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

Background

Enterococci are normal inhabitants of human and animal gastrointestinal tracts. However, enterococci are also a common cause of health-care associated infections in humans, especially in hospitalized patients. Two species of enterococci, *Enterococcus faecalis* and *Enterococcus faecium*, are responsible for most human disease caused by enterococci.

Enterococci resistant to antimicrobials can be found in livestock, such as pigs. There are concerns that resistant enterococci, or bacteria that acquire resistance genes from them, could be transferred to humans through food and result in resistant infections. It is possible that foodborne transmission of enterococci could play a role in human illness. However, the extent of any contribution to human illness from enterococci of livestock origin is not well understood.

Enterococcus on U.S. swine sites

In 2012, USDA's National Animal Health Monitoring System (NAHMS) conducted a study on swine health and management practices from a randomly selected sample of swine production sites in 13 States.[1] These States represented about 91 percent of the U.S. pig inventory and 89 percent of U.S. pork producers with 100 or more pigs. Data were collected via two interviews, and a subset of production sites chose to participate in the collection of biological specimens for phase II of the study. Overall, 2,119 swine production sites participated in the first interview from July 16 through August 15, 2012.

On 117 production sites, fecal specimens from late finisher pigs were collected from pen floors. For each site, up to 15 fecal samples were collected and cultured for *Enterococcus*. Fecal specimens were collected from October 1, 2012, through February 28, 2013. A total of 1,720 specimens were cultured for *Enterococcus*. At least one sample was culture positive for *Enterococcus* on all but one site and in 88.6 percent of the 608 pens sampled. Additionally, 71.0 percent of 1,720 specimens were culture positive for *Enterococcus*.

Between two and four different *Enterococcus* species were isolated on 84.5 percent of sites. Five different species were isolated on 9.5 percent of sites. Among the 1,221 isolates, 10 different *Enterococcus* species were identified. Together, *E. faecalis* and *E. faecium* accounted for 51.1 percent of isolates. In addition, 82.1 and 59.0 percent of sites were positive for *E. faecalis* and *E. faecium*, respectively (table 1).

Table 1. Percentage of isolates and percentage of herds, by *Enterococcus* species

Species	Percent isolates	Percent herds
E. hirae	36.9	82.1
E. faecalis	35.1	82.1
E. faecium	16.0	59.0
E. durans	3.4	21.4
E. casseliflavus	2.2	13.7
*E. spp**	4.1	24.8
E. mundtii	0.7	6.0
E. gallinarum	0.7	6.8
E. saccharolyticus	0.5	4.3
E. avium	0.3	2.6
E. solitarius	0.1	0.9

*Species not identified.

Antimicrobial susceptibility

Antimicrobial-susceptibility testing was performed only on *E. faecalis* and *E. faecium*. Of the 624 *E. faecalis* and *E. faecium* isolates, 563 were tested for resistance to a panel of 16 antimicrobial drugs. The National Antimicrobial Resistance Monitoring System (NARMS) break points were used to classify isolates as susceptible, intermediate, or resistant. Resistance to lincomycin was most common, and resistance to tetracycline was very common, followed by resistance to erythromycin and tylosin (table 2).

[1] Iowa, Illinois, Indiana, Kansas, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, Ohio, Pennsylvania, South Dakota, Texas.

Generally, a higher percentage of *E. faecalis* isolates were resistant to an antimicrobial than *E. faecium* isolates. This finding was particularly true for resistance to gentamicin and chloramphenicol. However, the opposite was true for nitrofuantoin, ciprofloxacin, and penicillin. No *Enterococcus* isolates were resistant to linezolid or vancomycin.

Resistance to vancomycin is of particular interest, since this antimicrobial is commonly used to treat humans with serious enterococcal infections. None of the isolates was resistant to vancomycin. Resistance to quinupristin/dalfopristin (Synercid®) is also of importance because this antimicrobial is used to treat vancomycin-resistant *E. faecium* infections.

Table 2. Percentage of *E. faecalis* and *E. faecium* Isolates resistant to the following Antimicrobials[1]

	Percent	
Antimicrobial	***E. faecalis***	***E. faecium***
Lincomycin (Lin)	97.9	93.1
Tetracycline (Tet)	89.2	60.9
Erythromycin (Ery)	68.9	40.2
Tylosin (Tyl)	68.9	35.1
Streptomycin (Str)	36.0	34.5
Kanamycin (Kan)	31.6	21.3
Gentamicin (Gen)	17.0	0.6
Chloramphenicol (Chl)	13.1	4.6
Nitrofurantoin (Nit)	2.3	29.9
Ciprofloxacin (Cip)	4.9	20.7
Penicillin (Pen)	0.3	9.8
Linezolid (Liz)	0.0	0.0
Vancomycin (Van)	0.0	0.0
Synercid (Qui)[2]	—	43.7
Tigecyclin (Tig)[3]	—	—
Daptomycin (Dap)[3]	—	—

[1]Intermediate isolates were classified not resistant.
[2]*E. faecalis* is intrinsically (naturally) resistant to quinupristin/ dalfopristin (Synercid); therefore, percentage of resistant isolates could not be determined.
[3]No resistance break points have been established for tigecycline and daptomycin; therefore, percentage of resistant isolates could not be determined.

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Table 3 shows the percentage of *E. faecium* and *E. faecalis* isolates by the number of antimicrobials they were resistant to. The median number of antimicrobials that *E. faecalis* and *E. faecium* species were resistant to was five and three, respectively.

Table 3. Percentage of *E. faecalis* and *E. faecium* isolates, by number of antimicrobials resistant to*

	Percent	
Number of antimicrobials	***E. faecalis***	***E. faecium***
0	1.8	1.1
1	2.3	11.5
2	6.5	24.3
3	15.9	16.7
4	4.4	8.6
5	22.6	7.5
6	17.2	9.2
7	13.9	12.1
8	9.0	3.5
9	5.4	3.5
10	1.0	1.1
Total	100.0	100.0

*Intermediate isolates were classified as not resistant.

Table 4 shows the five most common resistance patterns among *E. faecalis* isolates, which were seen in 64.5 percent of isolates. Three of these patterns included resistance to lincomycin, tetracycline, erythromycin, and tylosin.

Table 4. Percentage of *E. faecalis* isolates, by top five resistance patterns[1]

Resistance pattern[2]	**Percent**
Lin, Tet, Ery, Tyl	22.1
Lin, Tet	15.2
Lin, Tet, Ery, Tyl, Str	11.3
Lin only	8.0
Lin, Tet, Ery, Tyl, Kan, Str	6.9
Total	64.5

[1]Intermediate isolates were classified as not resistant.
[2]See table 2 for full names of the antimicrobials corresponding to the abbreviations listed here.

Table 5 shows the five most common resistance patterns among *E. faecium* isolates, which were seen in 41.9 percent of isolates. Three of these patterns included resistance to lincomycin, tetracycline, erythromycin, and tylosin.

Table 5. Percentage of *E. faecium* isolates, by top five resistance patterns[1]

Resistance pattern[2]	Percent
Lin only	11.5
Lin, Nit	10.9
Lin, Tet, Qui, Ery, Tyl, Kan, Str	7.5
Lin, Tet, Qui, Ery, Tyl, Str	6.3
Lin, Tet, Qui, Ery, Tyl	5.7
Total	41.9

[1]Intermediate isolates were classified as susceptible.
[2]See table 2 for full names of the antimicrobials corresponding to the abbreviations listed here.

Conclusions

Enterococcus organisms that normally inhabit the gastrointestinal tracts of people and animals were isolated from swine fecal samples on almost all sites. *E. faecalis* and *E. faecium* were isolated from the majority of sites, with *E. faecalis* being more common than *E. faecium*. *E. faecalis* and *E. faecium* isolates were most commonly resistant to lincomycin and tetracycline. None of the *Enterococcus* isolates was resistant to vancomycin, which is important for treating human infections.

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