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# Geographic information system localization of community-acquired MRSA soft tissue abscesses

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Geographic information system;
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**Abstract**

**Background:** Soft tissue infections with methicillin-resistant *Staphylococcus aureus* (MRSA) pose an ever-increasing risk to children in the community. Although historically these infections were limited to children with prolonged hospitalization, the authors have seen an increase in community-acquired infections in children without identifiable risk factors. The goal of this study is to determine the incidence of truly community-acquired MRSA soft tissue infections in our community and geographically map regions of increased risk.

**Methods:** After obtaining the institutional review board's approval, a retrospective chart review was conducted on 195 patients records who underwent an incision and drainage of soft tissue infections from January 1, 2000, to December 31, 2003. Thirteen patients were excluded from the study because no cultures were taken at the time of incision and drainage.

**Results:** The most common organism isolated from wound culture was *S aureus*, 40% (73/182), of which 45% (33/73) were MRSA. Eighty-one percent (27/33) of MRSA infections were in Springfield, 1 of 18 towns represented in the patient population. Geographic information system analysis identified a significant MRSA cluster 1.96 km in diameter within the city of Springfield.

**Conclusions:** Geography proved to be a significant risk factor for presenting with MRSA infection. Geographic maps of antibiotic resistance can be used to guide physician antibiotic selection before culture results are available. This has significant implications for the health care provider in proper antibiotic selection within the community.



The role of *Staphylococcus*, or *Micrococcus*, in the pathogenesis of abscesses was originally characterized by Ogston in 1882 [1]. *Staphylococcus aureus* remains an important and dangerous human pathogen. Methicillin-resistant *S aureus* (MRSA) was first reported in 1968 [2]. Historically, the risk factors associated with MRSA infections included prolonged exposure to antibiotics, critical illness, and extended hospitalization [3]. Methicillin-resistant *S aureus* infections have been described to originate from nosicomial reservoirs. It has been demonstrated that by eradicating the nosicomial pool within a nursery, MRSA colonization and infection of infants could be significantly curtailed [4].

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One of the first references appreciating MRSA as a community-acquired pathogen was in 1989 [5]. Over the last decade of the 20th century, the incidence of community-acquired MRSA infections has significantly increased, accounting for 259 of every 100 000 hospital admissions from 1993 to 1995 [6]. In the 21st century, the incidence of methicillin resistance in community-acquired staphylococcal infections in children has been reported to range from 33% to 40% [7,8].

As many as 70% of children with community-acquired MRSA infections have no identifiable risk factors [6]. The goal of this study is to report the incidence of community-acquired MRSA soft tissue abscesses in our community and determine whether geography can be identified as a specific risk factor.

## 1. Methods

After obtaining the institutional review board's approval, a retrospective chart review was conducted on 195 patient records. These patients selected had an incision and drainage procedure performed on a soft tissue infection by one group of pediatric surgeons between January 1, 2000, and December 31, 2003. The patient group included inpatients, emergency room consults, and office patients. Children known to have underlying medical conditions that predisposed to recurrent hospitalization for soft tissue infections, such as pilonidal disease, hydradenitis, and perirectal disease, were not included in the study. Thirteen patients were excluded from the study because cultures were not obtained at the time of the original incision and drainage.

Age, sex, site of infection, home address, and culture results were recorded for all patients. The sites of soft tissue infections were compared by $\chi^2$ analysis.

Geographic information system (GIS) analysis was performed on the children with *S aureus* infections. The addresses of the children were geo-coded, assignment of a specific latitude and longitude coordinate. Geo-coding was performed in Arc GIS from ESRI (Environmental Services Research Institute, Redlands, Calif) using GDT Dynamap/2000 v14.1 (Geographic Data Technology, Lebanon, NH) Two addresses could not be geo-coded because an appropriate address was not available in the patient records, PO box only. Addresses were also mapped with ArcGIS. The presence of clustering was analyzed with the spatial scan statistic [9] using SatScan software [10] (http://www.satscan.org, Boston, Mass). The spatial scan statistic imposes an infinite number of circular windows on a map that vary in both size and location. There are 3 different mathematical models to test the statistical significance of the potential cluster windows. The Bernouli model was most appropriate for this study as a group of controls, methicillin-sensitive *S aureus* (MSSA), was compared to the group of cases (MRSA).

## 2. Results

The age of patients in the study ranged from 15 days to 22.34 years with a mean age of 9.36 years. The male-to-female ratio for the study population was 1:1.

The most common isolated organism was *S aureus*. This was present in 73 (40%) of 182 cases reviewed. Fifty-two (29%) of the cultures had no growth. Twenty-six (14%) of the cultures grew *Staphylococcus nonaureus*. The next 2 most frequently observed organisms in the population were 5 (3%) group A *Streptococcus* and 5 (3%) *Klebsiella pneumoniae*.

Of the *S aureus* isolates, 45% (33/73) were methicillin-resistant. The mean age for the MRSA group was 9.5 years (range, 0.6-17.4 years). The male-to-female ratio for this group was 1.4:1. The remaining 55% of the isolates (40/73) were MSSA. The mean age for the MSSA group was 9.72 years (range, 0.5-21.4 years). The male-to-female ratio for the MSSA group was 1:1. The difference in the mean ages between these 2 groups was not statistically significant by 2-tailed Student *t* test ($P = .891$). There was no significant difference between the male/female ratios of the 2 groups by $\chi^2$ analysis ($\chi^2 = 0.42$).

The incidence of MRSA and MSSA by body region is tabulated in Table 1. There was a statistically significant increase in the incidence of methicillin resistance in the buttock region, and there was a statistically significant increase in the incidence of methicillin sensitivity in lower extremity infections.

The 73 children with staphylococcal soft tissue infections had resident addresses over 18 different cities and towns in the Western Massachusetts region serviced by one group of pediatric surgeons. Fifty-six percent (41/73) of the children resided in the city of Springfield, but 79% (26/33) of the children with MRSA infections resided in Springfield. The difference in this distribution was statistically significant by $\chi^2$ analysis ($\chi^2 = 12.5$).

**Table 1** Distribution of *Staphylococcus* soft tissue infections

| | Total | Head and neck | Trunk | Upper extremity | Lower extremity | Axilla | Groin | Buttock |
|---|---|---|---|---|---|---|---|---|
| MSSA | 40 | 12% (5) | 10% (4) | 15% (6) | 35% (14) | 15% (6) | 7.5% (3) | 5% (2) |
| MRSA | 33 | 6% (2) | 12% (4) | 6% (2) | 9% (3) | 30% (10) | 9% (3) | 27% (9) |
| $\chi^2$ | | 0.86 | 0.08 | 1.48 | 6.79* | 2.47 | 0.06 | 7.01* |

$\chi^2 > 3.84$ correlates to a $P < .05$.

* Statistically significant.

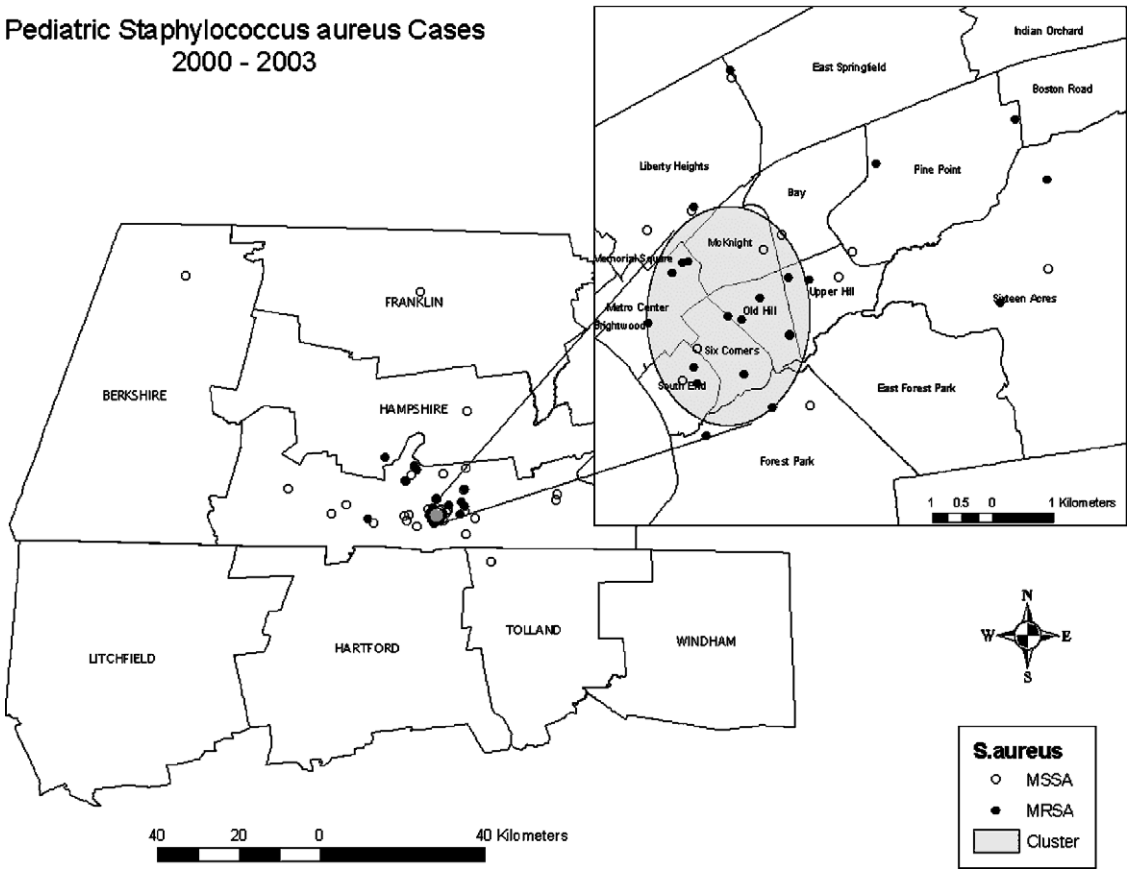


**Fig. 1** Home addresses for 70 children with *S aureus* soft tissue infections are mapped in the western Massachusetts region. The city of Springfield and its neighborhoods are enlarged. The MRSA cluster identified encompasses significant regions of 5 adjoining neighborhoods.

The addresses for the 70 children with *S aureus* soft tissue infections were geo-coded and mapped (Fig. 1). A statistically significant cluster of 30 children, 21 MRSA cases, were identified using SaTScan encompassing nearly 5 neighborhoods of Springfield (Fig. 1). The region was 1.80 km in diameter centered about 42.105072N latitude by 72.572845W longitude ($P = .047$).

## 3. Discussion

The importance of geographic relationships between causative agents and disease is frequently underappreciated in understanding illness [11]. With the increasing availability of computational computer power, collections of GIS analysis software, and databases of precise geographic data the field of medical geography is expanding rapidly [12]. The availability of the tools to map disease allows the investigator to discover the causes for geographic variations [13]. These causes of geographic variations in disease are potential previously unidentified risk factors. A patient's home and work addresses are available pieces of information before history, physical, or laboratory tests are taken. Maps of geographic risk factors can give the physician important insight into a patient's differential diagnosis before the results of special studies such as laboratory tests and radiological imaging are available.

Traditional risk factors associated with MRSA colonization and infections such as prolonged hospitalization, extended exposure to antibiotics, and critical illness do not apply to community-acquired cases [6]. Other factors such as a history of other family members exposure to MRSA or family members working in the health care industry may play a more important role. In this study, a significant cluster of community-acquired MRSA soft tissue infections were identified. This supports the hypothesis of geography playing an important role as a risk factor. The Springfield cluster identified had an overall relative risk of 1.5 for MRSA when compared to the remainder of the population.

Considering the significance of geography in this study, we propose that the single most important risk factor for developing a community-acquired MRSA soft tissue abscess is initial colonization with MRSA from the community. It is now possible to identify children at an increased risk of MRSA soft tissue infections by graphing their home addresses on the map created in this study. Once the choice has been made to initiate antibiotic therapy, our map of methicillin sensitivity in the Springfield region of Massachusetts can be used to guide antibiotic selection before culture results would be available. In fact, the geographic

information is available before incision and drainage. With the prospective collection of data on antibiotic sensitivity and geography, maps of increasing accuracy and usefulness could be created and modified on a yearly or monthly basis.

We plan on sharing data with public health agencies of our region to facilitate the implementation of effective preventative measures. Attempts to control outbreaks of MRSA in the community can become catastrophic failures if the extent of the reservoir is underestimated [14]. Mapping of MRSA clusters in the community can help distinguish between de novo cases and local spread. This information is essential for planning effective strategies toward limiting the reservoir of MRSA in the community [15]. An effective strategy for preventing MRSA soft tissue infections will include focusing available resources on neighborhoods in the community known to have higher rates of colonization. Although MRSA colonization is difficult to irradiate, interventions such as hygiene education and daily bathing can effect a dramatic decrease in the overall incidence of soft tissue infections. Continuing to map MRSA cases over time will track and document the effectiveness of preventative interventions.

In conclusion, colonization of the community with MRSA has been found to be a significant risk factor for children presenting with MRSA soft tissue abscesses. Geocoding and mapping of their home addresses can identify children who are at an increased risk of having an antibiotic-resistant infection.

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## Discussion

*Daryl Cass, MD, FAAP (Houston, TX):* Unfortunately, we see a large number of abscesses at our institution, and our numbers seem to be somewhat different. About 80% of the abscesses that come in from the community have MRSA, and we are now seeing some *S aureus* that are clindamycin and bactrim resistant. So it seems that there are significant regional variations.

*Michael V. Tirabassi, MD (Springfield, MA):* Yes, it is very much regionally dependent. In our community, we are starting to see a lot of MRSA, but not a majority yet, so by implementing strategies like this, we can better identify children at risk. Once you start to see very high rates like you do, like I think that this information would be of no value in Houston whatsoever, because your resistance rate is so high GIS is of limited usefulness. You undoubtedly have to employ empiric coverage for MRSA on nearly all of the children to whom you give antibiotics. But in communities with a lower incidence, by using mapping technology like this, you can better direct antibiotic therapy and give the broader coverage for MRSA to children that are higher risk.

*Deborah Loeff, MD, FAAP (Chicago, IL):* Anecdotally, we are seeing very similar occurrences of MRSA in buttock and groin abscesses too. I work at two different hospitals about 30 miles apart, and we're seeing the same type of incidence. Do you have any thoughts as to what has been changing epidemiologically with the observations of MRSA?

*Michael V. Tirabassi, MD (Springfield, MA):* Well, showing, at least in our community, where there's a geographic risk factor, we have to say that unfortunately this is part of the normal colonization of the community, and I think that whatever happens that leads you to develop an abscess, whether it be an insect bite or a breakdown of the tissue skin barrier, the initial infectious organism is going to be one that's initially colonizing the area. We have specific communities in our town now where MRSA is very common. I am sure if I went into the high-risk communities and cultured everybody's skin, a number of cultures would be positive for MRSA. I think it's just something that we have to deal with at this point.

They're not getting it at the hospital anymore, or it's gotten out of the hospital. Hopefully it doesn't continue to get worse.

*Naomi Golonka, MD (Houston, TX):* I just want to reiterate what Dr Cass said, and I'm actually looking at some of these patients in a study. We probably had close to 5000 of these over a 3-year period, probably about 3200 of whom were actually community acquired and never had abscesses before. Sheldon Kaplan, our infectious disease specialist, is very concerned about this because this number is exponentially growing. He said the only thing that's really helped the worse infections is a Clorox bleach bath two or 3 times a day.