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

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- 22 occasions
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25 Summary

24

26 Hand hygiene is a key component in reducing infection. There are few reports on the 27 prevalance of methicillin- resistant Staphlococcus aureus (MRSA) on healthcare 28 workers' (HCWs) hands. The aim of this study was to establish if HCWs fingertips were 29 contaminated with MRSA in a clinical hospital setting. The study was conducted in an 30 acute tertiary referral hospital on four MRSA wards that were part of a larger research 31 study on MRSA epidemiology and four other wards not included. The fingertips from all 32 categories of 523 HCWs were sampled on 822 occasions by the imprinting of fingertips 33 on MRSA chromogenic agar plates. The type of hand hygiene agent used, if any, and the 34 immediate prior activity of the HCW were recorded. Overall, 38/822 (5%) fingertips 35 from 523 HCWs were MRSA-positive; 12/194 (6%) after clinical contact, 10/138 (10%) 36 after contact with the patient's environment and 15/346 (4%) after no specific contact. 37 MRSA was recovered on 2/61 (3%) occasions after use of alcohol hand rub, 2/35 (6%) 38 after 4% chlorhexidine detergent, 7/210 (3%) hand washing with soap and water, and 39 27/493 (5%) when no hand hygiene had been performed. MRSA was recovered from 40 HCWs on seven of the eight wards. MRSA was more frequently present on fingertips on 41 the four non-study wards versus the four MRSA-study wards, 18/250 (7%), 3/201 (1%), 42 respectively, p = <0.004). The isolation of MRSA from HCWs fingertips, including after 43 hand hygiene, indicates that more educational programmes are necessary to improve the 44 quality of hand hygiene to prevent transmission of MRSA.

46 Introduction

47 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 48 49 hand hygiene compliance and the *in vitro* effectiveness of hand hygiene agents, but there 50 are few reports on the effectiveness of hand hygiene in eradicating nosocomial 51 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 52 studies have investigated the prevalence of MRSA on hands in clinical practice.^{8,9} 53 54 55 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 56 achieve.^{11,12} The aim of this study was to investigate MRSA hand carriage on all 57 58 categories of HCWs associated with hand hygiene occasions and also with other non-59 specific occasions in a hospital where MRSA is endemic. In addition, the hand hygiene 60 agent used was recorded.

61

62 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

68 environmental decontamination to reduce MRSA. The eight wards included in this study 69 of MRSA hand carriage were four medical and four surgical wards that were considered 70 representative of the hospital. The study was conducted in two phases; phase one was 71 conducted on one ward (MRSA study ward) over a five-week period as an initial test 72 ward and phase two was conducted eight months later over a four-week period on eight 73 wards (seven other wards plus repeat sampling on the initial study ward).

74

75 All wards, except one 29 bed ward, had up to 35 beds and consisted of a mixture of two, 76 four, and six-bedded bays and five single rooms for isolation or other segregration 77 purposes. None of the single rooms had negative-pressure ventilation or an ante room to 78 carry out hand hygiene and don personal protective equipment before entering. Wash 79 hand sinks were available at each of the two, four and six-bedded bays, and in four of the 80 five single rooms on each ward. Alcoholic hand rub dispensers were placed at each hand 81 wash sink and outside single rooms, and also inside and outside the entrance doors to 82 each ward. It is not hospital policy to issue individual alcohol hand gel to HCWs.

83

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

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

94	Sampling procedure: Hand sampling involved imprinting the tips of all fingers and								
95	thumbs of both hands on one MRSA Select chromogenic agar plate (Bio-Rad Life								
96	Science Group, France). Standard laboratory procedures were used for processing								
97	samples and for the confirmation of MRSA (i.e. detection of coagulase and oxacillin								
98	resistance). During phase two, 7/8 wards were sampled twice, once at 9.30 h and once at								
99	14.00 h, on different days. Sampling was conducted by two researchers for approximately								
100	1-2 hours per session, obtaining approximately 50 samples on each ward. The initial								
101	phase 1 ward was re- sampled once. No neutralizing solution was used to negate the								
102	antimicrobial effects of hand hygiene agents.								
103									
104	Hand hygiene occasions: The occasions for hand hygiene that were recorded were								
105	derived from CDC and national guidelines on hand hygiene ^{1,2,3} and were as follows:								
106	• Before social hand contact with patients								
107	• After social hand contact with patients								
108	• Before clinical contact with patients								
109	• After clinical contact with patients								
110	• Before entering an isolation room								
111	• 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.

118

119 Hand hygiene educational intervention: Due to what was considered a high prevalence 120 of MRSA on HCWs hands during the first two weeks of phase one on one ward, an 121 educational intervention was deemed necessary. Screening ceased for one week when 122 this occurred, thereafter, sampling was completed in two weeks. This educational 123 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 124 125 for hand hygiene and the use of appropriate hand hygiene agents. HCWs on that ward 126 performed hand hygiene under observation and used both GloGerm[™] cream (UV 127 Systems PLC, UK) and a fluorescent light box, that highlights the effectiveness of 128 removal of the hand hygiene agent.

129

130 *Statistical analysis*: Statistical analysis was performed using Epi Info 6 (version 6.04c;

131 Centers for Disease Control and Prevention, Atlanta, GA). Odds ratios were calculated.

132 The Mantel-Haenszel chi-square method was used to assess the significance of the

133 difference between proportions.¹³

135 **Results**

154

136 MRSA was recovered from 38/822 (5%) fingertips from 523 HCWs during both phases 137 of the study (Table 1). MRSA was isolated, 12/194 (6%) after clinical contact, 10/138 138 (10%) after contact with the patient's environment and 15/346 (4%) after no specific 139 contact. MRSA was isolated from 11/329 (3%) fingertips when hand hygiene was 140 performed, but 27/493 (5%) when no hand hygiene was used. MRSA was less frequently 141 recovered after use of alcohol hand rub, 1/59 (2%), than after 4% chlorhexidine 142 detergent, 2/35(6%), or after hand washing with soap and water, 7/210(3%). MRSA was 143 recovered from fingertips following 10/138 (7%) environmental contacts. In nine of these 144 10 cases, hand hygiene had not been performed; on the other occasion, alcohol hand rub 145 and soap and water handwash combined, had been used. MRSA was not recovered after 146 contact with equipment or the environment of known MRSA-positive patients. 147 148 MRSA was not recovered on the 21 occasions when HCWs used gloves with or without 149 hand hygiene. The fingertips of 27/493 (5%) HCWs were positive for MRSA when no 150 hand hygiene had been performed before sampling versus 11/329 (3%) when hand 151 hygiene or gloves were worn. On four of 30 (13%) hand hygiene occasions, fingertips 152 were positive for MRSA following hand hygiene after contact with known MRSA 153 patients; 4% chlorhexidine detergent had been used on two occasions and soap and water

155 MRSA patients, one HCW had used alcohol hand rub, one alcohol and soap and water,

on the other two. Of the 26 occasions that were MRSA-negative after contact with known

156 ten soap and water, four gloves only, seven 4% chlorhexidine detergent and three had not157 performed any hand hygiene.

158

159

160 **Phase one study**

161 MRSA was recovered from HCWs fingertips 17/371 (5%) occasions on one medical

162 ward over a five-week period. After MRSA was recovered from HCWs at a higher than

163 anticipated frequency during the first two weeks, sampling ceased to facilitate an

164 educational intervention. MRSA was recovered from 11/182(6%) of HCWs fingertips

165 during the pre-education intervention and 6/189 (3%) after the intervention. Repeat

166 sampling on this ward during phase two, eight months later, did not reveal MRSA on

167 fingertips of any HCWs.

168

169 **Phase two study**

170 Phase two took place eight months after phase one. MRSA was recovered on 21/451

171 (5%) hand hygiene occasions from HCWs fingertips on eight wards. MRSA was

172 recovered more frequently, 14/214 (7%) on medical than 7/235 (3%) on surgical wards,

173 OR 2.26 (95% CI 0.83-6.31), p=<0.08. MRSA was recovered more frequently from the

174 fingertips on the four wards not included in the larger MRSA research study, 18/250

175 (7%), versus the four MRSA study wards, 3/201 (1%), OR 5.12 (95% CI 1.40-20.18),

176 p=<0.004. MRSA was recovered less frequently, 7/231 (3%) when sampled at 09:30 h

177 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 nonstudy 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 MRSApositive patients both isolated and cohorted.

185

186 **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.

193

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.

206

207 Bacterial hand contamination has been reported as higher following clinical activities 208 compared with non-clinical activities (i.e. entering wards, reviewing patient notes, administrative work, etc),¹⁷ and this is consistent with our findings of 6% after clinical 209 210 contact and 4% after no specific contact. The contamination of fingertips after reported 211 'no specific contact', indicates possible contamination of the administrative areas, e.g. 212 desks, telephones, etc. or because HCWs may have incorrectly indicated that they had no 213 specific contact with a patient or the environment, as they did not remember their last 214 hand hygiene occasion.

215

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.

221	A number of studies have shown that the patient environment is frequently contaminated
222	and therefore a risk for transmission of MRSA. ^{23,24} The recovery of 7% of MRSA from
223	HCWs fingertips after contact with the environment, not associated with MRSA isolation
224	rooms, may indicate un-identified MRSA patients in the ward or environmental
225	reservoirs and the need for enhanced environmental decontamination. It may also suggest
226	that MRSA is easier to recover from the fingertips following contact with the
227	environment, than from the actual environment itself.
228	

229 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 230 231 there is report of a 3% MRSA carraige rate when hands were sampled after the removal of gloves.²⁶ 232

234 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 235 236 HCW hand contamination when not directly involved in patient care. MRSA was not 237 recovered after social hand contact (i.e. non-clinical contact, but touching the patient such 238 as when shaking hands), possibly because HCWs attending patients had conducted hand 239 hygiene after their last clinical contact. While not statistically significant, less MRSA was 240 recovered from fingertips in the morning (3%), than in the afternoon (6%), suggestive 241 that repeated exposure to MRSA and inadequate hand hygiene throughout shifts may lead 242 to more hand contamination.

244 There was less MRSA following the education intervention on one ward during phase 245 one but this did not completely eliminate MRSA hand carriage. However, eight months 246 later, no MRSA was found on HCWs fingertips on that same ward, suggesting sustained 247 improved hand hygiene practice. It may also indicate that the sampling of HCW hands 248 may be an alternative method of creating awareness and improving compliance, as well 249 as conventional approaches such as observation of practice, education and posters on 250 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 251 252 difference was not statistically significant. This may have been related to greater 253 exposure of HCWs to MRSA patients on medical wards, with more long-stay patients 254 than surgical wards. Significantly more MRSA was recovered from the fingertips on non-255 study wards, indicating, perhaps, that the research created a heightened awareness on the 256 study wards and may have led to improved professional practice. In addition, the number 257 of MRSA patients on wards was not a predictor for increased MRSA from fingertips, as 258 less MRSA was recovered on the study wards where more MRSA patients were 259 isolated/cohorted than on the non-study wards.

260

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

266 agents were used, may have been an underestimation. The sampling of hands is often 267 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 268 269 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 270 271 relatively large numbers of samples over a short period of time on each ward, as was the 272 case in this study. While, only fingertips were cultured in our study, the 5% MRSA 273 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%,⁸ 274 and also when individual fingertips were sampled.²⁶ The presence of researchers on the 275 276 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 277 278 confidential, we were unable to identify the categories of HCWs with a higher carriage. 279 Some HCWs probably provided multiple samples but we were unable to derive a HCW 280 carriage rate rather than a sample positivity rate due to the conditions required for 281 institutional ethical approval. The study was conducted exclusively during day time and 282 not during the evening or at night when levels of hand hygiene and rates of MRSA 283 carriage may be different. In addition, it was not possible to establish if transmission of 284 MRSA from HCW hands to patients occurred.

285

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

289	assessment to practice. ^{1,2,3} If a decrease in MRSA hand carriage is to be achieved, hand
290	hygiene technique must be adequate, and all patient, environmental and administrative
291	contacts should be considered potentially hazardous.
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295	our research programme.
296	

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299 **References**

- 300 1. World Health Organisation (WHO), WHO Guidelines on Hand Hygiene in Health Care: First
- 301 *Global Patient Safety Challenge, Clean Care is Safer Care.* World Health Organisation 2009,
- 302 Geneva, Switzerland. http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf
- 303 (accessed Oct. 26, 2009).
- 304
- 305 2. Boyce JM, Pittet D. Guideline for Hand Hygiene in Health-Care Settings: recommendations of
- 306 the Healthcare Infection Control Practices Advisory Committee and the
- 307 HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *MMWR* 2002:51:RR-16.
- 308
- 309 3. SARI Infection Control Sub-committee. *Guidelines for Hand Hygiene in Irish Health Care*
- 310 *Settings.* Health Protection Surveillance Centre 2005, Dublin.
- 311
- 312 4. Wilson AP, Hayman S, Whitehouse T. et al. Importance of the environment for patient
- 313 acquisition of methicillin-resistant *Staphylococcus aureus* in the intensive care unit: a baseline
- 314 study. *Crit Care Med* 2007; **35**: 2275-2279.

315

5. Bhalla A, Pultz NJ, Gries DM, *et al.* Acquisition of nosocomial pathogens on hands after

317 contact with environmental surfaces near hospitalized patients. Infect Control Hosp Epidemiol

- 318 2004;**25**:164-167.
- 319
- 320 6. Cespedes C, Miller M, Quagliarello V, Vavagiakis P, Klein RS, Lowy FD. Differences
- 321 between *Staphylococcus aureus* isolates from medical and nonmedical personnel. *J Clin*

322 *Microbiol* 2002;**7**: 2594-2597.

324	7. Cookson B, Peters B, Webster M, Phillips I, Rahman M, Noble W. Staff carriage of epidemic
325	methicillin-resistant Staphylococcus aureus. J Clin Microbiol 1989; 27:1471-1476.
326	
327	8. McBryde ES, Bradley LC, Whitby M, McElwain DL. An investigation of contact transmission
328	of methicillin -resistant Staphylococcus aureus. J Hosp Infect 2004; 58: 104-108.
329	
330	9. Cimiotti JP, Wu F, Della- Latta P, Nesin M, Larson E. Emergence of resistant staphylococci
331	on the hands of new graduate nurses. Infect Control Hosp Epidemio 2004:25: 431-435.
332	
333	10. Pittet D. Compliance with hand disinfection and it's impact on hospital – acquired infections.
334	Journal of Hospital Infection 2001;48: Suppl A S40-46.
335	
336	11. Macdonald DJ, McKillop EC, Trooter S, Gray A. Improving hand-washing performance – a
337	crossover study of hand-washing in the orthopaedic department. Ann R Coll Surg Engl 2006; 88:
338	289-291.
339	
340	12. Creedon, SA . Healthcare workers' hand decontamination practices : compliance with
341	recommended guidelines. J Adv Nurs; 2005;51: 208-216.
342	
343	13. Daly LE, Bourke GJ, McGilvray JW. Interpretation and uses of medical statistics: Blackwell
344	Scientific, Oxford. 1991.
345	
346	14. Tvedt C, Bukholm G. Alcohol-based hand disinfection: a more robust hand-hygiene method
347	in an intensive care unit. J Hosp Infect 2005; 5: 229-234.
348	

349	15. Kac G, Podglajen I, Gueneret M, Vaupré S, Bissery A, Meyer G. Microbiological evaluation
350	of two hand hygiene procedures achieved by healthcare workers during routine patient care: a
351	randomized study, J Hosp Infect 2005; 60: 32-39.
352	
353	16. Patrick DR, Findon G, Miller TE. Residual moisture determines the level of touch-contact-
354	associated bacterial transfer following hand washing. Epidemiol Infect 1997; 119:319-325.
355	
356	17. Pittet D, Mourouga P, Perneger TV. Compliance with hand washing in a teaching hospital.
357	Ann Int Med 1999; 130 : 126-130.
358	
359	18. Huang R, Mehta S, Weed D, Price CS. Methicillin-resistant Staphylococcus aureus survival
360	on hospital fomites. Infect Control Hosp Epidemiol 2006;27:1267-1269.
361	
362	19. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate
363	surfaces? A systemic review. BMC Infect Dis 2006; 6:130-133.
364	
365	20. Neely AN, Maley MP. Survival of enterococci and staphylococci on hospital fabrics and
366	plastic. J Clin Microbiol 2000; 38 :724-726.
367	
368	21. Oomaki M, Yorioka K, Oie S, Kamiya A. Staphylococcus aureus contamination on the
369	surface of working tables in the ward staff centers and it's preventative methods. Biol Pharm Bull
370	2006; 29 :1508-1510.
371	
372	22. Panhotra BR, Saxena AK, Al-Mulhim AS. Contamination of patients' files in intensive care
373	units : an indication of strict hand washing after entering case notes. A J Infect Control 2005;33:

- 373
- 374 398-401.

375	23. Sexton T, Clarke P, O'Neill E, Dillane T, Humphreys H. Environmental reservoirs of					
376	methicillin-resistant Staphylococcus aureus in isolation rooms: correlation with patient isolates					
377	and implications for hospital hygiene. J Hosp Infect 2006; 62: 187-194.					
378						
379	24. Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to					
380	methicillin-resistant Staphylococcus aureus: possible infection control implications. Infect					
381	Control Hosp Epidemiol 1997; 18 :622-627.					
382						
383	25. Hayden MK, Blom DW, Lyle EA, Moore CG, Weinstein RA. Risk of hand or glove					
384	contamination after contact with patients colonized with vancomycin-resistant Enterococcus or					
385	the colonized patients' environment. Infect Control Hosp Epidemiol 2008; 29:149-154.					
386						
387	26. Snyder GM, Thom KA, Furuno JP. et al. Detection of methicillin-resistant Staphlococcus					
388	aureus and vancomycin-resistant Enterococci by healthcare workers on infection control gown					
389	and gloves. Infect Control Hosp Epidemiol 2008; 29: 583-589.					
390						
391	27. Larson E, Kretzer EK. Compliance with hand washing and barrier precautions.					

Journal of Hospital Infection 1995; **30**: Suppl: 88-106.

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 After environmental	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
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

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.

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



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

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