# Skin and Invasive Methicillin-Resistant *Staphylococcus aureus* Infections in Indiana

January 1, 2008 to March 30, 2008

Jean Svendsen RN, BS
Sara Sczesny MPH, BS, MT(ASCP)

## Background

In the fall of 2007, the *Journal of the American Medical Association* (JAMA) published an article describing invasive Methicillin Resistant *Staphylococcus aureus* (MRSA) infections in the United States. During the same time period, three highly publicized deaths from MRSA occurred in young individuals across the United States. This resulted in increased awareness of MRSA and increased interest by some legislators and the public in MRSA being a reportable disease. To address this issue, the Indiana State Department of Health (ISDH) enacted a 90-day emergency rule requiring laboratories to report cases of skin and invasive MRSA infections.

*Staphylococcus aureus*, or Staph, is one of the most common causes of bacterial infection among humans. Infections typically occur on the skin or in soft tissue and are often referred to collectively as skin and soft tissue infections (SSTIs). SSTIs are usually minor and present as red, swollen, warm, painful pustules or boils that may accumulate pus and drain. Severe or invasive infections may arise. Invasive infections are defined as those that occur in a normally sterile body site such as blood, cerebrospinal fluid (CSF), pleural fluid, pericardial fluid, peritoneal fluid, joint/synovial fluid, bone, and internal body tissue. When Staph is present without clinical symptoms of disease, an individual is said to be colonized. It is estimated that approximately 1/3 of the population in the United States carries Staph. This may occur at various anatomical sites, but the anterior nares is the most frequent site. Staph colonization is common in both hospitalized and non-hospitalized individuals.

MRSA is a type of Staph that has developed resistance to beta-lactam drugs (penicillin, methicillin, cephalosporins, carbapenems, etc.) by blocking the binding sites of the drugs on the organism's cell wall. MRSA is not new. In fact, it has been reported around the world since the 1960's. Less than 1% of the U.S. population is believed to carry MRSA. When infections with MRSA occur, they are categorized as healthcare-associated MRSA (HA-MRSA) or community-associated MRSA (CA-MRSA). The most common types of HA-MRSA and CA-MRSA differ genetically. MRSA infections are most commonly associated with healthcare delivery. Approximately 85% of all MRSA infections in the U.S. are HA-MRSA with 2/3 having received healthcare services outside of the hospital setting while 1/3 received healthcare within the hospital setting.. The other 12-15% are CA-MRSA infections and have no obvious exposure to healthcare services. It is important to note that MRSA rates may be markedly different from one place to the next depending on the population being studied. MRSA has been investigated in the

following populations with varying rates: athletes, children, close living conditions, ethnically closed communities, the homeless, long-term rehabilitation centers, nursing homes, military recruits, men who have sex with men, and prisoners.

HA-MRSA infections are typically more serious in nature. The most common genotype of HA-MRSA is USA100. HA-MRSA infections result in longer, more expensive hospital stays and infected patients are more likely to die as a result of the infection. HA-MRSA infections are more commonly seen in people 65 years or older. CA-MRSA infections are usually SSTIs. The most common genotypes of CA-MRSA are USA300 and USA400. CA-MRSA infections are typically seen in younger populations than HA-MRSA infections. MRSA is transmitted directly via skin-to-skin contact with colonized or infected individuals or indirectly by contact with contaminated surfaces and objects. There are many risk factors for MRSA infection. Among them are the following: history of MRSA infection or colonization, history of recurrent skin infections, close contact with someone known to have MRSA, admission to a healthcare or long-term care facility within the last 12 months, antibiotic use within the last 6 months, placement of a permanent indwelling catheter or medical devices that pass through the skin, recent dialysis, weakened immune system, chronic illness, injectable drug use, incarceration within the last 12 months, crowded living conditions, participation in sports that include skin-to-skin contact or the sharing of equipment and clothing, and poor personal hygiene.

MRSA prevention is simple yet complex. Simple in that hand hygiene is the best way to prevent the transmission of MRSA and complex because prevention is dependent upon identifying the specific risk factors unique to the various populations that are at increased risk for MRSA infections. Effective prevention requires understanding of the epidemiology, pathogenesis, and transmission of MRSA. There are many approaches to MRSA prevention depending on the setting one is trying to prevent infections in. Proper hand hygiene, comprised of hand washing and the use of hand sanitizers, is the single most effective means of preventing the spread of MRSA in any setting. Methods specific to MRSA prevention in the healthcare setting include the following: active surveillance programs, antibiotic stewardship, cohorting care, contact precautions, decolonization, decontaminating shared medical equipment, maintaining appropriate staffing ratios, proper diagnosis and treatment of infections, and staff education. Prevention methods for CA-MRSA include avoiding contact with infected people's wounds and bandages, decontaminating shared equipment, educating the public on signs and symptoms of a Staph infection, following the manufacturer's guidelines when using cleaning products, not sharing personal items, promoting improved personal hygiene, and proper care and containment of infections.

With all this information in mind, ISDH desired to better understand the burden of MRSA infections in the state to determine the best course of action to take in order to address public health concerns. To accomplish this, ISDH conducted a 90 day cross-sectional study. The knowledge gained from this study was used to determine the best approach to monitoring MRSA infections in Indiana. It will be used to apply prevention initiatives that are effective in populations at higher risk for MRSA infection as well. Knowledge and awareness are essential to preventing and controlling MRSA infections in the state of Indiana. The goal of this study was to determine where resources will be most effectively used to insure that their impact will be greatest on MRSA infection prevention and control.

## Methods

In this 90 day cross-sectional study, laboratory reports of skin and invasive MRSA infections occurring from January 1, 2008 to March 30, 2008 were reported to ISDH. All reports received by April 15, 2008 were included in this study. Reports were submitted to ISDH by 84 laboratories. A case was defined as the presence of a skin or invasive MRSA infection that has been confirmed by microscopic, bacteriologic, immunologic, serologic, or other laboratory method. Active surveillance cultures were not included in this study. The following data points were requested: the testing facility's name, patient's first and last name, patient's gender, patient's date of birth or age, county of patient, provider or laboratory, site of infection, collection date, and antibiotic susceptibilities. Reports were submitted via mail, fax, and electronic submission.

Paper (mailed and faxed) reports were reviewed by 2 individuals to determine if case requirements were met. When a date of birth was not submitted, the age of the patient was subtracted from the year 2008 to determine the year of birth. Once the year of birth was determined, the day of birth defaulted to January 1 of that year. The county of the patient was determined by the patient's address. If the patient's address was not reported, the provider's address was used. In cases where neither the patient's nor the provider's address was available, the county of the laboratory was used. For skin infections, cases were placed into 1 of 13 categories based on anatomical location. See Table 1 for a summary of these categories. For invasive infections, sites were not categorized. If case requirements were not met, the report was excluded from the study. Duplicated reports were excluded as well. For this study, duplications were defined as reports of infection at the same site within 30 days of the first collection. If collection sites differed, all sites were noted as long as the case definition was met.

Paper reports were entered into a database in Microsoft Office Access 2003. Electronic reports were submitted by the Regenstrief Institute which receives data from the Indiana Network for Patient Care (INPC). These reports were routed to the Indiana National Electronic Disease Surveillance System (I-NEDSS). From there, reports were merged from I-NEDSS and Microsoft Access into a single dataset in SAS, version 9.1. The SAS program then eliminated duplicates based on same first and last patient name, date of birth, and test date. The remaining reports were assessed for specimen type and county of residence. Frequencies and percentages were calculated in SAS. Data was then placed into tables in Microsoft Office Excel 2003 to generate charts.

## Results

Over 260 hours were spent reviewing and entering data for 6,984 paper reports received during the 90 days. One thousand three hundred and seventy-three reports were initially excluded because they did not meet the case requirements. Nine hundred and fifty-two additional reports were excluded after determining that they were duplicates. A total of 4,659 paper reports were hand entered into the Access database. Fourteen thousand five hundred and forty electronic reports were received for a total of 19,199 reports in SAS. The combined reports were assessed for duplication. Ten thousand seven hundred and ninety reports were eliminated due to duplication leaving 8,409 reports. One hundred and sixty-four reports were excluded because they were not Indiana residents. Finally, an additional 2,604 reports were excluded because they did not meet the case requirements leaving a total of 5,641 reported MRSA infections for the 90 day study period. See Table 2 for a summary.

MRSA infections were reported in all Indiana counties with the highest frequencies in the most populated counties. Based on MRSA infections reported, 48% of individuals infected were males while 45% were females. Gender was not provided for 7% of the cases. Refer to Figure 1. Reported MRSA infections occurred most frequently among the following age groups: 20-29 (784), 40-49 (755), and 50-59 (728) year olds. The age groups with the least amount of MRSA cases reported were less than 1 year of age (62) and 5-9 (162) year olds. Age could not be determined for 10 cases. The distribution of reported MRSA infections for all age groups can be found in Figure 2.

Ninety-one percent of the reported MRSA infections were SSTIs and 9% were invasive infections. These findings are depicted in Figure 3. MRSA infections were reported at single sites as well as multiple sites. Reported infections were most commonly categorized as skin infections without an anatomical site specified (1,195). The most frequent categories listed for MRSA infections with an anatomical site specified are the leg (908), head (529), and buttocks (484). Figure 4 is a summation of the distribution of MRSA in Indiana by infected body site. Infections at multiple sites were noted in 50 cases. Fifty-two percent of these cases were SSTIs at multiple sites, 44% were a combination of an invasive infection and a SSTI, and 4% were invasive infections at multiple sites. See Figure 5 for a representation of this data. Susceptibility patterns were reported in only 44% of cases. No further analysis was performed since the data was not consistently reported.

Looking at invasive MRSA infections more closely, blood was by far the most frequent site reported, more infections occurred in males, and infections occurred more often in older populations. Blood stream infections accounted for 406 of the 525, or approximately 77%, invasive MRSA infections. Refer to Figure 6 for frequencies of all invasive sites reported. Males accounted for 55% of all invasive MRSA infections while women accounted for 36%. Gender was not provided for the other 9% of infections. Refer to Figure 7. Invasive MRSA infections were most frequently reported in the following age groups: 50-59 (102), 60-69 (90), 70-79 (85), and 80+ (101) years old while invasive infections were reported the least in the 5-9 (3) and 10-19 (7) year old age groups. To see the frequency of invasive MRSA infections in all age groups, refer to Figure 8.

## Discussion

Overall, the process of this study was very time consuming. There were 21,524 reports received during the 90 days. Reports were received by paper and electronically in a multitude of formats resulting in missing data points. At least 20 hours per week, in addition to normal workloads, was required for reviewing and entering reports into the database. This time allotment does not include any time spent addressing electronic reports or phone calls regarding reporting. There were many reports (3,977) that were excluded because they did not meet the case requirements. Cases commonly excluded were urine, respiratory, and genital cultures, nasal swabs, mouth, puss, tubing, pumps, catheters, drainage, dialysates, non-sterile fluids, non-Indiana residents, and no sources given. Receiving both electronic and paper reports resulted in many duplicate reports (11,742) that were ultimately excluded. As expected, the highest frequencies of MRSA infection occurred in counties (Allen, Lake, Marion, Saint Joseph, Vanderburgh) with the largest cities in the state.

In general, MRSA infections were evenly distributed between males and females. This finding is consistent with other MRSA studies. MRSA infections most commonly occurred in 20-29 year olds and individuals age 40-59. These findings were unexpected. Although the study was unable to differentiate HA-MRSA and CA-MRSA, typically HA-MRSA is more common in older populations while CA-MRSA is more common in younger populations. If this held true for the Indiana's population, one would expect to see higher frequencies among the young and the elderly. Instead frequencies were highest among the age groups between the young and elderly.

An overwhelming majority of reported cases were SSTIs. Only 9% of MRSA infections were invasive in nature. This is consistent with findings in other studies. Unfortunately, infection sites were not consistently categorized on reports. The most frequent category of MRSA infection was skin without any anatomical site specified. This accounted for just over a fifth of all cases. Had these cases been better categorized prior to submission to ISDH, a clearer picture of the burden of MRSA infections could have been achieved. Results for invasive MRSA infections were similar to findings in other studies. The most common type of invasive MRSA was bacteremia. More cases of invasive MRSA infections were reported in males than females, and the elderly experienced more invasive infections than younger age groups. These findings were expected. Even though susceptibility patterns were to be reported, less than half of the cases reported included this information. This information would have helped to better describe the burden of MRSA infections in Indiana.

## Conclusion

Unfortunately, the findings of this study did not provide much insight about several significant factors regarding the burden of MRSA infections. The study did not differentiate HA-MRSA from CA-MRSA nor was severity of infection noted. The study did not establish risk factors for Indiana residents either. Antimicrobial susceptibility patterns were not studied due to the low number of laboratories reporting this data point. What the study did show was that nearly all the findings were consistent with what is already known about MRSA infections. More importantly, the study brought to light problems with the way the data was submitted. This is very important because it allows for the development and implementation of a more useful way to study the burden of MRSA infections in the state of Indiana. Most cases of MRSA infections in Indiana were SSTIs, which are typically not life threatening. Invasive MRSA infections on the other hand are life threatening. Invasive HA-MRSA infections are typically already being addressed by healthcare professionals. This does not hold true for most invasive CA-MRSA infections. These are the cases that appear in the media and cause panic. The public wants to know what the health department is doing about the problem when these stories appear in the media. These concerns can be addressed by studying severe CA-MRSA infections in the state.

The best approach to studying severe CA-MRSA would be to develop an electronic case report so that all healthcare professionals would be submitting the exact same form with the exact same data points. This would eliminate reports that do not meet case requirements, eliminate report duplication between paper and electronic submission, and eliminate missing data points which are all issues with the current study. The first step on the form should be to determine if a suspected case actually meets the case definition for a severe CA-MRSA infection. Next, demographic and clinical information

should be collected so that the severity of these cases can be accurately described. Thorough laboratory information should be collected including antimicrobial susceptibility patterns. Based on this study, the most effective way to use ISDH resources would be to narrow the case definition down to severe CA-MRSA infections, develop an electronic report submission form, and continue to focus efforts on prevention of MRSA infections.

Table 1- MRSA Infection Site Categories

| Category | Reported Site of Infection |
|---|---|
| Head | Cheek, chin, ear, eye, eyebrow, face, forehead, head, jaw, lacrimal duct, lip, mandible, neck, nose, scalp, temple |
| Axilla | Armpit, axilla |
| Chest | Breast, chest, clavicle, nipple, sternum, thoracic fluid, trunk |
| Abdomen | Abdomen, abdominal fluid, abdominal wall, peg site, stomach, suprapubic, umbilicus |
| Arm | Arm, biceps, elbow, forearm, shoulder, wrist |
| Hand | Digit, finger, hand, thumb |
| Buttocks | Buttocks, coccyx, gluteal, gluteus, perianal, perirectal, rectum, sacrum |
| Back | Back, flank, lumbar, scapula, trunk |
| Hip | Hip, ischial, pelvis, pubis |
| Groin | Cervix, genitals, groin, inguinal, labia, penis, perineum, scrotum, testicle, vagina |
| Leg | Above/below knee amputation, ankle, calf, knee, leg, lower extremity, shin, stump, tibia, thigh |
| Foot | Foot, hallux, heel, metatarsal, toe |
| Skin (no anatomical site specified) | Abscess, boil, carbuncle, cyst, furuncle, incision, lesion, pustule, skin, surgical site, ulcer, wound |

Table 2- Report Inclusion Summary

| | |
|---|---|
| Paper reports | 6984 |
| Excluded based on case definition | -1373 |
| Duplicate reports | -952 |
| Remaining paper reports | 4659 |
| Electronic reports | +14540 |
| Total reports | 19199 |
| Duplicate reports | -10790 |
| Non-Indiana residents | -164 |
| Excluded based on case definition | -2604 |
| Total reports at 90 days | 5641 |

Figure 1- Reported SSTI and Invasive MRSA Infections in Indiana by Gender, January 1, 2008 to March 30, 2008

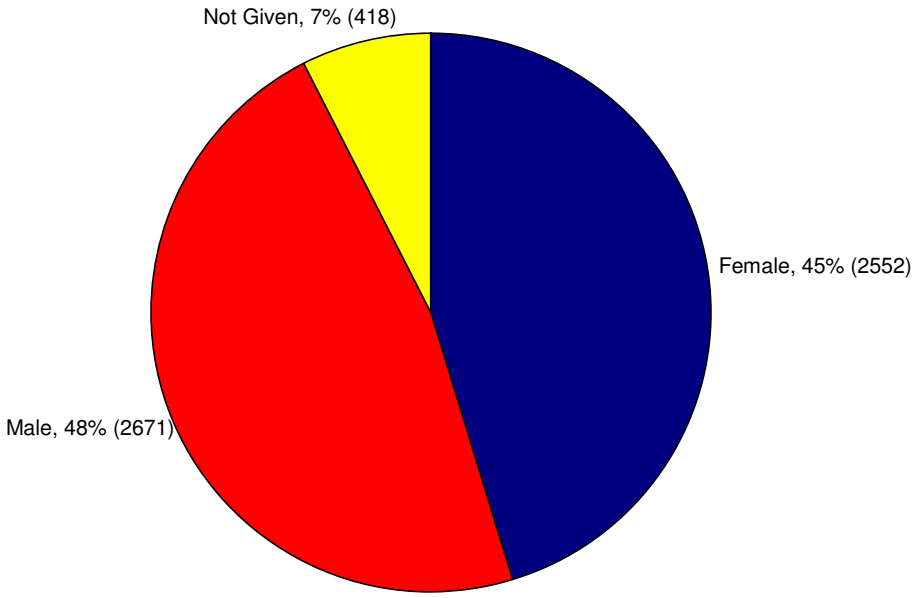


Figure 2- Distribution of MRSA Infections in Indiana by Age, January 1, 2008 to March 30, 2008

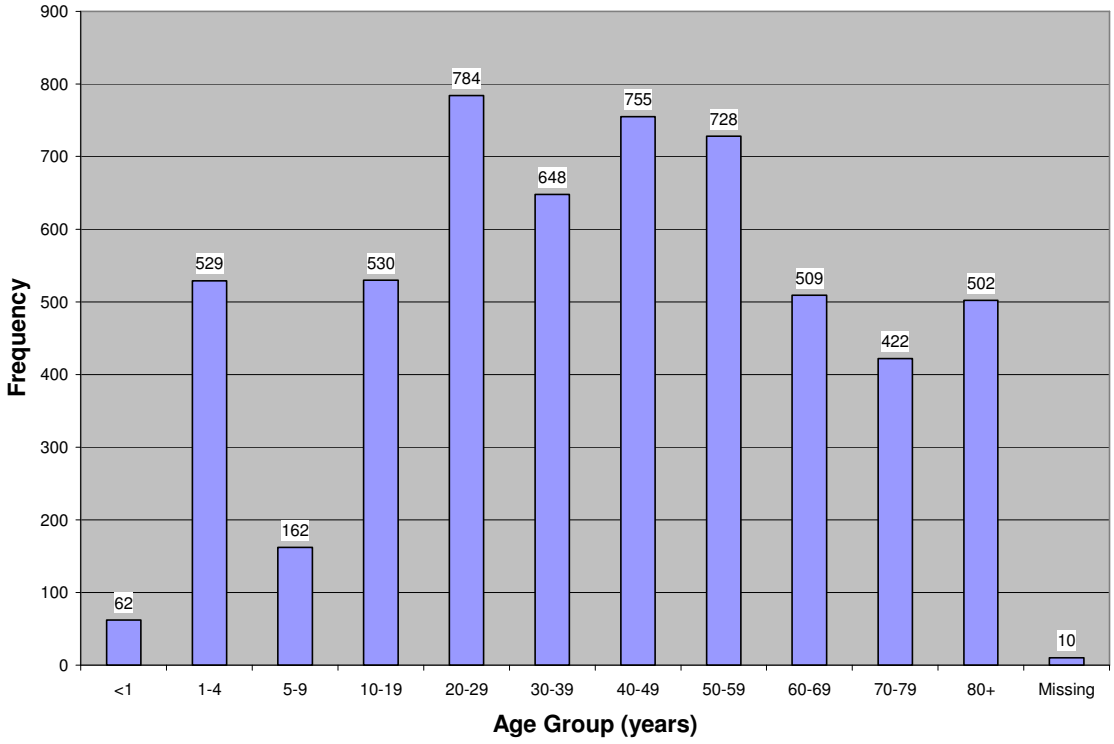


Figure 3- SSTI and Invasive MRSA Infections Reported in Indiana, January 1, 2008 to March 30, 2008

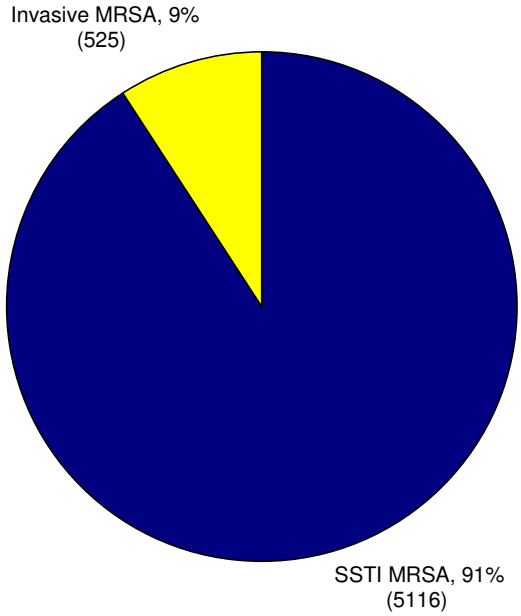


Figure 4- Distribution of MRSA Infections in Indiana by Infected Body Site, January 1, 2008 to March 30, 2008

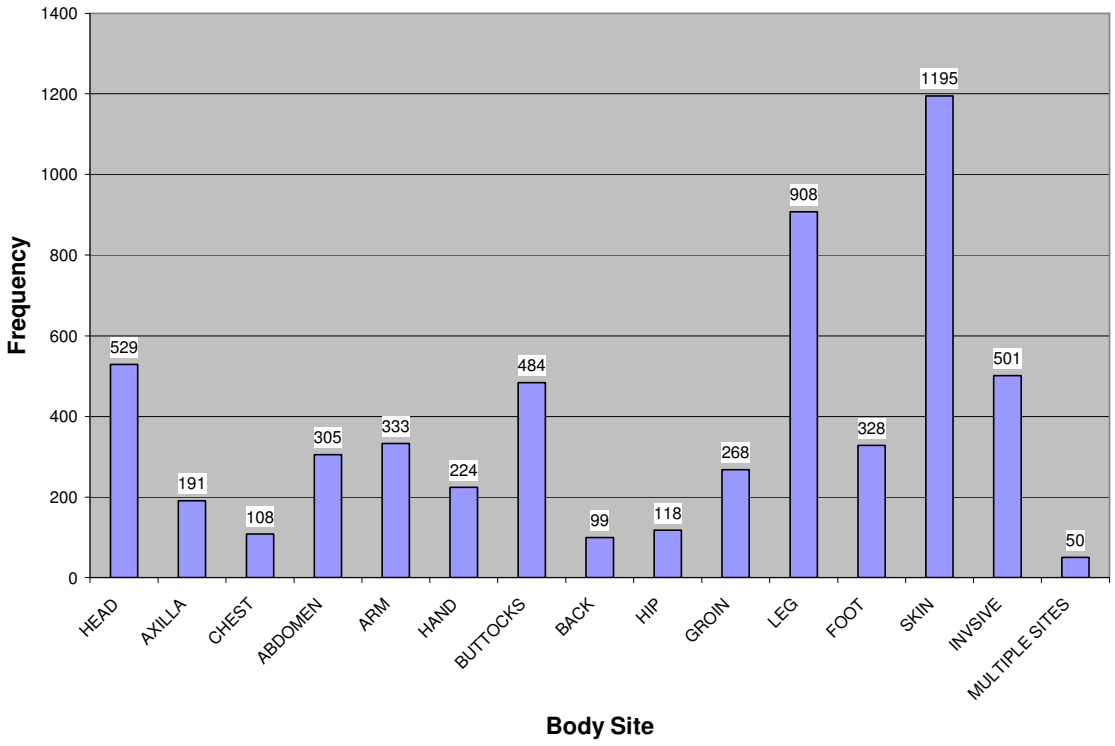


Figure 5- Distribution of MRSA Infections Occurring at Multiple Sites in Indiana, January 1, 2008 to March 30, 2008

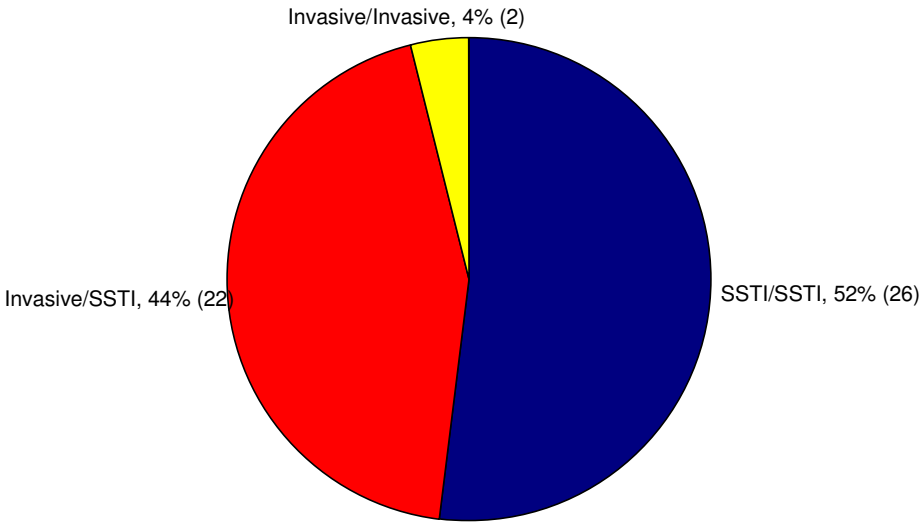


Figure 6- Distribution of Invasive MRSA Infections in Indiana by Body Site, January 1, 2008 to March 30, 2008

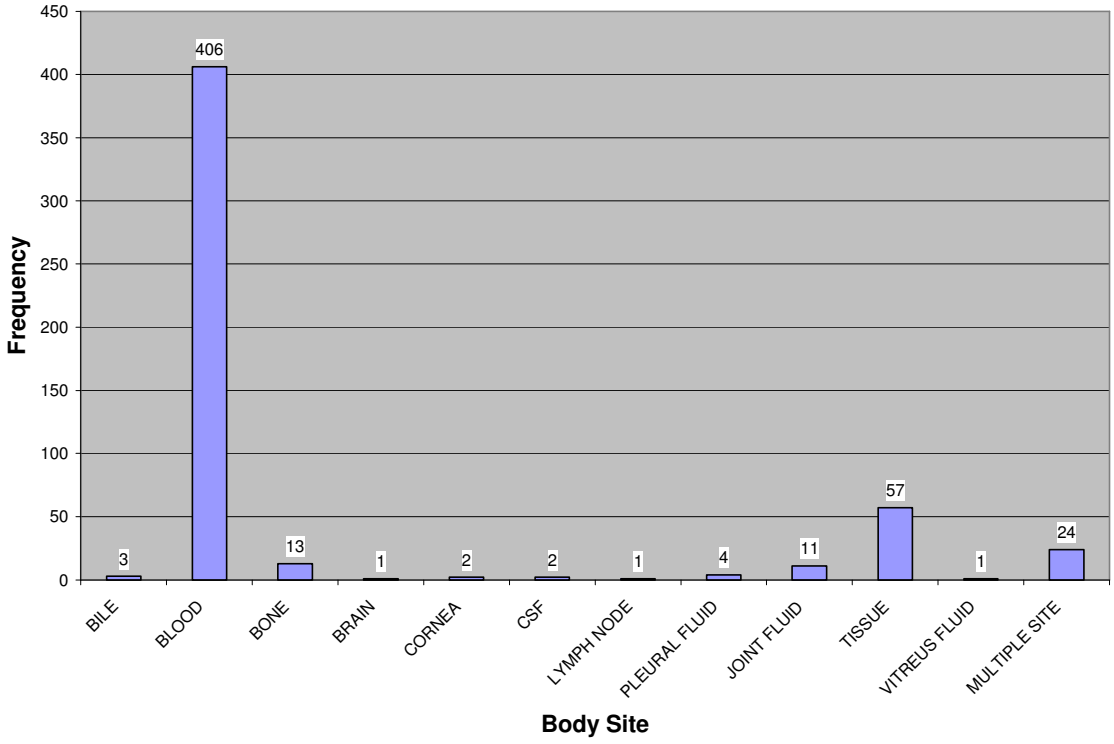


Figure 7- Invasive MRSA Infections in Indiana by Gender, January 1, 2008 to March 30, 2008

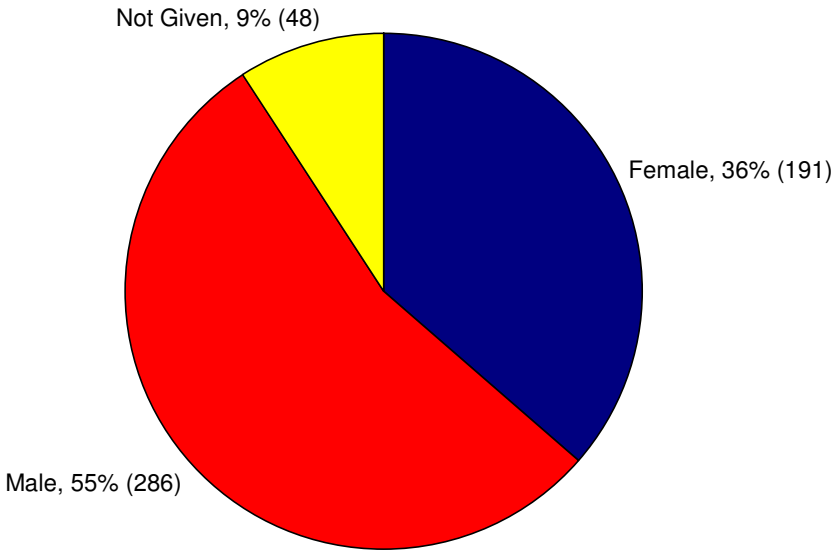
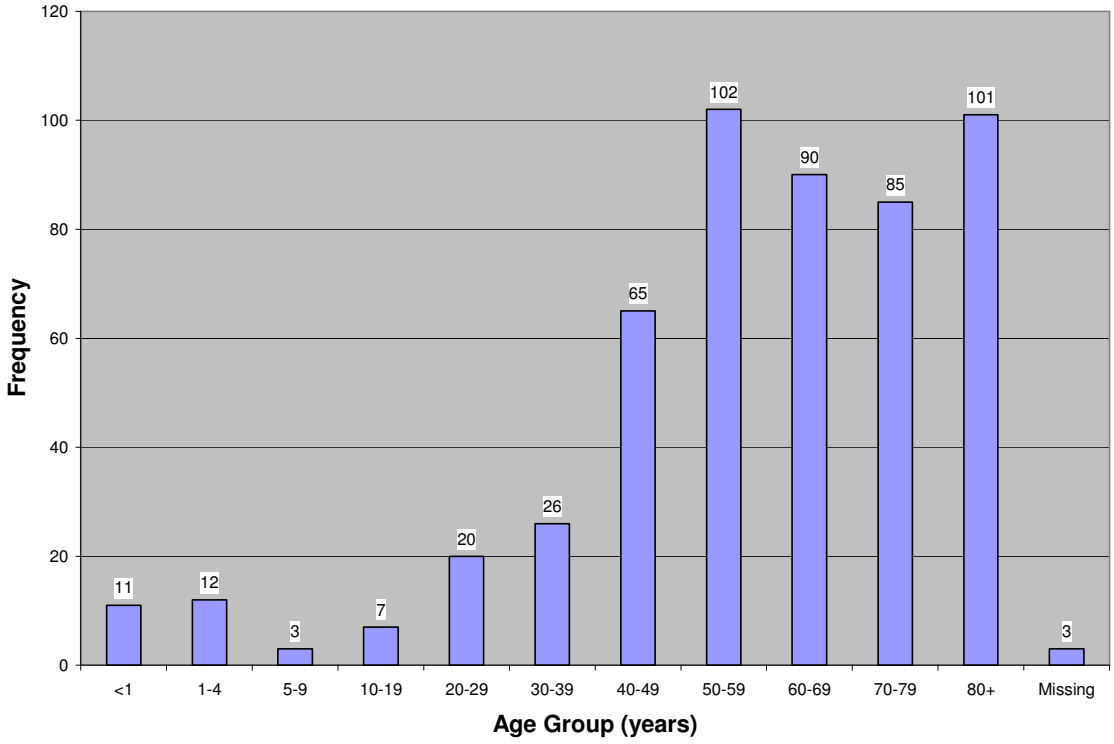


Figure 8- Invasive MRSA Infections in Indiana by Age Group, January 1, 2008 to March 30, 2008



References

Association for Professionals in Infection Control and Epidemiology, Inc. (APIC). *Guide to the Elimination of Methicillin-Resistant Staphylococcus aureus (MRSA) Transmission in Hospital Setting*. (2007). Retrieved February 26, 2008 from http://www.apic.org/content/NavigationMenu/GovernmentAdvocacy/MethicillinResistantStaphylococcusauresMRSA/Resources/MRSAguide.pdf

Beam, J.W. and Buckley, B. (2006). Community-acquired methicillin-resistant *Staphylococcus aureus*: Prevalence and risk factors, *Journal of Athletic Training*, 41, 337-40.

Buck, J.M., Como-Sabetti, K., Harriman, K.H., Danila, R.N., Boxrud, D.J., Glennen, A. et al. (2005). Community-associated methicillin-resistant *Staphylococcus aureus*, Minnesota 2000-2003. *Emerging Infectious Diseases*, 11, 1532-8.

Centers for Disease Control and Prevention (CDC). CA-MRSA: Public FAQs. Retrieved on February 16, 2008 from http://www.cdc.gov/ncidod/dhqp/ar_mrsa_ca_public.html

CDC. Fact Sheet: Invasive MRSA. Retrieved on February 16, 2008 from http://www.cdc.gov/ncidod/dhqp/ar_mrsa_Invasive_FS.html

CDC. MRSA in Healthcare Settings. Retrieved on February 16, 2008 from http://cdc.gov/ncisos/dhqp/ar_MRSA_spotlight_2006.html

Davis, S.L., Perri, M.B., Donabedian, S.M., Manierski, C., Singh, A., Vager, D. et al. (2007). Epidemiology and outcomes of community-associated methicillin-resistant *Staphylococcus aureus* infection. *Journal of Clinical Microbiology*, 45, 1705-11.

Farley, J.E. (2008). Epidemiology, clinical, manifestations, and treatment options for skin and soft tissue infections caused by community-acquired methicillin-resistant *Staphylococcus aureus*. *American Academy of Nurse Practitioners*, 20, 85-92.

Graham III, P.L., Lin, S.X., and Larson, E.L. (2006). A U.S. population-based survey of *Staphylococcus aureus* colonization. *Annals of Internal Medicine*, 144, 318-25.

Griffin, F.A. (2007). Reducing Methicillin-Resistant *Staphylococcus aureus* (MRSA) infections. *The Joint Commission Journal on Quality and Patient Safety*, 33, 726-31.

Henderson, D.K. (2006). Managing methicillin-resistant staphylococci: A paradigm for preventing nosocomial transmission of resistant organisms. *American Journal of Infection Control*, 34, S46-54.

Klevens, R.M., Morrison, M.A., Nadle, J, Petit, S., Gershman, K., Ray, S., et al. (2007). Invasive methicillin-resistant *Staphylococcus aureus* infections in the United States. *Journal of the American Medical Association*, 298, 1763-71.

Kuehnert, M.J., Kruszon-Moran, D., Hill, H.A., McQuillan, G., McAllister, S.K., Fosheim, G., et al. (2006). Prevalence of *Staphylococcus aureus* nasal colonization in the United States, 2001-2002. *The Journal of Infectious Diseases*, 193, 172-9.

Maree, C.L., Daum, R.S., Boyle-Vavra, S., Matayoshi, K. and Miller, L.G. (2007). Community-associated methicillin-resistant *Staphylococcus aureus* isolates causing healthcare-associated infections. *Emerging Infectious Diseases*, 13, 236-42.

Naimi, T.S., LeDell, K.H., Como-Sabetti, K., Borchardt, S.M., Boxrud, D.J., Etienne, J. et al. (2003). Comparison of community and health care-associated methicillin-resistant *Staphylococcus aureus* infection. *Journal of the American Medical Association*, 290, 2976-84.

Rim, J.Y. and Bacon III, A.E. (2007). Prevalence of community-acquired methicillin-resistant *Staphylococcus aureus* colonization in a random sample of healthy individuals. *Infection Control and Hospital Epidemiology*, 28, 1044-6.

Sabol, K.E., Echevarria, K.L., and Lewis II, J.S. (2006). Community-associated methicillin-resistant *Staphylococcus aureus*: New bug, old drugs. *The Annuals of Pharmacotheraphy*, 40, 1125-33.

Siegel, J.D., Rhinehart, E., Jackson, M., and Chiarello, L. (2006). *Management of Multidrug-Resistant Organisms in Healthcare Settings*. Retrieved February 26, 2008 from www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf