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When are the hands of healthcare workers positive for methicillin-resistant *Staphylococcus aureus*?

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Running Title: Sampling HCWs hands for MRSA

Summary

Hand hygiene is a key component in reducing infection. There are few reports on the prevalance of methicillin- resistant *Staphlococcus aureus* (MRSA) on healthcare workers' (HCWs) hands. The aim of this study was to establish if HCWs fingertips were contaminated with MRSA in a clinical hospital setting. The study was conducted in an acute tertiary referral hospital on four MRSA wards that were part of a larger research study on MRSA epidemiology and four other wards not included. The fingertips from all categories of 523 HCWs were sampled on 822 occasions by the imprinting of fingertips on MRSA chromogenic agar plates. The type of hand hygiene agent used, if any, and the immediate prior activity of the HCW were recorded. Overall, 38/822 (5%) fingertips from 523 HCWs were MRSA-positive; 12/194 (6%) after clinical contact, 10/138 (10%) after contact with the patient's environment and 15/346 (4%) after no specific contact. MRSA was recovered on 2/61 (3%) occasions after use of alcohol hand rub, 2/35 (6%) after 4% chlorhexidine detergent, 7/210 (3%) hand washing with soap and water, and 27/493 (5%) when no hand hygiene had been performed. MRSA was recovered from HCWs on seven of the eight wards. MRSA was more frequently present on fingertips on the four non-study wards *versus* the four MRSA-study wards, 18/250 (7%), 3/201 (1%), respectively, p=<0.004). The isolation of MRSA from HCWs fingertips, including after hand hygiene, indicates that more educational programmes are necessary to improve the quality of hand hygiene to prevent transmission of MRSA.

Introduction

Hand hygiene is one of the most important elements in preventing infection and the frequency and technique are important.[1,2,3] Previous reports have largely concentrated on hand hygiene compliance and the *in vitro* effectiveness of hand hygiene agents, but there are few reports on the effectiveness of hand hygiene in eradicating nosocomial pathogens in a clinical setting. While the carriage of MRSA on the hands of healthcare workers (HCWs) has been reported as part of the wider investigation of MRSA,[4-7] few studies have investigated the prevalence of MRSA on hands in clinical practice.[8,9]

Hand hygiene campaigns and education result in improved hand hygiene and a decrease in cross contamination with MRSA,[10] but sustained improvement is difficult to achieve.[11,12] The aim of this study was to investigate MRSA hand carriage on all categories of HCWs associated with hand hygiene occasions and also with other non-specific occasions in a hospital where MRSA is endemic. In addition, the hand hygiene agent used was recorded.

Materials and methods

Setting and participants: The study was conducted in an adult 700-bed tertiary referral hospital on four wards that were part of a wider programme of research on MRSA (MRSA study wards) and four non-study wards. This research programme includes assessing the value of near universal screening for MRSA, the level of MRSA contamination, the use of PCR for rapid diagnosis and the contribution of enhanced

environmental decontamination to reduce MRSA. The eight wards included in this study of MRSA hand carriage were four medical and four surgical wards that were considered representative of the hospital. The study was conducted in two phases; phase one was conducted on one ward (MRSA study ward) over a five-week period as an initial test ward and phase two was conducted eight months later over a four-week period on eight wards (seven other wards plus repeat sampling on the initial study ward).

All wards, except one 29 bed ward, had up to 35 beds and consisted of a mixture of two, four, and six-bedded bays and five single rooms for isolation or other segregration purposes. None of the single rooms had negative-pressure ventilation or an ante room to carry out hand hygiene and don personal protective equipment before entering. Wash hand sinks were available at each of the two, four and six-bedded bays, and in four of the five single rooms on each ward. Alcoholic hand rub dispensers were placed at each hand wash sink and outside single rooms, and also inside and outside the entrance doors to each ward. It is not hospital policy to issue individual alcohol hand gel to HCWs.

Ethical approval was obtained from the hospital's ethics committee on condition that participation was voluntary, anonymous and that HCWs were given written and verbal information about the study. All categories of staff, i.e. medical, nursing, care assistants, support and allied health professionals were eligible to participate and HCWs could participate more than once provided that the hand hygiene occasions were different. A written report of each ward's results were provided to individual wards and also to the hospital's infection prevention and control team (IPCT). MRSA is endemic in the

hospital, with 645 new MRSA cases per 21 883 (3%) hospital admissions during the study period.

***Sampling procedure**:* Hand sampling involved imprinting the tips of all fingers and thumbs of both hands on one MRSA Select chromogenic agar plate (Bio-Rad Life Science Group, France). Standard laboratory procedures were used for processing samples and for the confirmation of MRSA (i.e. detection of coagulase and oxacillin resistance). During phase two, 7/8 wards were sampled twice, once at 9.30 h and once at 14.00 h, on different days. Sampling was conducted by two researchers for approximately 1-2 hours per session, obtaining approximately 50 samples on each ward. The initial phase 1 ward was re- sampled once. No neutralizing solution was used to negate the antimicrobial effects of hand hygiene agents.

Hand hygiene occasions: The occasions for hand hygiene that were recorded were derived from CDC and national guidelines on hand hygiene[1,2,3] and were as follows:

- Before social hand contact with patients
- After social hand contact with patients
- Before clinical contact with patients
- After clinical contact with patients
- Before entering an isolation room
- After leaving an isolation room

- After contact with ward equipment or the environment

In addition, activities associated with hand hygiene and the hand hygiene agent used (e.g. soap and water, alcohol hand rub, 4% chlorhexidine detergent), and if no hand hygiene was performed, were recorded. Data were also recorded if there was contact with a known MRSA patient or the patient's equipment or if contact with the environment had occurred before hand sampling.

Hand hygiene educational intervention: Due to what was considered a high prevalence of MRSA on HCWs hands during the first two weeks of phase one on one ward, an educational intervention was deemed necessary. Screening ceased for one week when this occurred, thereafter, sampling was completed in two weeks. This educational intervention was conducted by the IPCT and involved six hand hygiene training sessions, including demonstration of the steps of handwash technique,[2] advice on the occasions for hand hygiene and the use of appropriate hand hygiene agents. HCWs on that ward performed hand hygiene under observation and used both GloGerm™ cream (UV Systems PLC, UK) and a fluorescent light box, that highlights the effectiveness of removal of the hand hygiene agent.

***Statistical analysis*:** Statistical analysis was performed using Epi Info 6 (version 6.04c; Centers for Disease Control and Prevention, Atlanta, GA). Odds ratios were calculated. The Mantel-Haenszel chi-square method was used to assess the significance of the difference between proportions.[13]

Results

MRSA was recovered from 38/822 (5%) fingertips from 523 HCWs during both phases of the study (Table 1). MRSA was isolated, 12/194 (6%) after clinical contact, 10/138 (10%) after contact with the patient's environment and 15/346 (4%) after no specific contact. MRSA was isolated from 11/329 (3%) fingertips when hand hygiene was performed, but 27/493 (5%) when no hand hygiene was used. MRSA was less frequently recovered after use of alcohol hand rub, 1/59 (2%), than after 4% chlorhexidine detergent, 2/35(6%), or after hand washing with soap and water, 7/210 (3%). MRSA was recovered from fingertips following 10/138 (7%) environmental contacts. In nine of these 10 cases, hand hygiene had not been performed; on the other occasion, alcohol hand rub and soap and water handwash combined, had been used. MRSA was not recovered after contact with equipment or the environment of known MRSA-positive patients.

MRSA was not recovered on the 21 occasions when HCWs used gloves with or without hand hygiene. The fingertips of 27/493 (5%) HCWs were positive for MRSA when no hand hygiene had been performed before sampling *versus* 11/329 (3%) when hand hygiene or gloves were worn. On four of 30 (13%) hand hygiene occasions, fingertips were positive for MRSA following hand hygiene after contact with known MRSA patients; 4% chlorhexidine detergent had been used on two occasions and soap and water on the other two. Of the 26 occasions that were MRSA-negative after contact with known MRSA patients, one HCW had used alcohol hand rub, one alcohol and soap and water,

ten soap and water, four gloves only, seven 4% chlorhexidine detergent and three had not performed any hand hygiene.

Phase one study

MRSA was recovered from HCWs fingertips 17/371 (5%) occasions on one medical ward over a five-week period. After MRSA was recovered from HCWs at a higher than anticipated frequency during the first two weeks, sampling ceased to facilitate an educational intervention. MRSA was recovered from 11/182(6%) of HCWs fingertips during the pre-education intervention and 6/189 (3%) after the intervention. Repeat sampling on this ward during phase two, eight months later, did not reveal MRSA on fingertips of any HCWs.

Phase two study

Phase two took place eight months after phase one. MRSA was recovered on 21/451 (5%) hand hygiene occasions from HCWs fingertips on eight wards. MRSA was recovered more frequently, 14/214 (7%) on medical than 7/235 (3%) on surgical wards, OR 2.26 (95% CI 0.83-6.31), p=<0.08. MRSA was recovered more frequently from the fingertips on the four wards not included in the larger MRSA research study, 18/250 (7%), *versus* the four MRSA study wards, 3/201 (1%), OR 5.12 (95% CI 1.40-20.18), p=<0.004. MRSA was recovered less frequently, 7/231 (3%) when sampled at 09:30 h than 14/220 (6%) at 14:00 h (OR 0.46 (95%CI 0.16-1.25), p=0.09.

The number of occasions when MRSA was recovered from the fingertips of HCWs and the number of MRSA-positive patients present on each of the eight wards are shown in Figure 1. During the sampling phase, there were 42 MRSA-positive patients on the 8 wards; 23 on the MRSA study wards (17 in single rooms, 6 cohorted) and 19 on the non-study wards (7 in single rooms, 12 cohorted). Two wards with long-stay patients, one medical study ward (10) and the other a medical non-study ward (8), had MRSA-positive patients both isolated and cohorted.

Discussion

The recovery rate of MRSA from HCWs fingertips after contact with patients and their environment, and also when HCWs were not engaged in clinical contact, is of concern as there is a risk of transmission of MRSA and other pathogens from HCWs to patients, if hands are not adequately decontaminated. However, it is not clear if this rate of MRSA carriage is above or below what might be expected in a clinical environment where MRSA is endemic, as few if any similar studies have been undertaken.

MRSA was recovered after hand hygiene, including in two instances, after using 4% chlorhexidine detergent, presumably due to poor hand hygiene technique. MRSA was recovered on 3% of occasions after hand washing with soap and water. Previous reports have highlighted the inadequacy of soap and water to remove MRSA,[14] and also the superiority of alcohol hand rub.[15] Damp hands have been reported as associated with higher contamination of hands.[16] Hand sampling took place during the present study,

immediately after hand washing and drying when hands may not have been adequately dried, and this may partly explain the higher recovery of MRSA after washing hands. Despite the availability of alcohol hand rub throughout the wards, only 63 HCWs used alcohol hand rub in contrast to 210 that used soap and water. Promotion of the use of alcohol hand rub when appropriate could possibly result in reduced contamination with MRSA.

Bacterial hand contamination has been reported as higher following clinical activities compared with non-clinical activities (i.e. entering wards, reviewing patient notes, admininstrative work, etc),[17] and this is consistent with our findings of 6% after clinical contact and 4% after no specific contact. The contamination of fingertips after reported 'no specific contact', indicates possible contamination of the administrative areas, e.g. desks, telephones, etc. or because HCWs may have incorrectly indicated that they had no specific contact with a patient or the environment, as they did not remember their last hand hygiene occasion.

The survival times of staphylococci on objects and the environment has been reported as ranging from days to months[18,19] and MRSA has been isolated from patient charts and computer keyboards.[20-22] Even when HCWs are not in contact with patients or their immediate environment, hand hygiene is necessary when entering and leaving wards or other clinical areas to reduce transient carriage of MRSA on hands.

A number of studies have shown that the patient environment is frequently contaminated and therefore a risk for transmission of MRSA.[23,24] The recovery of 7% of MRSA from HCWs fingertips after contact with the environment, not associated with MRSA isolation rooms, may indicate un-identified MRSA patients in the ward or environmental reservoirs and the need for enhanced environmental decontamination. It may also suggest that MRSA is easier to recover from the fingertips following contact with the environment, than from the actual environment itself.

MRSA was not recovered following the hand hygiene occasions when gloves had been worn. Gloves have been found to confer protection against bacterial carraige,[25] although there is report of a 3% MRSA carraige rate when hands were sampled after the removal of gloves.[26]

Our findings confirm other reports of hand contamination following clinical contact with patients and their immediate environment,[25,] but also highlights the additional risk of HCW hand contamination when not directly involved in patient care. MRSA was not recovered after social hand contact (i.e. non-clinical contact, but touching the patient such as when shaking hands), possibly because HCWs attending patients had conducted hand hygiene after their last clinical contact. While not statistically significant, less MRSA was recovered from fingertips in the morning (3%), than in the afternoon (6%), suggestive that repeated exposure to MRSA and inadequate hand hygiene throughout shifts may lead to more hand contamination.

There was less MRSA following the education intervention on one ward during phase one but this did not completely eliminate MRSA hand carriage. However, eight months later, no MRSA was found on HCWs fingertips on that same ward, suggesting sustained improved hand hygiene practice. It may also indicate that the sampling of HCW hands may be an alternative method of creating awareness and improving compliance, as well as conventional approaches such as observation of practice, education and posters on hand hygiene. MRSA was more frequently recovered from HCWs fingertips on medical wards, 7%, compared to 3% on surgical wards, as has been reported elsewhere,[15] but this difference was not statistically significant. This may have been related to greater exposure of HCWs to MRSA patients on medical wards, with more long-stay patients than surgical wards. Significantly more MRSA was recovered from the fingertips on non-study wards, indicating, perhaps, that the research created a heightened awareness on the study wards and may have led to improved professional practice. In addition, the number of MRSA patients on wards was not a predictor for increased MRSA from fingertips, as less MRSA was recovered on the study wards where more MRSA patients were isolated/cohorted than on the non-study wards.

There are a number of limitations to this study. In laboratory processing, no neutralizing solution was used to inactivate residual antimicrobial compounds from the hand hygiene agents. These compounds could have been carried over on to the agar plate and may have potentially led to some false-negative results, particularly in relation to the chlorohexidine scrub. As such, the figures relating to MRSA recovery after hand hygiene

agents were used, may have been an underestimation. The sampling of hands is often conducted by the 'glove juice' method, with volunteers immersing hands in sterile gloves containing sterile liquid media.[8] This method samples the whole hand surface, not just the fingertips, and also allows for quantitation of the bacteria isolated. The imprinting of fingertips on to agar plates has been reported elsewhere,[15] and is convenient when taking relatively large numbers of samples over a short period of time on each ward, as was the case in this study. While, only fingertips were cultured in our study, the 5% MRSA recovery rate may be an underestimation of MRSA hand carriage rate. However, this rate is similar to other reports when the 'glove juice' method was used, with a rate of 3%,[8] and also when individual fingertips were sampled.[26] The presence of researchers on the ward had the potential to alter hand hygiene behaviour and therefore as suggested these results may well be conservative.[15,27] Also, as the study was both voluntary and confidential, we were unable to identify the categories of HCWs with a higher carriage. Some HCWs probably provided multiple samples but we were unable to derive a HCW carriage rate rather than a sample positivity rate due to the conditions required for institutional ethical approval. The study was conducted exclusively during day time and not during the evening or at night when levels of hand hygiene and rates of MRSA carriage may be different. In addition, it was not possible to establish if transmission of MRSA from HCW hands to patients occurred.

HCWs in our institution receive training for their roles and responsibilities and one of the most important components of this is hand hygiene. It is mandatory that as part of all medical and healthcare training programmes, hand hygiene skills are part of the formal

assessment to practice.[1,2,3] If a decrease in MRSA hand carriage is to be achieved, hand hygiene technique must be adequate, and all patient, environmental and admininstrative contacts should be considered potentially hazardous.

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Conflict of interest: None declared

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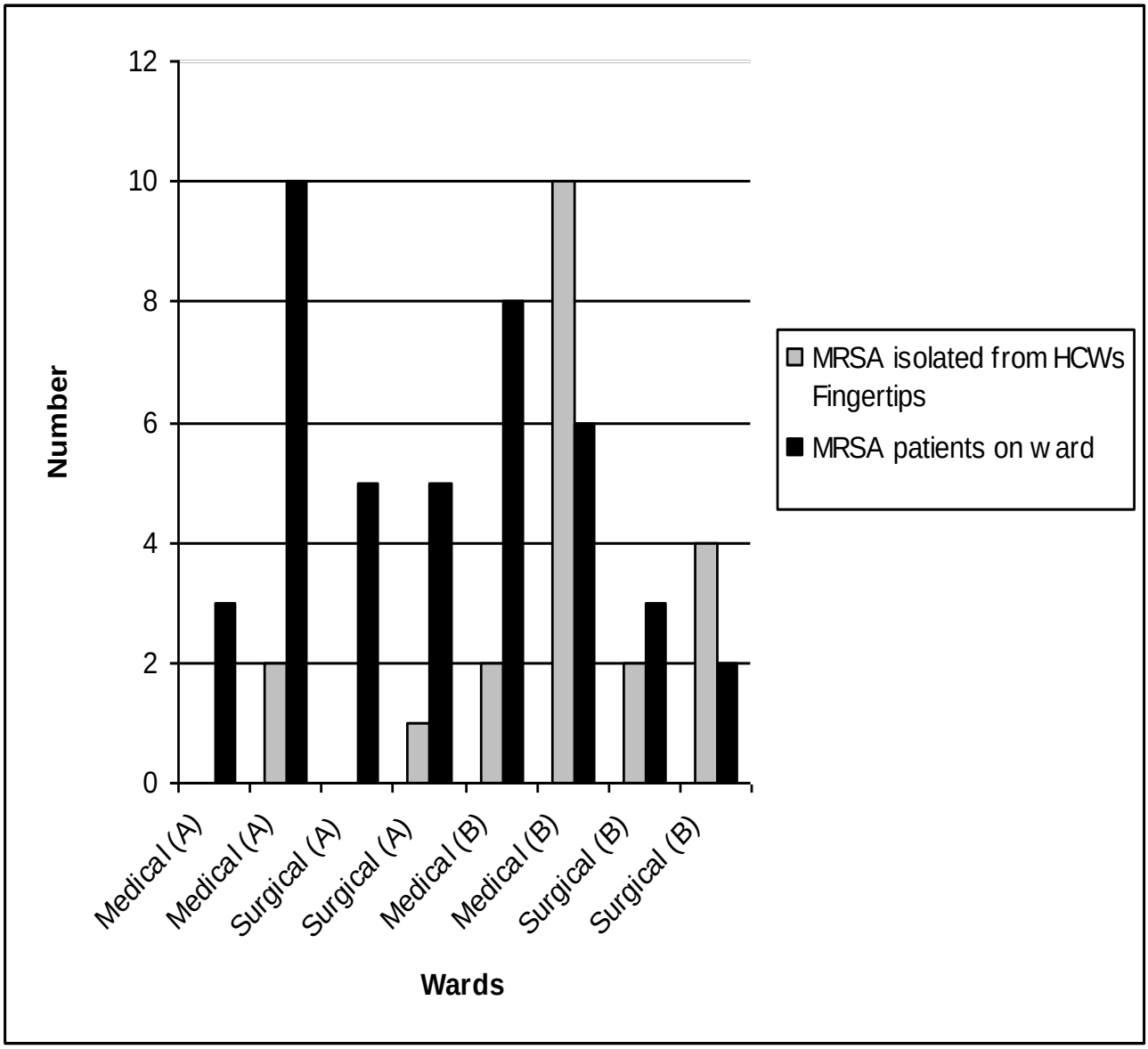
Table 1. Hand hygiene occasions and hand hygiene agents associated with the recovery of the number and percentage ( ) of MRSA from the fingertips of healthcare workers.

Hand hygiene occasions	Gloves only	Gloves and Alcohol hand rub	Gloves and Handwash	Gloves & 4% chlorhexidine detergent	Alcohol hand rub	Alcohol and handwash	Handwash	4% chlorhexidine detergent	No hand hygiene	Total
Before clinical contact	0/1(0)	-	-	-	0/2(0)	0/1(0)	0/6(0)	0/1(0)	1/25(4)	1/36(3)
Before isolation room	-	-	-	-	-	-	0/1(0)	-	0/1(0)	0/2(0)
Before social hand contact	-	-	-	-	-	-	0/1(0)	-	0/2(0)	0/3(0)
After clinical contact	0/8(0)	0/1(0)	0/2(0)	0/2(0)	0/28(0)	0/2(0)	5/87(6)	2/18(11)	5/46(11)	12/194(10)
After environmental contact	0/4(0)	-	-	-	0/6(0)	1/1(100)	0/24(0)	0/1(0)	9/102(9)	10/138(7)
After isolation room	-	-	-	-	-	-	0/2(0)	0/4(0)	0/2(0)	0/8(0)
After social hand contact	-	0/1(0)	-	0/1(0)	0/6(0)	-	0/29(0)	0/7(0)	0/51(0)	0/95(0)
No specific contact	0/1(0)	-	-	-	1/17(6)	-	2/60(3)	0/4(0)	12/264(5)	15/346(4)
Total	**0/14(0)**	**0/2(0)**	**0/2(0)**	**0/3(0)**	**1/59(2)**	**1/4(25)**	**7/210(3)**	**2/35(6)**	**27/493(5)**	**38/822(5)**

Figure 1. The number of occasions (38) when MRSA was recovered from HCWs fingertips (822) and the number (42) of MRSA patients present on eight wards.



A, wards included in larger MRSA study; B, wards not included in study