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Methicillin-Resistant *Staphylococcus aureus* in Pork Production Shower Facilities▽

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As methicillin-resistant *Staphylococcus aureus* (MRSA) has been found in pigs, we sought to determine if MRSA is present in pork production shower facilities. In two production systems tested, 3% and 26% of shower samples were positive for MRSA. *spa* types identified included t034, t189, t753, and t1746.

Livestock-associated methicillin-resistant *Staphylococcus aureus* (LA-MRSA) is a novel pathogen associated with cattle, veal calves, horses, pigs, and poultry (11–13, 15, 16, 19, 22–24, 26). To date, multilocus sequence type 398 (ST398) has been most often associated with LA-MRSA. The *spa* type most commonly associated with ST398 in North America is t034, although up to 24 other associated *spa* types have been identified in North America and Europe (21).

ST398 nasal carriage has been identified in people with occupational exposure to swine (4, 6, 12, 17, 19, 26). In the U.S., ST398 colonization has been reported in two publications (2, 19), but environmental reservoirs were not examined in those studies. Locker room and athletic facilities are known reservoirs for human MRSA strains (14, 20).

Shower-in, shower-out facilities are common in modern pork production systems. Previous research has suggested that pork production shower facilities do not harbor MRSA (1); however, the presence of MRSA in pigs on those farms was not examined. We sought to determine if MRSA can be cultured from showers within production systems known to harbor pigs that yielded MRSA-positive nasal swabs.

Two conventional swine production systems were selected for this study in Iowa and Illinois. We sampled two wean-to-finish sites with 6,500 pigs each in production system A (PSA). In production system B (PSB), we sampled one 5,200-sow site, two nursery sites consisting of approximately 15,000 pigs at two sites, and one 8,000-animal finisher site.

Swine nasal swabs. In PSA, prior to shower sampling, pigs at both wean-to-finish sites were sampled ($n = 50$). In PSB, swine nasal swabs had been previously collected ($n = 209$) (19). Sampling, bacterial isolation, and molecular typing were conducted as previously described (19). At PSA, no MRSA was detected in swine nasal swab samples from the first site, and 7/25 (28%) of samples were positive for MRSA from the second site. Overall, the prevalence of MRSA in swine at PSA was 7/50 (14%). In PSB, 147/209 (70%) of swine nasal swab samples were positive for MRSA (19). From PSA, two swine nasal samples were chosen for additional molecular testing. Both were negative for the Panton-Valentine leukocidin gene (*pvl*, a potential virulence gene) (18) and were *spa* type t1746. Multilocus sequence typing (MLST) did not identify an established sequence type. From PSB, swine nasal swab samples had been previously confirmed as ST398 by MLST (19).

Shower swabs. In 10 showers, we collected 10 samples each using sterile swabs (BD BBL culture swabs with Stuart liquid media; Becton Dickinson and Company) moistened with sterile phosphate-buffered saline. We focused on areas in the showers and changing room that workers contact frequently, because so-called "hand-touch" sites are frequently contaminated with pathogens in hospitals (5). In PSA, we found one positive sample from three showers, for an overall prevalence of 1/30 (3%). The positive sample was taken from clothing hooks on the "dirty" side of the shower changing area, where employees enter the shower area before accessing the rooms holding pigs. The isolate was *pvl* negative and *spa* type t034. Previously, *spa* type t034 has been associated with ST398 in the Ridom SpaServer database (www.ridom.de).

In PSB, we found 18 positive samples from seven showers, for an overall prevalence of 18/70 (26%). MRSA-positive samples were collected from the following sites: shower floor ($n = 5$), shower drain ($n = 3$), clean side floor ($n = 2$), locker handle ($n = 2$), shower curtain, shower wall, dirty-side floor, light switch, chair, and soap bottle (one each). All isolates were *pvl* negative. Identified *spa* types were t034, t1746, t189, and t753. One sample (*spa* type t189) was identified as ST188. Novel sequence types were identified for four samples (*spa* types 1746 and 753) (Table 1).

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TABLE 1. Characteristics of selected swine nasal swabs and shower swabs

Sample	Production system	Source	*spa* type	Repeat sequences	MLST type[a]	Antimicrobial resistance[c]
1	A	Nasal, swine	t1746	07-120-12-23-02-12-23	Novel[b]	TET
2	A	Nasal, swine	t1746	07-120-12-23-02-12-23	Novel	TET
3	A	Locker room hooks (dirty side), wean to finish site	t034	08-16-02-25-02-25-34-24-25		TET, OXA, CLI
4	B	Locker room chair (dirty side), sow site	t1746	07-120-12-23-02-12-23	Novel	TET, OXA
5	B	Shower floor, sow site	t189	07-23-12-21-17-34	ST188	None
6	B	Shower drain, sow site	t753	08-16-52-25-02-25-34-24-25	Novel	TET, OXA
7	B	Shower floor, sow site	t034	08-16-02-25-02-25-34-24-25		TET, OXA
8	B	Shower floor, nursery site	t034	08-16-02-25-02-25-34-24-25		TET, OXA, CLI, ERY (intermediate)

[a] MLST was not performed for *spa* type t034; ST398 was associated with t034 in previous work (19).
[b] Allelic profiles of novel sequence types most closely matched that of ST398 in the Ridom SpaServer database.
[c] TET, tetracycline, OXA, oxacillin, CLI, clindamycin, ERY, erythromycin.

Eight samples were selected for antimicrobial susceptibility testing. Five of eight (63%) isolates were resistant to oxacillin, seven (88%) were resistant to tetracycline, and two (25%) were resistant to clindamycin (Table 1). Samples that were susceptible to oxacillin by the broth microdilution test were recultured on MRSA selective plates and were retested with the MRSA latex agglutination test and *mecA* PCR (3) to ensure that samples were correctly identified as MRSA. Oxacillin-susceptible, *mecA*-positive MRSA has been previously reported (10, 25).

spa type t1746 was identified in swine nasal swab samples from PSA and from a locker room chair in PSB. Upon further testing, a novel sequence type associated with *spa* type 1746 was found. *spa* type t189 was isolated from a shower floor at the sow site at PSB. This *spa* type has previously been associated with ST188 (7). Our sample was also identified as ST188 by MLST. *spa* type t753 was isolated from a shower drain at the PSB sow site. A novel ST was identified for this isolate.

At site 5, a finishing location in PSB, we observed that although 50% of swine sampled were colonized with MRSA, no shower samples were positive. Interestingly, this shower was separated from the swine barn, indicating that physical separation from animals or dust may be important. This arrangement may also limit airborne spread, which has been previously documented for *S. aureus* in and around swine barns (8, 9).

This study had several limitations, including a small sample size. We did not test human workers at the farm. Therefore, we cannot be sure of the relative contributions of MRSA of human versus livestock origin in our positive shower samples. Both production systems tested utilize antimicrobials for prophylactic and therapeutic reasons. We did not test production systems that abstain from antimicrobial use and therefore cannot speculate on antimicrobial use and the finding of MRSA in showers. Further studies are needed to determine whether environmental MRSA reservoirs are associated with an increased risk of colonization and/or infection in pork production workers and to determine the most effective methods of MRSA control in the shower environment.

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REFERENCES

1. **Amass, S. F., R. Jolie, J. L. Schneider, and P. Morgan.** 2005. A pilot study to determine the prevalence of methicillin-resistant *Staphylococcus aureus* in showers at pork production facilities, gymnasiums, and private residences in Indiana. J. Swine Health Prod. **13:**150–151.
2. **Bhat, M., et al.** 2009. *Staphylococcus aureus* ST398, New York City and Dominican Republic. Emerg. Infect. Dis. **15:**285–287.
3. **Bosgelmez-Tinaz, G., S. Ulusoy, B. Aridogan, and F. Coskun-Ari.** 2006. Evaluation of different methods to detect oxacillin resistance in *Staphylococcus aureus* and their clinical laboratory utility. Eur. J. Clin. Microbiol. Infect. Dis. **25:**410–412.
4. **Cui, S., et al.** 2009. Isolation and characterization of methicillin-resistant *Staphylococcus aureus* from swine and workers in China. J. Antimicrob. Chemother. **64:**680–683.
5. **Dancer, S. J.** 2009. The role of environmental cleaning in the control of hospital-acquired infection. J. Hosp. Infect. **73:**378–385.
6. **Denis, O., et al.** 2009. Methicillin-resistant *Staphylococcus aureus* ST398 in swine farm personnel, Belgium. Emerg. Infect. Dis. **15:**1098–1101.
7. **Ghaznavi-Rad, E., et al.** 2010. Predominance and emergence of clones of hospital-acquired methicillin-resistant *Staphylococcus aureus* in Malaysia. J. Clin. Microbiol. **48:**867–872.
8. **Gibbs, S. G., et al.** 2006. Isolation of antibiotic-resistant bacteria from the air plume downwind of a swine confined or concentrated animal feeding operation. Environ. Health Perspect. **114:**1032–1037.
9. **Green, C. F., S. G. Gibbs, P. M. Tarwater, L. C. Mota, and P. V. Scarpino.** 2006. Bacterial plume emanating from the air surrounding swine confinement operations. J. Occup. Environ. Hyg. **3:**9–15.
10. **Hososaka, Y., et al.** 2007. Characterization of oxacillin-susceptible mecA-positive *Staphylococcus aureus*: a new type of MRSA. J. Infect. Chemother. **13:**79–86.
11. **Juhasz-Kaszanyitzky, E., et al.** 2007. MRSA transmission between cows and humans. Emerg. Infect. Dis. **13:**630–632.
12. **Khanna, T., R. Friendship, C. Dewey, and J. S. Weese.** 2008. Methicillin resistant *Staphylococcus aureus* colonization in pigs and pig farmers. Vet. Microbiol. **128:**298–303.
13. **Leenders, A. C., M. Janssen, N. H. M. Renders, and M. Pelk.** 2007. Pig's MRSA on a poultry farm? Infectieziekten Bull. **18:**43–44.
14. **Montgomery, K., T. J. Ryan, A. Krause, and C. Starkey.** 2010. Assessment of athletic health care facility surfaces for MRSA in the secondary school setting. J. Environ. Health **72:**8–11.
15. **Mooji, R., A. Troelstra, J. M. Jenkins, and S. F. T. Thijsen.** 2007. MRSA in calves. Infectieziekten Bull. **18:**236.
16. **Mulders, M. N., et al.** 2010. Prevalence of livestock-associated MRSA in broiler flocks and risk factors for slaughterhouse personnel in The Netherlands. Epidemiol. Infect. **138:**743–755.
17. **Neela, V., et al.** 2009. Prevalence of ST9 methicillin-resistant *Staphylococcus aureus* among pigs and pig handlers in Malaysia. J. Clin. Microbiol. **47:**4138–4140.
18. **Rasigade, J. P., et al.** 2010. Global distribution and evolution of Panton-Valentine leukocidin-positive methicillin-susceptible *Staphylococcus aureus*, 1981–2007. J. Infect. Dis. **201:**1589–1597.
19. **Smith, T. C., et al.** 2009. Methicillin-resistant *Staphylococcus aureus* (MRSA) strain ST398 is present in Midwestern U.S. swine and swine workers. PLoS One **4:**e4258.
20. **Stanforth, B., A. Krause, C. Starkey, and T. J. Ryan.** 2010. Prevalence of community-associated methicillin-resistant *Staphylococcus aureus* in high school wrestling environments. J. Environ. Health **72:**12–16.

21. **Vanderhaeghen, W., K. Hermans, F. Haesebrouck, and P. Butaye.** 2010. Methicillin-resistant *Staphylococcus aureus* (MRSA) in food production animals. Epidemiol. Infect. **138:**606–625.
22. **Voss, A., F. Loeffen, J. Bakker, C. Klaassen, and M. Wulf.** 2005. Methicillin-resistant *Staphylococcus aureus* in pig farming. Emerg. Infect. Dis. **11:**1965–1966.
23. **Weese, J. S., et al.** 2005. Methicillin-resistant *Staphylococcus aureus* in horses and horse personnel, 2000–2002. Emerg. Infect. Dis. **11:**430–435.
24. **Weese, J. S., et al.** 2005. Community-associated methicillin-resistant *Staphylococcus aureus* in horses and humans who work with horses. J. Am. Vet. Med. Assoc. **226:**580–583.
25. **Witte, W., B. Pasemann, and C. Cuny.** 2007. Detection of low-level oxacillin resistance in mecA-positive *Staphylococcus aureus*. Clin. Microbiol. Infect. **13:**408–412.
26. **Wulf, M., and A. Voss.** 2008. MRSA in livestock animals—an epidemic waiting to happen? Clin. Microbiol. Infect. **14:**519–521.