c] One epidemic MRSA strain colonized 5 patients and 3 staff members; another epidemic strain spread to 17 patients and 11 staff members
[d] The Wilhelmina Children's Hospital was added to the University Medical Center Utrecht in 1999

Table 2 Calculated costs of the "search and destroy" policy to eradicate methicillin-resistant *Staphylococcus aureus* at the University Medical Center Utrecht, 1991–2000

Reason costs were incurred	Explanation of costs	Cost (in euro 1,000)
Cleaning	ICU and wards	207
HCW	temporary suspension from work	149
Cultures	patients (screening, positives, and surveillance)	673
	HCWs (screening, positives, and surveillance)	280
Drugs	additional/special	72
Department costs	additional material (disposable)	213
Loss of hospitalization days		931
Fewer surgical procedures		249
Total		2,774

was 60 for the 10-year period. Sixteen of them caused an outbreak (Table 1): eight had cultures that were unexpectedly positive and eight had been previously hospitalized abroad. This number would undoubtedly have been much higher without the "search and destroy" policy.

The two largest outbreaks during the 10-year period were encountered simultaneously from November 1996 until July 1997 at the Division of Surgery. These outbreaks were caused by two different MRSA strains from two patients who were unexpectedly positive for MRSA. During this 8-month episode, these two patients transmitted MRSA to a total of 36 other people (22 patients and 14 HCWs). Fortunately, an outbreak of such magnitude has only occurred twice within the last 15 years.

To detect the introduction of MRSA into a ward and to control any outbreaks, 77,800 swabs were taken for microbiological culturing; 347 of the cultures were positive for MRSA. These cultures were subdivided into screening cultures (to detect MRSA-positive patients and HCWs), positive cultures (to prove colonization with MRSA), and surveillance cultures (to follow up on an MRSA-positive patient and his/her contacts). The price for culturing varied between euro 12 for a negative culture and euro 46 for a first positive culture. The financial costs are shown in Table 2.

A subdivision between regular wards and ICUs was made with regard to the costs related to cleaning and decontamination. ICUs had to be completely decontaminated six times (in total, euro 7,000) and wards 11 times (euro 134,000). ICUs had to be dismantled four times; in one case, the ICU floor was partially renewed (wool carpeting was replaced by linoleum, which is easier to disinfect) and ventilation filters and machines were overhauled. The costs involved in decontamination represented costs for both HCWs and material (Table 2). The wards had to be closed 33 times during a total of 16 outbreaks: regular wards were closed 19 times and ICUs 14 times (median, 7 days; range, 3–16 days).

The isolation box in the emergency department, used for patients suspected or proven to be MRSA positive, had to be decontaminated after each visit: 1,434 visits in 10 years (euro 66,000). The cost of additional disposable material (e.g. gowns [euro 115,000], masks [euro 55,000], and gloves [euro 43,000]) over the entire period was euro 213,000. Extra costs for mupirocin nasal ointment, 1% chlorhexidine, and daily doses of vancomycin (as a substitute for flucloxacillin) had to be taken into account as well (euro 72,000). We encountered only colonization and no infections with MRSA in our patients; therefore, we never had to prescribe vancomycin therapeutically.

Because they were found to be colonized with MRSA, 29 HCWs were temporarily suspended from working for a total of 439 days (range, 2–300 days). These HCWs were all treated for MRSA carriage with mupirocin nasal ointment and 1% chlorhexidine (both hand soap and shampoo). One HCW had to discontinue working for 300 days. As this HCW had a chronic skin disease, MRSA eradication therapy was not successful, and patient-related work had to be discontinued.

Hospitals in the Netherlands are financially compensated for a fixed number of patients based on the actual number of patients treated in the preceding year, irrespective of the length of stay. The hospitalization of more patients is not compensated, while failure to reach the budgeted number of patients results in budget cuts the following year. Because the "search and destroy" policy demands that wards be closed during an MRSA outbreak, the overall number of admissions during an outbreak is lower. The results of this study show that the total number of lost hospitalization days during the 10-year period was approximately 2,265. By multiplying the number of days times the cost of 1 day of hospitalization (euro 385 at a regular ward and euro 680 at an ICU), a net loss of euro 931,000 was calculated. One should realize, however, that a certain gain was obtained as well: a lower number of patients means lower costs and less care (i.e. fewer staff members) required. The fact that patients who could not be admitted electively may have faced both social and financial problems was not taken into account. The number of surgical interventions decreased substantially during the outbreaks. In fact, elective surgery could not be performed at least 250 times (euro 249,000).

An extensive effort was required to maintain this successful "search and destroy" policy. While a number of costs could not be expressed directly (e.g. intangible costs), the costs that could be calculated to keep the institute MRSA free amounted to at least 6 million Dutch guilders (euro 2,800,000).

The efforts and costs involved in the "search and destroy" strategy can be avoided if microbiological culturing, hospitalization in isolation, and temporary work suspension are abandoned. Compared to the current situation, then, a theoretical gain of euro 280,000 would be encountered each year. In such a case, however, one also expects an increase in the endemic level of MRSA. If this occurs, then the prophylactic, empiric, and therapeutic use of antibiotics will increase in order to treat patients colonized or infected with MRSA. Glycopeptides should be administered empirically on a large scale as prophylaxis and after confirmative culturing as well. Due to the increased use of vancomycin, a higher incidence of both vancomycin intermediate-susceptible *Staphylococcus aureus* and vancomycin-resistant enterococci might also be encountered [7]. In situations of high MRSA endemicity, glycopeptides have become the first choice of treatment for *Staphylococcus aureus* infection, although they have been found to be inferior to flucloxacillin for treatment of methicillin-susceptible *Staphylococcus aureus* infection [8]. They are nephrotoxic, have to be given intravenously, and are expensive.

On the basis of the number of defined daily doses (DDD) of antibiotics in the current antimicrobial policy in our hospital, the current infection rate, and the calculated substitutions with glycopeptides, the estimated amount of money spent on antibiotics would then be at least euro 800,000 each year in the hypothetical situation. This means that an extra euro 520,000 (euro 800,000 minus euro 280,000) would have to be spent each year, in the absence of a "search and destroy" policy.

Discussion

This study was performed to determine the financial and logistical consequences of the strict MRSA policy that is generally adhered to in the Netherlands. The data were collected as a consequence of the "search and destroy" policy, a policy that leads to frequent culturing of patients and HCWs, hospitalization of patients in isolation, reduced hospital admissions, and temporary closure of wards. Since the costs involved in such a strict policy are considerable, the question arose whether this money is well spent.

The "search and destroy" policy has been applied successfully in the Netherlands since 1986. A less than 0.5% incidence of MRSA has been maintained, which is very low compared to rates in the surrounding countries: Austria (22%), Belgium (25%), Germany (6%), and France (33%). In the hypothetical situation that the "search and destroy" policy is completely abandoned, the endemic level of MRSA would increase gradually to ≥50%. This is based on observations made previously in countries like Portugal, Italy, and Spain [9]. Needless to say, an increased incidence of MRSA would put a constant pressure on the hospital management and budget.

High costs may also be encountered if secondary resistance emerges. In the USA, a high incidence of MRSA led to a high use of vancomycin. Due to this increased usage of vancomycin, the incidence of vancomycin-resistant enterococci increased as well; in fact, up to 25% of the enterococci in U.S. ICUs are currently resistant [10]. Infections due to vancomycin-resistant enterococci were seen particularly in high-risk patients [7]. In a situation where an increased number of vancomycin intermediate-susceptible *Staphylococcus aureus* are present, an infection control policy similar to the one we already know for MRSA would, in our opinion, be an adequate tool to decrease the incidence.

A strict policy is justified in case of an extremely low incidence of MRSA, like in the Netherlands. In an institute where the incidence of MRSA is 20 or 30%, it might be a good strategy to first define all MRSA strains present using a DNA/RNA fingerprinting technique and then focus on the most prevalent strain (epidemic strains). When a strict policy is applied only to those patients carrying the epidemic strain, we believe that not only the overall incidence of MRSA but also the financial and logistical consequences would decrease substantially. Much depends, however, on the local situation. Strong infection control programs have proven to be beneficial in both Europe and Canada, even in countries with hospitals that have endemic strains of MRSA [11, 12, 13]. Mulligan et al. [14] confirmed that, despite the highly visible financial consequences, it is important to stress that the prevention of hospital infection – also with regard to MRSA – is cost-effective. Rubinovitch and Pittet [15] also stated that screening for MRSA in high-risk patients upon admission is cost-effective in the endemic setting.

Even though the "search and destroy" policy relies heavily on the efforts aimed at eradicating MRSA, we have shown that the necessary expenses compare favorably, in the long run, to those of the hypothetical situation without such a policy. Unfortunately, the Dutch reimbursement system does not compensate the hospital for additional costs that are incurred in order to adhere to the strict MRSA policy [16]. Such a reimbursement would be of great value to hospitals/wards during MRSA outbreaks. In conclusion, we believe that the "search and destroy" policy is recommendable not only because of the resultant epidemiological benefits but also because of the resultant financial benefits, and that the national and even international benefits in preventing an increased incidence of MRSA with all its consequences should be considered by all governments.

References

1. Barret SP, Mummery RV, Chattapadhyay B (1998) Trying to control MRSA causes more problems than it solves. J Hosp Infect 39:85–93
2. Spicer WJ (1984) Three strategies in the control of staphylococci, including methicillin-resistant *Staphylococcus aureus*. J Hosp Infect 5 [Suppl A]:45–49

3. Verhoef J, Beaujean D, Blok H, Baars A, Meyler A, van der Werken C, Weersink A (1999) A Dutch approach to methicillin-resistant *Staphylococcus aureus*. Eur J Clin Microbiol Infect Dis 18:461–466
4. de Neeling AJ, van Leeuwen WJ, Schouls LM, Schot CS, van Veen-Rutgers A, Beunders AJ, Buiting AGM, Hol C, Ligtvoet EEJ, Petit PL, Sabbe LJM, Griethuysen AJA, Embden JDA (1998) Resistance of staphylococci in The Netherlands: surveillance by an electronic network during 1989–1995. J Antimicrob Chemother 41:93–101
5. Fluit AC, Wielders CL, Verhoef J, Schmitz FJ (2001) Epidemiology and susceptibility of 3,051 *Staphylococcus aureus* isolates from 25 university hospitals participating in the European SENTRY study. J Clin Microbiol 39:3727–3732
6. Mintjes-de Groot AJ, van Hassel CAN, van Linge RH, Verburgh HA (1996) Estimation of extra charges, extra nursing procedures and prolongation of stay attributable to hospital-acquired infections. In: Surveillance and control of hospital-acquired infections in The Netherlands. Dissertation, Erasmus University, Rotterdam, The Netherlands
7. Fridkin SK (2001) Vancomycin-intermediate and resistant *Staphylococcus aureus*: what the infectious diseases specialist needs to know. Clin Infect Dis 32:108–115
8. Gonzalez C, Rubio M, Romero-Vivas J, Gonzalez M, Picazo JJ (1999) Bacteremic pneumonia due to *Staphylococcus aureus*: a comparison of disease caused by methicillin-resistant and methicillin-susceptible organisms. Clin Infect Dis 29:1171–1177
9. Voss A, Milatovich D, Wallrauch-Schwarz C, Rosdahl VT, Braveny I (1994) Methicillin-resistant *Staphylococcus aureus* in Europe. Eur J Clin Microbiol Infect Dis 29:50–55
10. Murray BE (2000) Vancomycin-resistant enterococcal infections. N Engl J Med 342:710–721
11. Chaix C, Durand-Zaleski I, Albert C, Brun-Buisson C (1999) Control of endemic methicillin-resistant *Staphylococcus aureus*: a cost-benefit analysis in an intensive care unit. JAMA 282:1745–1751
12. Papia G, Louie M, Tralla A, Johnson C, Collins V, Simor AE (1999) Screening high-risk patients for methicillin-resistant *Staphylococcus aureus* on admission to the hospital: is it cost effective? Infect Control Hosp Epidemiol 20:473–477
13. Kim T, Oh PI, Simor AE (2001) The economic impact of methicillin-resistant *Staphylococcus aureus* in Canadian hospitals. Infect Control Hosp Epidemiol 22:99–104
14. Mulligan ME, Murray-Leisure KA, Ribner BS, Standiford HC, John JF, Korvick JA, Kauffman CA, Yu VL (1993) Methicillin-resistant *Staphylococcus aureus*: a consensus review of the microbiology, pathogenesis, and epidemiology with complications for prevention and management. Am J Med 94:313–328
15. Rubinovitch B, Pittet D (2001) Screening for methicillin-resistant *Staphylococcus aureus* in the endemic hospital: what have we learned? J Hosp Infect 47:9–18
16. Wagenvoort JHT (1997) Containment of an 18-month MRSA III-29 epidemic. Hyg Medizin 22:314–329