Introduction
The Centers for Disease Control and Prevention (CDC) have identified methicillin-resistant *Staphylococcus aureus* (MRSA) as an emerging health risk and have posted guidelines to prevent outbreaks among athletes (CDC, 2010a, 2010b; Gorwitz, Jernigan, & Jernigan, 2006; Strout, 2006). MRSA is a group of bacteria that are resistant to treatment with methicillin. Two types of MRSA are identified in the literature: hospital-associated MRSA (HA-MRSA) and community-associated MRSA (CA-MRSA) (Beam & Buckley, 2006; Begier et al., 2004; CDC, 2010a; Claudio, 2008; Gorwitz et al., 2006; Romano, Lu, & Holtom, 2006; Samuels, 2007; Strout, 2006; Weiner, 2008). The CDC has worked with many agencies to develop an international definition of CA-MRSA, which includes the following criteria: the athlete a) is in an outpatient setting; b) has no history of previous MRSA infection; c) has no history of hospitalization, nursing home, skilled nursing facility, or hospice in the past year; d) has no history of dialysis or surgery in the past year; e) has no permanent indwelling catheter or medical device through the skin; and f) is an otherwise healthy individual (Gorwitz et al., 2006; Levenhagen, 2008; Mississippi State Department of Health, 2007, 2009). An increase in CA-MRSA outbreaks has been noted in basketball, football, rugby, volleyball, and wrestling athletes (Beam & Buckley, 2006; Begier et al., 2004; Fagan, 2005; Gorwitz et al., 2006; Guttman, 2008; Hawkes et al., 2007; Levenhagen, 2008; Mississippi State Department of Health, 2007; Romano et al., 2006; Salgado, Calfee, & Farr, 2003; Stevens, Bearman, Rosato, & Edmond, 2008; Strout, 2006; Weiner, 2008). Among athletes, CA-MRSA may be spread from a) skin-to-skin contact with open abrasions or a contaminated person; b) surface-to-skin contact with contaminated treatment tables, sports equipment, synthetic turf, locker room (LR) or restroom surfaces, therapeutic whirlpools and exercise equipment, stethoscopes, or blood pressure cuffs; or c) sharing personal items, such as towels, razors, soap, and clothing (Beam & Buckley, 2006; Begier et al., 2004; Claudio, 2008; Fagan, 2005; Gorwitz et al., 2006; Levenhagen, 2008; Mississippi State Department of Health, 2009; Romano et al., 2006; Salgado et al., 2003; Sampathkumar, 2007; Sedgwick et al., 2007; Stevens et al., 2008; Strout, 2006; Weiner, 2008).

Abstract
Methicillin-resistant *Staphylococcus aureus* (MRSA) is a group of bacteria resistant to antibiotic treatment. Open abrasions, therapeutic whirlpools, treatment tables, locker rooms (LR), and athletic equipment are identified as potential areas of transmission in athletic training rooms (ATR) and LR facilities. To determine the prevalence of MRSA and to identify control measures in ATR and LR, the authors collected samples from nine surfaces at seven high schools over a four-month period. Initial analyses considered both suspected colonies and confirmed MRSA colonies with analyses of variance revealing significant differences of suspected colonies based on regular cleaning product and facility surface. Further results, however, focused on MRSA colonies as the primary variable, rather than suspected colonies. Results indicate a need for more effective cleaning products and schedules in LRs.

to HA-MRSA athletes, whose immune systems may be compromised by other health conditions (Sedgwick, Dexter, & Smith, 2007). Both strains of MRSA can cause serious health problems, however, if not recognized and treated in a timely and appropriate manner (Mississippi State Department of Health, 2007, 2009). In an effort to educate the public about MRSA, Hawkes and co-authors (2007) and Sampathkumar (2007) identified the “5 Cs of transmission” (Crowded living, skin-to-skin Contact, Compromised skin, Contaminated personal items, and lack of Cleanliness).

An increase in CA-MRSA outbreaks has been noted in basketball, football, rugby, volleyball, and wrestling athletes (Beam & Buckley, 2006; Begier et al., 2004; Fagan, 2005; Gorwitz et al., 2006; Guttman, 2008; Hawkes et al., 2007; Levenhagen, 2008; Mississippi State Department of Health, 2007; Romano et al., 2006; Salgado, Calfee, & Farr, 2003; Stevens, Bearman, Rosato, & Edmond, 2008; Strout, 2006; Weiner, 2008). Among athletes, CA-MRSA may be spread from a) skin-to-skin contact with open abrasions or a contaminated person; b) surface-to-skin contact with contaminated treatment tables, sports equipment, synthetic turf, locker room (LR) or restroom surfaces, therapeutic whirlpools and exercise equipment, stethoscopes, or blood pressure cuffs; or c) sharing personal items, such as towels, razors, soap, and clothing (Beam & Buckley, 2006; Begier et al., 2004; Claudio, 2008; Fagan, 2005; Gorwitz et al., 2006; Levenhagen, 2008; Mississippi State Department of Health, 2009; Romano et al., 2006; Salgado et al., 2003; Sampathkumar, 2007; Sedgwick et al., 2007; Stevens et al., 2008; Strout, 2006; Weiner, 2008).
Infection control measures in the delivery of health care are vitally important to protect all high-risk groups, including athletes, from CA-MRSA (Romano et al., 2006). The CDC (2010b) and others emphasize good personal hygiene as the key to prevention and control of CA-MRSA outbreaks (Beam & Buckley, 2006; Gorwitz et al., 2006; Guttman, 2008; Mississippi State Department of Health, 2007, 2009, Strout, 2006). Such practices among athletic groups include frequent hand washing, covering abrasions or seeping wounds, disallowing athletes with open wounds in whirlpools or saunas, discouraging shared personal items, requiring showers after all practices and games, wearing sandals in showers, isolating athletes who have infections, and washing protective gear after each use (Adams, 2008; Beam & Buckley, 2006; CDC, 2010a; Fagan, 2005; Gorwitz et al., 2006; Guttman, 2008; Hawkes et al., 2007; Mississippi State Department of Health, 2007, 2009; Romano et al., 2006; Salgado et al., 2003; Sampathkumar, 2007; Samuels, 2007; Sedgwick et al., 2007; Strout, 2006; Weiner, 2008).

The risk factors for MRSA apply directly to the athletic training setting and have the potential to increase the prevalence of CA-MRSA acquisition (Beam & Buckley, 2006). Since MRSA can be transmitted by skin-to-skin contact, or surface-to-skin contact through any break in the cutaneous layer of skin, health care providers in the athletic setting (i.e., certified athletic trainers [AT]) are encouraged to take a proactive approach to prevention and control (Newell, 2007). Recommended infection control measures use terms such as “frequently,” “regular intervals,” “routinely,” “thoroughly,” and “cleaning schedule,” but do not define such terms. Additionally, while antimicrobial treatment is recommended, specific products are not identified (Fagan, 2005; Guttman, 2008; Hawkes et al., 2007; Levenhagen, 2008; Mississippi State Department of Health, 2007, 2009; Romano et al., 2006; Sedgwick et al., 2007; Strout, 2006; Weiner, 2008). Prevention is vital to maintaining a safe, healthy environment in which athletes can participate without the risk of contracting a potentially harmful pathogen (Fagan, 2005).

The need for prevention and control methods is understood, but data regarding the efficacy of such methods in athletic facilities is lacking. Well-designed studies that are specific to the athletic setting are difficult to find, and are needed to identify the prevalence, risk factors, and efficient CA-MRSA prevention and treatment strategies in athletic facilities (Beam & Buckley, 2006; Hawkes et al., 2007; Montgomery, Ryan, Krause & Starkey, 2010; Salgado et al., 2003; Stanforth, Krause, Starkey & Ryan, 2010). Until the level of contamination for environmental sources and surfaces of acquisition are known, transmission of CA-MRSA in athletic facilities will continue (Beam & Buckley, 2006). Therefore, the purpose of our study was to assess the prevalence of Staphylococcus aureus, specifically CA-MRSA, in relation to cleaning schedules and cleaning products used in high school athletic training rooms (ATR) and LR facilities.

### Table 1
Pathogen Control Plans by Facility

<table>
<thead>
<tr>
<th>Facility (# of Athletes*)</th>
<th>Cleaning Implement</th>
<th>Athletic Training Room Product No Intervention</th>
<th>Athletic Training Room Product Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Treatment table</td>
<td>Taping table</td>
</tr>
<tr>
<td>A (142)</td>
<td>Cloth towel</td>
<td>Whizzer ea. ath.</td>
<td>Whizzer ea. ath.</td>
</tr>
<tr>
<td>C (402)</td>
<td>Cloth or paper towel</td>
<td>Whizzer daily</td>
<td>Whizzer daily</td>
</tr>
<tr>
<td>E (186)</td>
<td>Cloth towel</td>
<td>Matt Kleen ea. ath.</td>
<td>Matt Kleen daily</td>
</tr>
<tr>
<td>F (Control) (390)</td>
<td>Cloth towel and filter box</td>
<td>Sanizide hourly</td>
<td>Sanizide hourly</td>
</tr>
<tr>
<td>G (369)</td>
<td>Paper towel</td>
<td>Bleach H₂O weekly</td>
<td>Bleach H₂O weekly</td>
</tr>
</tbody>
</table>

*Total number of athletes = 2194.
* Site had two ATR facilities.
* After each athlete.
* NR = Not reported.
### TABLE 2

<table>
<thead>
<tr>
<th>Nonintervention Product</th>
<th>Active Ingredients</th>
<th>Cleaning Schedule</th>
<th>Confirmed MRSA Cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>After Each Athlete</td>
<td>Hourly</td>
</tr>
<tr>
<td>Bleach water (paper towel)</td>
<td>Sodium hypochlorite CAS# 7681-52-9</td>
<td>5%–10%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Sodium hydroxide CAS# 1310-73-2</td>
<td>&lt;1%</td>
<td>–</td>
</tr>
<tr>
<td>Matt Kleen (cloth towel)</td>
<td>Alkyl 60% C14, 30% C16, 5% C12, 5% C18 dimethyl benzyl ammonium chlorides</td>
<td>2.25%</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Alkyl (68% C12, 32% C14) dimethyl ethylbenzyl Ammonium chlorides</td>
<td>2.25%</td>
<td>–</td>
</tr>
<tr>
<td>Sanizide (cloth towel)</td>
<td>n-Alkyl (60% C14, 30% C16, 5% C12, 5% C18) dimethyl benzyl ammonium chlorides</td>
<td>0.105%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>n-Alkyl (68% C12, 32% C14) dimethyl ethylbenzyl ammonium chlorides</td>
<td>0.105%</td>
<td>–</td>
</tr>
<tr>
<td>Whizzer (cloth or paper towel)</td>
<td>Octyl decyl dimethyl ammonium chloride</td>
<td>1.30%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Didecyl dimethyl ammonium chloride Alkyl (C14, 50%; C12, 40%; C16, 10%)</td>
<td>1.953%</td>
<td>–</td>
</tr>
</tbody>
</table>

### Methods

Permission to collect cultures from athletic facility surfaces was acquired from administrators at seven high schools. Although no samples from human subjects were obtained, institutional review board approval was obtained due to a risk of increased exposure to MRSA with an imposed cleaning schedule that was less frequent than each school’s regular cleaning schedule. Vinyl gloves were worn during sample collection and assessment of cultures in order to reduce the risk of exposure to CA-MRSA or other pathogens.

Prior to culture collection the ATRs were asked to complete a brief questionnaire for demographic data, such as number of male and female athletes, number of suspected and confirmed cases of CA-MRSA in the previous year, and information on pathogen control plans used in the ATR and LR, such as cleaning schedule, cleaning product, and cleaning implement (Table 1). One site indicated the use of Eagle 5000 electronic air purification system (EAPS) in the ATR and boys’ LR as part of the cleaning protocol. Filter boxes are used for smoke, odor, and microbial control and are available commercially. Other sites used bleach water, Matt Kleen, Sanizide, and Whizzer in the ATR. Table 2 provides information about the active ingredient for each product and the number of positive MRSA cultures.

Statistics were primarily descriptive in nature; they included simple frequencies to assess the number of suspected MRSA colonies and to compare surfaces as well as intervention/nonintervention phases. Due to the small number of confirmed MRSA outcomes, significance testing was restricted to the use of analysis of variance (ANOVA) for determining if facility room (three levels: ATR, Boys’ LR, Girls’ LR) made a difference in number of suspected MRSA colonies. The researcher hypothesized that the boys’ LR would have higher numbers of suspected MRSA colonies than either of the other rooms. To allow for violation of the assumptions of this test, significance level was set at .01. Locker room cleaning products and schedules were not as complete, with three sites unable to access information due to inconsistent custodial schedules or personnel changes during the study timeline. Of the four other sites, one used Matt Kleen, two used Sanizide, and one site used Whizzer.

An ABAB experimental design was implemented in which the baseline condition of “regularly used disinfecting product and schedule” (A) was randomly assigned an imposed cleaning product and schedule (B) in the ATR. The imposed cleaning product was one of two disinfecting agents randomly selected from the list of U.S. Environmental Protection Agency (U.S. EPA)–approved MRSA disinfectants (Cavicide: U.S. EPA...
and Citrus Scent Lysol Brand Anti-

bacterial Kitchen Cleanser II: EPA #777-91),

and were different than the regular cleaning

products used at each school. The interven-
tion cleaning schedule was after each athlete,
every hour, or daily. The AT at each site was
provided with a spray bottle with either Cavi-
cide or Lysol with assurance that more clean-
ing product would be provided if needed.

Each AT was instructed to follow the prod-
cut guidelines for use indicated on the clean-
ing product label and was asked to use the
normal cleaning implement (Table 1) with
the product. All participants consented to
follow and use the imposed cleaning sched-
ule and product in the athletic training room
during the intervention months of September
and November. Each site was visited biweekly
to offer additional product or assistance and
to note compliance with the protocol. While
it was not possible to rely on first-hand obser-
vation of compliance, conversations with ATs
on site indicated they followed the interven-
tion protocol. No obvious departures from
the prescribed protocol were noted and no
disruptions or problems adhering to the pre-
scribed protocol were reported. No interven-
tion was imposed on the LRs because of the
lack of oversight in those areas, although data
were collected in those facilities following the
same schedule as in the ATRs.

Sample Collection

Samples were collected from nine surfaces
(treatment tables, taping tables, countertops
in the ATRs, and floors, benches, and show-
ers in both boys’ and girls’ LRs) from the
seven high schools on eight separate collect-
date from August through November 2009. Eight cultures from each of the sur-
faces were obtained from each school for a
total of 656 cultures (one site had two ATRs).
Each school used its regular cleaning prod-
cut and cleaning schedule in the ATR during
August and October, and the imposed clean-
ing product and schedule during September
and November. The cleaning product and
schedule for the LRs did not change.

Cultures were collected with 50 mm Rodac
contact plates filled with mannitol salt agar
with a convex surface that allowed for easy
culture sampling by pressing the plates onto
a surface. Each plate was labeled with an
indelible marker as to the exact location and
date from which the culture was obtained.
The plates included a grid for simplified enu-
meration of bacterial colonies.

A bacterial colony consists of a mass of
bacterial cells arising from a single organ-
ism. Most bacterial media contain 0.5%
sodium chloride, but mannitol salt agar con-
ains 7.5% sodium chloride to inhibit
many common isolated bacteria. The dif-
ferential aspect of the agar is the addition
of the sugar, mannitol, and the pH indica-
tor, phenol red. Common organisms that
survive in the high salt concentration are
staphylococci. Of the staphylococci, only S.
aureus will ferment mannitol. The ferme-
tation of mannitol produces acid products
that cause a color change (from orange-red
to bright yellow) in the medium. This color
change indicates the presumptive presence
of S. aureus.

The S. aureus colonies identified on manni-
tol salt agar were confirmed as MRSA by use
of CHROMagar MRSA. CHROMagar MRSA
allows for differentiation between MRSA and
other variants by using a specific chromogenic
agar. The colonies of MRSA demonstrated a
mauve color while other bacteria, including
other types of S. aureus, demonstrated either
a blue or white color (Figure 1).

Each plate was placed in a standard incu-
bator, set at 35°C–37°C (98.6°F) for 18 to
48 hours. After evaluation for MRSA, each
contact plate was placed in a biohazard waste
bag before being placed in an autoclave set at
121°C at 25 pounds per square inch (psi) for
15 minutes.

Results

The variables measured were number of
colonies of S. aureus, labeled as suspected
MRSA, and the number of positive MRSA
colonies, labeled as confirmed MRSA. Sus-
ppected MRSA colonies presented with mor-
phology and color consistent with S. aureus
on Rodac plates, and were transferred to
CHROMagar MRSA plates. Positive MRSA
colonies displayed a mauve color on the
CHROMagar MRSA contact plates (Figure 1).
Statistics were primarily descriptive in
nature; they included simple frequencies
to assess the number of suspected S. aureus
colonies and to compare surfaces as well as intervention/nonintervention phases. Due to the small number of confirmed MRSA colonies, significance testing was restricted to the use of ANOVA for determining if facility room (ATR, Boys’ LR, Girls’ LR) made a difference in number of suspected MRSA colonies. The researcher hypothesized that the boys’ LR would have higher prevalence of suspected MRSA colonies than either of the other rooms. To allow for violation of the assumptions of this test, significance level was set at .01.

Facilities that used bleach and bleach-water solutions in the LRs had significantly more suspected colonies than facilities that used other regular cleaning products (Sani-zide, Matt Kleen, and Whizzer) (p < .001). The following information addresses the percentages of positive MRSA cultures (rather than suspected S. aureus colonies) found on the nine surfaces.

**Athletic Training Rooms**
Of the 656 cultures collected (80–96 per high school), MRSA colonies were detected in each high school, ranging from 4 to 16 positive MRSA cultures out of 80–128 (5–18.8%) surface contacts (Table 3). Four schools were void of positive MRSA cultures in the ATR. Three of the seven ATRs presented positive MRSA cultures when no intervention was imposed (treatment tables [1/32], taping tables [1/32], and counter tops [2/32]), compared to just two schools when an intervention product and schedule were imposed (taping tables [2/32] and counter tops [1/32]) (Figure 2).

** Locker Rooms**
Of the 67 positive MRSA cultures collected during this study, 60 (89.6%) were found in LR facilities (Figure 3). Contrary to what was hypothesized, the girls’ LR surfaces presented the highest rate of positive MRSA cultures, followed by the boys’ LR and ATR surfaces. Figures 4 and 5 show the rates of positive MRSA cultures compared to LR cleaning products and schedules, respectively. The rate of positive MRSA cultures was also assessed by the type of flooring found in the LR facilities. The highest rate of MRSA was found in both girls’ and boys’ LRs where carpet was present, followed by concrete and tile (Figure 6).

**Cleaning Products**
Of the regular cleaning products used in the ATR at the different schools, bleach-water solutions had the highest rate of positive MRSA cultures (1/12, 8.3%), followed by Whizzer (3/48, 6.2%). The use of Matt Kleen, Sani-zide, and Sanizide with a filter box showed no MRSA strains. Of the imposed cleaning products, use of Lysol resulted in a higher rate of positive MRSA cultures (2/36, 5.6%) than did Cavicide (1/48, 2.1%).

**Cleaning Schedule**
Positive MRSA cultures were found in 4.2% of both the regular cleaning schedule samples (3/36 “after each athlete,” 0/24 “hourly,” 0/24 “daily,” and 1/12 “weekly”) and the imposed cleaning schedule samples (1/24 “after each athlete,” 1/24 “hourly,” and 2/48 “daily”).

**Discussion**
Keeping in mind that only the ATR cleaning products and cleaning schedules were altered, ATR and LR will be discussed separately.
Athletic Training Room

During the intervention phase, positive MRSA cultures from treatment tables and countertops decreased; however, the number from taping tables doubled. One possible reason for this is that the initial samples were taken prior to the start of the fall sports season, allowing the possibility that the taping table surfaces may not have been used over the summer. Additionally, the months of intervention (September and November) were likely to service more athletes than the nonintervention months (August and October) with the beginning of the fall semester in September and the crossover between the fall and winter sports seasons in November. The accuracy of information gleaned from our study depends upon the integrity of the ATs in following the intervention protocol specifically assigned to each facility.

Locker Room

A greater risk of exposure to MRSA existed in the LR facilities than in the ATRs. Normal LR sanitation products reported by ATs at each school included ReJuvNal, Sanizide, bleach-water solutions, and pure bleach. Of these products, Clorox bleach is the only one listed on U.S. EPA’s List H for registered products effective against MRSA. The school where Sanizide and filter boxes were used in the boys’ LR showed the lowest incidence of MRSA colonies (0); the filter boxes were absent in the girls’ LR where four positive MRSA cultures were obtained. While it is tempting to attribute the higher MRSA count in the girls’ LR to the absence of filter boxes, too many other variables were present (e.g., possible difference in cleaning schedules) to explain the discrepancy. Coaches and ATs typically expressed concern over the boys’ LR facilities; however, the results actually demonstrated a higher percentage of MRSA colonies on the girls’ LR floor and shower surfaces. These findings indicate the importance of sanitation in all athletic facilities, rather than only in boys’ LR facilities.

The highest incidence of MRSA was found in girls’ and boys’ carpeted LRs (20.8% and 20.2%, respectively). While a carpeted LR cuts down on the noise level and may be aesthetically pleasing, coaches and administrators should note the increased risk of exposure to MRSA and other pathogens.
that can be trapped in the carpet fibers. The results of our study demonstrate that tile floors have the lowest rate of MRSA; however, the rate of positive MRSA cultures for all LR floor surfaces was higher than 10%. Personnel responsible for purchasing LR sanitation products are encouraged to select products from List H of U.S. EPA’s registered products effective against MRSA and vancomycin-resistant enterococcus faecalis or faecium (VRE) for approved MRSA disinfectants (U.S. Environmental Protection Agency, 2009).

**Conclusion**

Our study examined the role of disinfecting products and schedules in the control of MRSA and other pathogens in athletic facilities. Only ATRs had sufficient supervision over sanitation practices to modify the cleaning products and schedules with an intervention. Cultures obtained from LRs represent the number of pathogens and positive MRSA cultures present without product or schedule intervention.

While this study represents a small sample of athletic facilities, the results support the notions that MRSA exists and should be controlled within athletic facilities such as ATRs and LRs. Athletic training rooms were significantly cleaner than LRs when considering overall pathogens, which can most likely be attributed to the consistent (i.e., hourly or more frequent) attention to sanitation of the surfaces. This only holds true, however, if the ATs at each site followed the reported or assigned cleaning protocol. As indicated by Montgomery and co-authors (2010), future studies in which each athletic facility is assessed separately to obtain a statistically valid number of samples are warranted.

Carpeted LR floors were identified as the surface with the highest incidence of positive MRSA cultures. School administrators should take note of the relatively inexpensive modification to reduce the incidence of MRSA, and replace LR carpet with nonslip tile floors. In addition, universal precautions, such as those recommended by CDC (2010b) should be taught and emphasized to anyone using ATR and LR facilities to reduce the risk of MRSA transmission in athletic facilities. Finally, since patterns of facility use vary throughout the year, further evaluation of ATR and LR facilities should include the full year with regular and intervention products and schedules to determine the most effective cleaning product and schedule for controlling MRSA in athletic facilities.

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