ORIGINAL ARTICLE

Nasal Swab Screening for Methicillin-Resistant *Staphylococcus aureus*—How Well Does It Perform? A Cross-Sectional Study

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OBJECTIVE. To determine the proportion of methicillin-resistant *Staphylococcus aureus* (MRSA) detections identified by nasal swabbing using agar culture in comparison with multiple body site testing using agar and nutrient broth culture.

DESIGN. Cross-sectional study.

PATIENTS. Adult patients admitted to 36 general specialty wards of 2 large hospitals in Scotland.

METHODS. Patients were screened for MRSA via multiple body site swabs (nasal, throat, axillary, perineal, and wound/invasive device sites) cultured individually on chromogenic agar and pooled in nutrient broth. Combined results from all sites and cultures provided a gold-standard estimate of true MRSA prevalence.

RESULTS. This study found that nasal screening performed better than throat, axillary, or perineal screening but at best identified only 66% of true MRSA carriers against the gold standard at an overall prevalence of 2.9%. Axillary screening performed least well. Combining nasal and perineal swabs gave the best 2-site combination (82%). When combined with realistic screening compliance rates of 80%–90%, nasal swabbing alone probably detects just over half of true colonization in practice. Swabbing of clinically relevant sites (wounds, indwelling devices, etc) is important for a small but high-prevalence group.

CONCLUSIONS. Nasal swabbing is the standard method in many locations for MRSA screening. Its diagnostic efficiency in practice appears to be limited, however, and the resource implications of multiple body site screening have to be balanced against a potential clinical benefit whose magnitude and nature remains unclear.

Infect Control Hosp Epidemiol 2012;33(8):803-808

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections are a significant cause of healthcare-associated infections in Scotland[1] and are associated with increased mortality, morbidity, and healthcare costs.[2-9] Patients colonized with MRSA on admission are at a much higher risk of infection[10] and act as a reservoir for potential transmission to other patients. Screening for MRSA colonization or infection on admission to the hospital, if effective, could greatly reduce these risks when coupled with targeted infection control measures.[11] For screening to be fully effective, it has, above all, to be sensitive in detecting patients who are carriers; this was a key factor identified in a major study of the clinical effectiveness and cost-effectiveness of MRSA screening in Scotland.[12,13] Published estimates of the effectiveness of MRSA screening for various body sites are largely based on restricted or specialized patient groups[14-22] rather than the general hospital population, which was the subject of this study.

METHODS

The study was a cross-sectional survey of elective and emergency admissions to inpatient care in 2 acute care hospitals that had participated in the Scottish MRSA screening Pathfinder project.[12] These hospitals were a large, 690-bed district general hospital (Crosshouse Hospital) and a large, 879-bed teaching hospital (Aberdeen Royal Infirmary), and they were considered to be representative of similar hospitals elsewhere in the country. Recruitment took place from February to August 2010.

Pediatric, obstetric, and psychiatric admissions were excluded from the study at both sites, as were day case patients,

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Received August 26, 2011; accepted February 26, 2012; electronically published June 21, 2012.

 0899-823X/2012/3308-0007$15.00. DOI: 10.1086/666639

those under 16 years old, those without documented consent to participate, those swabbed more than 48 hours after admission, and adults with severe mental or physical incapacity (as defined in Scottish law,[23] an ethical approval requirement). Where patients screened positive, they were isolated where possible and managed according to standard local clinical protocols.

A minimum sample size of 7,680 admission episodes was required to ensure 95% confidence that the proportion of MRSA detections found on anatomical site screening was within ±5% of the actual proportion. This assumed MRSA prevalence in the admission population to be 5% (interim findings of the Pathfinder project[24]) and the sensitivity of testing to be in the region of 70% (lower-end estimate from manufacturers).

Patients were swabbed with rayon-tipped swabs on admission at 4 body sites: nostrils, perineum, axilla, and throat. Nasal swabs were premoistened, and dry swabs were also taken from skin wounds, indwelling medical device sites, and other potentially infected or colonized sites if present. Dedicated screeners were employed at Aberdeen Royal Infirmary (alerted by ward staff to new admissions), whereas ward staff carried out screening at Crosshouse Hospital. This was primarily for operational reasons but had the theoretical benefit of reducing the effects of any systematic bias overall in patient selection. A standard training program and protocol were used in both hospitals.

Swabs from individual body sites were inoculated directly onto Oxoid Brilliance MRSA chromogenic agar. In addition, samples from all sites for each patient were pooled in Oxoid's selective mannitol nutrient broth and incubated at 37°C for 18–34 hours before being plated on selective agar. Suspect colonies were confirmed by coagulase test using the Prolex Staph Xtra Latex kit. The gold-standard estimate of true MRSA colonization was defined as at least 1 confirmed agar or broth/agar MRSA culture from any swab or pooled swab set for each patient admission.

Data collection forms were scanned into a holding database and subjected to manual and automated validation; corresponding laboratory data were subjected to further validation and linked within a Microsoft SQL database. All statistical calculations were undertaken in Stata 9 (StataCorp). Differences in performance between the anatomical sites were assessed using the McNemar test for paired proportions. Patients with incomplete swab sets were excluded from analysis.

Ethical approval (09/MRE/0050) was obtained in June 2009 from the Scotland A Research Ethics Committee.

RESULTS

From an initial recruitment cohort of 12,889 admissions, 10,314 met the above study inclusion criteria (3,781 from Crosshouse Hospital and 6,533 from Aberdeen Royal Infirmary); 10,077 had a complete set of data, documented consent, and swab results recorded.

There was evidence of some variation in demographics between the 2 sites (Table 1). Aberdeen Royal Infirmary patients had a higher rate of admission from other hospitals (2.3% vs 0.7%) and a higher proportion of elective admissions (41.6% vs 24.4%) than Crosshouse Hospital patients (both $P < .001$), but these differences are probably characteristic of the different types of hospital involved.

The positive results from anatomical site swabs plus the "clinically significant" site swabs (for those with wounds, indwelling devices, etc) cultured on agar plus the nutrient broth isolates collectively gave the gold-standard approximation of true positives for comparison purposes. Some 298 positive colonizations were detected within the combined gold-standard total, with 25 (8.4%) detected by broth culture alone, giving a 2.96% prevalence among the 10,077 patients with complete anatomical swab sets.

There were no statistically significant differences in positivity for the nasal, axillary, or perineal swabs between the 2 hospitals. Broth and throat positivity was significantly higher at Crosshouse Hospital than at Aberdeen Royal Infirmary ($P = .022$ and .003, respectively).

Table 2 shows the detections for each anatomical site and the incremental benefit of swabbing additional body sites. Of the 273 swabs that were MRSA positive by agar culture alone, the highest yield was from nasal swabs (198/273; 72.5% of agar positives); axillary, throat, and perineal swabs identified 8.4%, 37.7%, and 39.1% of agar positives, respectively.

In comparison with the gold standard, nasal swabbing alone identified 66.4% (198/298) of MRSA-positive admissions. For a 2-swab regimen, ascertainment rose by 10.1% and 15.8% by adding throat and perineal screening, respectively; axillary screening increased ascertainment over nasal swabbing alone by only 2.4%. Screening all 4 sites gave the best ascertainment (91.6% [95% confidence interval, 87.9%–94.3%] of gold-standard positives), but excluding axillary screening reduced this only marginally (90.3% [95% confidence interval, 86.3%–93.4%]).

Of the total admission population, 1.6% (162/10,077) had swabs taken from other clinically significant sites (eg, wounds or indwelling devices), and 15.4% (25/162) of these were positive by the gold standard. Of these 25 colonized admissions, 40% (10/25) were identified by nasal swabbing alone, and 84% (21/25) were identified from wound or device site swabs; in combination, these 2 swabs identified all gold-standard colonizations. There was therefore no incremental benefit in adding additional body site swabs for this group.

DISCUSSION

Nasal swabbing using agar culture identified two-thirds of the total MRSA carriers who were diagnosed by multiple body site screening using agar plus nutrient broth culture. Nasal swab screening combined with culture on agar is a commonly applied method for detecting MRSA carriage. It is, however, costly in terms of staff time and laboratory processing, and

TABLE 1. Epidemiological Characteristics of Study Sites (N = 10,314)

Characteristic	Crosshouse Hospital		Aberdeen Royal Infirmary		Total no.
	No.	% (95% CI)	No.	% (95% CI)	
Gender					
Male	1,729	45.7 (44.16–50.15)	3,197	48.9 (47.72–50.15)	4,926
Female	2,052	54.3 (52.66–55.84)	3,336	51.1 (49.85–52.28)	5,388
Age					
≤49 years	1,008	26.7 (25.25–28.07)	1,789	27.4 (26.33–28.50)	2,797
50–64 years	1,006	26.6 (25.17–27.99)	1,859	28.5 (27.35–29.54)	2,865
65–79 years	1,257	33.3 (31.82–34.83)	2,096	32.1 (30.93–33.20)	3,353
≥80 years	510	13.5 (12.35–14.53)	789	12.1 (11.28–12.87)	1,299
Admitted from					
Home	3,737	98.8 (98.49–99.18)	6,315	96.7 (96.27–97.14)	10,052
Other hospital	26	0.7 (0.47–0.10)	148	2.27 (1.91–2.64)	174
Care home	11	0.3 (0.16–0.52)	14	0.21 (0.10–0.33)	25
Other	7	0.2 (0.09–0.38)	53	0.81 (0.58–10.17)	60
Unknown	0	0.0 (...)	3	0.05 (0.02–0.13)	3
Type of admission					
Elective	923	24.4 (23.06–25.80)	2,715	41.6 (40.31–42.71)	3,638
Emergency	2,856	75.6 (74.20–76.94)	3,816	58.4 (57.29–56.69)	6,672
Unknown	2	0.1 (0.0–0.19)	2	0.0 (0.008–0.11)	4
Specialty admitted to[a]					
Low risk	3,369	89.1 (88.42–90.39)	3,802	58.2 (57.29–59.69)	7,171
High risk	399	10.6 (1.58–11.57)	2,698	41.3 (40.31–42.71)	3,097
Unknown	13	0.3 (...)	33	0.5 (...)	46

NOTE. Modified with permission from *NHS Scotland MRSA Screening Pathfinder Programme: The Value of Nasal Swabbing versus Full Body Screening or Clinical Risk Assessment to Detect MRSA Colonisation at Admission to Hospital*, copyright Health Protection Scotland.[30] CI, confidence interval.

[a] Risk of colonization as defined in the Scottish Pathfinder study.[12]

the sensitivity of the technique in detecting true carriers in the general patient population is poorly understood. This study sought to determine the likely true sensitivity of nasal swabbing and the effect on ascertainment of swabbing additional body sites.

One of the key findings in this study was that nasal swabbing alone appears to detect only 66% of "true-positive" cases as assessed by the gold-standard measure (all body site swabs on chromogenic agar plus broth culture combined). There is no way of assessing how many additional cases the gold standard may have missed, so the value of 66% for nasal/chromogenic agar screening is a best-case estimate. This efficiency of identifying MRSA carriers will be further reduced in the real-time hospital environment by the documented difficulty in ensuring compliance with swabbing—observed compliance rates during the Pathfinder study[12] ranged from 80% at the outset to 90% during the latter stages (and then only with considerable additional input to maximize compliance in the context of the study). Therefore, a realistic estimate of 80% compliance with universal nasal swabbing would detect only approximately 53% of true MRSA carriage. This suggests that, with a strategy of universal nasal screening, almost half of true MRSA carriers would go undetected in practice.

MRSA colonization was detected most frequently by nasal screening and least frequently by axilla screening. For a 2-swab approach, the combination of nasal plus perineum swabbing produced a significantly better detection rate (82.2%) than nasal swabbing alone (66.4%); nasal plus throat swabbing also produced a better detection rate than nasal swabbing alone (76.5%), but with overlapping confidence intervals. Perineal colonization is a proxy measure for rectal colonization, which is reported as being more likely to cause environmental contamination and has been associated with high dispersal.[15,25] Perineal swabbing on this basis would be the site of choice for second swab screening given this propensity for transmission; however, it may be less acceptable to patients than throat screening and more demanding of staff time (patients may require assistance to undress and maneuver). Compliance with a universal 2-swab approach may thus be lower than nasal swabbing alone but could potentially be applied more rigorously to selected higher-risk groups.

A broad range of individual-site detection rates are quoted in the literature and are generally higher than those in this study.[15,21,25,26] However, there is generally no gold-standard measure of total colonization other than combined swab/agar results in these other studies, and positive results for swab/agar testing only within this study are broadly similar for

TABLE 2. Number of Positive Samples by Anatomical Site (Chromogenic Agar) and Percentage Positive Compared with the Gold Standard (N = 10,077, n = 298)

Anatomical site(s)	MRSA-positive samples (n = 298)	% of gold-standard positives identified (95% CI)	% of additional MRSA detection compared with nasal alone (95% CI)
Nasal alone	198	66.4 (60.9–71.6)	...
Axilla alone	23	7.7 (5.2–11.3)	...
Throat alone	103	34.6 (29.4–40.1)	...
Perineum alone	107	35.9 (30.7–41.5)	...
Nasal/axilla	205	68.8 (63.3–73.8)	2.4 (0.95–4.8)
Nasal/throat	228	76.5 (71.4–81.0)	10.1 (6.9–14.1)
Nasal/perineum	245	82.2 (77.5–86.1)	15.8 (11.8–20.4)
Nasal/throat/axilla	234	78.5 (73.5–82.8)	12.1 (8.6–16.3)
Nasal/throat/perineum	269	90.3 (86.3–93.4)	23.8 (19.1–29.1)
Nasal/axilla/perineum	250	83.9 (79.3–87.6)	17.5 (13.3–22.2)
Nasal/throat/axilla/perineum	273	91.6 (87.9–94.3)	25.2 (20.3–30.5)

NOTE. Modified with permission from *NHS Scotland MRSA Screening Pathfinder Programme: The Value of Nasal Swabbing versus Full Body Screening or Clinical Risk Assessment to Detect MRSA Colonisation at Admission to Hospital*, copyright Health Protection Scotland.[30] CI, confidence interval; MRSA, methicillin-resistant *Staphylococcus aureus*.

nasal positives (72% [245/273] of all swab/agar isolates here, compared with 70.5% and 73.2% elsewhere[23,27]); findings were similar for nasal plus throat (83.5% vs 82.2%)[15] and nasal plus perineal (90% vs 89.6% and 92.2%).[15,17] The isolation rates described by other studies[18,21,25,26] can be higher, but these studies vary in their population samples and detection methods. Some studies were undertaken with inpatients at a higher risk of colonization or combined clinical samples with screening samples.

The actual clinical impact on infection rates of relatively inefficient detection of MRSA carriage is unknown, but the Scottish Pathfinder project[12] found indications of reduced MRSA infection and carriage associated with a 1-year period of universal nasal swabbing at an overall 85% compliance. A recent study[28] also suggests that even relatively low ascertainment of MRSA carriage may be effective. The Pathfinder study[12] found that approximately half of the MRSA infections diagnosed in the hospital occur in patients not recognized as being colonized on admission; those patients will be partly undiagnosed carriers and partly true negatives who acquire their colonization or infection directly or indirectly from patients who are colonized at admission. A recent Scottish study that examined the dynamics of MRSA transmission during a program of universal nasal screening and decolonization found the same overall MRSA colonization prevalence on admission and discharge of 2.9%, but it also found that 1.3% of patients who were MRSA positive on discharge had not been positive on admission.[29]

For those admissions with indwelling devices or wounds (surgical wounds, pressure ulcers, diabetic ulcers, etc), MRSA detection is considerably improved by including clinical site swabbing in the screening strategy. Nasal swabbing alone identified only 40% of positive MRSA admissions in this subgroup, but a combination of nasal and wound/device swabbing identified 100% of confirmed carriers. For this small group, therefore, there is no benefit in recommending additional body site swabbing; however, it does reemphasize the need for stringent application of the current UK recommendation[27] on swabbing all clinically significant sites on admission. Notwithstanding this, the simpler practicalities of reliably applying a 2-swab (nasal plus perineal) regimen to all patients probably outweigh the marginal financial benefits of using nasal swabs only in these patients.

The major potential limitation to the validity and generalizability of the findings presented here is the opportunistic nature of recruitment of patients to the study. Previous experience with the Pathfinder study[10] suggests that screening compliance is lower in short-stay patients, who are also likely to have a lower prevalence of MRSA carriage. While this may increase the apparent carriage rate in the hospital population, this will be counterbalanced at least to an extent by the residual true positives who remain undiagnosed. Any systematic bias should also be mitigated by the fact that 2 different hospital types were involved and 2 different operational strategies for screening were employed; for the latter, it was noted that recruitment was more problematic where dedicated screeners rather than ward staff were employed.

Universal nasal swabbing for MRSA is less effective in practice than previously thought in identifying patients with MRSA carriage, but improving ascertainment from 54% to 72% (assuming 80% compliance) by using a 3-fold combination of nasal, throat, and perineal swabs would come at a significant cost in terms of staff time and resources. Further study of the parameters and economic modeling around the various approaches suggested by this study is required to inform national policy options and will be the subject of an additional publication.

ACKNOWLEDGMENTS

The study would not have been possible without the hard work of the project staff at Crosshouse Hospital (National Health Service [NHS] Ayrshire and Arran) and Aberdeen Royal Infirmary (NHS Grampian) and without the collaboration and assistance of the hospital and laboratory staff at each site. In addition, we would like to individually acknowledge and thank S. Fleming, B. Gemmell, Dr F. MacKenzie, and S. Stewart for their contributions. The data in this study were submitted to the Scottish Government in a report available online (http://www.documents.hps.scot.nhs.uk/hai/mrsa-screening/pathfinder-programme/mrsa-pathfinder-admissions-2011-02-23.pdf).

Financial support. The study was funded by the Scottish Government Heath Directorates.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

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