Commensal *Enterococcus* on U.S. Swine Sites: Prevalence and Antimicrobial Drug Susceptibility

Background

Enterococci are normal inhabitants of human and animal gastrointestinal tracts. These organisms have been known to cause human illnesses, such as meningitis, septicemia, endocarditis, arthritis, and pneumonia.[1 2 3] Two species of *Enterococcus*, *E. faecalis* and *E*. *faecium*, have been associated with foodborne illness in humans worldwide,[4] although *Enterococcus* has not been identified as a major cause of foodborne illness in the United States.

Food animals such as pigs can be reservoirs for *E. faecium* organisms, some of which may be resistant to antimicrobials. In addition, there is potential for resistance components of enterococci to be transferred to other bacteria, including those that cause human illness. In the United States, the emergence of *Enterococcus* with resistance to gentamicin, penicillin, synercid, and vancomycin in humans has been a concern.[5]

Enterococcus on U.S. swine sites

In 2006, USDA's National Animal Health Monitoring System (NAHMS) conducted a study on swine health and management practices from a random sample of swine production sites in 17 States*. These States represented about 94 percent of the U.S. pig inventory and 94 percent of U.S. pork producers with 100 or more pigs. Overall, 2,230 swine production sites participated in the first interview from July 1 to August 15, 2006.

As part of Swine 2006, fecal samples were collected from pen floors on 135 sites. On each site, up to 15 fecal samples were collected from pens containing grower/finisher pigs and cultured for *Enterococcus*. From September 5, 2006, through March 15, 2007, 1,362 samples were cultured for *Enterococcus*.

Overall, at least one sample was found culture-positive for *Enterococcus* on 99.3 percent of sites, 96.1 percent of barns, and 71.4 percent of pens. Additionally, 69.0 percent of samples were culture positive. Between two and four different *Enterococcus* species were isolated on 76.1 percent of sites. Some sites (12.7 percent) had as many as five or six different species isolated. Among the 940 isolates, there were 11 different *Enterococcus* species; *E. faecalis* and *E. faecium* accounted for 35.3 percent of isolates. In addition, 71.1 and 33.3 percent of sites were positive for *E. faecalis* and *E. faecium*, respectively (table 1).

Table 1. Percentage of *Enterococcus* Isolates and Percentage of Sites Positive for *Enterococcus, by Species*

Species	Percent Isolates	Percent Sites
E. hirae	29.6	71.1
E. faecalis	27.4	71.1
*E.spp**	16.0	49.6
E. faecium	7.9	33.3
E. mundtii	7.7	16.3
E. casseliflavus	3.0	15.6
E. gallinarum	2.5	14.8
E. avium	2.0	12.6
E. durans	1.6	8.1
E. solitarius	1.4	8.9
E. saccharolyticus	0.8	5.9
E. pseudoavium	0.1	0.7
Total	100.0	NA

*Species not identified.

* Arkansas, Colorado, Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, Ohio, Pennsylvania, South Dakota, Texas, and Wisconsin.

Antimicrobial susceptibility

All the available isolates were tested for resistance to a panel of 17 antimicrobial drugs.** Resistance break points used by the National Antimicrobial Resistance Monitoring System were used to classify isolates as susceptible, intermediate, or resistant. Of the 940 original isolates, 83 could not be re-grown from stocks and were not tested for susceptibility. Of the remaining 857 isolates, resistance to lincomycin was most common (96.0 percent of isolates), followed by resistance to tetracycline (81.9 percent) and flavomycin (57.1 percent) [table 2].

No *Enterococcus* isolates were resistant to vancomycin or linezolid. Only 2.5 percent of isolates were resistant to gentamicin, and all of those isolates were *E. faecalis.*

Table 2. Number and Percentage of Antimicrobial Resistance[1] Among *Enterococcus* Isolates

Antimicrobial	Number Resistant (n=857)	Percent
Lincomycin	823	96.0
Tetracycline	702	81.9
Flavomycin	489	57.1
Tylosin	451	52.6
Erythromycin	447	52.2
Synercid[2]	----	----
Streptomycin	194	22.6
Kanamycin	139	16.2
Nitrofurantoin	71	8.3
Penicillin	53	6.2
Chloramphenicol	33	3.9
Ciprofloxacin	26	3.0
Tigecycline[3]	----	----
Gentamicin	21	2.5
Daptomycin[3]	----	----
Linezolid	0	0.0
Vancomycin	0	0.0

[1]Intermediate isolates were classified as not resistant.
[2]*E. faecalis* is intrinsically (naturally) resistant to synercid. Among the other 602 isolates, 162 (26.9%) were resistant.
[3]No resistance break points have been established for tigecycline and daptomycin. There were 835 and 850 isolates at or below the break point for susceptibility for tigecycline and daptomycin, respectively.

Table 3 shows the percentage of isolates by the number of antimicrobials they were resistant to for *E. faecium*, *E. faecalis*, and all other *Enterococcus* species. *E. faecalis* isolates were resistant to a higher number of antimicrobials than *E. faecium*. For example, 35.2 percent of *E. faecalis* isolates were resistant to five or more antimicrobials, compared with only 25.7 percent of *E. faecium* isolates.

Table 3. Number of Antimicrobials by Number and Percentage of *Enterococcus* Isolates Showing Resistance*

	Percent		
Number Antimicrobials*	*E. faecium* Isolates (n=74)	*E. faecalis* Isolates (n=255)	All Other *Enterococcus* spp. Isolates (n=528)
0	0.0	0.0	0.4
1	8.1	7.1	3.6
2	14.9	16.5	25.4
3	35.1	5.9	19.5
4	16.2	35.3	6.8
5	2.7	12.6	8.3
6	10.8	13.7	16.5
7	5.4	8.6	7.2
8	5.4	0.3	9.1
9	0.0	0.0	2.2
10	1.4	0.0	1.0
Total	100.0	100.0	100.0

*Intermediate isolates were classified as not resistant based on 15 antimicrobials evaluated for *E. faecium* (dropping tigecycline and daptomycin) and based on 14 antimicrobials for *E. faecalis* (dropping tigecycline, daptomycin and dynercid).

The resistance patterns of *E. faecalis* and *E. faecium* isolates to four drugs are shown in table 4.[5] All isolates were susceptible to vancomycin. *E. faecalis* showed resistance to gentamicin, while *E. faecium* did not; the opposite was true for resistance to penicillin.

Table 4. Species of Resistant *Enterococcus* Isolates and Resistance Patterns from Swine Feces

Species	Number Isolates	Percent Species Isolates	Resistance
Faecalis* (n=255)	21	8.2	Gentamicin
	0	0.0	Penicillin
	0	0.0	Vancomycin
Faecium (n=74)	0	0.0	Gentamicin
	9	12.2	Penicillin
	8	10.8	Synercid
	0	0.0	Vancomycin

[1]**E. faecalis* is intrinsically (naturally) resistant to synercid.

** Chloramphenicol, ciprofloxacin, daptomycin, erythromycin, flavomycin, gentamicin, kanamycin, lincomycin, linezolid, nitrofurantoin, penicillin, streptomycin, synercid, tetracycline, tigecycline, tylosin, and vancomycin.

Conclusions

Given that *Enterococcus* spp. is a commensal organism that inhabits the gastrointestinal tract of many people and animals it is not surprising that it was frequently recovered on swine operations. *E. faecalis* is more common on swine sites, while the prevalence of *E. faecium* is much lower. Resistance of *Enterococcus* isolates to antimicrobial drugs on swine sites varies by bacterial species.

References

1 Murray, B.E. 1990. The life and times of the *Enterococcus*. *Clin Microbiol Rev*; 3(1):46-65.

2 Lu, Hong-Zhou, Xin-Hua Weng, Haijing Li, You-Kuan Yin, Mao-Yin Pang, and Yi-Wei Tang. 2002. *Enterococcus faecium*-related outbreak with molecular evidence of transmission from pigs to humans. *J Clin Microbiol*; 40(3):913–917.

3 Kahn, C.M. (ed.). 2005. In: The Merck Veterinary Manual 9th ed. Merck & Co., Inc., Whitehouse Station, N.J. p. 585.

4 Cliver, D.O. and H.P. Riemann (eds.). 2002. In: Foodborne Diseases 2nd ed. Academic Press, San Diego, Calif. p. 154.

5 CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): Human Isolates Final Report, 2004. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2007. p. 47-54.

For more information, contact:
USDA:APHIS:VS:CEAH
NRRC Building B, M.S. 2E7
2150 Centre Avenue
Fort Collins, CO 80526-8117
970.494.7000
E-mail: NAHMS@aphis.usda.gov
http://nahms.aphis.usda.gov