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

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

3  
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22 occasions

23 **Running Title: Sampling HCWs hands for MRSA**

24

## 25 **Summary**

26 Hand hygiene is a key component in reducing infection. There are few reports on the  
27 prevalence of methicillin-resistant *Staphylococcus 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.

45

## 46 **Introduction**

47 Hand hygiene is one of the most important elements in preventing infection and the  
48 frequency and technique are important.<sup>1,2,3</sup> Previous reports have largely concentrated on  
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  
52 workers (HCWs) has been reported as part of the wider investigation of MRSA,<sup>4-7</sup> few  
53 studies have investigated the prevalence of MRSA on hands in clinical practice.<sup>8,9</sup>

54

55 Hand hygiene campaigns and education result in improved hand hygiene and a decrease  
56 in cross contamination with MRSA,<sup>10</sup> but sustained improvement is difficult to  
57 achieve.<sup>11,12</sup> The aim of this study was to investigate MRSA hand carriage on all  
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**

63 *Setting and participants:* The study was conducted in an adult 700-bed tertiary referral  
64 hospital on four wards that were part of a wider programme of research on MRSA  
65 (MRSA study wards) and four non-study wards. This research programme includes  
66 assessing the value of near universal screening for MRSA, the level of MRSA  
67 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 segregation  
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

84 Ethical approval was obtained from the hospital's ethics committee on condition that  
85 participation was voluntary, anonymous and that HCWs were given written and verbal  
86 information about the study. All categories of staff, i.e. medical, nursing, care assistants,  
87 support and allied health professionals were eligible to participate and HCWs could  
88 participate more than once provided that the hand hygiene occasions were different. A  
89 written report of each ward's results were provided to individual wards and also to the  
90 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.

93

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<sup>1,2,3</sup> 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



112       • After contact with ward equipment or the environment

113 In addition, activities associated with hand hygiene and the hand hygiene agent used  
114 (e.g. soap and water, alcohol hand rub, 4% chlorhexidine detergent), and if no hand  
115 hygiene was performed, were recorded. Data were also recorded if there was contact  
116 with a known MRSA patient or the patient's equipment or if contact with the  
117 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,  
124 including demonstration of the steps of handwash technique,<sup>2</sup> advice on the occasions  
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.<sup>13</sup>

134

## 135 **Results**

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  
154 on the other two. Of the 26 occasions that were MRSA-negative after contact with known  
155 MRSA patients, one HCW had used alcohol hand rub, one alcohol and soap and water,

156 ten soap and water, four gloves only, seven 4% chlorhexidine detergent and three had not  
157 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),  $p = 0.09$ ).

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

185

## 186 **Discussion**

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

193

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

200 immediately after hand washing and drying when hands may not have been adequately  
201 dried, and this may partly explain the higher recovery of MRSA after washing hands.  
202 Despite the availability of alcohol hand rub throughout the wards, only 63 HCWs used  
203 alcohol hand rub in contrast to 210 that used soap and water. Promotion of the use of  
204 alcohol hand rub when appropriate could possibly result in reduced contamination with  
205 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,  
209 administrative work, etc),<sup>17</sup> and this is consistent with our findings of 6% after clinical  
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

216 The survival times of staphylococci on objects and the environment has been reported as  
217 ranging from days to months<sup>18,19</sup> and MRSA has been isolated from patient charts and  
218 computer keyboards.<sup>20-22</sup> Even when HCWs are not in contact with patients or their  
219 immediate environment, hand hygiene is necessary when entering and leaving wards or  
220 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.<sup>23,24</sup> 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  
230 worn. Gloves have been found to confer protection against bacterial carriage,<sup>25</sup> although  
231 there is report of a 3% MRSA carriage rate when hands were sampled after the removal  
232 of gloves.<sup>26</sup>

233

234 Our findings confirm other reports of hand contamination following clinical contact with  
235 patients and their immediate environment,<sup>25</sup> but also highlights the additional risk of  
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.

243

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  
251 wards, 7%, compared to 3% on surgical wards, as has been reported elsewhere,<sup>15</sup> but this  
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

261 There are a number of limitations to this study. In laboratory processing, no neutralizing  
262 solution was used to inactivate residual antimicrobial compounds from the hand hygiene  
263 agents. These compounds could have been carried over on to the agar plate and may have  
264 potentially led to some false-negative results, particularly in relation to the  
265 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  
268 containing sterile liquid media.<sup>8</sup> This method samples the whole hand surface, not just the  
269 fingertips, and also allows for quantitation of the bacteria isolated. The imprinting of  
270 fingertips on to agar plates has been reported elsewhere,<sup>15</sup> and is convenient when taking  
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  
274 is similar to other reports when the ‘glove juice’ method was used, with a rate of 3%,<sup>8</sup>  
275 and also when individual fingertips were sampled.<sup>26</sup> The presence of researchers on the  
276 ward had the potential to alter hand hygiene behaviour and therefore as suggested these  
277 results may well be conservative.<sup>15,27</sup> Also, as the study was both voluntary and  
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

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



289 assessment to practice.<sup>1,2,3</sup> 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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296

297 **Conflict of interest:** None declared

298

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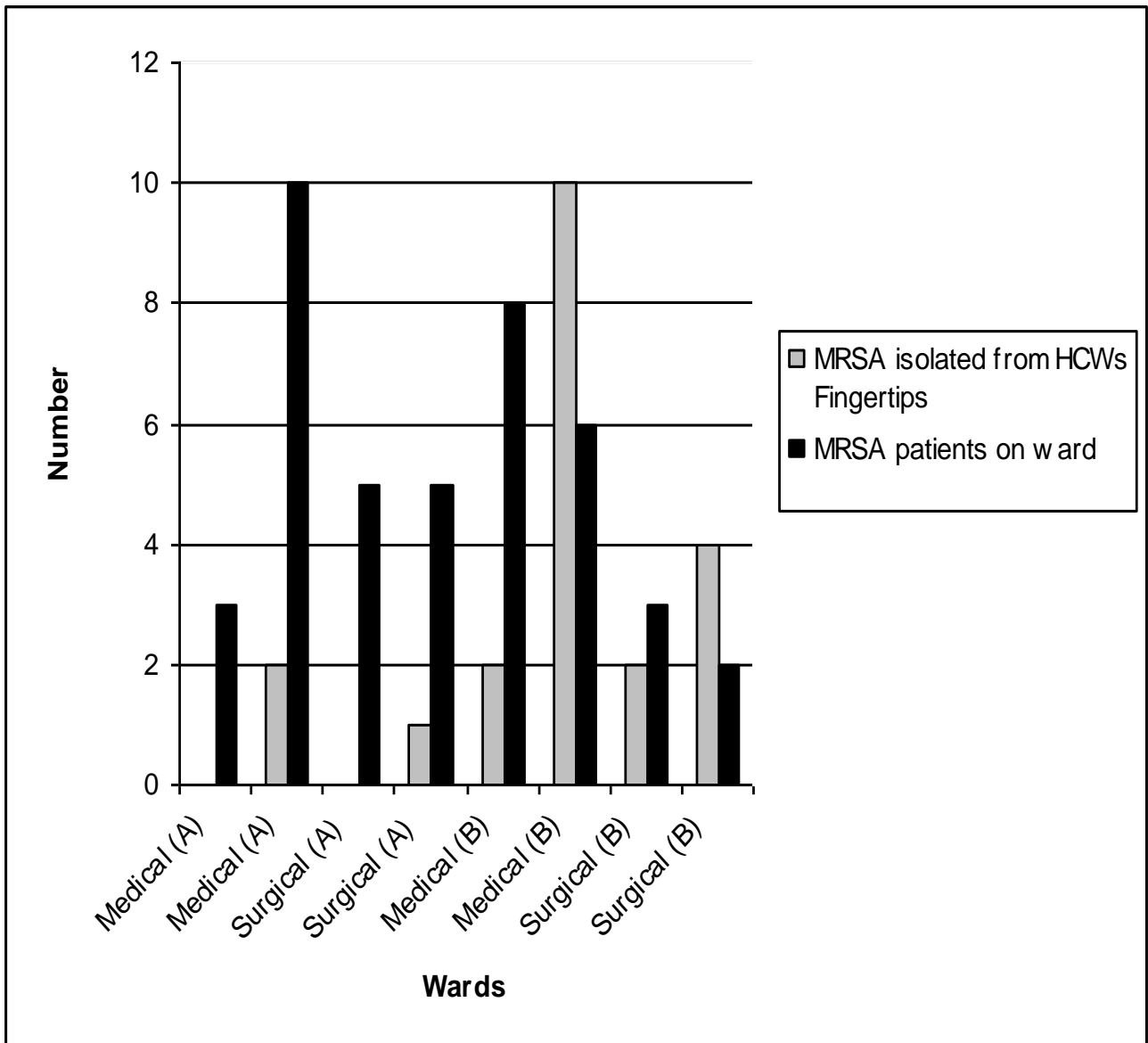
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**Table 1. Hand hygiene occasions and hand hygiene agents associated with the recovery of the number and percentage ( ) of MRSA from the fingertips of healthcare workers.**

<b>Hand hygiene occasions</b>	<b>Gloves only</b>	<b>Gloves and Alcohol hand rub</b>	<b>Gloves and Handwash</b>	<b>Gloves &amp; 4% chlorhexidine detergent</b>	<b>Alcohol hand rub</b>	<b>Alcohol and handwash</b>	<b>Handwash</b>	<b>4% chlorhexidine detergent</b>	<b>No hand hygiene</b>	<b>Total</b>
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)
<b>Total</b>	<b>0/14(0)</b>	<b>0/2(0)</b>	<b>0/2(0)</b>	<b>0/3(0)</b>	<b>1/59(2)</b>	<b>1/4(25)</b>	<b>7/210(3)</b>	<b>2/35(6)</b>	<b>27/493(5)</b>	<b>38/822(5)</b>

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**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.**



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

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