

Effects of administration of antimicrobials in feed on growth rate and feed efficiency of pigs in multisite production systems

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Objective—To evaluate effect of various regimens for administration of antimicrobials in feed on growth rate and feed efficiency (feed/gain) of pigs in multisite production systems.

Design—Controlled trial.

Animals—24,099 growing pigs in 3 multisite production systems.

Procedure—10 trials involving various regimens for administration of antimicrobials in feed were evaluated. Trial 1 compared effects of 2 antimicrobial regimens on finishing pig performance. Trials 2 through 10 compared growth rate and feed efficiency of nursery and finishing pigs given antimicrobials in feed with values for control pigs not given antimicrobials.

Results—In trial 1, no significant differences were observed between the 2 antimicrobial regimens. In the remaining trials, growth rate of nursery pigs fed antimicrobials was significantly improved, compared with growth rate of control pigs. However, growth rate of finishing pigs and feed efficiency of nursery and finishing pigs were not significantly improved by adding antimicrobials to the feed.

Conclusions and Clinical Relevance—Results suggest that use of antimicrobials in the feed to promote growth should be limited to the nursery phase in multisite pig production systems. Use of antimicrobials in the feed of finishing pigs should be limited to therapeutic applications in which a diagnosis of bacterial infection susceptible to the antimicrobial to be used has been confirmed. (*J Am Vet Med Assoc* 2002;220:1690–1695)

Current dogma suggests that administration of antimicrobials to pigs in their feed improves growth rate and feed efficiency. However, the response is expected to be lower among pigs exposed to fewer infectious agents and among pigs housed in clean environments.¹ Production methods used to raise pigs in the United States have improved profoundly during the past 15 years,² with adoption of novel operational methods and methods for improved hygiene. As a result, bacterial infection pressures have been reduced.

One widely implemented change in pig production methods in the United States has been the adoption of multisite pig production systems.³ In such sys-

tems, piglets are weaned away from the adult swine and reared as a segregated population isolated from exposure to bacterial and viral pathogens carried by older swine. These segregated pigs are exposed to fewer infectious agents and grow faster on less feed. It seems likely, therefore, that pigs raised in these multisite pig production systems would be expected to have reduced responses, both in terms of growth rate and in terms of feed efficiency, to administration of antimicrobials in the feed, compared with pigs raised in historic production systems that have lower hygienic standards and greater exposure to bacterial pathogens.

Reducing the use of antimicrobials in the feed would have an immediate positive economic impact on the swine industry, as these additives represent a substantial portion of the expenses associated with feeding pigs. Additionally, reduced antimicrobial usage would reduce the pressure for selection of antimicrobial-resistant bacteria.⁴ The purpose of the study reported here was to evaluate the effects of various regimens for administration of antimicrobials in feed on growth rate and feed efficiency of pigs in multisite production systems.

Materials and Methods

The study consisted of 10 trials involving nursery and finishing pigs in 3 multisite pig production systems. Antimicrobial regimens that were selected for evaluation included regimens commonly used in the production systems studied and regimens that were under consideration for routine use for nonspecific disease prevention and improvement of growth rate and feed efficiency in these systems. Only regimens that involved administration of antimicrobials in the feed were considered for evaluation.

Recommendations of the attending veterinarians regarding therapeutic administration of antimicrobials in the water or by injection during the study trials were not altered. These therapeutic uses of antimicrobials were not monitored, other than a stipulation that during the study trials, all pens in a barn were to be treated similarly if antimicrobials were administered in the water. Generally, administration of antimicrobials in the water was limited to 72 hours.

Antimicrobials were administered by injection only to those pigs with clinical signs of illness. A confirmed diagnosis of infection with a specific bacterial pathogen was made in only 1 trial in the study (trial 10), in which an outbreak of *Salmonella* ser Choleraesuis infection was confirmed by bacterial culture. All pigs in all treatment groups in trial 10 were given an oral *Salmonella* vaccine.^a Other pathogens identified at all 3 production systems included *Mycoplasma hyopneumoniae*, porcine reproduction and respiratory syndrome virus, *Pasteurella multocida*, *Escherichia coli*, *Lawsonia intracellularis*, *Streptococcus suis*, and *Haemophilus parasuis*.

The first trial began in March 1997, and the last trial concluded in May 2001. All treatment groups in each trial

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were fed an identical nutritional regimen, with the exception of incorporation of antimicrobials. Nutritional regimens were in accordance with published nutritional guidelines.^{5,6} In trials involving finishing pigs, appropriate dietary alterations were made to meet nutritional requirements according to sex. All pigs were of similar genotype within a production system.

Experimental protocol—Trial 1 involved a total of 17,791 finishing pigs allocated into 30 groups (mean \pm SEM number of pigs initially assigned to each group, 593 \pm 8). Groups were randomly assigned to treatment groups at the time of transfer from the nursery to the finishing barn in a balanced incomplete block design. A block consisted of a single barn that contained 1 group of barrows and 1 group of gilts. Treatments were assigned in a 2 \times 2 factorial arrangement with antimicrobial treatment and sex being the 2 factors. A data retrieval error precluded analysis of data from 1 barn. Thus, treatment 1 consisted of 8 barrow groups and 7 gilt groups, and treatment 2 consisted of 7 barrow groups and 8 gilt groups.

Two regimens for administration of antimicrobials in the feed were evaluated in trial 1. The first treatment consisted of a combination of bacitracin methylene disalicylate and chlortetracycline. Bacitracin was fed continuously at a rate of 33 ppm (mg/kg); chlortetracycline was fed during weeks 1, 5, 9, and 13 of the finishing period (440 ppm; 9 kg of feed/pig). The second treatment consisted of intermittent administration of tylosin. Tylosin was fed during weeks 1, 5, 9, and 13 of the finishing period (110 ppm; 9 kg of feed/pig). The duration of administration of tylosin was shorter than the 21 days listed for prevention or control of proliferative enteropathy (ileitis) associated with *Lawsonia intracellularis* infection and reflected the regimen commonly used in the production system at the time of the study. All pigs in this trial had been fed carbadox (55 ppm) during the nursery period.

Trials 2 through 6 involved 108 groups representing a total of 3,648 nursery pigs. In trials 2, 3, and 4, the experimental unit consisted of 2 pens (21 pigs/pen) supplied by a single fence-line feeder. In trials 5 and 6, the experimental unit was a single pen (5 pigs/pen). For these 5 trials, pigs fed antimicrobials were compared with pigs fed a control diet that did not contain any antimicrobials.

Trial 2 used 3 antimicrobial regimens: a combination of bacitracin methylene disalicylate (33 ppm) and roxarsone (37 ppm), administration of carbadox at a rate of 55 ppm for the first 11 days and 11 ppm for the remaining 14 days, and administration of carbadox at a rate of 55 ppm for the first 11 days and 27.5 ppm for the remaining 14 days. Trial 3 used 2 antimicrobial regimens: administration of carbadox at a rate of 55 ppm for the first 11 days and 27.5 ppm for the remaining 14 days, and administration of tilmicosin at a rate of 200 ppm for the first 21 days and carbadox at a rate of 27.5 ppm for the remaining 7 days. Tilmicosin was administered under the provisions of a veterinary feed directive from the attending veterinarian for control of respiratory tract disease associated with *P. multocida* infection. Trial 4 used 3 antimicrobial regimens: a combination of neomycin (110 ppm) and oxytetracycline (110 ppm), a second combination of neomycin (154 ppm) and oxytetracycline (154 ppm), and administration of carbadox at a rate of 55 ppm for the first 11 days and 27.5 ppm for the remaining 21 days. Trials 5 and 6 both consisted of administration of carbadox (55 ppm) for 28 days.

Trials 7 through 10 involved 116 groups representing a total of 2,660 finishing pigs (25 pigs/group in trials 7 and 10 and 20 pigs/group in trials 8 and 9). In all trials, feed intake was recorded by pen; therefore, pen was considered the experimental unit. Similar to trials 2 through 6, pigs in trials 7 through 10 that were fed antimicrobials were compared with pigs fed a control diet that did not contain any anti-

microbials. All finishing pigs used in each trial were obtained from a single nursery. Specific antimicrobials fed during the nursery period to these pigs were not documented; however, it was standard practice to feed an antimicrobial during the nursery period, and all pigs in a nursery were fed the same antimicrobial. Nursery pigs from trials 2 through 6 were not used in any of these trials.

Trial 7 used 3 antimicrobial regimens: administration of carbadox (27.5 ppm) until pigs weighed 45 kg (99 lb) followed by administration of carbadox (11 ppm) until pigs weighed 82 kg (180 lb) and then administration of virginiamycin (11 ppm) until pigs were market weight; administration of tylosin at a rate of 44 ppm during weeks 1 through 4 of the finishing period, at a rate of 22 ppm during weeks 5 through 12, and at a rate of 11 ppm for the remainder of the trial; and administration of tylosin at a rate of 110 ppm (9 kg of feed/pig) during weeks 1, 5, 9, and 13 of the finishing period.

Trial 8 used 2 antimicrobial regimens: continuous feeding of bacitracin methylene disalicylate (33 ppm) and continuous feeding of tylosin (11 ppm). Trial 9 also used 2 antimicrobial regimens: administration of tylosin at a rate of 44 ppm during weeks 1 through 7 of the finishing period and then at a rate of 22 ppm during weeks 8 through 11, with no antimicrobials given in the feed for the remainder of the finishing period; and continuous feeding of bacitracin methylene disalicylate (33 ppm) with the addition of chlortetracycline (440 ppm) during weeks 3 and 9. Trial 10 used a single antimicrobial regimen of continuous feeding of bacitracin methylene disalicylate (33 ppm) with the addition of chlortetracycline (440 ppm; 9 kg of feed/pig) during weeks 1, 5, and 9.

Pig production systems—All 10 trials were performed at production systems with facilities operated on an all-in–all-out basis. The barns had been in use for at least 2 years, with the exception of the facility used in trial 7. The barn used in trial 7 had previously housed 2 groups of finishing pigs. Facilities were routinely cleaned and disinfected between groups of pigs.

The first production system was a 3,000-sow multisite pig production system in which all sows and nursing piglets were located at 1 site and all nurseries were located at a separate site. During the course of the study, this system was expanded to 10,000 sows, with sows housed at 2 additional sites. The expansion of the number of sows was accompanied by the addition of multiple nursery sites containing 2 to 4 nursery barns operated on an all-in–all-out basis by barn. A single nursery room or building was filled with weaned pigs commingled from all sow farms (approx 3 rooms/wk with 1,200 pigs/room at the time of trial 10). The nurseries were operated on an all-in–all-out basis by room, with routine cleaning and disinfection between groups. Finishing barns contained 1,200 pigs/barn and were located on multiple sites (maximum of 4 barns/site). All barns were of a similar design with double-curtain sides, deep pits, and slatted floor pens. Each barn contained 48 pens with 25 pigs/pen. Pens were equipped with a 4-hole dry self-feeder and cup water source or with a wet-dry feeder; a single feeder type was used in all pens in each barn. Each side of the barn contained 24 pens to which a single feed bin supplied feed; thus, each side of the barn was an experimental unit. Each barn contained a group of barrows on 1 side and a group of gilts on the other. Feed was supplied from a single feed mill that only produced swine feed.

Trials 7 and 10 were performed in a 1,200-head finishing barn of a design similar to that for other barns in the production system. However, the barn had been modified to include a scale to weigh pens of pigs and a feeding system to track feed intake by pen. This barn was part of a single site containing 4 finishing barns that were operated on an all-in–all-out basis by barn. After all pigs were marketed from a

barn, the facility was thoroughly cleaned of visible organic matter with a hot-water power washer and disinfected according to standard procedures.

The second production system consisted of 24,000 sows located at multiple different sites during gestation and lactation. Pigs from all sow farms were commingled at the time of weaning into 1 of several 6,000-head nursery buildings, each on a different site and containing 2 rooms with 3,000 pigs/room. A nursery building was entirely filled during a 5- to 7-day period. The nursery buildings were operated on an all-in-all-out basis by site, with a 7-day period between groups when the building was empty. During this period, the nursery, including all flooring and equipment, was cleaned with a hot-water power washer, disinfected, and allowed to dry. Trials 2, 3, and 4 were performed in a single nursery building of the second production system that had been modified to include a scale to weigh pens of pigs and a feeding system to track feed intake by pen. This nursery was managed in the same fashion as all other nurseries in the production system.

Pigs from a single nursery were moved to multiple finishing sites, and pigs from only 1 nursery were used to fill a given finishing site. The finishing barns were operated on an all-in-all-out basis by site and were of similar design to those in the first production system. Trials 8 and 9 were performed in a 480-head finishing barn of similar design to the others in the system, with the exception that 20 (instead of 25) pigs were housed per pen. Other modifications included a scale to weigh pens of pigs and a feeding system to track feed intake by pen. This finishing barn was 1 of 5 on that particular site that was operated on an all-in-all-out basis with thorough cleaning and disinfecting before introduction of the next group of pigs. Cleaning and disinfecting procedures were the same for all facilities throughout this production system.

The third production system consisted of a 150-sow farrow-to-finish farm managed by the Kansas State University Swine Teaching and Research Center. Sows were batch farrowed in groups once every 5 weeks. Thus, at any time there were 5 groups (2 nursery and 3 finishing) of growing pigs housed at the farm. Each group of pigs was treated as a distinct population segregated from other populations of growing and adult pigs with biosecurity barrier protocols in place to limit movement of personnel and equipment between groups. Also, no pigs were transferred from 1 group to another. Pigs that left a group for teaching or research were not returned to the group. Trials 5 and 6 were performed in a single nursery of the third production system. The nursery room was completely emptied of pigs, and standard cleaning and disinfecting procedures were instituted before arrival of the next group.

Statistical analyses—For trial 1, the experimental unit was half the finishing barn (approx 600 pigs). Pigs in each experimental unit were weighed as a group at the time of transfer from the nursery and at the time of marketing or culling. Pigs that died were not weighed; however, the date of death was recorded. Average daily gain was calculated as weight gain divided by total pig days. Weight gain was calculated as the total weight of all pigs sold or culled minus weight of pigs transferred from the nursery. A pig day was defined as 1 live pig for 1 day. Feed efficiency was calculated as amount of feed consumed by the group divided by weight gain. Data were analyzed with an ANOVA that included the fixed effects of antimicrobial regimen and sex and their interaction with a random effect of barn. Data reported are least-square means and the **standard error of the difference (SED)**. Analyses were performed with standard software.⁷

For trials 2 through 10, the experimental unit was a pen or 2 pens (trials 2, 3, and 4). Pigs assigned to each experi-

mental unit were weighed as a group at the beginning and end of each trial. Additionally, all pigs that died during a trial were weighed individually. Average daily gain and feed efficiency were calculated in a similar manner as for trial 1, with the exception that weight of pigs that died was included in the calculation of weight gain. Experimental units in a trial were assigned to treatment in a completely randomized design, with initial weight balanced across treatment within trial. An ANOVA was performed, including the fixed effects of antimicrobial regimen (yes vs no), the trial by regimen interaction, and, for trials involving finishing pigs, sex. As such, in each trial all antimicrobial regimens were pooled into 1 treatment for analysis of the fixed effect of feeding antimicrobials. The nursery and finishing pig data were analyzed separately with data pooled across all nursery groups and all finishing groups. Data are reported as least-squares means and SED. Values of $P < 0.05$ were considered significant.

Results

A significant interaction between antimicrobial regimen and sex was not detected in trial 1 ($P > 0.15$). In addition, there were no significant differences between antimicrobial regimens in regard to any of the variables evaluated (Table 1), including growth rate, feed efficiency, and percentage marketed. As expected, growth rate was significantly ($P < 0.001$) more rapid for barrows, compared with gilts (average daily gain, 0.75 and 0.72 kg [1.65 and 1.58 lb], respectively), and feed efficiency was significantly poorer (2.80 and 2.71 feed efficiency, respectively).

Interactions between antimicrobial regimen and trial were not detected in trials involving nursery (trials 2 through 6) or finishing (trials 7 through 10) pigs ($P > 0.49$), suggesting that responses were similar across all trials for both production periods. In trials 3 and 5, nursery pigs given antimicrobials in their feed had significantly ($P < 0.05$) higher average daily gains than did control pigs that were not fed antimicrobials (Table 2). When data for all 5 trials were pooled, average daily gain was significantly ($P < 0.001$) higher among pigs fed antimicrobials than among control pigs that were not fed antimicrobials. Feed efficiency was not significantly ($P > 0.11$) different between groups when data were analyzed individually for each trial or pooled for all 5 trials. No significant ($P > 0.20$) differ-

Table 1—Comparison of the effects of 2 regimens for administration of antimicrobials in the feed to finishing pigs in a multi-site pig production system

Variable	Antimicrobial regimen		SED	Pvalue
	Bacitracin-chlortetracycline*	Tylosin†		
Initial weight (kg)	18.5	18.4	0.3	0.89
Average daily gain (kg)	0.73	0.73	0.01	0.95
Feed efficiency (feed/gain)	2.76	2.75	0.03	0.75
Mortality rate (%)	4.4	3.9	0.6	0.43
Culling rate (%)	4.1	4.4	0.5	0.49
Marketed rate (%)	91.5	91.7	0.8	0.85

Data are given as mean value for 15 groups (mean \pm SEM, 593 \pm 8 pigs/group initially) for each antimicrobial regimen.

*Bacitracin methylene disalicylate was fed continuously at a rate of 33 ppm (mg/kg) and chlortetracycline was fed during weeks 1, 5, 9, and 13 of the finishing period (440 ppm; 9 kg of feed/pig). †Tylosin was fed during weeks 1, 5, 9, and 13 of the finishing period (110 ppm; 9 kg of feed/pig).

SED = Standard error of the difference.

Table 2—Effect of administration of antimicrobials in the feed on growth rate and feed efficiency of nursery and finishing pigs reared in multisite pig production systems

Trial No.	Initial weight (kg)	Duration (d)	Average daily gain (kg)			Feed efficiency (feed/gain)		
			Control	Treated	SED	Control	Treated	SED
2	5.9	32	0.409	0.427	0.012	1.50	1.46	0.026
3	7.7	28	0.505*	0.528*	0.009	1.48	1.47	0.019
4	6.5	32	0.446	0.462	0.012	1.50	1.48	0.025
5	6.3	28	0.410*	0.449*	0.014	1.35	1.34	0.031
6	6.3	28	0.412	0.427	0.014	1.39	1.37	0.031
Mean	6.7	NA	0.436†	0.458†	0.006	1.44	1.42	0.012
7	34.6	98	0.787	0.792	0.011	2.58	2.55	0.045
8	90.2	56	0.734	0.743	0.014	3.76	3.72	0.059
9	24.5	116	0.809	0.805	0.014	2.51	2.52	0.059
10	44.6	98	0.791	0.772	0.015	2.77	2.80	0.061
Mean	48.3	NA	0.778	0.778	0.007	2.90	2.90	0.028

*Values for control and treated pigs were significantly ($P < 0.05$) different. †Values for control and treated pigs were significantly ($P < 0.001$) different.
NA = Not applicable. SED = Standard error of the difference.
Trials 2 through 6 involved nursery pigs; trials 7 through 10 involved finishing pigs. In each trial, values for control pigs that were not given antimicrobials in their feed were compared with values for treated pigs given antimicrobials in their feed. See text for details of antimicrobial regimens.

ences in average daily gain or feed efficiency were observed for trials involving finishing pigs (trials 7 through 10) within a trial or when data were combined for all 4 trials.

Discussion

In trial 1 in this study, we compared 2 regimens for administration of antimicrobials in the feed of finishing pigs under field conditions but did not include a control group that did not receive antimicrobials. Outcomes of these 2 groups were surprisingly similar, but it was not possible to determine whether this was because the regimens were of equal efficacy or because there was no response to either regimen. A previous study⁸ indicated that the magnitude of response differed with antimicrobial regimen for finishing pigs given antimicrobials in their feed, with the change in growth rate ranging from 0 to 8.9% and the change in feed efficiency ranging from -1.8 to 3.8%. Because of the lack of response in trial 1, we initiated additional trials that included a control group that did not receive antimicrobials in their feed.

Although mortality rate is important when assessing the economic impact of giving antimicrobials in the feed, data on mortality rate were not collected in trials 2 through 10. We had anticipated that the group-to-group coefficient of variation would be greater than 80% when using a pen of pigs as the experimental unit. With this large variation, detecting a 1% difference in mortality rate if mean mortality rate for control pigs was 4% (ie, a 25% reduction) would have required 216 replicates.⁹ Therefore, we would not have had enough replicates to detect meaningful differences in mortality rates.

Our results indicate a greater response in terms of average daily gain among nursery pigs than among finishing pigs when antimicrobials were added to the feed, but magnitude of the response was less than that reported previously.^{8,10} We did not observe significant improvements in feed efficiency in any trial or when data were pooled for the 5 trials involving nursery pigs or the 4 trials involving finishing pigs, which is different from previous reports.^{8,10} Considering the SED we

observed, we would have been able to detect differences between treatments in feed efficiency of 1.7% in trials involving nursery pigs and 1.9% in trials involving finishing pigs with an α of 0.05.

The National Research Council¹ has suggested that the positive effects of antimicrobials on the growth rate and feed efficiency of pigs are well documented. In drawing this conclusion, the Council relied on 2 reports^{8,10} that summarized data for studies involving 1,194 experiments with 32,555 pigs. The combined results of these experiments suggested that growth rate was improved 16.4% in nursery pigs (ie, pigs that weighed 7 to 25 kg [15 to 55 lb]), 10.6% in growing pigs (ie, pigs that weighed 17 to 49 kg [37 to 108 lb]), and 4.2% in growing-finishing pigs (ie, pigs that weighed 24 to 89 kg [53 to 196 lb]). In contrast, our study indicated only a 5.0% improvement in growth rate among nursery pigs and no improvement in growth rate among finishing pigs. The same National Research Council¹ summary indicated that feed efficiency was improved 6.9% in nursery pigs, 4.5% in growing pigs, and 2.2% in finishing pigs.

We suggest 3 possible reasons for the difference between results of the present study and results summarized in previous reports.^{8,10} The first is potential bias associated with any historic summary that uses published data. There is a bias toward publication of trials with positive results.^{11,12} Therefore, historic summaries could be biased toward positive results.

The second potential explanation for the marked difference between historic summary data and our results is the excellent performance of control pigs in the present study that were not given antimicrobials in their feed. Although performance of these control groups was not dramatically better than contemporary production standards observed in many modern production systems, they were considerably better than those reported in a previous summary of similar trials.⁸ For example, performance of control pigs in trial 3 in the present study represented a 21% improvement in growth rate and 33% improvement in feed efficiency, compared with control pigs in the previous summary report.⁸ Early research indicated that the improvement

associated with feeding antimicrobials increased as the performance level of the control pigs fed diets without an antimicrobial decreased.¹³ Therefore, because control groups in the present study grew considerably faster and had better feed efficiency, compared with control groups in previous summary reports,^{8,10} we expect a lower response to feeding antimicrobials.

The third potential explanation for the difference between historic data and results of the present study is the better hygienic conditions under which pigs in the present study were raised. In the past, it has been observed that responses to administration of antimicrobials in the feed were greater under field conditions, compared with controlled research situations.^{14,b} This was likely a result of cleaner conditions in the controlled research environment. Since the experiments summarized in the reports by Zimmerman⁸ and Hays¹⁰ were performed, the way pigs are raised has changed dramatically, particularly with the implementation of multisite pig production methods. We believe this hygienic improvement is the major reason for the lower response to feeding antimicrobials in the present study. Chronic bacterial infection is a metabolic burden that has a detrimental effect on growth in pigs because of diversion of nutrients.^{15,16} Use of multisite pig production methods decreases vertical pathogen spread from adult to growing pigs and lateral pathogen spread among groups of growing pigs. Additionally, the sanitation and hygiene procedures used between groups with multisite production methods reduce the environmental pathogen burden to which susceptible arriving young pigs are exposed.

We believe that results of the present study are an indication that use of multisite pig production methods reduces the infectious pathogen burden on pigs that in turn decreases the need for production (ie, non-therapeutic) use of antimicrobials. In addition, we believe that our results imply that there has been a shift in the potential benefits of adding antimicrobials to the feed of growing pigs versus their costs and challenge the dogma that antimicrobials should routinely be included in the diets of growing pigs for enhancement of production.

Results of the present study are not necessarily generalizable to the entire US swine population. However, we believe that they may be representative of results expected for other similar multisite production systems. Recent economic analyses of the benefits of adding antimicrobials to the feed of pigs to promote growth rely heavily on the suggestion that feeding antimicrobials improves growth rate and feed efficiency by 5 to 10%^{17,18} or use values from previous summary reports.¹⁹ We believe our data indicate that future economic analyses of the growth-promoting effects of antimicrobials should assume a wider range for improvements in growth rate and feed efficiency to account for the range of responses that might be obtained in the industry as a whole.

The magnitude of the impact of agricultural antimicrobial use on development of antimicrobial resistance in human pathogens has not been conclusively established. However, there is a link between the use of antimicrobials in food animals, the development

of resistance to these drugs, and human disease.^{19,20} It is generally agreed that better infection control and limiting use of antimicrobials to instances when bacterial infection has been confirmed generally reduces development of antimicrobial resistance among bacterial populations^{4,17,21,22} and that reducing exposure of pigs to antimicrobials leads to lower rates of antimicrobial resistance.²³ Much of the public debate about antimicrobial use in agriculture has focused on antimicrobial resistance,^{17,22,24} and little discussion has been focused on the efficacy of using antimicrobials to improve growth rate or feed efficiency in food animals. In fact, some authors have suggested that modern intensive methods of food animal production would not be possible without the subtherapeutic use of antimicrobials in feed.¹⁸ On the basis of our results, however, we contend just the opposite. Our results suggest that modern, intensive multisite pig production methods may actually require less use of antimicrobials and perhaps then for therapeutic purposes, not for production purposes.

We acknowledge that some of the antimicrobial regimens tested in the present study were intended for prevention or control of specific diseases and that antimicrobials were administered at therapeutic dosages.^{18,19} In addition, we acknowledge that some of the regimens included intermittent use of antimicrobials at therapeutic dosages. However, regimens used in these trials were currently used or were being considered for use in the production systems studied, with the expectation that these antimicrobial regimens would result in improvements in health, growth rate, and feed efficiency. The sole intent of these antimicrobial regimens was improvement of growth rate and feed efficiency by preventing disease or through inherent growth-promoting properties of the antimicrobials. Also, we believe the regimens were reflective of antimicrobial regimens being used in many modern North American pig production systems. Therefore, on the basis of our results and in accordance with judicious antimicrobial use guidelines,²⁵ we believe that antimicrobials should be used in pigs only following documentation of a susceptible bacterial pathogen in the group of pigs at risk.

It appears from our results that in the type of multisite pig production systems involved in the present study, use of antimicrobials in feed for growth promotion should be limited to nursery pigs. Because feed consumed during the nursery period represents about 10% of the total feed consumed from weaning to market, limiting use of antimicrobials in the feed to the nursery period would lead to a substantial reduction in antimicrobial usage. Furthermore, there was little evidence in the present study to support use of antimicrobials at therapeutic dosages in an intermittent or metaphylactic manner without diagnosis of a specific bacterial pathogen. Thus, use of antimicrobials in the feed should be limited to instances when diagnosis of a susceptible bacterial infection has been confirmed. In accordance with judicious antimicrobial use guidelines, a confirmed diagnosis is required to ensure the proper antimicrobial is selected and used at the proper dosage. We believe that wide-scale adoption of multi-

site pig production systems has greatly reduced the need for production use of antimicrobials in the feed of pigs.

^aArgus SC, Megan Health Inc, St Louis, Mo.

^bMellièrè AL, Brown H, Rathmacher RP. Finishing swine performance and responses to tylosin (abstr). *J Anim Sci* 1973;37:286.

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