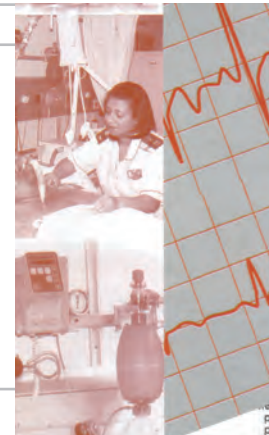**ARTICLE**

Evaluation of a protocol to control methicillin-resistant *Staphylococcus aureus* (MRSA) in a surgical cardiac intensive care unit

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Methicillin-resistant *Staphylococcus aureus* (MRSA) is a major health care problem in intensive care units.

Purpose. To evaluate how nurses implement the methicillin-resistant *S. aureus* protocol (MRSAP) in a surgical cardiac intensive care unit (SCICU), and to evaluate the change in MRSA infection rates after implementation of the protocol.

Methods. The knowledge of nursing staff and their compliance to the MRSAP were assessed with a survey questionnaire and by conducting observations in the unit. Screening compliance and the reduction in infection rates were investigated using a retrospective records review.

Results. There was an 88% (23 respondents) awareness of the MRSAP, but knowledge of the detailed content was variable. The staff were satisfied with the existing standards of infection control in the SCICU (85%, 22), and 64% (142) of the observed nurse-patient contacts complied with routine hygiene measures, such as hand hygiene. Few actual cases of MRSA infection were identified during the study period. Owing to the small number of cases it was not possible to test for the significance of this difference at SCICU level, but a chi-square test on the hospital MRSA cases for the same period demonstrated a highly significant reduction (χ^2=6.2×10^{-41}, df=1, *p*<0.0001).

Conclusions. There was evidence to support efficacy of the MRSAP in the reduction of MRSA infections.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a major health care problem related to morbidity and mortality in intensive care units.[1] Nosocomial infections (such as MRSA), also termed health care associated/acquired infections (HAI), occur as a result of hospital or health care treatment and are secondary to a patient's original condition.[2] HAIs are costly, both directly and indirectly, as they deplete the limited financial resources available for health care delivery.[3] While no detailed HAI statistics for South Africa (SA) were found, the guideline on the management of nosocomial infections in SA[4] estimated that 1 in 7 patients was at high risk of an HAI in SA hospitals. Unpublished statistics from the Centers for Disease Control and Prevention (CDC) in the USA[5] estimated that approximately $3.5 billion per annum had been incurred by hospitals in excess health care costs due to HAIs. The CDC also estimated that HAIs affected approximately 1.7 million patients per annum, of whom about 99 000 died. This figure makes it clear that HAIs are a common cause of death, being one of the 10 leading causes overall.[5]

An organism that has been identified as a substantial factor associated with HAI is methicillin-resistant *S. aureus* (MRSA).[6] This organism is the multidrug-resistant version of *S. aureus* (a Gram-positive bacterium), which colonises the epidermis and is present in the anterior nares of 25 - 30% of the healthy population. It is endemic in many hospitals worldwide (including SA) and is difficult and expensive to treat.[7] *Staphylococcus* bacteraemia was investigated at two academic hospitals in Johannesburg, and it was found that MRSA was significantly associated with mortality and that admission to an ICU was also a highly significant independent predictor for mortality.[8]

Following an outbreak of MRSA in the surgical cardiac intensive care unit (SCICU) of the study hospital in 2005, an MRSA protocol (MRSAP) was implemented. The MRSAP provides a comprehensive standard of care for the management of MRSA risk and infection, with emphasis on hand hygiene and other routine hygiene measures as the mainstay of effective infection prevention and control of transmission. Patients in ICUs are most vulnerable to HAI as they have the most invasion sites, are least able to participate in their own care, and often suffer from multiple pathologies.[9,10] A study[11] identified cardiac surgery patients as having particularly high rates of HAI. Patients over 35 years old, males in particular, and those suffering from diabetes mellitus, were identified as being at additional risk for HAI. An increase in localised MRSA colonisation (as identified by the current hospital screening programme) has implications for possible increases in HAI rates and poses a further threat to cardiac surgery patients, who have already been identified as being at risk. In light of such implications, it is crucial to evaluate the implementation of the MRSA protocol.

Purpose of the study

To evaluate implementation of the MRSAP in the SCICU and the change in MRSA infection rates after implementation.

Research questions

The following research questions were asked: (*i*) did the nurses in the SCICU comply with the MRSAP? (*ii*) which parts of the MRSAP, if any, were best utilised? and (*iii*) was there a significant decrease in the number of MRSA infections in the SCICU after implementation of the MRSAP?

Method

This two-part study used a programme evaluation framework.[12]

Part 1 of the study evaluated SCICU nursing compliance with the MRSAP and included three components. An MRSAP survey was carried out among the nursing staff, observations of nursing compliance with the MRSAP were conducted, and patient records data were collected to determine whether screening swabs had been obtained appropriately and whether there was documentation of screening results.

Part 2 of the study compared MRSA infection rates before the implementation of the MRSAP (2003 - 2005) with those after its implementation (2006 - 2008). This aspect of the study was a retrospective, non-experimental quantitative study with a quasi-experimental design based on records review. The patient records data were required in order to ascertain the number of patients admitted over the study period and the number with MRSA infections. Hospital and SCICU MRSA infection rates were calculated. Infection rates before and after implementation of the MRSAP were compared to look for significant differences.

Population

The staff population comprised all permanent nursing staff working in the SCICU, plus any other nursing staff on duty during the periods of observational data collection. The records review included the records of all patients admitted to the SCICU from 2003 to 2008.

Setting

The study was conducted in a 6-bed surgical cardiothoracic intensive care unit in a private hospital in KwaZulu-Natal. All cardiac surgery patients arrived in the unit ventilated, typically being extubated in less than 8 hours. The nurse/patient ratio was variable depending on the patient's condition, but all ventilated patients had a minimum nurse/patient ratio of 2:1 on arrival in the unit, decreasing to 1:1 after initial stabilisation. The nurse to non-ventilated patient ratio was typically 1:2. Surgical patients typically stayed in the unit for 2 - 4 days, although formal data were not collected as part of this study.

Sample and sampling

The survey to assess staff knowledge and observe compliance with the MRSAP required a convenience sampling approach. Inclusion criteria were all the permanent SCICU staff (except for the researcher and unit manager), and those of the agency staff on duty who agreed to participate. Written informed consent was obtained from all participants. Observation periods were carefully selected so that the researcher would be present at times of maximum patient activity. A systematic random sample of patient records data on infection rates was collected and the assumption had to be made that, except for the novel interventions in the MRSAP, the standard of infection control practice was similar over the entire period, despite any changes in staff. Thirty-two staff members were invited to participate in the study and 27 agreed.

Research instruments

A six-question survey was designed to assess nursing staff awareness and understanding of the MRSAP. An observation tool was designed to collect data on routine hygiene practices of nurses in the SCICU when caring for patients at a high risk of infection. Defined contact indicators, which specified what did and did not constitute correct patient contacts in terms of compliance with routine hygiene requirements, were used to facilitate consistency of observations. These included hand hygiene and the use of personal

protective equipment (PPE).[13,14] Data collection sheets were designed in order to record the infection risk stratification data and MRSA infection data for patients admitted during the study period.

Data collection process

Data collection was carried out over a 4-month period (July - October 2008) and the data were collected in three phases: (*i*) the survey questionnaire and informed consent forms were distributed to staff and collected when complete; (*ii*) observations were recorded by the researcher of the nurses' compliance with routine hygiene measures at the times of maximum patient interaction, i.e. when receiving patients from the cardiac theatre and during the first 2 postoperative days; and (*iii*) patient listings were compiled from the SCICU admission books and entered into Microsoft Excel spreadsheets along with other available information, such as age, gender and surgical procedure. A systematic random sample of case records was then requested. A search of HAI and MRSA was conducted on the infection control nurses' records and the MRSA case data pertaining to the SCICU were extracted.

A major problem encountered was lack of access to patient files, as many of the files requested failed to arrive from the archives. From the total number of patients (N=759) in the transition and MRSAP period, a 34.3% (N=260) probability sample of the files was requested on the advice of the statistician. However, during the 4-month period of data collection only 14.6% (N=38) of the requested records arrived, resulting in an ultimate patient file sample of only 5%.

Data analysis

The data obtained were entered into Microsoft Excel spreadsheets as coded data and, where necessary, subsequently imported into Statistical Package for Social Sciences version 15.0 for further analysis. Descriptive statistics were used to calculate response rates, response accuracy and observed and documented compliance with the MRSAP. De-identified responses from the staff survey were rated by the researcher, unit manager and infection control nurse, and averaged marks were calculated. Risk factors regarding infection in the pre- and post-MRSAP patient groups were compared in order to determine the comparability of the two groups. Infection rates were calculated using the total number of infected cases divided by the total number of cases for the relevant periods. In order to assess comparability of patient groups before and after intervention, chi-square and Mann-Whitney *U*-tests were used as appropriate for the non-parametric data and independent *t*-tests for equality of means. The planned chi-square test for significant difference between the number of MRSA-infected cases could not be done as the number of cases found was too small.

The SCICU MRSA infection rates were compared with the hospital MRSA infection rates during the study period using a bar chart to provide context for the results. Hospital MRSA infections were compared for significant difference using a chi-square test.

Validity and reliability

The three data collection instruments were based on the MRSAP, which provided face validity. They were reviewed by both an experienced researcher and a statistician. A pilot test was carried out, using 8 nurses from a different ICU, implementing the same MRSAP, to assess content validity and stability of the instrument (reliability). The instruments were then revised accordingly before data collection.

Ethics

Ethical approval was obtained from the University of KwaZulu-Natal Ethics Committee, and permission to conduct the study was granted by the nurse manager on behalf of hospital management. Participation was voluntary and written consent was obtained from the respondents, who were informed of the right to withdraw from the research at any time. Confidentiality was assured through the use of anonymous responses, coded data sheets and de-identification of data before analysis so that data could not be traced back to individuals. The data were kept in a secure place available only to the research team.

Results

Questionnaires were handed out to all eligible staff (32) and 27 agreed to participate, but only 26 questionnaires were returned, giving a return rate of 81%. The researcher observed the nursing practices of 78% (21) of the staff who consented to participate. Evaluation of the nursing knowledge and compliance with the MRSAP is set out in Table I.

Staff awareness and understanding of the MRSAP in the SCICU

The majority of the respondents (88%, 23) knew about the MRSAP and 96% (25) knew that routine screening of swabs was required, although only 50% (13) were rated as responding absolutely correctly regarding which swabs were required. For the nursing of MRSA-positive patients (which includes the use of barrier precautions) only 27% (7) of the respondents' responses were rated as completely accurate. All staff members (26) indicated awareness of the use of chlorhexidine soap/scrub as part of the MRSAP, but only 54% (14) were rated as using it correctly. Most of the staff (85%, 22) appeared to be satisfied with the current standard of infection control in the SCICU, with 62% (16) having no specific comment to make and 23% (6) being positively satisfied. Only 15% (4) made comments suggesting that improvements were

Table I.   **Evaluation of nursing knowledge of and compliance with MRSAP**

		Existence of MRSAP	Need for screening swabs	Precautions for MRSA patients	Use of chlorhexidine soap	Correct barrier nursing
Awareness		88%	96%	88%	100%	N/A
Knowledge	Complete	N/A	50%	27%	54%	
	Incomplete		46%	61%	46%	
	None	12%	4%	12%	0%	
Compliance		N/A	42%*	N/A	100%	60%

*Inadequate data – see text.

necessary to comply with the MRSAP. Appropriate use of PPE (particularly gloves) and better bins (i.e. where the pedal to raise the lid worked) for the disposal of clinical waste were improvements identified by the respondents.

Observed staff compliance with the MRSAP

Observation of infection control practices during patient contacts was performed while the respondents were caring for patients after cardiac surgery (63%, 143/226) and medical patients requiring ventilatory support (30%, 67). For most of the time (73%, 38) the care was administered by registered nurses. Of all the observed patient contacts (221), 64% (142) were correct. Barrier precautions were observed to be used correctly 60% (3) of the time and chlorhexidine wash (as per MRSAP) compliance was 100% (6). For both barrier nursing and chlorhexidine washes the number of observations was small and may not be representative.

Contacts could not be observed on 7% of occasions (15). Non-compliance was observed for 29% (64) of the contacts. These included simple failure to use appropriate hand hygiene measures, failure to use PPE such as gloves when obtaining arterial blood gases, or failing to swab IV ports before accessing them.

Assessment of screening compliance

Although a 34% (260) probability sample of case files was requested for screening compliance, only 15% (38) of the requested files were actually obtained. Enquiries indicated that a change of storage area for files had resulted in enormous difficulties in identifying the location of particular files. Those obtained were not evenly distributed throughout the study period, so only a 5% convenience sample was ultimately obtained.

Comparison of MRSA infection rates before and after the MRSAP

For reliable comparison it was necessary to demonstrate that the two groups of patients were similar with respect to infection risk. The risk factors of procedure, gender and age were available for all patients in both the admission records and the case files, and the results for these factors were therefore reliable. The previously described problem of not obtaining the requested records, which resulted in a 7% (106) convenience sample of case files for infection risk stratification, meant that the quality of data available for infection risk stratification with respect to history of diabetes mellitus and smoking may not have been fully representative and, therefore, not entirely reliable.

Comparability of patient groups before and after MRSAP

The data obtained indicated that there was no significant difference in terms of infection risk between the patient groups before and after the MRSAP (p>0.1) with respect to procedure (χ^2=1.408, df=3), gender (χ^2=0.023, df=1), diabetes mellitus (χ^2=1.520, df=3) and smoking status (χ^2=1.996, df=2). The results for age suggested that the two groups were comparable except for one category – the female cardiac surgery

patients in SCICU in the post-intervention period were significantly younger than the males (t=2.696, df=245.705, p<0.01).

Reduction in SCICU and hospital MRSA infection rates

Few actual cases of MRSA infection were identified during the study period. Three cases from the total number of admissions were identified before the MRSAP (1.08%) and 1 from the total number of admissions after the MRSAP (0.35%). Owing to the small number of cases it was not possible to test for the significance of this difference at SCICU level, but a chi-square test on the hospital MRSA cases for the same period demonstrated a highly significant reduction (χ^2=6.2x10^{-41}, df=1, p<0.0001). Fig. 1 illustrates the difference between the hospital and SCICU rates.

Discussion

The discrepancies noted between the generally good awareness of the policy on the one hand but the limited knowledge regarding its detailed content on the other, provide scope for further education to improve the knowledge of the policy. For example, only 7 staff members (27%) had their responses rated as completely accurate with respect to nursing MRSA-positive patients. Had the seniority of these staff in the unit been known, the implications of this finding would have been easier to assess.

Only 15% (4) of the staff members had any apparent dissatisfaction with the status quo, the rest either having no comment or being satisfied with this aspect of nursing care in the unit. This may suggest that the relatively consistent non-compliance rate (27 - 31%) is in some way intrinsic to staff practice and could possibly merit further study. It has been suggested[15] that motivation rather than knowledge could be one of the most challenging factors to overcome in improving compliance with hand hygiene. A survey of hospital staff[16] found that staff attitude to guidelines in general, and the CDC hand hygiene guideline in particular, affected their acceptance and self-reported implementation of this guideline.
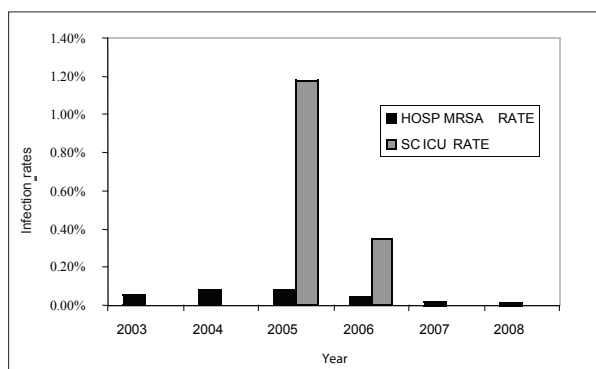

Fig. 1. Comparison of hospital and SCICU MRSA rates.

Given the importance of routine hygiene measures in ICUs, the compliance rate of 64% is not very encouraging. However, other studies on hand hygiene report much lower compliance rates. For example, the World Health Organization[17] indicated that doctors and nurses clean their hands appropriately less than 50% of the time. They further suggest that at busy times in critical care situations this figure may fall to 10% or less. Van de Mortel *et al*.[18] measured hand hygiene compliance at 47.6% at baseline in their study to promote hand hygiene through the use of alcohol-based hand disinfection for all categories of staff, which over 3 years improved significantly to 66.2% (p<0.001). In a study[19] on performance feedback as a method to improve compliance, hand hygiene compliance among registered nurses was assessed at 71% at baseline. After the intervention phase, where feedback was given to staff, registered nurse compliance rose significantly to 86% (p=0.0433). These authors[19] demonstrated improved compliance with hand hygiene from baseline measures for 3 months following feedback on performance, which subsequently deteriorated back to near baseline. However, the registered nurse subgroup maintained their performance better than most other staff groups observed. The authors recommended repeating performance review and feedback at yearly intervals in order to maintain improved performance. The need for performance monitoring was also identified[20] when effective implementation of practice initiatives is expected.

It must be acknowledged that when nurses know that they are under observation there is the potential for improved compliance through their heightened awareness during that particular aspect of care (the 'Hawthorne effect'),[14] and covert observation has been used previously[13] for that very reason. For the present study covert observation was not possible, both for ethical reasons and due to the researcher's position in the SCICU.

A research group[21] developed a standardised hand hygiene observation tool in order to address the issue of comparability of data between institutions. These authors found that the existing standardised tools either lacked sufficient clarity in their standard operating procedures or were too complex to allow good inter-rater agreement. Wherever researchers are aiming to compare different institutions, or more than one researcher is used, such issues become very important to the reliability of the results.

A review of methods of measuring compliance with hand hygiene[14] identified that the three major methods used are direct observation, self-report and indirect measures, such as hand hygiene product use or change in infection rates or transmission rates. It was therefore tempting to attribute the statistically significant decrease in infections at hospital level and the SCICU

to the MRSAP. However, the logic of this might be considered dubious without making some attempt to demonstrate compliance with the MRSAP, which this study has attempted to do.

There was evidence from the staff survey and observational study that the identified reduction in MRSA infections was due to the introduction of the MRSAP. The previously described problems encountered in collecting screening data meant that no conclusions could be drawn about this particular aspect of the MRSAP. When assessing indirect measures that have been used to measure improved hand hygiene compliance, such as a change in infection rates, it was demonstrated that improved hand hygiene compliance alone does not always correlate with decreased HAI rates.[14] This might suggest that a set of comprehensive and targeted measures, such as the MRSAP described and evaluated in this study, is the best approach to the reduction of HAI in general, and MRSA in particular. Other authors[21] supported the need for multi-faceted interventions.

It is possible that some of the decrease in infection rate in this study was simply due to the younger, female cardiac surgery patients who had a lower risk of infection, rather than to the MRSAP.

Limitations

The highly specialised nature of the SCICU means that the results cannot be generalised. Also, because there could be no direct assessment of past infection control practice, it had to be assumed that current practice was similar to pre-intervention practice. Reliability of observational data could not be ascertained due to having only one researcher and also to the potential for the 'Hawthorne effect', since the nurses knew they were being observed. Failure to obtain adequate samples of records data with respect to the screening of swabs meant that nursing compliance with the MRSAP could not be adequately assessed. The small number of MRSA cases found severely limited the extent of analysis of these data.

Recommendations

SCICU staff members need to improve knowledge of the MRSAP before improved compliance can be achieved. Particular areas of concern were the limited knowledge with respect to obtaining and following up on the results of MRSA screening swabs, barrier nursing and the use of chlorhexidine soap in the SCICU, as well as complacency regarding the current infection control practice in the SCICU. The wider use of systematic evaluations of infection control practices would allow for some comparison of results between units and institutions. Use of a standardised observation tool to facilitate such comparisons should be considered.

Conclusions

The MRSAP used in this study was found to be effective for reducing MRSA infection rates in an SCICU, despite the inadequate screening data. Efficacy of the MRSAP was demonstrated through adequate staff understanding and compliance, and the significant reduction of MRSA infection in the SCICU. While infection rate results could not be statistically compared, a larger study comprising all of the ICUs would provide sufficient data to test for statistically significant difference. Further research with respect to implementation of, and compliance with, infection control measures could both improve quality of patient care and decrease the burden of a preventable infectious disease such as HAI due to MRSA in SA.

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