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Journal

Infection Control and Hospital Epidemiology, 34(2)

ISSN

0899-823X

Authors

McKinnell, James A

Huang, Susan S

Eells, Samantha J

et al.

Publication Date

2013-02-01

DOI

10.1086/669095

Published in final edited form as:
Infect Control Hosp Epidemiol. 2013 February ; 34(2): 161–170. doi:10.1086/669095.

Quantifying The Impact of Extra-Nasal Testing Body Sites for MRSA Colonization at the Time of Hospital or Intensive Care Unit Admission

James A. McKinnell, MD[1,2], **Susan S. Huang, MD, MPH**[3], **Samantha J. Eells, MPH**[1], **Eric Cui, BS**[3], and **Loren G. Miller, MD, MPH**[1]

[1]Infectious Disease Clinical Outcomes Research Unit (ID-CORE), Division of Infectious Disease, Los Angeles Biomedical Research Institute, Harbor-UCLA Medical Center, Torrance, CA

[2]Torrance Memorial Medical Center, Torrance, CA

[3]Division of Infectious Diseases and Health Policy Research Institute, University of California, Irvine School of Medicine, Irvine, California

Abstract

Objective—Methicillin-resistant *Staphylococcus aureus* (MRSA) is a common cause of healthcare-associated infections. Recent legislative mandates require nares screening for MRSA at hospital and ICU admission in many states. However, MRSA colonization at extra-nasal sites is increasingly recognized. We conducted a systematic review of the literature to identify the yield of extra-nasal testing for MRSA.

Design—We searched MEDLINE from January 1966 through January 2012 for articles comparing nasal and extra-nasal screening for MRSA colonization. Studies were categorized by population tested, specifically those admitted to ICUs, and those admitted to hospitals with a high prevalence (≥6%) or low prevalence (<6%) of MRSA carriers. Data were extracted using a standardized instrument.

Results—We reviewed 4,381 abstracts and 735 manuscripts. Twenty-three manuscripts met criteria for analysis (n=39,479 patients). Extra-nasal MRSA screening increased yield by approximately one-third over nares alone. The yield was similar upon ICU admission (weighted average 33%, range 9%–69%), and hospital admission in high (weighted average 37%, range 9–86%) and low prevalence (weighted average 50%, range 0–150%) populations. Comparing individual extra nasal sites, testing the oropharynx increased MRSA detection by 21% over nares alone; rectum by 20%; wounds by 17%; and axilla by 7%.

Conclusions—Extra-nasal MRSA screening at hospital or ICU admission in adults will increase MRSA detection by one-third compared to nares screening alone. Findings were consistent among subpopulations examined. Extra-nasal testing may be a valuable strategy for outbreak control or in settings of persistent disease, particularly when combined with decolonization or enhanced infection prevention protocols.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is one of the most common causes of healthcare-associated infections.[1] MRSA causes up to 40% of healthcare associated

Dr. James McKinnell (Dr.McKinnell@yahoo.com) 1124 West Carson St., Box 466 Torrance, CA 90502 T 310 222-5693 F 310 782-2016.

Potential Conflicts of Interest:
None of the authors have any conflicts of interest to disclose in relation to this manuscript.

infections worldwide, with particularly high incidence in the United States (US), Asia, and many European countries.[1–4]

Many hospitals use MRSA nares screening as a key component of MRSA infection prevention programs.[5–10] Investigations in high MRSA prevalence populations have shown that active surveillance combined with contact precautions or decolonization protocols are associated with reduced MRSA transmission.[10–14] Grass roots efforts to prevent MRSA infections in hospitals have led to legislative methods to mandate MRSA screening in the US. In the US, nine states have passed legislation mandating MRSA nares screening for high risk patients being admitted to the hospital, particularly those admitted to intensive care units (ICUs).[15]

Recent investigations have found that MRSA colonization at sites other than the nares is common. Importantly, a proportion of patients who test positive for extra-nasal MRSA colonization have a negative nasal swab for MRSA.[16–20] These findings suggest that persons colonized with MRSA only at extra-nasal body sites may be an important unrecognized reservoir of MRSA in hospitals. However, many prior investigations were done in outpatient settings and their significance for hospitalized patients is unclear. There have been no attempts to systematically quantify the increase in detection of MRSA carriers from extra-nasal testing among patients being admitted to hospitals or ICUs. To examine the scope of extra-nasal colonization in hospitalized patients, we performed a systematic review of the literature to measure the utility of testing extra-nasal body sites in addition to traditional nares testing alone to identify MRSA colonization in patients being admitted to hospitals and ICUs.

Methods

Search Strategy

To find published manuscripts evaluating extra-nasal MRSA colonization upon hospital and/or ICU admission, we performed a literature search of Medline from 1966 to January 2012 and of EMBASE from 1980 to January 2012. We limited studies to English language and human subjects and searched for the following terms: [(((((((screening) OR swab) OR surveillance) AND (((Methicillin) OR Meticillin) OR Oxacillin)) AND ((((((hospital) OR intensive care) OR ICU) OR inpatient) OR ward) OR Unit)]. In addition, we examined the bibliography of all identified articles to look for additional relevant references.

Study Selection

Each abstract from publications identified by the search criteria underwent detailed review to identify potential studies for inclusion. Studies that collected data from pediatric patients, screened patients >48 hours after admission, or during brief (<2 month) outbreaks were excluded. Reports describing clinical infections, non-hospitalized patients, laboratory-based surveys, or review articles were also excluded. Each abstract was independently reviewed by two reviewers from a pool of 3 reviewers given identical instructions on review criteria (J.M., S.E., E.C). The full-text article was reviewed if it was determined to have potentially relevant data by both reviewers. Discrepant recommendations underwent arbitration by the third reviewer. Reviewers were not permitted to evaluate any manuscript that they authored.

Data Extraction

Two reviewers from our pool of reviewers independently extracted data on MRSA colonization from each manuscript using a standardized instrument. Descriptive data collected for each study included time period of investigation, country of investigation, and hospital characteristics including type (tertiary care, community, teaching or other), bed size,

and annual admissions. Reviewers also described the study population sampled (e.g. ICU population, total hospital population, sub-specialty patients (orthopedics), etc.). Compliance with MRSA screening protocols, MRSA diagnostic testing method, and method of body swabbing were also evaluated.

To evaluate the added yield of various sites of extra-nasal screening, reviewers collected the number of patients tested at each body site and the number of patients who tested positive for MRSA at each body site. We attempted to contact authors when any of these data elements were not provided in the manuscript.

Data Synthesis

Investigations were stratified into two screening groups: those screened at hospital admission and those screened at ICU admission. Studies containing data on hospital admission screening were further subdivided into studies conducted in populations at low MRSA prevalence and those in high MRSA prevalence (defined as MRSA colonization at any body site >6%). The 6% cutoff was determined *post hoc* based on the MRSA prevalence distribution among studies.

The additional capture of MRSA carriage by extra-nasal screening beyond traditional nares-only screening was calculated for each individual study. Studies were weighted by the sample size of patients screened in each study. Results are reported as the absolute and relative increase in the proportion of MRSA carriers identified by the testing of any extra-nasal site compared to nares testing alone. In addition, the relative benefit of screening specific sites, including the oropharynx, rectum, wounds, and axilla, was calculated for each study based upon sampled sites. Results are reported as the absolute and relative increase in number of MRSA carriers detected from each body site. To ensure that our results were not biased by the process of combining results from multiple investigations (i.e. Simpson's paradox), we performed graphical analyses and comparative analyses of data from each individual study.[21,22]

Results

The electronic search yielded 4,381 abstracts for review. Among these, 3,646 references met exclusion criteria (Figure), leaving 735 manuscripts selected for full-text review.

Review of the 735 full-text manuscripts identified 22 investigations that reported concurrent data on screening nares and extra-nasal body sites in the same patient population.[16–19,23–40] During the initial review of this manuscript by the journal, it was brought to our attention that there was a recently published very large investigation of non-nares MRSA carriage.[41] Even though it fell outside of the time of our search criteria, we chose to include this study in the analysis because of its size and importance to this analysis. The remaining investigations were excluded for the following reasons: screening did not occur at admission (n=304), lack of explicit data required to calculate additional extra-nasal yield (n=165), MRSA carriage was not assessed at extra-nasal sites (n=155), admission and periodic surveillance swabs could not be separated (n=40), study was conducted in a long term care facility (n=13), screening occurred during an outbreak (n=10), no results related to MRSA (n=10), conducted in pediatric patients (n=9), and healthcare worker screening studies (n=7) (Figure).

The majority of the 23 investigations included in our analysis were conducted in Europe (n=13). Other studies were conducted in North America (n=6), Asia (n=3), and Australia (n=1). All studies were conducted between 1996 and 2007 and included a total of 49,793 screening tests for MRSA. Studies were conducted at university hospitals (n=22),

community hospitals (n=16), military hospitals (n=1) or were not defined (n=5) (some studies included data from more than one hospital).

We identified 4 studies that focused on multi-site screening of patients on ICU admission and 19 reports on multi-site screening at hospital admission. When dividing studies of hospital admission screening into high MRSA prevalence populations and low MRSA prevalence populations, 9 studies were conducted in populations with relatively low prevalence (MRSA at any body site ≤6%) and 10 studies were done in populations with relatively high MRSA prevalence (>6%). Notably, four studies with relatively high MRSA were conducted within a cohort of patients with a history of MRSA. Among all studies, MRSA colonization prevalence ranged from 1.3% to 69.1%, with a weighted average of 5.0% (Table 1).

Additional Detection of MRSA from Extra-Nasal Testing

Testing for MRSA carriage at extra-nasal body sites increased detection of MRSA carriers in all but one study. The number of MRSA carriers detected with extra-nasal testing on hospital admission increased by 50% (range 0–150%) in low prevalence populations and by 37% (range 9–86%) in high prevalence populations. Extra-nasal testing at ICU admission increased detection of MRSA carriers by 33% (range 9–69%). Absolute differences in MRSA detection were larger in higher prevalence investigations (Table 2). Few investigations (n=6) increased detection of MRSA by more than 3 absolute percentage points and only one investigation by greater than 10 absolute percentage points.

Benefit from Individual Body Sites Compared to Nares Alone

Among the 23 manuscripts, we identified 10 manuscripts that provided data on patients colonized at individual extra-nasal body sites with negative nares screening. Multiple investigations reported on patients with positive perirectal testing (n=7 studies) with negative nares screening. Fewer studies examined the additional yield of screening for MRSA in the oropharynx (n=4 studies), axilla (n=3 studies) and wound (n=1 study) compared to nares alone (Table 3). Most studies reported on the additional yield of a single extra-nasal body site (n=6 studies), with fewer manuscripts reporting data from two extra-nasal body sites (n=3).

Testing the oropharynx identified 21% more patients than nares testing alone (range 6–31%) (Table 4). Perirectal testing identified 20% (range 11–22%) more MRSA colonized persons, wound testing identified 17% more MRSA colonized persons and axilla testing identified 7% more MRSA colonized persons. There were insufficient data to build a model to explore the benefit of combining multiple extra-nasal body sites.

Discussion

MRSA screening is becoming commonplace in many parts of the world.[7–9] To our knowledge, our investigation is the first systematic review of the literature to look at the incremental benefit of swabbing extra-nasal body sites over the nares alone. Our data suggest that screening for MRSA at the nares alone will only identify two-thirds to three-quarters of all MRSA carriers. Interestingly, the proportion of MRSA colonization detected by nares screen alone was relatively consistent across various cohorts and geographic distributions.

Of note, extra-nasal testing identified additional MRSA colonized patients in all but one manuscript. The only investigation that did not identify additional MRSA colonized patients with extra-nasal testing was a small investigation (n=96 patients) in a low-prevalence population (2.1% MRSA colonization) of women admitted to a labor and delivery ward.[29] A

larger study of women admitted to labor and delivery (n=499 patients) with a slightly higher prevalence (4.8% MRSA colonization) did identify additional MRSA colonized patients with non-nares testing (Table 2).[26]

Our observation that extra-nasal testing would increase the number of patients identified as MRSA carriers by 33–50% has implications for active MRSA surveillance programs. Active surveillance testing assumes that asymptomatically colonized patients serve as a reservoir of MRSA for patient-to-patient transmission of MRSA within the hospital.[42–45] Extra-nasal body sites may be a source for contamination of healthcare workers hands, medical equipment, or as a reservoir for future infection of the colonized individual. Inadvertent contamination of healthcare workers hands or medical equipment by unidentified MRSA carriers can lead to further transmission of MRSA within a hospital. [46–50] One limitation of this hypothesis is that the transmissibility of MRSA from non-nasal body sites compared to nasal sites is poorly understood. It is possible that nasal sites contribute more heavily to MRSA transmissibility than extra-nasal sites. On the other hand, the converse may also be true. Oropharyngeal or skin contamination maybe more likely to contact healthcare worker hands or clothing and contribute significantly more to transmissibility. Clearly, the transmissibility of each extra-nasal site or of the number of colonized sites is worthy of future investigation. Understanding how colonized body sites predict infection or transmissibility may inform effective targets for MRSA screening.

While our data suggest that nares testing alone will substantially underestimate the total burden of MRSA, the absolute differences in MRSA detection were relatively modest. Few investigations increased detection of MRSA carriers by more than 3 absolute percentage points (n=6) and only one investigation showed a 10% absolute increase in detection. It is notable that studies conducted in populations of high MRSA colonization prevalence were associated with higher absolute differences in MRSA detection. This association suggests that in clinical settings where MRSA prevalence is increasing or high, such as outbreak environments, burn units, or if national trends in many countries continue unabated, extra-nasal testing may be an important component to surveillance testing. However, in most clinical settings where MRSA colonization prevalence ranges from 2–6%, the additional benefit of extra-nasal testing would be relatively small and may not be cost effective.[51]

Screening the oropharynx provided the highest additional yield for MRSA detection over nares screening alone. Importantly, the estimate of yield from oropharynx testing may be partially skewed by a single study conducted in the ICU setting.[40] The other three non-ICU studies all found additional benefit from oropharyngeal screening, but the relative yield was somewhat more modest (6–15%). Our results may reflect the importance of oropharyngeal secretions in ICU settings as a reservoir for MRSA carriage or it may reflect better sampling due to intubation.[17,18] Additional studies are needed to evaluate whether the routine testing of sputum and tracheal aspirates in ICUs provides sufficient capture beyond nares screening and routine clinical testing to provide substantial added yield in this setting.[52]

There are limitations to our investigation. First, as noted above, few investigations tested more than one extra-nasal body site, which will tend to underestimate the yield of extra-nasal testing in the detection of MRSA carriage. Secondly, we found relatively few studies (n=23) that contained data on the number of patients with positive extra-nasal testing and negative routine nares testing. We identified even fewer studies that provided multi-site comparisons to measure the benefit of individual extra-nasal body sites over nares alone (n=10). As a result, we were unable to estimate the benefit of swabbing multiple sites simultaneously. Third, there are data suggesting that not all MRSA strains colonize non-nares sites equally.[53] Therefore, findings from studies where typical strains of MRSA are healthcare-associated (e.g., USA100) may not reflect findings in geographic locales where

community-associated strains (e.g., USA 300) are more prevalent among MRSA strains.[53] Lastly, references chosen for this review encompass variable settings and variable years. One important consideration is that some of the studies included in our review used extra-nasal testing for MRSA among high-risk sub-populations, e.g. those with a history of MRSA, making generalizability of our final estimates difficult.

There are strengths to our study. First, to our knowledge, this is the first attempt to systematically quantify the additional benefit from testing for MRSA at extra-nasal body sites in patients being admitted to the hospital or ICU. Second, many large studies were part of our systematic literature review. In total, we identified 23 references containing data on 49,556 patients screened for MRSA. Lastly, the observation that extra-nasal testing identified more MRSA carriers was consistent across nearly every investigation across a wide array of patient cohorts, hospital types, and geographic locations.

Our results may have implications for policy makers and investigators attempting to develop optimal screening protocols to detect MRSA for routine infection prevention or application of targeted decolonization. Extra-nasal only colonized persons may serve as an important hidden reservoir for MRSA transmission. Before extra-nasal testing for MRSA can be proposed for routine surveillance, the attributable risk of transmission and infection from extra-nasal MRSA colonization should be clearly determined. However, extra-nasal testing could be valuable for control of disease outbreaks or in settings of persistent disease among vulnerable patients, such as hemodialysis units, burn patients, and the immunocompromised.

Acknowledgments

Financial Support:

The current project was supported by the Agency for Healthcare Research and Quality grant number RC4AI092327. JM received support from the NIH/NCRR/NCATS UCLA CTSI Grant Number KL2TR000122. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or Agency for Healthcare Research and Quality.

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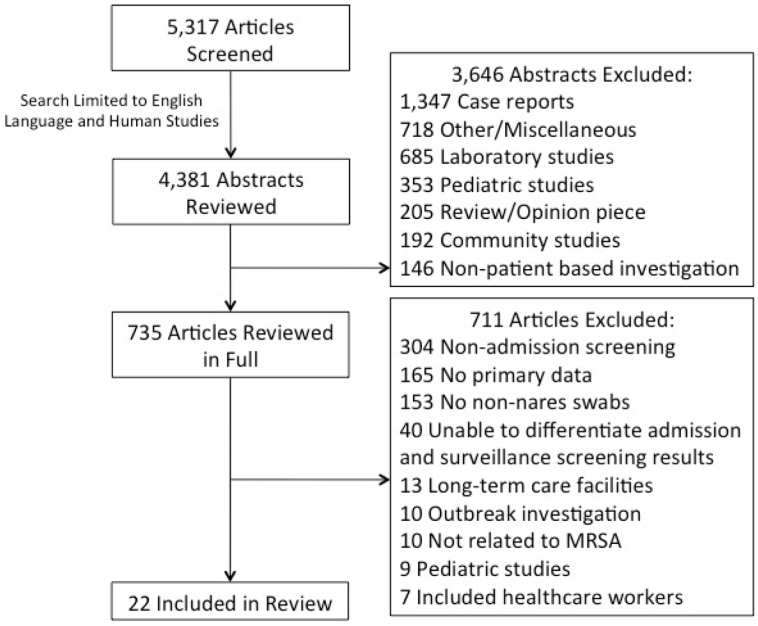

Figure.

Study Selection Process and Reasons for Exclusion of References

Figure Legend: Our systematic review of the literature identified 22 manuscripts that met inclusion criteria for further analysis. During the initial review of the manuscript by the journal, it was brought to our attention that there was a recently published very large investigation of non-nares MRSA carriage. We chose to include this study in the analysis because of its size and importance to the field.

Table 1

Investigations that Screened for MRSA Colonization on Admission to the Hospital or ICU and Reported Results from Nasal and Extra-Nasal Testing

Reference	Cohort	Location	Date of Study	Type of Hospital	Category	MRSA Colonization at Any Body Site	Nasal	Extra- Nasal	Oropharynx	Rectum*	Wound	Axilla	Groin
Papia 1999	Patients with a history of hospital admission in the last three months or transferred from a hospital or nursing home	Toronto, Ontario, Canada	5/1996–4/1997	University Hospital	Low Prevalence	1.3% (23/1,742)	0.9% (15/1,742)	0.8% (14/1,742)	-	0.2% (4/1,742)	-	-	-
Troillet 1998	Patients admitted to medicine, general surgery, vascular surgery, and podiatry	Boston, MA, USA	9/1996–12/1996	University Hospital	Low Prevalence	1.8% (7/387)	1.6% (6/387)	8.5% (6/71)	-	-	8.5% (6/71)	-	-
Beigihya 2007	Patients admitted to labor and delivery with intact amniotic membranes and a gestational age greater than 24 weeks	Cleveland, Ohio, USA	4/2005–3/2006	Public Hospital	Low Prevalence	2.1% (2/96)	2.1% (2/96)	1.0% (1/96)	-	-	-	-	-
Currie 2008	Patients with hospital associated risks for MRSA	Toronto, Ontario, Canada	1/2004–6/2007	Community Teaching	Low Prevalence	2.7% (627/23,365)	1.8% (419/23,365)	1.8% (423/23,365)	-	1.6% (382/23,365)	1.5% (88/5,881)	-	-
Matheson 2012	Patients admitted to inpatient care in 2 acute care hospitals	Kilmarnock and Aberdeen, Scotland	2/2010–8/2010	Community Teaching	Low Prevalence	3.0% (298/10,077)	2.0% (198/10,077)	2.3% (233/10,077)	1.0% (103/10,077)	1.1% (107/10,077)	-	0.2% (23/10,077)	-
Huang 2009	Women admitted to labor and delivery	Taiwain, Taiwan	7/2005–10/2007	University Hospital and Maternity Hospital	Low Prevalence	4.8% (24/499)	4.2% (21/499)	0.8% (4/499)	-	-	-	-	-
Thyagarajan 2009	Consecutive patients admitted to trauma with a hip fracture	Wales, UK	Not stated	University Hospital	Low Prevalence	5.2% (21/403)	2.1% (18/403)	2.0% (8/403)	0.3% (2/440)	1.5% (6/403)	-	-	-
Esposito 2003	Patients admitted to general	Napoli, Italy	3/2001–10/2001	Not stated	Low Prevalence	5.2% (16/315) [1]	4.5% (7/332)	4.9% (16/315) [2]	0.5% (1/327)	5.1% (16/315)	-	-	-

Reference	Cohort	Location	Date of Study	Type of Hospital	Category	MRSA Colonization at Any Body Site	Nasal	Extra- Nasal	Oropharynx	Rectum*	Wound	Axilla	Groin
	surgery, orthopedics and obstetrics and gynecology												
Samad 2002	Patients admitted to general surgery and orthopedics	Wales, UK	11/2000–1/2001	District General Hospital	Low Prevalence	5.3% (23/430)	3.5% (15/430)	1.9% (8/430)	-	-	-	-	-
Furuno 2006	Patients without a history of MRSA or VRE, ICU admission or prison ward admission	Baltimore, Maryland, USA	12/2003–9/2004	University Hospital	High Prevalence	7.6% (53/699)	7.0% (49/697)	1.1% (6/555)	-	1.1% (6/555)	-	-	-
Nishikawa 2009	Patients admitted to a geriatric hospital	Aichi, Japan	11/2003–12/2003	Geriatric Hospital	High Prevalence	8.0% (11/138)	4.3% (6/138)	5.8% (8/138)	-	6.8% (8/138)	-	-	-
Eveillard 2006	Patient with a history of MRSA, chronic skin lesion, hospitalization in last year, hospital transfer, or ICU admissions	Colombes, France	7/2002–6/2003	University Hospital	High Prevalence	8.8% (110/1,250)	7.2% (90/1,250)	5.6% (70/1,250)	-	4.6% (57/1,250)	-	2.5% (31/1,250)	-
Dupeyron 2006	Patients admitted to chronic liver disease unit	Paris, France	3/2000–9/2004	Not stated	High Prevalence	9.2% (206/2,242)[3]	9.2% (206/2,242)	5.8% (82/1,406)	-	5.8% (82/1,406)	-	-	-
Girou 2000	Patients admitted to a dermatology ward who were transferred from another hospital, had a history of hospitalization in last three years, or had chronic skin lesions during period A, followed by universal screening period B.	Creteil, France	9/1996–12/1997	University Hospital	High Prevalence	11.5% (50/436)	8.5% (37/436)	4.6% (20/436)	-	-	-	-	-

Reference	Cohort	Location	Date of Study	Type of Hospital	Category	MRSA Colonization at Any Body Site	Nasal	Extra- Nasal	Oropharynx	Rectum*	Wound	Axilla	Groin
Baker 2010	Patients with no history of MRSA infection in the previous 12 months	Boston, MA, USA	10/2008–2/2009	VA Medical Center	High Prevalence	12.7% (19/150)	10.7% (16/150)	8.0% (12/150)	6.7% (10/149)	2.7% (3/111)	-	0.7% (1/150)	-
Campillo 2001	Patients admitted to chronic liver disease unit	Paris, France	1/1996–1/2000	Not Stated	High Prevalence	16.7% (125/748)	13.4% (100/748)	12.4% (93/748)	-	12.4% (93/748)		-	-
Dupeyron 2001	Patients admitted to chronic liver disease unit	Creteil, France	1/1996–6/98	Not stated	High Prevalence	17.4% (96/551)	13.4% (79/589)	11.5% (48/417)	-	11.5% (48/417)		-	-
van Hal 2002	Patients with a history of MRSA colonization or infection	Darlinghurst, Australia	Not stated	Not stated	High Prevalence	38.0% (78/205)	52.5% (53/101)	24.0% (25/104)	-	-	-	15.4% (8/52)	32.7% (17/52)
Rohr 2004	Patients with a recent diagnosis of MRSA carriage	Bochum, Germany	10/1998–8/2001	University Hospital	High Prevalence	69.1% (56/81)	54.3% (44/81)	65.4% (53/81)	-	-	-	28.4% (23/81)	38.3% (31/81)
Lucet 2003	Patients admitted to medical and surgical ICU	Paris, France	7/1/1997–12/31/1997	2 Tertiary Care and 9 University Hospitals	ICU	6.9% (162/2,347)	5.4% (126/2,347)	3.1% (72/2,347)	-	-	-	-	-
Batra 2008	Patients admitted to medical and surgical ICU	London, UK	11/2004–1/2006	University Hospital	ICU	7.1% (105/1,470)	4.2% (63/1,470)[4]	5.9% (86/1,470)[4]	4.1% (61/1,470)	2.9% (43/1,470)	3.7% (9/243)	-	-
Harbarth 2007	Patients admitted to the surgical ICU	Geneva, Switzerland	3/2005–5/2005	University Hospital	ICU	8.7% (13/150)	8.0% (12/150)[5]	5.3% (8/150)[5]	5.3% (8/150)	-	-	-	-
Ho 2003	Patients admitted to medical and surgical ICU	Hong Kong, China	8/1/1999–11/30/1999	10 Public Hospitals + 1 University Hospital	ICU	12.1% (206/1,697)	8.8% (147/1,671)	9.7% (165/1,697)	8.9% (148/1,697)	3.6% (60/1,663)	-	-	-
-	All Studies Weighted Average	-	-	-	-	4.7%	3.4%	3.0%	2.1%	2.1%	1.7%	0.7%	36.1%
-	Weighted Average of Low Prevalence Studies	-	-	-	-	2.8%	1.9%	1.9%	1.0%	1.4%	1.6%	0.2%	-
-	Weighted Average of High	-	-	-	-	12.4%	10.6%	7.9%	6.7%**	6.4%	-	4.1%	36.1%

Reference	Cohort	Location	Date of Study	Type of Hospital	Category	MRSA Colonization at Any Body Site	Nasal	Extra- Nasal	Oropharynx	Rectum*	Wound	Axilla	Groin
	Prevalence Studies												
-	Weighted Average of ICU Studies	-	-	-	-	8.6%	6.8%	5.9%	6.6%	3.3%	3.7%	-	-

[1] Likely proportion. Overall data not clear, could be 24/315 (7.6%).

[2] Overlap between rectal and pharyngeal culture results not given.

[3] Likely proportion, overall data not clear; could be 336/2242 (15.0%),

[4] Culture swabs for nares, axilla, and perineum were pooled. These data were not included in all analyses.

[5] Results of nares and perineum were combined as “non-nares”. *Includes rectal, perineal, and stool samples.

- No data available.

Infect Control Hosp Epidemiol. Author manuscript; available in PMC 2014 February 01.

Table 2

Relative Benefit of Extra-Nasal Testing over Traditional Nasal Only Testing for MRSA Colonization on Admission to the Hospital or ICU

	MRSA Colonization at Any Site (Range)	Nasal MRSA Colonization (Range)	Proportion of Carriers Detected by Nasal Screen (Range)	Extra-Nasal Colonization (Range)	Absolute Increase in Number of Carriers Identified by Extra-Nasal Testing (Range)	Relative Increase in Number of Carriers Identified by Extra-Nasal Testing (Range)
Hospital Admission						
Low MRSA Prevalence[*]	2.8% (1.3–5.3%)	1.9% (0.9–4.5%)	68% (42–100%)	1.9% (0.8–8.5%)	0.9% (0–3%)	50% (0–150%)
High MRSA Prevalence[**]	26% (7.6–69%)	19% (7.2–54%)	73% (55–92%)	12% (1.1–65%)	7% (1–15%)	37% (9–86%)
ICU Admission	9.1% (6.9–12.1%)	6.8% (5.4–8.8%)	75% (72–78%)	5.9% (3.1–9.7%)	2% (1–3%)	33% (9–69%)
All Studies	4.6% (1–69%)	3.5% (0.9–54.3%)		2.9% (0.8–64%)		

[*] Low MRSA prevalence: Those investigations with MRSA colonization at any site less than 6%.

[**] High MRSA prevalence: Those investigations with MRSA colonization at any site greater than or equal to 6%.

Table 3

Investigations that Screened for MRSA Colonization on Admission to the Hospital or ICU and Reported Results from Individual Extra-Nasal Sites Compared to Nasal Testing

Reference	Cohort	Location	Date of Study	Type of Hospital	Category	MRSA Colonization at Any Site	Nares	Relative Oropharynx	Relative Rectum*	Relative Wound	Relative Axilla
Troillet 1998	Patients admitted to medicine, general surgery, vascular surgery, and podiatry	Boston, MA, USA	9/1996–12/1996	University Hospital	Low Prevalence	7	6	-	-	17% (7/6)	-
Matheson 2012	Patients admitted to inpatient care in 2 acute care hospitals	Kilmarnock and Aberdeen, Scotland	2/2010–8/2010	Community Teaching	Low Prevalence	298	198	15% (238/198)	23% (245/198)	-	4% (205/198)
Thyagarajan 2009	Consecutive patients admitted to trauma with a hip fracture	Wales, UK	Not stated	University Hospital	Low Prevalence	21	18	6% (19/18)	11% (20/18)	-	-
Furuno 2006	Patients without a history of MRSA or VRE, ICU admission or prison ward admission	Baltimore, Maryland, USA	12/2003–9/2004	University Hospital	High Prevalence	53	49	-	8% (53/49)	-	-
Nishikawa 2009	Patients admitted to a geriatric hospital	Aichi, Japan	11/2003–12/2003	Geriatric Hospital	High Prevalence	11	6	-	83% (11/6)	-	-
Eveillard 2006	Patient with a history of MRSA, chronic skin lesion, hospitalization in last year, hospital transfer, or ICU admissions	Colombes, France	7/2002–6/2003	University Hospital	High Prevalence	110	90	-		-	13% (102/90)
Baker 2010	Patients with no history of MRSA infection in the previous 12 months	Boston, MA, USA	10/2008–2/2009	VA Medical Center	High Prevalence	19	16	13% (18/16)		-	6% (17/16)
Campillo 2001	Patients admitted to chronic liver disease unit	Paris, France	1/1996–1/2000	Not Stated	High Prevalence	125	100	-	25% (125/100)	-	-
Dupeyron 2001	Patients admitted to chronic liver disease unit	Creteil, France	1/1996–6/98	Not stated	High Prevalence	96	79	-	22% (96/79)	-	-
Ho 2003	Patients admitted to medical and surgical ICU	Hong Kong, China	8/1/1999–11/30/1999	10 Public Hospitals + 1 University Hospital	ICU	206	147	31% (293/147)	15% (169/147)	-	-

[1] Estimated, could be 24, overall data not clear.

[2] Estimated could be 336, overall data not clear.

[3] Culture swabs for nares, axilla, and perineum were pooled. These data were not included in all analyses.

[4] Results of nares and perineum were combined. These data were not included in all analyses.

* Includes rectal, perineal, and stool samples.

** Only one reference in this category.

- No data available.

Table 4

Relative Benefit of Testing Individual Extra-Nasal Body Sites Over Traditional Nasal Only Testing for MRSA Colonization on Admission to the Hospital or ICU

	Oropharyngeal Yield	Rectum Yield*	Wound Yield	Axilla Yield
Hospital Admission				
Low MRSA Prevalence†	+14%	+23%	+17%**	+4%
High MRSA Prevalence††	+13%**	+22%	-	+12%
ICU Admission	+31%**	+15%**	-	-
All Studies	+21%	+20%	+17%	+7%

*Includes rectal, perineal, and stool samples.

**Represents data from only a single study in this category.

†Low MRSA prevalence: Those investigations with MRSA colonization at any site less than 6%.

††High MRSA prevalence: Those investigations with MRSA colonization at any site greater than or equal to 6%.