



TITLE: Risk Factors and Carriage of Methicillin-Resistant *Staphylococcus aureus*: Clinical Evidence

DATE: 07 May 2012

RESEARCH QUESTIONS

1. What is the evidence regarding the risk factors for patient carriage of Methicillin-Resistant *Staphylococcus aureus* (MRSA)?
2. What is the evidence regarding the risk of infection in patients who are carriers of MRSA?
3. What is the evidence regarding the risk of long-term carriage in patients who are colonized or infected with MRSA?
4. What is the evidence regarding the length of time patients remain carriers of MRSA?

KEY MESSAGE

Fifty-five non-randomized studies were identified regarding the risk factors and carriage of MRSA: thirty-eight studies were identified regarding the risk factors for patient carriage, twelve studies regarding the risk of infection in patients who are carriers, two studies regarding the risk of long-term carriage in patients who are colonized or infected, and three studies were identified regarding the length of time patients remain carriers of MRSA.

METHODS

A limited literature search was conducted on key resources including PubMed, The Cochrane Library (2012, Issue 3), University of York Centre for Reviews and Dissemination (CRD) databases, Canadian and abbreviated lists of major international health technology agencies, as well as a focused Internet search. No filters were applied to limit the retrieval by study type. Where possible, retrieval was limited to the human population. The search was limited to

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English language documents published between Jan 1, 2009 and Apr 23, 2012. Internet links were provided, where available.

RESULTS

Rapid Response reports are organized so that the higher quality evidence is presented first. Therefore, health technology assessment reports, systematic reviews, and meta-analyses are presented first. These are followed by randomized controlled trials and non-randomized studies.

Fifty-five non-randomized studies were identified regarding the risk factors and carriage of MRSA: thirty-eight studies were identified regarding the risk factors for patient carriage, twelve studies regarding the risk of infection in patients who are carriers, two studies regarding the risk of long-term carriage in patients who are colonized or infected, and three studies were identified regarding the length of time patients remain carriers of MRSA. No relevant health technology assessment reports, systematic reviews, meta-analyses, or randomized controlled trials were identified.

Health Technology Assessments

No literature identified.

Systematic Reviews and Meta-analyses

No literature identified.

Randomized Controlled Trials

No literature identified.

Non-Randomized Studies

Risk factors for patient carriage of MRSA

1. Bilavsky E, Lerman Y, Rabinovich A, Salomon J, Lawrence C, Rossini A, et al. Carriage of methicillin-resistant *Staphylococcus aureus* on admission to European rehabilitation centres—a prospective study. *Clin Microbiol Infect*. 2012 Mar 24.
[PubMed: PM22512722](#)

Clin Microbiol Infect 2012 ABSTRACT: This study aimed to determine the prevalence of and risk factors for methicillin-resistant *Staphylococcus aureus* (MRSA) carriage among patients newly admitted to rehabilitation centres. It is a prospective study examining MRSA carriage on admission to seven rehabilitation wards in four countries. Risk factors for MRSA carriage were analysed using univariate and multivariate analyses. **A total of 1204 patients were studied. Among them, 105 (8.7%) had a positive admission MRSA screening result. The MRSA carriers were more likely to be male, to have had a recent stay in another long-term-care facility or >2 weeks acute-care hospital stay, history of colonization with MRSA, reduced level of consciousness, peripheral vascular disease and pressure sores. In multivariable logistic regression male gender (odds ratio (OR) 2.2, 95% confidence interval (CI) 1.4-3.6, p 0.001), history of MRSA positivity (OR 6.8, 95% CI 3.8-12.3, p <0.001), peripheral vascular disease (OR 2.5, 95% CI 1.2-5, p 0.013), recent stay in another long-term-care facility (OR 2.1, 95% CI 1.3-3.5, p 0.004), or long (>2 weeks) acute-care hospital stay (OR**

1.9, 95% CI 1.2-3, p 0.004), remained significant risk factors for MRSA carriage.

MRSA carriage is common on admission to rehabilitation centres but less so, than previously described in long-term-care facilities. Male gender, history of MRSA positivity, previous hospitalization and peripheral vascular disease may predict MRSA carriage, and may serve as indicators for using pre-emptive infection control measures.

2. Costelloe C, Lovering A, Montgomery A, Lewis D, McNulty C, Hay AD. Effect of antibiotic prescribing in primary care on methicillin-resistant *Staphylococcus aureus* carriage in community-resident adults: a controlled observational study. *Int J Antimicrob Agents*. 2012 Feb;39(2):135-41.
[PubMed: PM22079534](#)

The objectives of this study were to investigate the relationship between primary care antibiotics prescribed within 2 months and 12 months and the carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) in nasal flora from a large representative sample of community-resident adults. *S. aureus* isolates were obtained from nasal samples submitted by UK resident adults aged ≥ 16 years registered with 12 general practices in the former Avon and Gloucestershire health authority areas. Individual-level antibiotic exposure data during the 12 months prior to providing the samples were collected from the primary care electronic records. MRSA status was determined by measuring resistance to ceftiofuran. **In total, 6937 adults were invited to take part, of whom 5917 returned a nasal sample. *S. aureus* was identified in 946 samples and a total of 761 participants consented to primary care record review and had complete data for the analyses. There was no evidence of an association between any antibiotic in the previous 2 months and MRSA isolation, with an adjusted odds ratio (aOR) of 1.33 [95% confidence interval (CI) 0.12-15; P=0.8]. There was a suggestion of an association between any antibiotic use in the previous 12 months and MRSA, with an aOR of 2.45 (95% CI 0.95-6.3; P=0.06).** In conclusion, there is a suggestion that antibiotics prescribed within 12 months is associated with the carriage of MRSA, but not within 2 months, although the 2-month analysis had fewer data subjects and was therefore underpowered to detect this association. A larger study would be able to clarify these associations further.

3. Horowitz IN, Baorto E, Cirillo T, Davis J. Methicillin-resistant *Staphylococcus aureus* colonization in a pediatric intensive care unit: risk factors. *Am J Infect Control*. 2012 Mar;40(2):118-22.
[PubMed: PM21803449](#)

BACKGROUND: Both methicillin-resistant *Staphylococcus aureus* (MRSA) and penicillin-resistant *Streptococcus pneumoniae* have become significant causes of disease, both in health care and community settings. **OBJECTIVES:** All patients admitted to our pediatric intensive care unit (PICU) currently had a rapid test for methicillin-resistant *Staphylococcus aureus* (MRSA) performed as per hospital guidelines. **This study looked at risk factors for colonization.** **METHODS:** Nasal swabs were tested for MRSA on all admissions to the PICU from May 2008 to September 2009 using polymerase chain reaction as per hospital guidelines. All patients enrolled were placed in either a MRSA-positive or a MRSA-negative group, which were compared with each other. Risk factors were assessed from a questionnaire and the resident history. **RESULTS:** **The prevalence of MRSA colonization in our study was 4.5%. Six hundred sixty-six**

patients were negative for MRSA, and 31 were positive. Patients in the MRSA colonization group were younger, more likely had family (household members) employed in medicine, and were more likely hospitalized or had undergone surgery within the previous 12 months. Prolonged neonatal intensive care unit stay (>1 week) was associated with MRSA colonization ($P < .001$). CONCLUSION: The percentage of patients positive for MRSA admitted to a PICU is low. Recent exposure to the health care system, especially a stay in the neonatal intensive care unit, is associated with an increased risk of colonization.

4. Kutlu SS, Cevahir N, Akalin S, Akin F, Dirgen CS, Bastemir M, et al. Prevalence and risk factors for methicillin-resistant *Staphylococcus aureus* colonization in a diabetic outpatient population: A prospective cohort study. *Am J Infect Control*. 2012 May;40(4):365-8. [PubMed: PM21864943](#)

BACKGROUND: Diabetes mellitus is a risk factor for methicillin-resistant *Staphylococcus aureus* (MRSA) colonization and infection. We attempted to determine the prevalence and risk factors for MRSA colonization in a population of outpatients with diabetes. **METHODS:** This prospective cohort study enrolled patients with diabetes. Anterior nares cultures were obtained from patients with diabetes admitted to outpatient endocrinology and metabolism clinics, and risk factors for MRSA colonization were analyzed. **RESULTS:** Out of the 304 patients evaluated, 127 (41.9%) were colonized with *S aureus* and 30 (9.9%) were colonized with MRSA. Overall, 23.6% of all *S aureus* isolates were MRSA. In multivariate analysis, factors independently associated with an increased risk of MRSA colonization included the presence of connective tissue disease (odds ratio, 7.075; 95% confidence interval, 2.157-23.209; $P = .001$) and insulin therapy (odds ratio, 3.910; 95% confidence interval, 1.652-9.251; $P = .002$). **CONCLUSIONS:** The prevalence of MRSA colonization in our sample of diabetic outpatients was 9.9%. Independent risk factors for MRSA colonization were the presence of connective tissue disease and insulin use. A better understanding of the epidemiology and risk factors for nasal MRSA colonization in the persons with diabetes may have significant implications for the treatment and prevention of MRSA infections.

5. Leung W, Malhi G, Willey BM, McGeer AJ, Borgundvaag B, Thanabalan R, et al. Prevalence and predictors of MRSA, ESBL, and VRE colonization in the ambulatory IBD population. *J Crohns Colitis*. 2012 Jan 9. Epub ahead of print. [PubMed: PM22398097](#)

BACKGROUND AND AIMS: Inflammatory bowel disease (IBD) patients may be at increased risk of acquiring antibiotic-resistant organisms (ARO). We sought to determine the prevalence of colonization of methicillin-resistant *Staphylococcus aureus* (MRSA), Enterobacteriaceae containing extended spectrum beta-lactamases (ESBL), and vancomycin-resistant enterococci (VRE) among ambulatory IBD patients. **METHODS:** We recruited consecutive IBD patients from clinics (n=306) and 3 groups of non-IBD controls from our colon cancer screening program (n=67), the family medicine clinic (n=190); and the emergency department (n=428) from the same medical center in Toronto. We obtained nasal and rectal swabs for MRSA, ESBL, and VRE and ascertained risk factors for colonization. **RESULTS:** Compared to non-IBD controls, IBD patients had similar prevalence of colonization with MRSA (1.5% vs. 1.6%), VRE (0% vs. 0%), and ESBL (9.0 vs. 11.1%). Antibiotic use in the prior 3 months was a risk

factor for MRSA (OR, 3.07; 95% CI: 1.10-8.54), particularly metronidazole. Moreover, gastric acid suppression was associated with increased risk of MRSA colonization (adjusted OR, 7.12; 95% CI: 1.07-47.4). Predictive risk factors for ESBL included hospitalization in the past 12 months (OR, 2.04, 95% CI: 1.05-3.95); treatment with antibiotics in the past 3 months (OR, 2.66; 95% CI: 1.37-5.18), particularly prior treatment with vancomycin or cephalosporins. CONCLUSIONS: Ambulatory IBD patients have similar prevalence of MRSA, ESBL and VRE compared to non-IBD controls. This finding suggests that the increased MRSA and VRE prevalence observed in hospitalized IBD patients is acquired in-hospital rather than in the outpatient setting.

6. Popovich KJ, Smith KY, Khawcharoenporn T, Thurlow CJ, Lough J, Thomas G, et al. Community-Associated Methicillin-Resistant Staphylococcus aureus Colonization in High-Risk Groups of HIV-Infected Patients. Clin Infect Dis. 2012 May;54(9):1296-303. [PubMed: PM22354926](#)

Background. We examined the epidemiology of community-associated methicillin-resistant Staphylococcus aureus (CA-MRSA) nasal colonization among 3 groups of human immunodeficiency virus (HIV)-infected and 1 group of HIV-negative outpatients. Methods. We determined prevalence and risk factors associated with MRSA colonization among women, recently incarcerated, and Hispanic HIV-infected patients and HIV-negative patients; isolates were typed by pulsed-field gel electrophoresis. Relative prevalence was calculated using Poisson regression, and logistic regression was used for multivariate analysis. Results. **Of 601 patients, 9.3% were colonized with MRSA; 11% of HIV-infected and 4.2% of HIV-negative patients were colonized (relative prevalence, 2.6; 95% confidence interval [CI], 1.12-6.07; P = .03). Among HIV-infected patients, recently incarcerated patients had the highest colonization prevalence (15.6%) followed by women (12%); Hispanic patients had the lowest (2.8%). Eighty percent of confirmed MRSA isolates were identified as USA300. On multivariate analysis, history of incarceration or residence in alternative housing (odds ratio [OR], 2.3; 95% CI, 1.1-4.7; P = .03) was associated with MRSA colonization; Hispanic ethnicity was negatively associated (OR, 0.3; 95% CI, .11-.98; P = .045). There was a trend (OR, 1.6; 95% CI, .9-3.0; P = .097) toward geographic location of residence being associated with colonization. After controlling for incarceration, residence, and geography, HIV status was no longer significantly associated with colonization.** Conclusions. The CA-MRSA and HIV epidemics have intersected. Examination of networks of individuals released from incarceration, both HIV positive and negative, is needed to assess the role of social networks in spread of CA-MRSA and inform prevention strategies.

7. Vandendriessche S, Hallin M, Catry B, Jans B, Deplano A, Nonhoff C, et al. Previous healthcare exposure is the main antecedent for methicillin-resistant Staphylococcus aureus carriage on hospital admission in Belgium. Eur J Clin Microbiol Infect Dis. 2012 Mar 1. Epub ahead of print. [PubMed: PM22382816](#)

This study aimed to estimate the prevalence of methicillin-resistant Staphylococcus aureus (MRSA) carriage upon hospital admission and to study the molecular epidemiology of MRSA in order to assess the proportion of Pantone-Valentine leukocidin (PVL)-positive community-associated (CA) and livestock-associated (LA)

MRSA strains. Epidemiological data on MRSA carriage upon hospital admission (2006-2009) were collected in a compulsory, continuous, national MRSA surveillance in Belgian acute-care hospitals. Additionally, 328 MRSA strains in 2005 and 314 strains in 2008 were collected in a separate, multicenter microbiological survey. Spa-typing, SCCmec-typing and MLST were performed; toxin genes were detected by PCR. **The overall prevalence of MRSA carriage upon hospital admission was 8.9 cases/1,000 admissions between 2006 and 2009. Of MRSA carriers, 37.5% had a known MRSA history, 39.4% had stayed in a care facility, 12.2% reported no contact with healthcare.** Over 90% of MRSA belonged to five healthcare-associated clones. Of these, MRSA spa-CC038-ST45-IV was in decline, mainly in favor of spa-CC008-ST8-IV. MRSA spa-CC002-ST5-IV, spa-CC002-ST5-II and spa-CC032-ST22-IV remained relatively stable. The proportion of PVL-positive CA-MRSA and LA-MRSA ST398 was below 2% of all MRSA. **The extra-hospital MRSA reservoir in Belgium mainly consists of persons with previous healthcare exposure.** PVL-positive CA-MRSA and LA-MRSA strains remained infrequent among hospitalized patients.

8. Wang CY, Wu VC, Wang WJ, Lin YF, Lin YH, Chen YM, et al. Risk factors for nasal carriage of methicillin-resistant *Staphylococcus aureus* among patients with end-stage renal disease in Taiwan. *J Formos Med Assoc.* 2012 Jan;111(1):14-8.
[PubMed: PM22333007](#)

BACKGROUND/PURPOSE: Patients with end-stage renal disease (ESRD) are at particular risk for methicillin-resistant *Staphylococcus aureus* (MRSA) infections, especially via nasal colonization of MRSA. Surveillance cultures are recommended to identify patients colonized by MRSA. **METHODS:** Clinical data and screening cultures of *S. aureus* from the anterior nares of 541 patients on long-term dialysis in the hospitals were performed in March 2007. The follow-up survey was conducted 1 year later. **RESULTS: A total of 32 (5.9%) of the 541 patients were positive nasal cultures for MRSA, while 89 (16.5%) were positive for methicillin-susceptible *S. aureus* (MSSA). In a multivariate analysis, risk factors for ESRD patients with MRSA colonization included congestive heart failure, nursing home admission, and nasogastric tube feeding in the last 3 months.** Follow-up of the 32 MRSA colonized patients showed that one (3.1%) died due to MSSA and three (9.3%) died due from MRSA infection. **CONCLUSIONS:** We found that patients with ESRD and MRSA nasal colonization were associated with a history of congestive heart failure, nursing home admission, and nasogastric tube feeding in the last 3 months.

9. Balma-Mena A, Lara-Corrales I, Zeller J, Richardson S, McGavin MJ, Weinstein M, et al. Colonization with community-acquired methicillin-resistant *Staphylococcus aureus* in children with atopic dermatitis: a cross-sectional study. *Int J Dermatol.* 2011 Jun;50(6):682-8.
[PubMed: PM21595661](#)

BACKGROUND: Bacterial infection with *Staphylococcus aureus* is a common complication of atopic dermatitis (AD). The incidence of community-acquired methicillin-resistant *S. aureus* infection (MRSA) in the AD population is unknown. **OBJECTIVES: This study aimed to assess the prevalence of *S. aureus* and MRSA in pediatric patients with AD, to compare disease severity, and to characterize the clonal diversity of the isolates.** **METHODS:** We carried out a prospective, cross-sectional study

of 200 patients with AD. The severity of AD was defined as mild, moderate, or severe depending on a composite AD severity score. A swab was taken from the nares of each patient and another from affected skin or folds. Genotyping of all *S. aureus* isolates was conducted by polymerase chain reaction (PCR) amplification of the *S. aureus* protein A (*spa*) gene. RESULTS: According to the severity score, 66.5% of subjects were ranked as having mild AD, 29.5% as having moderate and 4% as having severe AD.

Staphylococcus aureus colonization was seen in 61.5% of all patients, represented by 43.7% of skin swabs and 48% of nares swabs. Only one of the isolations represented MRSA. Older age and higher AD severity scores were associated with *S. aureus* colonization ($P = 0.03$ and $P < 0.001$, respectively). No significant associations were noted for attendance at day care, family members with frequent skin infections, or family members working in healthcare. Isolates from *spa* CC015 were cultured in 19.2% of patient samples. The single MRSA culture showed a new *spa* type that belonged to CC127. CONCLUSIONS: The results of this study confirm a high rate of *S. aureus* colonization of pediatric patients with AD. The low rate of MRSA requires further proof from larger prospective studies.

10. Celik G, Gulcan A, Dikici N, Gulcan E. Prevalence of nasal *Staphylococcus aureus* carriage in the patients undergoing hemodialysis and evaluation of risk factors and laboratory parameters. *Ren Fail.* 2011;33(5):494-8.

[PubMed: PM21545312](#)

BACKGROUND: **In this study, we aimed to determine the nasal carriage rate of *Staphylococcus aureus* and risk factors in hemodialysis (HD) patients.** METHODS: One hundred eighty-four HD patients were evaluated. A second sample was taken from the subjects, the wipe samples of whom were isolated as *S. aureus*. And subjects whose second samples' results were the same were deemed as *S. aureus* carriers. RESULTS: Fifty-two (28.3%) patients were identified as *S. aureus* carriers. In the control group, *S. aureus* carriage has been found out as 14.9% in 116 healthy subjects. The isolation rate of *S. aureus* has been found statistically significantly high in the age group of 41-61 years. **But, methicillin-resistant *S. aureus* (MRSA) isolation ratio has been statistically high in the group over the age of 61 years. Sepsis history and gastrointestinal system disease development is closely related to bacterial isolation. MRSA isolation ratios have been found high in chronic lung disease patients, diabetic patients, patients with infection history, and patients with impaired general state of health. The carriage ratios have been found higher in the patients who are settled in urban areas, are subjected to dialysis for more than 10 years, and are hospitalized in the past year. However, the difference between the other groups is not statistically significant.** CONCLUSIONS: *S. aureus* carriage must be screened on regular intervals in HD patients. Nasal *S. aureus* carriage follow-up and treatment is a process that will protect patients from more severe clinical pictures.

11. Chen CJ, Hsu KH, Lin TY, Hwang KP, Chen PY, Huang YC. Factors associated with nasal colonization of methicillin-resistant *Staphylococcus aureus* among healthy children in Taiwan. *J Clin Microbiol* [Internet]. 2011 Jan [cited 2012 Apr 23];49(1):131-7. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3020448>

[PubMed: PM21084507](#)

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been identified as a major

cause of community-associated (CA) *S. aureus* infections in the past decade. The main reservoir in the community for MRSA and the factors contributing to its worldwide spread remain poorly defined. Between July 2005 and June 2008, a total of 6,057 healthy children 2 to 60 months of age were screened for carriage of *S. aureus* and *Streptococcus pneumoniae* in Taiwan. The prevalence and epidemiological factors influencing MRSA carriage were determined. MRSA strains were tested for antimicrobial susceptibility and underwent molecular characterization. **The overall prevalences of MRSA and *S. aureus* carriage were 7.8% and 23.2%, respectively.** A majority (88%) of MRSA isolates belonged to a common Asian-Pacific CA-MRSA lineage, multilocus sequence type 59, and were resistant to multiple non-beta-lactam antibiotics. **The carriage rate of MRSA was higher among subjects 2 to 6 months old ($P < 0.0001$), residing in northern Taiwan ($P = 0.0003$), and enrolled later in the study ($P < 0.0001$). MRSA colonization was associated with the number of children in the family (adjusted odds ratio [aOR], 1.114; 95% confidence interval [CI], 1.002 to 1.240; $P = 0.0463$) and day care attendance (aOR, 1.530; 95% CI, 1.201 to 1.949; $P = 0.0006$). Breast feeding ($P < 0.0001$) and colonization with *S. pneumoniae* ($P = 0.0170$) were protective against MRSA colonization.** We concluded that epidemic CA-MRSA strains increasingly colonized Taiwanese children between 2005 and 2008. The carriage rate varied significantly across different demographical features. Crowding was an independent environmental risk factor that might accelerate CA-MRSA transmission in the community.

12. Crum-Cianflone NF, Shadyab AH, Weintrob A, Hospenthal DR, Lalani T, Collins G, et al. Association of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization with high-risk sexual behaviors in persons infected with human immunodeficiency virus (HIV). *Medicine (Baltimore)*. 2011 Nov;90(6):379-89.
[PubMed: PM22033452](#)

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections are an important cause of morbidity, especially among human immunodeficiency virus (HIV)-infected persons. Since an increasing number of MRSA skin and soft tissue infections involve the perigenital areas, some have suggested that these infections may be sexually transmitted. **We performed a cross-sectional study among HIV-infected adults from 4 geographically diverse United States military HIV clinics to determine the prevalence of and the factors (including sexual practices) associated with MRSA colonization.** Swabs were collected from the nares, throat, axillae, groin area, and perirectal area for *S. aureus* colonization. Data on sociodemographic characteristics, medical conditions, and sexual history were collected. Multivariate logistic regression models evaluated factors associated with carriage. We studied 550 HIV-infected adults with a median age of 42 years; 93% were male; and race/ethnicity was white for 46%, African American for 35%, and other for 19%. Median CD4 count was 529 cells/mm, 11% had a history of a MRSA infection, and 21% had a sexually transmitted infection within the last year, including 8% with syphilis. **One hundred eighty (33%) were colonized with *S. aureus* and 22 (4%) with MRSA.** The most common location for carriage was the nares, followed by the perigenital area (groin or perirectal area). **Factors associated with MRSA carriage in the multivariate analyses included a sexually transmitted infection in the last year (odds ratio [OR], 4.2; $p < 0.01$), history of MRSA infection (OR, 9.4; $p < 0.01$), and African American compared with white race/ethnicity (OR, 3.5; $p = 0.01$).** In separate multivariate models, syphilis, nongonococcal urethritis, and public bath use were also associated with MRSA carriage (all $p < 0.01$). In conclusion, a history of recent

sexually transmitted infections, including syphilis and urethritis, was associated with MRSA carriage. These data suggest that high-risk sexual activities may play a role in MRSA transmission.

13. Lu SY, Chang FY, Cheng CC, Lee KD, Huang YC. Methicillin-resistant *Staphylococcus aureus* nasal colonization among adult patients visiting emergency department in a medical center in Taiwan. PLoS ONE [Internet]. 2011 [cited 2012 Apr 23];6(6):e18620. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3113794>
[PubMed: PM21695178](#)

BACKGROUND: Within the past 10 years, methicillin-resistant *Staphylococcus aureus* (MRSA) has not only been a hospital pathogen but also a community pathogen. **To understand the carriage rate of methicillin-resistant *Staphylococcus aureus* (MRSA) among the adult patients visiting emergency department (ED), we conducted this study.** **METHODOLOGY/PRINCIPAL FINDINGS:** From May 21 to August 12, 2009, a total of 502 adult patients visiting emergency department (ED) of a tertiary care hospital in northern Taiwan were recruited in this study and surveyed for nasal carriage of MRSA. A questionnaire regarding the risk factors for MRSA acquisition was also obtained. **The overall prevalence of MRSA nasal carriage among the patients was 3.8%. The carriage rate was significantly higher in patients with risk factors for MRSA acquisition (5.94%) than those without risk factors (2.12%). Patients with urinary complaints, diabetes mellitus, chronic kidney disease and current percutaneous tube usage were significantly associated with MRSA colonization. By multiple logistic regression analysis, only current usage of catheters or tubes was the independent predictor for MRSA nasal colonization.** Of the 19 MRSA, most isolates belonged to one of two lineages, characterized as sequence type (ST) 239 (32%) and ST 59 (58%). The latter lineage, accounting for 83% of 6 isolates from patients without risk factors, is a community-associated (CA) clone in Taiwan, while the former lineage is among healthcare-associated clones. **CONCLUSION/SIGNIFICANCE:** A substantial proportion of patients visiting ED, particularly with current usage of percutaneous catheter or tubes, in northern Taiwan carried MRSA, mostly community strains, in nares.

14. Miller MB, Weber DJ, Goodrich JS, Popowitch EB, Poe MD, Nyugen V, et al. Prevalence and risk factor analysis for methicillin-resistant *Staphylococcus aureus* nasal colonization in children attending child care centers. J Clin Microbiol [Internet]. 2011 Mar [cited 2012 Apr 23];49(3):1041-7. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3067749>
[PubMed: PM21191058](#)

Children attending child care centers (CCCs) are at increased risk for infections, including those caused by methicillin-resistant *Staphylococcus aureus* (MRSA). Nasal colonization often precedes infection, and MRSA colonization has been associated with increased infection risk. Community-associated MRSA (CA-MRSA) has caused increased MRSA infections in the general population, including children. Little is known about the frequency of MRSA nasal colonization in young children, particularly in those attending CCCs where disease transmission is common. We sampled the nares of 1,163 children in 200 classrooms from 24 CCCs in North Carolina and Virginia to assess *S. aureus* colonization. MRSA strains were molecularly analyzed for staphylococcal cassette chromosome mec (SCCmec) type, Panton-Valentine leukocidin status, and

multilocus sequence type. **A case-control study was performed to identify risk factors for MRSA colonization. We found that 18.1% children were colonized with S. aureus and 1.3% with MRSA.** Molecular analysis of the MRSA strains identified 47% as CA-MRSA and 53% as health care-associated MRSA (HA-MRSA). Although two centers had multiple children colonized with MRSA, genotyping indicated that no transmission had occurred within classrooms. **The case-control study did not detect statistically significant risk factors for MRSA colonization. However, MRSA-colonized children were more likely to be nonwhite and to have increased exposure to antibiotics and skin infections in the home.** Both CA-MRSA and HA-MRSA strains were found colonizing the nares of children attending CCCs. The low frequency of colonization observed highlights the need for a large multicenter study to determine risk factors for MRSA colonization and subsequent infection in this highly susceptible population.

15. Schechter-Perkins EM, Mitchell PM, Murray KA, Rubin-Smith JE, Weir S, Gupta K. Prevalence and predictors of nasal and extranasal staphylococcal colonization in patients presenting to the emergency department. *Ann Emerg Med.* 2011 May;57(5):492-9. [PubMed: PM21239081](#)

STUDY OBJECTIVE: Methicillin-resistant *Staphylococcus aureus* (MRSA) is one of the most common causes of skin and soft tissue infections in patients presenting to the emergency department (ED). The prevalence of asymptomatic MRSA colonization in ED patients is less well described, particularly in the absence of a skin and soft tissue infection-related complaint. **The goals of this study are to assess the prevalence of nasal and extranasal staphylococcal colonization in ED patients, evaluate risk factors, and molecularly characterize the strains.** METHODS: We performed active surveillance for methicillin-susceptible *S. aureus* (MSSA) and MRSA colonization in 400 subjects presenting to an urban ED. Risk factor assessment was performed and culture testing was conducted on anterior nares, oropharynx, palms, groin, perirectal area, wounds, and catheter insertion sites. Multiplex polymerase chain reaction was used to identify the USA300/400 clonal types. RESULTS: The prevalence of colonization with MSSA was 39% (95% confidence interval 34.2% to 44.0%), and **prevalence of colonization with MRSA was 5% (95% confidence interval 3.1% to 7.6%).** Among MRSA-colonized subjects, an extranasal site tested positive in 80% of subjects, and 45% had exclusive extranasal colonization. USA300 was identified in 55% of MRSA-colonized subjects. **The main risk factors for MRSA colonization included HIV infection, diabetes, and participation in contact sports.** CONCLUSION: The overall prevalence of MRSA colonization in this ED population was lower than that reported in other high-risk ambulatory care settings. However, extranasal colonization was present in more than half of MRSA-colonized subjects, and USA300 was the predominant clonal type.

16. Verwer PE, Robinson JO, Coombs GW, Wijesuriya T, Murray RJ, Verbrugh HA, et al. Prevalence of nasal methicillin-resistant *Staphylococcus aureus* colonization in healthcare workers in a Western Australian acute care hospital. *Eur J Clin Microbiol Infect Dis.* 2011 Sep 10. Epub ahead of print. [PubMed: PM21909648](#)

Due to a longstanding comprehensive "search and destroy policy", methicillin-resistant *Staphylococcus aureus* (MRSA) is not endemic in Western Australian (WA) acute care hospitals. As the prevalence of MRSA in the community has increased, healthcare

workers (HCW) are at risk of importing MRSA into hospitals. **We aimed to determine the prevalence of and risk factors for nasal MRSA colonization in our HCW population.** A period prevalence study was conducted at an 850-bed tertiary hospital. Basic demographics and a nasal swab were obtained. **A total of 1,542 HCWs employed in our centre were screened for MRSA, of whom 3.4% (n = 52) were colonized. MRSA colonization was more common in patient care assistants (6.8%) and nurses (5.2%) than in allied health professionals (1.7%) and doctors (0.7%) (p < 0.01). Working in "high-risk" wards that cared for MRSA colonized/infected patients was the strongest risk factor for HCW MRSA colonization (p < 0.001).** ST1-IV and ST78-IV (the most common community clones in the region) were the most frequently identified clones. In conclusion, MRSA colonization of HCWs occurs primarily in HCWs caring for patients colonized or infected with MRSA. Surveillance screening of HCWs should be regularly performed on wards with patients with high MRSA colonization prevalence to prevent further spread in the hospital.

17. Bearman GM, Rosato AE, Assanasen S, Kleiner EA, Elam K, Haner C, et al. Nasal carriage of inducible dormant and community-associated methicillin-resistant *Staphylococcus aureus* in an ambulatory population of predominantly university students. *Int J Infect Dis.* 2010 Sep;14 Suppl 3:e18-e24.
[PubMed: PM20116313](#)

BACKGROUND: We studied risk factors for nasal colonization with inducible dormant methicillin-resistant *Staphylococcus aureus* (ID-MRSA) and community-associated MRSA (CA-MRSA) in a cohort of predominantly university students. **METHODS:** Nasal surveillance cultures were performed in student health and ambulatory clinics. Molecular features were identified and risk factors for CA-MRSA and ID-MRSA colonization were determined by logistic regression. **RESULTS:** Of the 1000 participants, 89% (n = 890) were university students. Sixty-four percent were female, 59% Caucasian. The mean age was 23.5 years; 1.6% (n = 16) were CA-MRSA and 1.4% (n = 14) were ID-MRSA colonized. Fifteen (94%) of the CA-MRSA strains were PFGE type IV. *pvl* (Panton-Valentine leukocidin gene) positivity was 75% in CA-MRSA and 57% in ID-MRSA. ID-MRSA isolates were pulsed-field gel electrophoresis (PFGE) type I, 7%; type II, 14%; type V, 7%; and type IV, 71%. CA-MRSA SCCmec classification was 94% type IV and 6% type V. **Risk factors for carriage of CA-MRSA were older age (OR 1.046, p=0.040) and dog ownership (OR 1.450, p=0.019). Single family home (OR 0.040, p=0.007) was a protective factor. There were no significant variables of association found for ID-MRSA colonization.** **CONCLUSIONS:** ID-MRSA/CA-MRSA colonization was low. Most isolates were PFGE types IV and II, *pvl*-positive and susceptible to several antibiotics. Older age and dog ownership were risk factors for CA-MRSA. Future studies are needed to assess the impact of ID-MRSA carriage.

18. Chen CB, Chang HC, Huang YC. Nasal methicillin-resistant *Staphylococcus aureus* carriage among intensive care unit hospitalised adult patients in a Taiwanese medical centre: one time-point prevalence, molecular characteristics and risk factors for carriage. *J Hosp Infect.* 2010 Mar;74(3):238-44.
[PubMed: PM20153554](#)

From 25 June to 11 July 2008, a total of 177 adult patients hospitalised in an intensive care unit (ICU) (94 in medical ICUs and 83 in surgical ICUs) at a tertiary care hospital

were screened for nasal carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) by polymerase chain reaction. **The overall prevalence of *S. aureus* and MRSA nasal carriage among the patients was 42% and 32%, respectively. MRSA carriage rate of the patients hospitalised in medical ICUs was significantly higher than that of those hospitalised in surgical ICUs (47% vs 16%, $P < 0.001$). Multivariate logistic regression analysis revealed that pneumonia, chronic obstructive pulmonary disease, current MRSA infection, and medical ICU admission were independent predictors for nasal carriage of MRSA.** Of the 38 MRSA isolates available for molecular analysis, a total of six pulsed-field gel electrophoresis (PFGE) patterns with two major patterns (F, 42%; A, 37%) were identified. Most MRSA isolates belonged to one of two major clones characterised as sequence type 5/PFGE F/*staphylococcal cassette chromosome mec* (SCCmec) II/*Panton-Valentine leucocidin* (PVL) genes negative (34%) and ST239/PFGE A/SCCmec III/PVL negative (26%), both clones being associated with healthcare-associated (HA) clones in Taiwan. Six isolates (16%) were characterised as ST59/SCCmec IV or V(T) and were associated with community strains in Taiwan. In conclusion, 32% of ICU hospitalised adult patients in a Taiwanese tertiary care teaching hospital between June and July 2008 were colonised with MRSA in their nares. Though most isolates were HA-MRSA, community strains accounted for a proportion of the isolates.

19. Jariyasethpong T, Tribuddharat C, Dejsirilert S, Kerdsin A, Tishyadhigama P, Rahule S, et al. MRSA carriage in a tertiary governmental hospital in Thailand: emphasis on prevalence and molecular epidemiology. *Eur J Clin Microbiol Infect Dis*. 2010 Aug;29(8):977-85. [PubMed: PM20509037](#)

We investigated prevalence and risk factors for methicillin-resistant *Staphylococcus aureus* (MRSA) in a case-control study performed in a 900-bed tertiary governmental healthcare facility in Bangkok, Thailand. Multivariate unconditional logistic regression was used to identify risk profiles for MRSA carriage. Phage typing, pulsed-field gel electrophoresis (PFGE), polymorphisms of the *coa* and *spa* genes, hypervariable region (HVR) of SCCmec, multi-locus sequence typing (MLST), and identification of ST30/ST8 mosaic chromosome by heteroduplex-polymerase chain reaction (heteroduplex-PCR) were used to demonstrate a clonal relationship. **Fifty-seven of 619 in-patients (9.2%) were positive for MRSA. Risk factors were being male, long admission, low modified McCabe score, history of MRSA infection, and use of broad spectrum cephalosporin.** Molecular typing results indicated close relatedness among MRSA isolates. Successful epidemic subtypes were recovered from many different wards. However, all subtypes with different multi-locus sequence types were single locus variants (SLVs) of ST239. Heteroduplex-PCR gave two positive bands from ST8/ST30 mosaic chromosomal structures in all SLVs indicating all isolates were of the ST239 origin. The burden of MRSA nosocomial infections is high in the governmental tertiary hospital. The sole ST239 and its SLVs identified in this hospital is striking and calls for better policy for infection control and prevention.

20. Matheson EM, Mainous AG, III, Hueston WJ, Diaz VA, Everett CJ. Vitamin D and methicillin-resistant *Staphylococcus aureus* nasal carriage. *Scand J Infect Dis*. 2010 Jul;42(6-7):455-60. [PubMed: PM20210515](#)

Studies have found that vitamin D plays an important role in mediating immune function

via a number of pathways, including enhancing the release of antimicrobial peptides in the skin. **Given these findings, we hypothesize that low serum vitamin D levels may increase the risk of nasal carriage of methicillin-resistant Staphylococcus aureus (MRSA).** A secondary data analysis of the National Health and Nutrition Examination Survey 2001-2004 was performed to investigate the association between serum vitamin D levels and MRSA nasal carriage for the non-institutionalized population of the USA. An estimated 2.7 million persons (1.2% of the population) are MRSA nasal carriers. An estimated 63.3 million persons (28.4% of the population) are vitamin D deficient (serum vitamin D <20 ng/ml). **In an adjusted logistic regression analysis controlling for age, race, gender, poverty income ratio, current health status, hospitalization in the past 12 months, and antibiotic use in the past month, individuals with vitamin D deficiency had a statistically significant increased risk of MRSA carriage of 2.04 (95% CI 1.09-3.84). Vitamin D deficiency is associated with an increased risk of MRSA nasal carriage.** Further trials may be warranted to determine whether vitamin D supplementation decreases the risk of MRSA colonization.

21. McCarthy NL, Sullivan PS, Gaynes R, Rimland D. Risk factors associated with methicillin resistance among Staphylococcus aureus infections in veterans. *Infect Control Hosp Epidemiol.* 2010 Jan;31(1):36-41.
[PubMed: PM19929688](#)

BACKGROUND: Methicillin-resistant Staphylococcus aureus (MRSA) is an emerging concern in infectious disease practice. Although MRSA infections occur in a wide variety of anatomic sites, the majority of studies considering the risk factors for methicillin resistance among S. aureus infections have focused on MRSA bacteremia. **OBJECTIVE:** **To describe risk factors associated with methicillin resistance among S. aureus infections at different anatomic sites.** **METHODS:** We collected information on the demographic and clinical characteristics of patients examined at the Atlanta Veterans Affairs Medical Center with S. aureus infections during the period from June 2007 through May 2008. We used multivariate logistic regression to describe factors significantly associated with methicillin resistance. **RESULTS:** There were 568 cases of S. aureus infection among 528 patients. **We identified 352 cases (62%) of MRSA infection and 216 cases (38%) of methicillin-sensitive S. aureus infection. The adjusted odds of methicillin resistance were higher among infections that occurred among patients who had a prior history of MRSA infection (odds ratio [OR], 3.9 [95% confidence interval {CI}, 2.3-6.4]) or resided in a long-term care facility during the past 12 months (OR, 2.0 [95% CI, 1.0-4.0]) but were lower for infections that occurred among patients who had undergone a biopsy procedure during the past 12 months (OR, 0.7 [95% CI, 0.6-0.9]).** Most cases of infection were community-onset infections (523 [92%] of 568 cases), and about one-half (278 [49%]) were not healthcare associated. **CONCLUSIONS:** Compared with previous studies of methicillin resistance among patients with S. aureus bacteremia, we found similar factors to be associated with methicillin resistance among S. aureus isolates recovered from more diverse anatomic sites of infection. Of note, nearly one-half of our cases of MRSA infection were not healthcare associated.

22. Peters PJ, Brooks JT, Limbago B, Lowery HK, McAllister SK, Mindley R, et al. Methicillin-resistant Staphylococcus aureus colonization in HIV-infected outpatients is common and detection is enhanced by groin culture. *Epidemiol Infect.* 2010 Sep 15;1-11.

[PubMed: PM20843384](#)

SUMMARY Although high rates of clinical infection with methicillin-resistant *Staphylococcus aureus* (MRSA) have been reported in HIV-infected adults, data on MRSA colonization are limited. We enrolled HIV-infected adults receiving care at the Atlanta VA Medical Center. Swabs from each participant's nares and groin were cultured with broth enrichment for *S. aureus*. Of 600 HIV-infected adults, 79 (13%) were colonized with MRSA and 180 (30%) with methicillin-susceptible *S. aureus*. MRSA pulsed-field gel electrophoresis types USA300 (n=44, 54%) and USA500/Iberian (n=29, 35%) predominated. Inclusion of groin swabs increased MRSA detection by 24% and USA300 detection by 38%. In multivariate analysis, MRSA colonization compared to no MRSA colonization was associated with a history of MRSA clinical infection, rarely or never using condoms, and contact with prisons and jails. In summary, the prevalence of MRSA colonization was high in this study of HIV-infected adults and detection of USA300 was enhanced by groin culture.

23. Ramsetty SK, Stuart LL, Blake RT, Parsons CH, Salgado CD. Risks for methicillin-resistant *Staphylococcus aureus* colonization or infection among patients with HIV infection. *HIV Med.* 2010 Jul 1;11(6):389-94.

[PubMed: PM20059572](#)

BACKGROUND: Risks for methicillin-resistant *Staphylococcus aureus* (MRSA) among those with HIV infection have been found to vary, and the epidemiology of USA-300 community-acquired (CA) MRSA has not been adequately described. **METHODS:** We conducted a retrospective review of HIV-infected out-patients from January 2002 to December 2007 and employed multivariate logistic regression (MLR) to identify risks for MRSA colonization or infection. Pulsed-field gel electrophoresis (PFGE) was used to identify USA-300 strains. **RESULTS:** Seventy-two (8%) of 900 HIV-infected patients were colonized or infected with MRSA. MLR identified antibiotic exposure within the past year [odds ratio (OR) 3.4; 95% confidence interval (CI) 1.5-7.7] and nadir CD4 count <200 cells/microL (OR 2.5; 95% CI 1.2-5.3) as risks for MRSA colonization or infection. Receipt of antiretroviral therapy (ART) within the past year was associated with decreased risk (OR 0.16; 95% CI 0.07-0.4). Eighty-nine percent of available strains were USA-300. MLR identified skin or soft tissue infection (SSTI) as the only predictor for infection with USA-300 (OR 5.9; 95% CI 1.4-24.3). **CONCLUSION:** Significant risks for MRSA among HIV-infected patients were CD4 count nadir <200 cells/microL and antibiotic exposure. Only the presence of an SSTI was associated with having USA-300, and thus the use of patient characteristics to predict those with USA-300 was limited. In addition, ART within the previous year significantly reduced the risk of MRSA colonization or infection.

24. Wang JT, Liao CH, Fang CT, Chie WC, Lai MS, Lauderdale TL, et al. Incidence of and risk factors for community-associated methicillin-resistant *Staphylococcus aureus* acquired infection or colonization in intensive-care-unit patients. *J Clin Microbiol* [Internet]. 2010 Dec [cited Apr 23];48(12):4439-44. Available from:

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3008468>

[PubMed: PM20926713](#)

The incidence of and risk factors for acquiring community-associated methicillin-

resistant Staphylococcus aureus (CA-MRSA) among patients staying in intensive care units (ICUs) remain unclear. We enrolled patients staying in two ICUs at the Far Eastern Memorial Hospital during the period of 1 September 2008 to 30 September 2009 to clarify this issue. Surveillance cultures for MRSA were taken from nostril, sputum or throat, axillae, and the inguinal area in all enrolled patients upon admission to the ICU, every 3 days thereafter, and on the day of discharge from the ICU. For each MRSA isolate, we performed multilocus sequence typing, identified the type of staphylococcal cassette chromosome mec, detected the presence of the Panton-Valentine leukocidin gene, and conducted drug susceptibility tests. Among the 1,906 patients who were screened, 203 patients were carriers of MRSA before their admission to the ICU; 81 patients acquired MRSA during their stay in the ICU, including 31 who acquired CA-MRSA. The incidence rates of newly acquired MRSA and CA-MRSA during the ICU stay were 7.9 and 3.0 per 1,000 patient-days, respectively. **Prior usage of antipseudomonal penicillins and antifungals and the presence of a nasogastric tube were found to be independent risk factors for acquiring CA-MRSA during the ICU stay when data for CA-MRSA carriers and patients without carriage of MRSA were compared (P=0.0035, 0.0330, and 0.0262, respectively). Prior usage of carbapenems was found to be a protective factor against acquiring CA-MRSA when data for patients with CA-MRSA and those with health care-associated MRSA acquired during ICU stay were compared (P=0.0240).**

25. Amorim ML, Vasconcelos C, Oliveira DC, Azevedo A, Calado E, Faria NA, et al. Epidemiology of methicillin-resistant Staphylococcus aureus (MRSA) nasal colonization among patients and healthcare workers in a Portuguese hospital: a pre-intervention study toward the control of MRSA. *Microb Drug Resist*. 2009 Mar;15(1):19-26.
[PubMed: PM19296773](#)

This two-year study investigated the epidemiology of nasal colonization with methicillin-resistant Staphylococcus aureus (MRSA) among patients and healthcare workers (HCWs) in two wards with a high frequency of MRSA isolation, at Hospital Geral de Santo Antonio (HGSA), Portugal. Three point-prevalence surveys per year were carried out. **A case-control approach was used to identify potential risk factors associated with MRSA carriage among patients.** Incidence rates and risk factors of MRSA carriage among HCWs who were negative at the baseline observation were estimated. **Prevalence of MRSA carriage among 276 patients screened was 5.1%. Admission to HGSA or attendance to the Diabetic Foot Outpatient Unit (DFOU) of HGSA within the past 12 months, and previous MRSA isolation were significant risk factors for MRSA carriage. Among HCWs (n = 126), the prevalence of MRSA carriage was 4.8% and the incidence rate was 61/1000 person-years. Nurses and nurse aids were the HCW categories with the highest risk of becoming colonized with MRSA over time (p = 0.01). One HCW chronically colonized was detected.** Molecular typing revealed a clonal identity for isolates recovered from patients and HCWs of the same wards, with 88.6% of isolates belonging to the EMRSA-15 (ST22-MRSA-IV) clone.

26. Askarian M, Zeinalzadeh A, Japoni A, Alborzi A, Memish ZA. Prevalence of nasal carriage of methicillin-resistant Staphylococcus aureus and its antibiotic susceptibility pattern in healthcare workers at Namazi Hospital, Shiraz, Iran. *Int J Infect Dis*. 2009 Sep;13(5):e241-e247.
[PubMed: PM19269873](#)

OBJECTIVE: The aim of this study was to determine the prevalence of nasal carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) among healthcare workers (HCWs) at Namazi Hospital, Shiraz, Iran. **METHODS:** This cross-sectional study was conducted from July to November 2006. Nasal swabs were taken from 600 randomly selected HCWs. The isolates were identified as *S. aureus* based on morphology, Gram stain, catalase test, coagulase test, and mannitol salt agar fermentation. To analyze sensitivity patterns of MRSA strains more precisely, minimum inhibitory concentrations (MICs) of antibiotics were determined by the E-test method. All methicillin-resistant isolates were examined for the existence of the *mecA* gene by total DNA extraction and PCR. **RESULTS:** The prevalence of nasal carriage of methicillin-sensitive *S. aureus* (MSSA) was 25.7% and of MRSA was 5.3%, with the highest nasal carriage of MRSA in surgical wards and the emergency department. There was no significant difference between the sexes ($p=0.247$), age ($p=0.817$), and years of healthcare service ($p=0.15$) with regard to the nasal carriage of MRSA and MSSA. **In the univariate analysis, a statistically significant difference was only found for occupation ($p=0.032$) between the carriage of MSSA and MRSA. In the multivariate analysis, the occupation 'nurse' was independently associated with MRSA carriage ($p=0.012$, odds ratio 3.6, 95% confidence interval 1.3-9.7).** The highest resistance rate for both gentamicin and clindamycin (69%) was noted among the MRSA strains. None of the MRSA strains were resistant to mupirocin, linezolid, fusidic acid, or vancomycin. The existence of the *mecA* gene in all 32 methicillin-resistant isolates was observed by PCR. **CONCLUSIONS:** This study revealed the prevalence of nasal carriage of *S. aureus* strains among HCWs to be lower than that found in other studies from Iran. The antibiotic susceptibility patterns also differed, perhaps as a result of the excessive use of antibiotics at our hospital. Only the occupation of nurse was an independent risk factor for MRSA carriage.

27. Baldwin NS, Gilpin DF, Hughes CM, Kearney MP, Gardiner DA, Cardwell C, et al. Prevalence of methicillin-resistant *Staphylococcus aureus* colonization in residents and staff in nursing homes in Northern Ireland. *J Am Geriatr Soc.* 2009 Apr;57(4):620-6. [PubMed: PM19392953](#)

OBJECTIVES: To determine the prevalence of, and factors associated with, methicillin-resistant *Staphylococcus aureus* (MRSA) colonization in residents and staff in nursing homes in one geographically defined health administration area of Northern Ireland. **DESIGN:** Point prevalence study. **SETTING:** Nursing homes. **PARTICIPANTS:** Residents and staff in nursing homes. **MEASUREMENTS:** Nasal swabs were taken from all consenting residents and staff. If relevant, residents also provided urine samples, and swabs were taken from wounds and indwelling devices. **RESULTS:** A total of 1,111 residents (66% of all residents) and 553 staff (86% of available staff) in 45 nursing homes participated. **The combined prevalence rate of MRSA in the resident population was 23.3% (95% confidence interval (CI)=18.8-27.7%) and 7.5% in staff (95% CI=5.1-9.9%). Residents who lived in nursing homes that were part of a chain were more likely to be colonized with MRSA (odds ratio (OR)=1.91, 95% CI=1.21-3.02) than those living in independently owned facilities. Residents were also more likely to be colonized if they lived in homes in which more than 12.5% of all screened healthcare staff (care assistants and nurses) were colonized with MRSA (OR=2.46, 95% CI=1.41-4.29) or if they lived in homes in which more than 15% of care assistants were colonized with MRSA (OR=2.64, 95% CI=1.58-4.42).** **CONCLUSION:** The findings suggest that there is substantial colonization of MRSA in

nursing home residents and staff in this one administrative health area. Implementation of infection control strategies should be given high priority in nursing homes.

28. Brugnaro P, Fedeli U, Pellizzer G, Buonfrate D, Rassu M, Boldrin C, et al. Clustering and risk factors of methicillin-resistant *Staphylococcus aureus* carriage in two Italian long-term care facilities. *Infection*. 2009 Jun;37(3):216-21.
[PubMed: PM19148574](#)

BACKGROUND: Methicillin-resistant *Staphylococcus aureus* (MRSA) is a well-recognized agent of health care-associated infections in long-term care facilities, but few data about the circulation of MRSA in this setting in Italy are available. **The aim of the study is to determine the prevalence and risk factors for MRSA carriage in nursing home residents in Vicenza (northeastern Italy).** **PATIENTS AND METHODS:** A point prevalence survey was conducted in two long-term care facilities (subdivided into 15 wards) from 12 June 2006 to 6 July 2006. Anterior nasal swabs were obtained from residents and laboratory screening for MRSA was performed; full antibiotic susceptibility was assessed in MRSA isolates. Macrorestriction analysis of chromosomal DNA was carried out by pulsed field gel electrophoresis (PFGE). For each subject, demographic data, length of stay, dependency, cognitive function, presence of medical devices, comorbidities, current and previous antibiotic treatment, previous hospital admission and presence of infection were assessed on the day of sample collection. Factors that were found to be significantly associated with MRSA carriage at univariate analysis were introduced into multilevel logistic regression models in order to estimate the odds ratios (OR) with 95% confidence intervals (CI) for the risk of MRSA colonization, taking into account the clustering of patients within wards. **RESULTS: Nasal swabs were obtained in 551 subjects; overall 43 MRSA carriers were detected (7.8%; CI = 5.7-10.4%).** The rate of nasal carriers was very similar in the two institutions, and varied from 0% (0/36) to 18% (7/39) between wards. Only two out of 15 wards were found to have no MRSA carriers; overall, three pairs of colonized roommates were detected. **Upon multilevel logistic regression, the risk of MRSA carriage was increased in patients with cancer (OR = 6.4; CI = 2.5-16.4), in those that had undergone recent hospitalization (OR = 2.2; CI = 1.0-4.4), and it reached OR = 4.0 (CI = 1.7-9.9) in those with three or more antibiotic treatments in the previous year; about 10% of the variability in MRSA carriage could be attributed to differences between wards.** Pulsed field gel electrophoresis analysis permitted the definition of six clusters; two of these comprised 78.6% of the studied isolates and were quite similar, with one being more strongly represented among subjects hospitalized in the previous 12 months. All of the MRSA strains were resistant to ciprofloxacin; nevertheless, the majority were susceptible to most other non-beta-lactam antibiotics. **CONCLUSION:** The study suggests that nursing homes are a significant reservoir for MRSA. Statistical and PFGE analyses indicate a scenario where MRSA seems to be endemic and individual risk factors, namely recent hospitalizations and repeated antibiotic treatments, play a major role in the selection of drug-resistant organisms. Infection control measures should be coordinated among different health care settings, and the appropriate use of antibiotics has emerged as an important issue for improving the quality of care.

29. Chacko J, Kuruvila M, Bhat GK. Factors affecting the nasal carriage of methicillin-resistant *Staphylococcus aureus* in human immunodeficiency virus-infected patients. *Indian J Med Microbiol*. 2009 Apr;27(2):146-8.

[PubMed: PM19384039](#)

Human immunodeficiency virus-infected patients attending skin outpatient department were studied for nasal carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) and associated factors affecting nasal colonization. Nasal swabs were used for isolation of *S. aureus*. MRSA were detected by agar screen and agar dilution methods. Careful examination for dermatoses was carried out. Forty-six of the 60 (76.67%) outpatients with HIV infection were colonized with *S. aureus* in the anterior nares. Significant number of *S. aureus* carriers were in the 31-40 year age group. **Methicillin resistance was found in eight (17.39%) isolates.** Of the 46 *S. aureus* strains, 29 (63%) were resistant to erythromycin, 69.5% to co-trimoxazole and 41.3% to ciprofloxacin. Co-trimoxazole use was found to be a risk factor for *S. aureus* carriage ($P = 0.0214$) but not for methicillin resistance. **Hospital stay for more than 10 days was a risk factor for methicillin resistance whereas stay for more than 25 days was found to be a highly significant risk factor.** Dermatophytosis and herpes simplex virus infection were other risk factors for nasal carriage of *S. aureus*.

30. Denis O, Jans B, Deplano A, Nonhoff C, De RR, Suetens C, et al. Epidemiology of methicillin-resistant *Staphylococcus aureus* (MRSA) among residents of nursing homes in Belgium. *J Antimicrob Chemother.* 2009 Dec;64(6):1299-306.
[PubMed: PM19808236](#)

OBJECTIVES: A national survey was conducted to determine the prevalence, risk factors and molecular epidemiology of methicillin-resistant *Staphylococcus aureus* (MRSA) carriage among nursing home (NH) residents in Belgium. **METHODS:** A random stratified, cross-sectional prevalence survey was conducted in NH residents who were screened for MRSA carriage by multisite enriched culture. Characteristics of NHs and residents were collected by a questionnaire survey and analysed by two-stage logistic regression modelling. MRSA isolates were genotyped by PFGE, staphylococcal cassette chromosome *mec* (SCC*mec*) typing, multilocus sequence typing (MLST) and resistance genes. **RESULTS: Of 2953 residents screened in 60 NHs, 587 (19.9%) were MRSA carriers. Risk factors included hospital contact, antibiotic exposure, impaired mobility and skin lesions at the resident level, and lack of MRSA surveillance, lack of antibiotic therapeutic formulary and the combination of less-developed infection control activities and a high ratio of physicians to residents at the institution level.** MRSA isolates showed eight major types, three of which were predominant: B2-ST45-SCC*mec* IV (49%; where ST stands for sequence type); A21-ST8-SCC*mec* IV (13%); and A20-ST8-SCC*mec* IV (10%). Each was recovered in 55, 21 and 25 NHs, respectively. The geographical distribution of NH genotypes paralleled that of acute-care hospitals. **CONCLUSIONS:** A high prevalence of MRSA carriage in NH residents was associated with hospital care, co-morbidities and less-developed coordination of institutional care. The predominant MRSA strains from NH residents and hospitalized patients of the same area were identical. Strengthening and coordination of MRSA surveillance and control activities are warranted within and between NHs and hospitals.

31. Ellis MW, Griffith ME, Jorgensen JH, Hospenthal DR, Mende K, Patterson JE. Presence and molecular epidemiology of virulence factors in methicillin-resistant *Staphylococcus aureus* strains colonizing and infecting soldiers. *J Clin Microbiol* [Internet]. 2009 Apr [cited 2012 Apr 23];47(4):940-5. Available from:

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2668321>
[PubMed: PM19213694](#)

Methicillin-resistant Staphylococcus aureus (MRSA) has emerged as an important cause of skin and soft-tissue infections (SSTI). The understanding of the molecular epidemiology and virulence of MRSA continues to expand. From January 2005 to December 2005, we screened soldiers for MRSA nasal colonization, administered a demographic questionnaire, and monitored them prospectively for SSTI. All MRSA isolates underwent molecular analysis, which included pulsed-field gel electrophoresis (PFGE) and PCR for Panton-Valentine leukocidin (PVL), the arginine catabolic mobile element (ACME), and the staphylococcal cassette chromosome mec (SCCmec). Of the 3,447 soldiers screened, 134 (3.9%) had MRSA colonization. Of the 3,066 (89%) who completed the study, 39 developed culture-confirmed MRSA abscesses. Clone USA300 represented 53% of colonizing isolates but was responsible for 97% of the abscesses ($P < 0.001$). Unlike colonizing isolates, isolates positive for USA300, PVL, ACME, and type IV SCCmec were significantly associated with MRSA abscess isolates. **As determined by multivariate analysis, risk factors for MRSA colonization were a history of SSTI and a history of hospitalization.** Although various MRSA strains may colonize soldiers, USA300 is the most virulent when evaluated prospectively, and PVL, ACME, and type IV SCCmec are associated with these abscesses.

32. Mathanraj S, Sujatha S, Sivasangeetha K, Parija SC. Screening for methicillin-resistant Staphylococcus aureus carriers among patients and health care workers of a tertiary care hospital in south India. Indian J Med Microbiol. 2009 Jan;27(1):62-4.
[PubMed: PM19172064](#)

A total of 200 subjects were screened for carriage of methicillin-resistant Staphylococcus aureus (MRSA) at different sites using oxacillin blood agar and mannitol salt agar with oxacillin. Overall carriage rate was 8.5%, with the highest rate in inpatients (15.6%) while the lowest was seen in health care workers (1.8%). The commonest site of colonization was the anterior nares. Oxacillin blood agar was found to be superior to mannitol salt agar with oxacillin for the isolation of MRSA. **Male sex and prolonged hospital stay were found to be the major risk factors for MRSA colonization.**

33. Melo EC, Fortaleza CM. Case-case-control study of risk factors for nasopharyngeal colonization with methicillin-resistant Staphylococcus aureus in a medical-surgical intensive care unit. Braz J Infect Dis. 2009 Dec;13(6):398-402.
[PubMed: PM20464328](#)

Nasopharyngeal colonization with methicillin-resistant Staphylococcus aureus (MRSA) often precedes the development of nosocomial infections. **In order to identify risk factors for MRSA colonization, we conducted a case-case-control study, enrolling 122 patients admitted to a medical-surgical intensive care unit (ICU).** All patients had been screened for nasopharyngeal colonization with S. aureus upon admission and weekly thereafter. Two case-control studies were performed, using as cases patients who acquired colonization with MRSA and methicillin-susceptible S. aureus (MSSA), respectively. For both studies, patients in whom colonization was not detected during ICU stay were selected as control subjects. Several potential risk factors were assessed in univariate and multivariable (logistic regression) analysis. MRSA and MSSA were

recovered from nasopharyngeal samples from 27 and 10 patients, respectively. **Independent risk factors for MRSA colonization were: length-of-stay in the ICU (Odds Ratio [OR]=1.12, 95%Confidence Interval[CI]=1.06-1.19, p<0.001) and use of ciprofloxacin (OR=5.05, 95%CI=1.38-21.90, p=0.015). The use of levofloxacin had a protective effect (OR=0.08, 95%CI=0.01-0.55, p=0.01).** Colonization with MSSA was positively associated with central nervous system disease (OR=7.45, 95%CI=1.33-41.74, p=0.02) and negatively associated with age (OR=0.94, 95%CI=0.90-0.99, p=0.01). In conclusion, our study suggests a role for both cross-transmission and selective pressure of antimicrobials in the spread of MRSA.

34. Nishikawa M, Tanaka T, Nakashima K, Senda K, Shibasaki M, Miura H, et al. Screening for methicillin-resistant *Staphylococcus aureus* (MRSA) carriage on admission to a geriatric hospital. *Arch Gerontol Geriatr.* 2009 Sep;49(2):242-5.
[PubMed: PM18977042](#)

Our objective is to identify risk factors for carriage of MRSA on admission to a geriatric hospital where MRSA is endemic. A prospective screening for MRSA carriage was conducted by swabbing anterior nares and anal skin for 6 weeks. One hundred and thirty-eight patients aged over 65 were enrolled after obtaining their informed consent. Swabs of anterior nares and anal skin of patients were submitted for culture for MRSA. The demographic, administrative, and clinical data for each participant were recorded, and their association with MRSA carriage was determined by stepwise regression analysis. **MRSA was recovered from 11 patients (11/138 patients, 8.0%), and from anal skin in 8 of them.** Without screening of anal skin, 5 out of 11 carriers had been missed. **Multivariate analysis revealed that hypoalbuminemia (adjusted risk ratio, RR=6.39, 95% confidence interval, CI=1.08-37.84) and bedridden status (RR=8.26, CI=1.04-65.31) were independent risk factors.** Screening of elderly patients for gastrointestinal colonization on admission had implications for early detection of the reservoir of MRSA. Systematic selective screening for MRSA carriage targeting high-risk patients with hypoalbuminemia or bedridden status would be useful for infection control of this resistant organism.

35. Rohde RE, Denham R, Brannon A. Methicillin resistant *Staphylococcus aureus*: carriage rates and characterization of students in a Texas university. *Clin Lab Sci.* 2009;22(3):176-84.
[PubMed: PM19827412](#)

OBJECTIVE: To evaluate the carriage rates of *Staphylococcus aureus* and methicillin resistant *Staphylococcus aureus* (MRSA) in a university student population and describe risk factors associated with the carriage of each. DESIGN: Cross-sectional study (N = 203). Institutional Review Board approval was obtained from Texas State University-San Marcos. SETTING: Texas State University-San Marcos, San Marcos, TX. PARTICIPANTS: Two-hundred and three university student samples were collected from December 2007 to July 2008. INTERVENTIONS: None indicated. MAIN OUTCOME MEASURES: The sample set was screened for *S. aureus* and MRSA identification by standard microbiological techniques and confirmed by use of a Vitek 2 per manufacturer recommendation. Antibiotic susceptibility testing was conducted on each MRSA isolate by Vitek 2. A questionnaire was conducted with each student to acquire demographic and risk factor information. Demographic data is shown by raw numbers,

percentages, mean, and median where applicable. The compiled data was screened and analyzed by chi square (p values) and odds ratio (OR) with confidence interval (CI) to determine significance. RESULTS: Of the 203 participants who were screened, 60 (29.6%) carried *S. aureus*. Univariate analysis found that only hospitalization in the past 12 months was significantly associated with the risk of being a *S. aureus* carrier (OR=3.0, 95% CI 1.28-7.03). Of the 60 participants that carried *S. aureus*, 15 were identified as MRSA. **This relates to a 7.4% MRSA carriage rate among generally healthy university students. Univariate analysis found that hospitalization in the past 12 months (OR = 4.2, 95% CI 1.29-13.36) and recent skin infection (OR = 4.4, 95% CI 1.07-18.24) were significantly associated with the risk of being a MRSA carrier.** No unique antibiotic susceptibility patterns were identified with the MRSA isolates. CONCLUSIONS: The carriage rate of *S. aureus* is consistent with similar studies. MRSA carriage in this university study appears high as compared to the general population. Although this study did not confirm a variety of risk factors for carriage of MRSA previously identified by others, university healthcare personnel should be aware of the changing epidemiology of MRSA and preventive measures needed to avoid outbreaks.

36. Shet A, Mathema B, Mediavilla JR, Kishii K, Mehandru S, Jeane-Pierre P, et al. Colonization and subsequent skin and soft tissue infection due to methicillin-resistant *Staphylococcus aureus* in a cohort of otherwise healthy adults infected with HIV type 1. *J Infect Dis.* 2009 Jul 1;200(1):88-93.
[PubMed: PM19463064](#)

Methicillin-resistant *Staphylococcus aureus* (MRSA) carriage and subsequent infection were prospectively compared among a well-defined group of 107 individuals infected with human immunodeficiency virus type 1 (HIV-1) who had no evidence of immune suppression and 52 epidemiologically matched, uninfected individuals. The carriage strains and infecting strains were genetically characterized. The cumulative prevalence of **MRSA carriage was significantly higher among HIV-infected individuals (16.8%) than among individuals without HIV infection (5.8%) (P = .04; odds ratio, 3.3 [95% confidence interval, 1.3-14.7]).** Fifteen of 21 MRSA isolates recovered from colonized individuals were identified as strain USA300. Of the 10 MRSA skin and soft tissue infections observed in this study, all occurred in HIV-infected individuals who were colonized with the same strain that caused the infection. **Previous antibiotic use was the only statistically significant risk factor for MRSA carriage.** These data highlight the fact that MRSA colonization and infection are important clinical issues among asymptomatic HIV-1-infected individuals.

37. Velazquez-Guadarrama N, Martinez-Aguilar G, Galindo JA, Zuniga G, Ibarra-Sosa A. Methicillin-resistant *S. aureus* colonization in Mexican children attending day care centres. *Clin Invest Med.* 2009;32(1):E57-E63.
[PubMed: PM19178880](#)

PURPOSE: To determine MRSA carriage rates and genetic relationships of *S. aureus* strains in children attending day care centres in 14 cities from three geographic regions in Mexico. MATERIALS AND METHODS: Cross-Sectional Study performed in apparently healthy children aged from 6 mo to 6 yr attending day care centres (DCCs). From September 2002 To January 2003, 2345 nasopharyngeal specimens from a similar number of children were collected. Nasopharyngeal samples for

bacterial isolation were obtained by standard methods. Antimicrobial susceptibility was determined and genetic relatedness of all MRSA isolates was determined by pulsed field gel electrophoresis (PFGE). **RESULTS: S. aureus was identified in 237 children (10.1%), twenty-two children had MSRA for an overall prevalence of MRSA carriage of 0.93%. Children attending DCCs from cities located in the north and south of Mexico showed higher prevalence than children from DCCs in the central region; 1.75%, and 1.71 vs. 0.08%, respectively (P < 0.05).** PFGE demonstrated six different restriction profiles of MRSA with a predominant pattern. **CONCLUSIONS:** We documented the presence of MRSA strain colonizing children attending DCCs in Mexico, mainly in the south and north regions of the country. Clone A and B which are closely related represented 45 % of the total of MRSA isolates. We found both, SCCmec type II and type IV strains in the three regions.

38. Wang JT, Liao CH, Fang CT, Chie WC, Lai MS, Lauderdale TL, et al. Prevalence of and risk factors for colonization by methicillin-resistant *Staphylococcus aureus* among adults in community settings in Taiwan. *J Clin Microbiol* [Internet]. 2009 Sep [cited 2012 Apr 23];47(9):2957-63. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2738089>
[PubMed: PM19625471](#)

In order to determine the prevalence of methicillin (meticillin)-resistant *Staphylococcus aureus* (MRSA) colonization among adults in community settings in Taiwan and identify its risk factors, we conducted the present study. For a 3-month period, we enrolled all adults who attended mandatory health examinations at three medical centers and signed the informed consent. Nasal swabs were taken for the isolation of *S. aureus*. For each MRSA isolate, we performed multilocus sequence typing, identification of the staphylococcal cassette chromosome mec, tests for the presence of the Panton-Valentine leukocidin gene, and tests for drug susceptibilities. **Risk factors for MRSA colonization were determined. The results indicated that the MRSA colonization rate among adults in the community settings in Taiwan was 3.8% (119/3,098).** Most MRSA isolates belonged to sequence type 59 (84.0%). **Independent risk factors for MRSA colonization included the presence of household members less than 7 years old (P < 0.0001) and the use of antibiotics within the past year (P = 0.0031).** Smoking appeared to be protective against MRSA colonization (P < 0.0001).

Risk of infection in patients who are carriers of MRSA

39. Reilly JS, Stewart S, Christie P, Allardice GM, Stari T, Matheson A, et al. Universal screening for methicillin-resistant *Staphylococcus aureus* in acute care: risk factors and outcome from a multicentre study. *J Hosp Infect.* 2012 Jan;80(1):31-5.
[PubMed: PM22104473](#)

BACKGROUND: A Health Technology Assessment (HTA) model on effectiveness of methicillin-resistant *Staphylococcus aureus* (MRSA) screening in Scotland suggested that universal screening using chromogenic agar was the preferred option in terms of effectiveness and cost. AIM: To test the model's validity through a one-year pilot-study. METHOD: A large one-year prospective cohort study of MRSA screening was carried out in six acute hospitals in NHS Scotland, incorporating 81,438 admissions. Outcomes (MRSA colonization and infection rates) were subjected to multivariable analyses, and trends before and after implementation of screening were compared. FINDINGS: The initial colonization prevalence of 5.5% decreased to 3.5%

by month 12 of the study ($P < 0.0001$). Colonization was associated with the number of admissions per patient, specialty of admission, age, and source of admission (home, other hospital or care home). Around 2% of all admissions with no prior history of MRSA infection or colonization tested positive. **Those who were screen positive on admission and not previously known positive were 12 times more likely than those who screened negative to develop infection, increasing to 18 times if they were both screen positive and previously known positive. MRSA infections (7.5 per 1000 inpatient-days overall) also reduced significantly over the study year ($P = 0.0209$).** CONCLUSION: The risk factors identified for colonization and infection indicate that a universal clinical risk assessment may have a role in MRSA screening.

40. Shurland SM, Stine OC, Venezia RA, Zhan M, Furuno JP, Miller RR, et al. USA300 methicillin-resistant *S. aureus* (USA300 MRSA) colonization and the risk of MRSA infection in residents of extended-care facilities. *Epidemiol Infect.* 2012 Mar;140(3):390-9. [PubMed: PM21767453](#)

To examine the pathogenesis of USA300 MRSA infection in long-term care residents, we performed a retrospective cohort study of 1691 adult residents of two extended-care facilities from 2003 to 2007 to assess whether the risk of subsequent MRSA infection is higher in USA300 MRSA-colonized residents compared to non-colonized residents or non-USA300 MRSA colonized residents. Six per cent of residents were colonized with USA300 MRSA; 12% of residents were colonized with non-USA300 MRSA; and 101 residents developed MRSA infection. **The risk of infection was twofold higher in residents colonized with USA300 MRSA compared to residents not colonized with MRSA [adjusted hazard ratio 2.3, 95% confidence interval (CI) 1.1-4.5]. The risk of infection in USA300 MRSA-colonized residents was similar to USA300 MRSA non-colonized residents (relative risk 1.1, 95% CI 0.5-2.3).** Our findings show that colonization with USA300 MRSA increases the risk of MRSA infection suggesting a similar pathogenesis.

41. Harinstein L, Schafer J, D'Amico F. Risk factors associated with the conversion of methicillin-resistant *Staphylococcus aureus* colonisation to healthcare-associated infection. *J Hosp Infect.* 2011 Nov;79(3):194-7. [PubMed: PM21640432](#)

The objective of the study was to identify risk factors for healthcare-associated methicillin-resistant *Staphylococcus aureus* (HA-MRSA) infections in patients with MRSA colonisation over an extended time period. This was a case-control study conducted at a community teaching hospital. Patients included 41 cases and 82 controls, aged ≥ 18 years, who were nares colonisation culture positive for MRSA and either did or did not develop an HA-MRSA infection within 60 days after index colonisation, respectively. Potential risk factors evaluated included: patient demographics, comorbid conditions, medication use, presence of invasive devices, presence of wounds or other infections, nutritional status, number of hospitalisations and time to infection development. **In the univariate analysis, the presence of peripheral vascular disease, three or more comorbidities, a central venous catheter, a Foley catheter, or two or more hospitalisations were significantly associated with increased risk for HA-MRSA infection. Multivariate analysis yielded a model that included presence of a central venous catheter (OR: 8.00; 95% CI: 3.13-20.4) or two or more hospitalisations (OR: 3.37; 95% CI: 1.37-8.26) as independent risk factors for MRSA infection in those with**

MRSA colonisation. In conclusion, risk factors independently associated with the conversion of MRSA colonisation to HA-MRSA infection include the presence of a central venous catheter or two or more hospitalisations. Strategies involving risk factor minimisation may be helpful in reducing HA-MRSA infections in this patient population.

42. Maraqa NF, Aigbivbalu L, Masnita-Iusan C, Wludyka P, Shareef Z, Bailey C, et al. Prevalence of and risk factors for methicillin-resistant *Staphylococcus aureus* colonization and infection among infants at a level III neonatal intensive care unit. *Am J Infect Control*. 2011 Feb;39(1):35-41.
[PubMed: PM21281885](#)

BACKGROUND: Methicillin-resistant *Staphylococcus aureus* (MRSA) is a well-known nosocomial pathogen of neonatal intensive care unit (NICU) patients and can cause both serious infections in preterm neonates and prolonged MRSA outbreaks in NICUs. **OBJECTIVES:** Our objectives were to determine the prevalence of and identify risk factors for MRSA colonization and infection in the NICU and the impact of an active surveillance program on MRSA in the NICU. **METHODS:** We collected weekly nasal MRSA surveillance cultures on 2,048 infants admitted to NICU over 3 years. Data on these infants were collected retrospectively. Characteristics of MRSA colonized and infected infants were analyzed and compared. **RESULTS:** MRSA colonization was detected in 6.74% of infants, and MRSA infection occurred in 22% of those colonized. Using clinical cultures alone, only 41 (27.5%) of 149 MRSA affected infants were identified. The majority (75%) developed MRSA infection within 17 days of colonization. For every 10-day increment in NICU stay, the odds ratio of being infected and colonized with MRSA increased by 1.32 and 1.29, respectively. Colonization was significantly associated with longer NICU stay, low birth weight, low gestational age, and multiple gestation status. **CONCLUSION:** Colonization is a risk factor for infection with MRSA in NICUs. Clinical cultures underestimate MRSA affected infants in NICUs, whereas active surveillance cultures could detect MRSA affected infants earlier and limit nosocomial spread.

43. Milstone AM, Goldner BW, Ross T, Shepard JW, Carroll KC, Perl TM. Methicillin-resistant *Staphylococcus aureus* colonization and risk of subsequent infection in critically ill children: importance of preventing nosocomial methicillin-resistant *Staphylococcus aureus* transmission. *Clin Infect Dis* [Internet]. 2011 Nov [cited 2012 Apr 23];53(9):853-9. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3189167>
[PubMed: PM21878424](#)

BACKGROUND: Methicillin-resistant *Staphylococcus aureus* (MRSA) colonization is a predictor of subsequent infection in hospitalized adults. The risk of subsequent MRSA infections in hospitalized children colonized with MRSA is unknown. **METHODS:** Children admitted to an academic medical center's pediatric intensive care unit between March 2007 and March 2010 were included in the study. Anterior naris swabs were cultured to identify children with MRSA colonization at admission. Laboratory databases were queried and National Healthcare Safety Network definitions applied to identify patients with MRSA infections during their hospitalization or after discharge. **RESULTS:** The MRSA admission prevalence among 3140 children was 4.9%. Overall, 56 children (1.8%) developed an MRSA infection, including 13 (8.5%) colonized on admission and 43 (1.4%) not colonized on admission (relative risk [RR], 5.9; 95% confidence interval [CI], 3.4-10.1). Of those, 10 children (0.3%)

developed an MRSA infection during their hospitalization, including 3 of 153 children (1.9%) colonized on admission and 7 of 2987 children (0.2%) not colonized on admission (RR, 8.4; 95% CI, 2.7-25.8). **African-Americans and those with public health insurance were more likely to get a subsequent infection (P < .01 and P = .03, respectively). We found that 15 children acquired MRSA colonization in the pediatric intensive care unit, and 7 (47%) developed a subsequent MRSA infection.** CONCLUSIONS: **MRSA colonization is a risk factor for subsequent MRSA infection in children. Although MRSA colonized children may have lower risks of subsequent infection than adults, children who acquire MRSA in the hospital have similarly high rates of infection.** Preventing transmission of MRSA in hospitalized children should remain a priority.

44. Maree CL, Eells SJ, Tan J, Bancroft EA, Malek M, Harawa NT, et al. Risk factors for infection and colonization with community-associated methicillin-resistant *Staphylococcus aureus* in the Los Angeles County jail: a case-control study. *Clin Infect Dis*. 2010 Dec 1;51(11):1248-57.
[PubMed: PM21034197](#)

BACKGROUND: Community-associated methicillin-resistant *Staphylococcus aureus* (MRSA) infections and outbreaks occur in correctional facilities, such as jails and prisons. Spread of these infections can be extremely difficult to control. Development of effective prevention protocols requires an understanding of MRSA risk factors in incarcerated persons. METHODS: We performed a case-control study investigating behavioral risk factors associated with MRSA infection and colonization. Case patients were male inmates with confirmed MRSA infection. Control subjects were male inmates without skin infection. Case patients and control subjects completed questionnaires and underwent collection of nasal swab samples for culture for MRSA. Microbiologic analysis was performed to characterize recovered MRSA isolates. RESULTS: **We enrolled 60 case patients and 102 control subjects. Of the case patients, 21 (35%) had MRSA nasal colonization, compared with 11 control subjects (11%) (P .001).** Among MRSA isolates tested, 100% were the USA300 strain type. **Factors associated with MRSA skin infection included MRSA nares colonization, lower educational level, lack of knowledge about "Staph" infections, lower rate of showering in jail, recent skin infection, sharing soap with other inmates, and less preincarceration contact with the health care system. Risk factors associated with MRSA colonization included antibiotic use in the previous year and lower rate of showering.** CONCLUSIONS: We identified several risks for MRSA infection in male inmates, many of which reflected preincarceration factors, such as previous skin infection and lower educational level. Some mutable factors, such as showering frequency, knowledge about Staph, and soap sharing, may be targets for intervention to prevent infection in this vulnerable population.

45. Simor AE, Gilbert NL, Gravel D, Mulvey MR, Bryce E, Loeb M, et al. Methicillin-resistant *Staphylococcus aureus* colonization or infection in Canada: National Surveillance and Changing Epidemiology, 1995-2007. *Infect Control Hosp Epidemiol*. 2010 Apr;31(4):348-56.
[PubMed: PM20148693](#)

OBJECTIVE: To determine the incidence and describe the changing epidemiology of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization or infection in

Canadian hospitals from 1995-2007. SETTING: Forty-eight hospitals participating in the Canadian Nosocomial Infection Surveillance Program. DESIGN: Prospective, laboratory-based surveillance for incident cases of MRSA colonization or infection among hospitalized patients. METHODS: Clinical and epidemiologic data were obtained by review of hospital records. Standard criteria were used to determine whether MRSA colonization or infection was present and whether the MRSA strain was healthcare associated or community associated. A representative subset of isolates was characterized by use of pulsed-field gel electrophoresis and staphylococcal cassette chromosome (SCC) mec typing. RESULTS: **From 1995 to 2007, a total of 37,169 hospitalized patients were newly identified as either infected or colonized with MRSA, and the overall incidence of both MRSA colonization and MRSA infection increased from 0.65 to 11.04 cases per 10,000 patient-days ($P < .001$). Of these 37,169 patients, 11,828 (32%) had an MRSA infection, and infection rate increased from 0.36 to 3.43 cases per 10,000 patient-days.** The proportion of community-associated MRSA strains increased from 6% to 23% ($P < .001$). The most common genotype (47% of isolates) was CMRSA-2 (USA100/800); in 2007, CMRSA-10 (USA300) was the second most common strain (27% of isolates), associated with SCCmec type IV. **Patients with CMRSA-10 were predominantly from western Canada and were more likely to be children (odds ratio [OR], 10.0 [95% confidence interval {CI}, 7.4-13.4]) and to have infection (OR, 2.3 [95% CI, 1.9-2.7]), especially skin and/or soft tissue infection (OR, 5.9 [95% CI, 5.0-6.9]).** CONCLUSIONS: The overall incidence of both MRSA colonization and MRSA infection increased 17-fold in Canadian hospitals from 1995 to 2007. There has also been a dramatic increase in cases of community-associated MRSA infection due to the CMRSA-10 (USA300) clone. Continued surveillance is needed to monitor the ongoing evolution of MRSA colonization or infection in Canada and globally.

46. Croft CA, Mejia VA, Barker DE, Maxwell RA, Dart BW, Smith PW, et al. Methicillin-resistant *Staphylococcus aureus* in a trauma population: does colonization predict infection? *Am Surg.* 2009 Jun;75(6):458-61.
[PubMed: PM19545092](#)

Methicillin-resistant *Staphylococcus aureus* (MRSA) is increasingly responsible for infections in hospitalized patients. Patients colonized with MRSA appear to be at higher risk for subsequent MRSA infections than those who are not colonized. **In this study, we determined MRSA colonization status of trauma patients at hospital admission and compared the incidence of subsequent MRSA infections between MRSA colonized and noncolonized patients.** Collected data were entered into databases at a single, Level I trauma center over a 13-month period. Three hundred fifty-five adult trauma patients were screened for MRSA on admission to the trauma intensive care unit. The patients were categorized into two groups, those colonized with MRSA at admission and those who were not. **Thirty-six of 355 patients (10.1%) were colonized. Of the 319 patients not colonized, 21 (6.6%) developed MRSA infections. Twelve of 36 (33.3%) colonized patients developed MRSA infections ($P < 0.001$).** No differences in types of MRSA infections were found between the two groups. **Colonized patients who developed MRSA infections had higher death rates, 22.2 versus 5.0 per cent ($P < 0.001$).** Patients colonized with MRSA on admission may be at higher risk for developing MRSA infections during hospitalization. MRSA screening protocols should be used to identify these at-risk patients.

47. Fascia DT, Singanayagam A, Keating JF. Methicillin-resistant *Staphylococcus aureus* in orthopaedic trauma: identification of risk factors as a strategy for control of infection. *J Bone Joint Surg Br.* 2009 Feb;91(2):249-52.

[PubMed: PM19190063](#)

We have conducted a case-control study over a period of ten years comparing both deep infection with methicillin-resistant staphylococcus aureus (MRSA) and colonised cases with a control group. Risk factors associated with deep infection were vascular diseases, chronic obstructive pulmonary disease, admission to a high-dependency or an intensive-care unit and open wounds. **Those for colonisation were institutional care, vascular diseases and dementia. Older age was a risk factor for any MRSA infection.** The length of hospital stay was dramatically increased by deep infection. These risk factors are useful in identifying higher-risk patients who may be more susceptible to MRSA infection. A strategy of early identification and isolation may help to control its spread in trauma units.

48. Longtin Y, Sudre P, Francois P, Schrenzel J, Aramburu C, Pastore R, et al. Community-associated methicillin-resistant *Staphylococcus aureus*: risk factors for infection, and long-term follow-up. *Clin Microbiol Infect.* 2009 Jun;15(6):552-9.

[PubMed: PM19416294](#)

Uncertainty persists about risk factors for community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) infections in Europe and the long-term efficacy of decolonization strategies. **To evaluate risk factors for CA-MRSA in Geneva, Switzerland, a hospital-based, retrospective case-control study of 26 patients with CA-MRSA infection and 60 control patients was performed.** To evaluate the long-term effect of a systematic decolonization strategy (with and without concomitant systemic antibiotic therapy) for CA-MRSA patients, a prospective cohort study of 79 patients with Panton-Valentine leukocidin-producing CA-MRSA isolates was conducted. **Nationality other than European Union or Swiss (adjusted OR 6.09; 95% CI 1.07-34.65) and absence of healthcare contact (adjusted OR 0.11, 95% CI 0.02-0.59) were independent predictors of CA-MRSA infection.** Forty-five cases were followed (median, 22 months) to assess the long-term efficacy of the decolonization strategy; 39/45 (86.7%) had no clinical relapse and were MRSA-negative at their last follow-up, whereas six remained MRSA-positive. Five of these six cases belonged to a family cluster. Decolonization rates were similar between infected patients and asymptomatic carriers (92.6% vs. 77.8%, $p = 0.20$). **This study shows a lack of readily modifiable risk factors for CA-MRSA infection in this population, and suggests the potential usefulness of conducting decolonization procedures in a setting with sporadic CA-MRSA infection.** Further studies are needed to elucidate the role of migration as a factor contributing to the emergence of CA-MRSA in Europe.

49. Sakaki H, Nishioka M, Kanda K, Takahashi Y. An investigation of the risk factors for infection with methicillin-resistant *Staphylococcus aureus* among patients in a neonatal intensive care unit. *Am J Infect Control.* 2009 Sep;37(7):580-6.

[PubMed: PM19535174](#)

BACKGROUND: The aims of this study were to investigate the risk factors of methicillin-resistant *Staphylococcus aureus* (MRSA) infection among infants to establish effective infection control measures for neonatal intensive care unit

(NICU). METHODS: Data were prospectively collected from 961 infants hospitalized in a teaching hospital in Japan, from July 2002 through December 2005. RESULTS: Among all infants, 28 (2.9%) developed MRSA infections. **Multivariate logistic regression analyses demonstrated the risk factors for developing MRSA infections to include a low birth weight (odds ratio [OR], 0.91; 95% confidence interval [CI]: 0.93-0.99), the presence of eye mucous (OR, 6.78; 95% CI: 2.87-16.01), the practice of kangaroo mother care (OR, 3.82; 95% CI: 1.11-13.13), and the MRSA colonization rate (OR, 11.12; 95% CI: 1.32-93.89).** CONCLUSION: The risk factors for developing a MRSA infection among infants in NICU were a low birth weight, the presence of eye mucous, the practice of kangaroo mother care, and a high MRSA colonization rate. Therefore, extra attention should be given to infants in high-risk groups demonstrating a low birth weight and the presence of eye mucous and who have undergone kangaroo mother care. As a result, the cohort isolation of infants with MRSA may therefore be an effective strategy to prevent MRSA infections.

50. Shukla S, Nixon M, Acharya M, Korim MT, Pandey R. Incidence of MRSA surgical-site infection in MRSA carriers in an orthopaedic trauma unit. *J Bone Joint Surg Br.* 2009 Feb;91(2):225-8.
[PubMed: PM19190058](#)

We examined the incidence of infection with methicillin-resistant *Staphylococcus aureus* (MRSA) in patients admitted to the Leicester Royal Infirmary Trauma Unit between January 2004 and June 2006. The influence of MRSA status at the time of their admission was examined, together with age, gender and diagnosis, using multi-variant analysis. **Of 2473 patients, 79 (3.2%) were MRSA carriers at the time of admission and 2394 (96.8%) were MRSA-negative. Those carrying MRSA at the time of admission were more likely to develop surgical site infection with MRSA (7 of 79 patients, 8.8%) than non-MRSA carriers (54 of 2394 patients, 2.2%, $p < 0.001$).** Further analysis showed that hip fracture and increasing age were also risk factors with a linear increase in relative risk of 1.8% per year. MRSA carriage at admission, age and the pathology are all associated with an increased rate of developing MRSA wound infection. Identification of such risk factors at admission helps to target health-care resources, such the use of glycopeptide antibiotics at induction and the 'building-in' of increased vigilance for wound infection pre-operatively.

Risk of long term-carriage in patients who are colonized or infected with MRSA

51. Lucet JC, Paoletti X, Demontpion C, Degraeve M, Vanjak D, Vincent C, et al. Carriage of methicillin-resistant *Staphylococcus aureus* in home care settings: prevalence, duration, and transmission to household members. *Arch Intern Med.* 2009 Aug 10;169(15):1372-8.
[PubMed: PM19667299](#)

BACKGROUND: Several studies have documented prolonged colonization with hospital-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) after hospital discharge. **However, information is lacking about factors associated with prolonged MRSA colonization and MRSA transmission to household contacts.** METHODS: From February 2003 to March 2004, adult inpatients (except obstetric patients) were screened for MRSA carriage before discharge to home health care. Bivariate and multivariate analyses were performed to evaluate rates and risk factors of MRSA carriage at discharge, MRSA clearance within 1 year, and MRSA transmission to household contacts.

RESULTS: We identified MRSA in 191 of the 1501 patients screened before discharge to home health care (12.7%). Of the 148 patients with MRSA who were observed, 75 cleared the organism within 1 year, with an estimated median time to clearance of 282 days (95% confidence interval [CI], 233-313 days). Clearance of MRSA was associated with self-sufficiency in daily activities (hazard ratio, 0.63; 95% CI, 0.40-1.00) (P = .049). Of the 188 included household contacts, 36 acquired MRSA (19.1%). Factors associated with household MRSA acquisition were older age (adjusted odds ratio, 1.71 per life decade; 95% CI, 1.32-2.21) (P = .001) and participation in the health care of the index patient (adjusted odds ratio, 3.58; 95% CI, 1.33-9.62) (P = .01). **CONCLUSIONS:** Hospital-acquired MRSA carriage was common at discharge to home health care and was frequently prolonged. Transmission occurred in nearly 20% of household contacts and was associated with older age and participation in health care of the index patient. Household contacts should apply infection control measures similar to those recommended in the hospital setting.

52. Datta R, Huang SS. Risk of infection and death due to methicillin-resistant *Staphylococcus aureus* in long-term carriers. Clin Infect Dis [Internet]. 2008 Jul 15 [cited 2012 Apr 23];47(2):176-81. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2649874>
PubMed: [PM18532892](https://pubmed.ncbi.nlm.nih.gov/18532892/)

Background-Patients with newly acquired methicillin-resistant *Staphylococcus aureus* (MRSA) have significant risks of short-term morbidity and mortality due to this pathogen. **We were interested in assessing whether long-term carriers have persistent risks of disease and whether all carriers, regardless of the duration of carriage, should be considered to be reasonable candidates for interventions to reduce the risk of infection.** **Methods-**We conducted a single-center retrospective cohort study to evaluate the risk of subsequent MRSA infection and death among patients known to have harbored MRSA for at least 1 year (i.e., prevalent carriers). **Results-****Among 281 prevalent carriers, 65 (23%) developed a total of 96 discrete and unrelated MRSA infections in the year after their identification as prevalent carriers.** The most common infections were pneumonia (accounting for 39% of MRSA infections), soft-tissue infection (14%), and central venous catheter infection (14%). Twenty-four percent of all infections involved bacteremia. **Thirty-eight MRSA infections occurred during a new hospitalization, and 32 (84%) of these infections were the reason for admission to the hospital.** MRSA contributed to 14 deaths, with 6 of these deaths deemed to be attributable to MRSA. **Harboring MRSA for <2 years and MRSA colonization at the time of detection as a prevalent carrier were predictive of subsequent infection with MRSA.** **Conclusions-**Individuals who are known to have harbored MRSA for >1 year are at high risk for subsequent MRSA morbidity and mortality and should be considered to be targets for intervention, in addition to individuals who have newly acquired this pathogen.

Length of time patients remain carriers of MRSA

53. Larsson AK, Gustafsson E, Nilsson AC, Odenholt I, Ringberg H, Melander E. Duration of methicillin-resistant *Staphylococcus aureus* colonization after diagnosis: a four-year experience from southern Sweden. Scand J Infect Dis. 2011 Jul;43(6-7):456-62.
PubMed: [PM21366406](https://pubmed.ncbi.nlm.nih.gov/21366406/)

BACKGROUND: The duration of colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) is not well known and there is debate as to whether

a patient colonized with MRSA ever can be defined as 'MRSA-negative'. METHODS: Since 2003 all notified MRSA cases have been systematically followed in Skane County, southern Sweden. Cultures are taken from the nares, throat, perineum and possible skin lesions. Contact tracing is conducted. The screening program continues as long as cultures are positive and then until 1 y of consecutive negative cultures for MRSA is completed. RESULTS: **Of the 578 MRSA cases during 2003-2006, 535 were included in this retrospective study. The median duration of colonization with MRSA was 5.9 months. Having household contacts with MRSA, young age, spa-type t002 and colonization in 2 or more locations, were significantly associated with a longer duration of colonization. Having a clinical infection treated with antibiotics (compared to clinical infection with no antibiotic treatment or asymptomatic carriage) was significantly associated with a shorter carriage time. Eradication treatment was associated with a shorter carriage time.** CONCLUSION: These results may have implications for the management of patients with MRSA carriage. **The study indicates that MRSA carriage can be defined as 'negative' in a follow-up program and shows the importance of performing contact tracing among household members.**

54. Mattner F, Biertz F, Ziesing S, Gastmeier P, Chaberny IF. Long-term persistence of MRSA in re-admitted patients. *Infection* [Internet]. 2010 Oct [cited 2012 Apr 23];38(5):363-71. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2945710>
[PubMed: PM20602144](#)

BACKGROUND: A better knowledge of methicillin-resistant *Staphylococcus aureus* (MRSA) persistence in hospitalised patients may impact on specific prevention strategies. **We have investigated the persistence of MRSA-carriage in patients admitted and re-admitted to a university hospital.** PATIENTS AND METHODS: Between January 2002 and October 2005 all MRSA-positive patients admitted to the university hospital of Hannover Medical School were assessed at first admission and all subsequent re-admissions. Patients re-admitted at least once were analysed for the persistence or loss of MRSA. The association of possible factors influencing the persistence of MRSA colonisation or infection (age group, gender, decolonisation therapy during first hospital stay due to MRSA positivity and colonisation of different anatomical sites) was analysed using univariate, multivariate and time-dependent analyses. RESULTS: **A total of 1,032 patients who had tested positive at least once for MRSA were admitted to our hospital during the study period, accounting for 2,038 admissions. Of these patients, 403 (39.1%) were admitted more than once (from two times to 21 times), and 238 (59.1%) of the re-admitted patients remained MRSA positive during all subsequent admissions. Fifty-five (13.6%) patients tested MRSA negative at their last admission, and 61 (15.1%) tested MRSA negative at at least two consecutive admissions. In 27 (6.7%) patients, the MRSA status differed more than once between subsequent admissions. Overall, the half-life time (HLT) of MRSA persistence was 549 days, with the duration of persistence dependent on the colonisation of different anatomical sites (HLT only wounds 117 days; HLT mouth, throat, bronchial secretions 627 days; HLT nose, wounds and other body sites 801 days; $p < 0.01$) and was prolonged if more than one body site was MRSA-positive (HR 2.18, 95% confidence interval 1.52-3.15).** CONCLUSION: A detailed knowledge of the dynamics of the loss of MRSA infection could result in a reduction of the incidence of MRSA in the future. Multiple anatomical site carriage of MRSA appeared to predict a prolonged persistence in our cohort of patients re-admitted to a university hospital.

55. Robicsek A, Beaumont JL, Peterson LR. Duration of colonization with methicillin-resistant *Staphylococcus aureus*. *Clin Infect Dis*. 2009 Apr 1;48(7):910-3.
[PubMed: PM19231982](#)

The duration of colonization with methicillin-resistant *Staphylococcus aureus* is not well defined. **During 1564 admissions after a clinical culture or surveillance test positive for methicillin-resistant *Staphylococcus aureus*, we retested patients for methicillin-resistant *Staphylococcus aureus* colonization. During the first year after the positive culture result was obtained, 48.8% of the patients (95% confidence interval, 45.8%-51.7%) remained colonized; at 4 years, 21.2% of the patients (95% confidence interval, 13.1%-31.4%) remained colonized.**

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