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Antimicrobial Drug Use and Veterinary Costs in U.S. Livestock Production

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Abstract

Antimicrobial drugs are fed to animals at low levels to treat diseases, to promote growth, and to increase feed efficiency. Incorporating low levels of antimicrobial drugs in livestock feeds has been shown to be a factor stimulating the development of antimicrobial drug-resistant bacteria in livestock. Since many of the drugs used to treat livestock are the same as or are related to drugs used in human health care, there is concern that resistant organisms may pass from animals to humans through the handling of animals or food derived from animals. The movement of pathogens from animals to humans, and vice versa, has been documented, but the extent to which it has occurred or could occur is unknown. Although it is estimated that as little as 10 percent of the problems of drug-resistant pathogens in humans originate in livestock health care practices, there is currently considerable debate about the frequency and costs of human disease outbreaks resulting from animals infected with drug-resistant pathogens. Several European countries have banned the growth-promoting use of antimicrobial drugs in livestock production as a precautionary measure to prevent resistant organisms from passing from animals to humans. This report presents preliminary estimates suggesting that discontinuing the use of antimicrobial drugs in hog production would initially decrease feed efficiency, raise feed costs, reduce production, and raise prices to consumers. Longer term effects were not examined.

Keywords: Antimicrobial drugs, pathogens, growth promotion, feed efficiency, therapeutic drug use, subtherapeutic drug use, subclinical

Contents

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Introduction

Antimicrobial drug resistance, the ability of bacteria or other microbes to resist the effects of antimicrobial drugs, is a global concern for both human health and agriculture (Swain Report to the English Parliament, the Institute of Medicine's National Research Council report (1980), the Council for Agricultural Science and Technology report, the Institute of Medicine report (1989), the World Health Organization report, the Committee on Drug Use in Food Animals report, and a General Accounting Office report). The specter of resistant livestock diseases affecting humans, human health, and human health care practices has heightened concerns about livestock drug use and motivated regulatory actions. In early 1999, the Center for Science in the Public Interest, representing 37 health and consumer groups, petitioned the U.S. Food and Drug Administration (FDA) to ban the use of penicillin, tetracycline, erythromycin, tylosin, lincomycin, virginiamycin, and bacitracin in livestock production (Reuters, March 9, 1999). A bill banning subtherapeutic feeding of the same seven antimicrobials was introduced into the House of Representatives in November 1999 (H.R. 3266, November 9, 1999). Several European countries have already banned the feeding of antimicrobial drugs to enhance growth or feed efficiency.

In the United States, the FDA has proposed a framework for evaluating and assuring the human safety of the antimicrobial effects of new animal drugs intended for use in food animals. The proposed guideline would classify antimicrobial drugs according to the extent to which they are useful in human health care. The new guidelines also propose setting predetermined thresholds for when actions should be taken to stem the emergence of resistant pathogens (Bernick).

The hypothesis that drug-resistant bacteria may be transferred to humans through food was first formally stated in 1969 (Swann). Proof of the actual transmission of antimicrobial-resistant diseases between animals and humans is difficult to establish and involves several steps: (1) the selection for and persistence of resistant bacteria in animals from subtherapeutic[1] doses of antimicrobial drugs, (2) the presence of resistant pathogens in animal products, (3) transmission of these pathogens to humans, and (4) diagnosis of human diseases caused by these pathogens (Cohen and Tauxe). In spite of the difficulties, studies tracing animal sources for human infection by drug-resistant pathogens do exist (Feinman; Holmberg, Wells, and Cohen; Okolo; Cohen and Tauxe; Lee *et al.*; and Thoen and Williams).

In animals, antimicrobial drugs are fed at low levels for therapeutic disease treatment or to promote animal growth and increase feed efficiency.[2] Walton points out that "a critical level or minimal inhibitory concentration (MIC) of antibiotic is needed to select resistance in bacteria" and that subtherapeutic levels to promote growth may not reach that critical level. However, correlations between drug-resistant bacteria and feeding practices using low levels of antimicrobial drugs are relatively high (Cohen and Tauxe; and Okolo).[3]

In humans, microbial resistance to antimicrobial drugs stems from over-reliance on antimicrobial drugs in human medicine, failure to adhere to prescriptions for the full duration of treatment, and increased clustering of people in hospitals, day care centers, and other similar places where humans congregate (*AHI Quarterly*). Two of the greatest sources of drug-resistant pathogens observed in humans are from drug-resistant pathogens encountered during hospitalization and misuse of antimicrobial drug prescriptions by both doctors and patients (U.S. Congress, Office of Technology Assessment and Committee on Drug Use in Food Animals). It is estimated that as little as 10 percent of the problems of antimicrobial resistance originate with livestock health practices (Bernick). The Committee on Drug Use in Food Animals offered the following perspective:

"While the use of antibiotics in food animals can cause resistance emergence, not all instances of resistance

[1]Subtherapeutic doses of antimicrobial drugs were generally considered to be less than 50 grams of antimicrobial per ton of feed for these studies. More recently, subtherapeutic doses are considered to be less than 200 grams per ton of feed.

[2]Growth rate is defined as pounds of weight gained per day. Feed efficiency is defined as pounds of feed fed per pound of gain. The two measures are related, but not identical: A 2-pound-per-day rate of gain (growth rate) can be achieved by feeding different amounts of even the same feed to different animals. And different animals can gain a pound on the same amount of feed (feed efficiency) but gain different amounts per day.

[3]For a collection of recent papers on selected aspects of the biology of antimicrobial drug resistance in livestock production, see the report by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), Antimicrobial Resistance Issues In Animal Agriculture, <http://www.aphis.usda.gov/vs/ceah/cei/#antimicrobial resistance>.

are clinically significant, involve resistance in pathogens, or cause an actual illness. In contrast, because the occurrence of infection in hospitals is often considered life-threatening, the risk to human health of hospital-acquired infections might be thought of as a greater risk."

Other situations that motivate the evolution of drug-resistant microbes include essentially any long-term use of antimicrobial drugs in either animals or humans (Feinman; Holmberg, Wells, and Cohen; Okolo; and Cohen and Tauxe). Bans against using antimicrobial drugs in livestock production are often the first-mentioned line of defense against potential ineffectiveness of antimicrobial drugs in human health care.

This report explores these issues and presents background material on the economic importance of antimicrobial resistance and antimicrobial drug use in livestock production. The objectives of this report are to summarize previous estimates of economic effects of antimicrobial drug use and bans in livestock production and to present a simple thought experiment in which costs associated with the disuse of antimicrobial drugs in producing swine are estimated. Swine are affected by a large number of bacterial diseases, most swine receive subtherapeutic doses of antimicrobial drugs during the production process (USDA, APHIS and Hayes *et al.*), and a large proportion of swine are produced on large confinement operations where diseases can spread rapidly.

The ability of pathogens to move between humans and animals raises many questions. The extent to which this transfer can occur and has occurred is unknown (figure 1). There is currently much debate about the frequency and costs of human disease outbreaks resulting from animals infected with antimicrobial drug-resistant pathogens. Food safety and human health depend in part on the production technologies employed to raise livestock, especially to the extent that pathogens or drug residues remain with the livestock all the way through the chain of processing events that begin at the farm and end with the consumer (figure 2).

The economic consequences of resistance to antimicrobial and other drugs are difficult to measure precisely. Effects from resistant microbes and their associated costs can range from virtually no impact on animal health to costs that exceed the value of an animal. The human health costs, while not addressed here, can also vary from no illness or discomfort to death.

Economic effects associated with low-level use of antimicrobial drugs in feeds may be negative, such as the possibility that costs of treating livestock diseases could be higher because of the necessity of using more expensive drugs effective on resistant pathogens.

Figure 1
Universe of bacteria

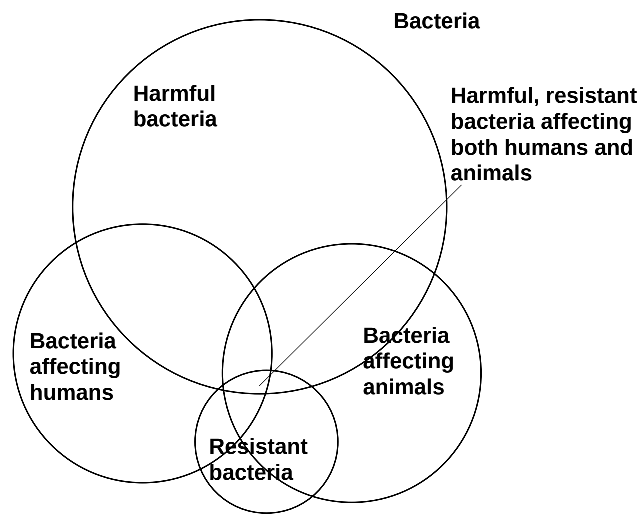
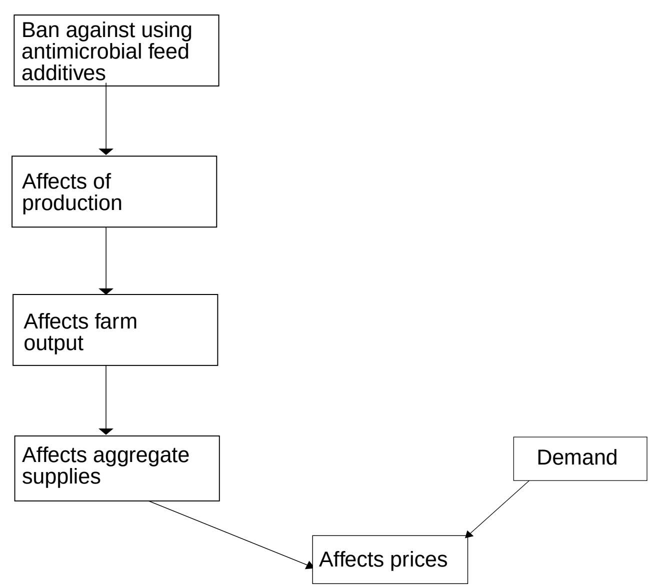


Figure 2
Effects of a ban on antimicrobials fed to livestock



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Or positive benefits could accrue to producers from not feeding low-level antimicrobial feed additives because of their ability to use less expensive antimicrobial drugs to treat disease outbreaks caused by susceptible pathogens. Benefits to consumers may, likewise, be positive, negative, or nonexistent. Positive benefits could include livestock products without antimicrobial-resistant microbes and, thus, safer food. Or there may not be any benefits to consumers that would offset the higher costs from a ban.

The work described in this report contributes to the Economic Research Service's mission of providing economic analysis on efficiency, efficacy, and equity issues related to agriculture, food, the environment, and rural development to improve public and private decision making.

The Economics of Using Drugs in Livestock Production

It is generally conceded that commercial livestock production in the United States, especially confinement production, would be virtually impossible without antimicrobial drugs. Therapeutic uses of antimicrobial drugs to treat specific infections can be at high or low levels. Although dosages below 200 grams per ton of feed are defined as subtherapeutic (Committee on Drug Use in Food Animals Panel on Animal Health, Food Safety, and Public Health), there may be no difference in the dosages for low-level therapeutic uses and uses of antimicrobial drugs as growth promotants—the only difference being the objective of drug administration.

In addition to therapeutic uses, antimicrobial drugs are fed to livestock for a variety of production management reasons. Low levels of antimicrobial drugs increase daily rates of weight gain and improve feed efficiency in livestock, lowering feed costs (Ensminger, 1987; North and Bell). Antimicrobial drugs in feed also slightly improve carcass quality in cattle (Ensminger, 1987). When steers and heifers are fed low levels of antimicrobial drugs, more fat is deposited and marbling increases, which can increase the value of the animal. When cattle are fed low levels of antimicrobial drugs, they have fewer diseases; therefore, fewer carcasses or livers are condemned during slaughter. Abscessed livers are particularly troublesome when feeding cattle rations containing relatively large amounts of grains and protein feeds. This occurs because antimicrobial drugs alter the microbial environment in the gastrointestinal tract, increasing the availability of some nutrients to the animal. Antimicrobial drugs can also alter metabolism of certain compounds, such as proteins and minerals, and can reduce stress from subclinical (a level of infection too low to produce noticeable symptoms) effects of pathogens. In either case, more energy contained in the feed is applied to growth and weight gain.

The effects of feeding low levels of antimicrobial drugs vary between livestock species. Rates of weight gain can be increased by about 6 percent and feed efficiency improved by about 4 percent in feeding beef steers and heifers for the slaughter market (Doane's). In swine, weight gains can be improved by about 10 percent and feed efficiency by about 5 percent (Doane's). Weight gains of up to 60 percent have been observed in dairy calves (Council for Agricultural Science and Technology (CAST)). Poultry growth and feed efficiency is also improved (North and Bell). Higher levels of production responses in swine have been reported in commercial settings than in experimental settings. The same pattern of higher commercial responses versus experimental responses likely persists for other livestock species. These improvements in production can amount to large economic gains for livestock producers.

In poultry production, especially broiler production, antimicrobial drugs are used as growth promotants in lieu of growth hormones for at least two reasons. First, no growth hormones are approved for use in poultry production. Second, hormones are ineffective in young birds because natural levels of hormones remain high for most of their relatively short production cycle.

Earlier committee, work group, and task force reports recommended banning subtherapeutic use of antimicrobial drugs in animal feeds as a precautionary response, despite insufficient evidence that human health problems arise directly from the practice (Swain Report to the English Parliament, the Institute of Medicine's National Research Council report (1980), the Council for Agricultural Science and Technology report, the Institute of Medicine report (1989), the World Health Organization report, the Committee on Drug Use in Food Animals report, and a General Accounting Office report). One author suggested that it is therapeutic uses that reach a critical level necessary for the development of resistant bacteria (Walton).

In most cases, however, therapeutic uses have been excluded from recommended bans.

A ban against using antimicrobial drugs in livestock production would come with a cost. Previous studies of the economic impacts of various partial and full bans of antimicrobial drugs in livestock feeds are summarized in table 1. None of these studies addressed the effects of livestock drug bans on human health and health care. Results from earlier studies vary, but show higher costs to producers and generally price increases for consumers as the result of partial or total bans against feeding low levels of antimicrobial drugs to livestock (table 1). Gilliam, *et al.*; Mann and Paulsen, and Wade and Barkley assumed a full ban of all antibiotics in feed; Dworkin and Headley looked at banning only selected antibiotics; and Allen and Burbee and USDA looked at both full and partial ban scenarios.[4] Gilliam *et al.,* assumed a full ban on antimicrobial drugs and looked at three scenarios for fed cattle and hogs. They allowed production to remain constant by (1) lengthening feeding periods or (2) feeding more animals, or (3) allowing production to decline by feeding the same number of animals for the same period as without the bans. Gilliam *et al.* estimated consumer effects only for their third case in which production declined, translating the increased production costs into a price increase and transferring the entire

[4]The Allen and Burbee (1972), Dworkin (1976), and Headley (1978) papers were not reviewed by this author, but their studies were summarized second-hand from reviews in the CAST report (1981).

Table 1—Results from previous studies of full and partial bans against using antibiotic feed additives in livestock production

Study	Year study was published	Aggregate costs per year (million dollars)	Aggregate costs per year (results adjusted to 1998 dollars; million dollars)
Allen and Burbee; and Gilliam *et al*[1]	1972; 1973	5,660	12,707
Dworkin (Beef and pork only)[1]	1976	2,140	4,804
Mann and Paulsen[1]	1976	580	1,302
Headley[1]			
I (ban penicillin and tetracycline)	1978	1,440	3,233
II(ban nitrofuran and sulfa compounds)	1978	4,680	10,507
USDA II (moderate efficiency, penicillin, tetracyclines, sulfa drugs, and nitrofurans banned)[1]	1978	1,240	2,784
Wade and Barkley (4% decrease in Supply; Supply elasticity of 0.40; 5% increase in Demand; Demand elasticity of -2.50)			
Swine (loss in consumer surplus, 1987 dollars)	1992	11.74	16.85
Swine (loss in producer surplus, 1987 dollars)	1992	12.59	18.07
National Research Council/Institute of Medicine			
Partial ban	1998	1,261	1,281
Total ban	1998	2,527	2,566
Hayes et al.			
Losses to producers	1999	160.3	160.3
Losses to consumers	1999	748	748

[1]Data from table 45 of the 1981 CAST report (Council for Agricultural Science and Technology, Antibiotics in Animal Feeds, Report No. 88): 5-year totals divided by 5 years.

increase to the consumer—a retail price increase of 7.18 cents per pound (1970 dollar equivalents). Allen and Burbee obtained similar results in a closely related study for broilers and turkeys looking at both full and partial antimicrobial bans with the same three production scenarios. Mann and Paulsen calculated producer and consumer effects of bans on antibiotics and DES (diethylstilbestrol) for five years after the bans. They found higher costs to producers and consumers. USDA looked at species by species bans on penicillin, tetracyclines, nitrofurans, and sulfas, a ban across all species, and economic effects for five years after bans with qualitatively similar results. They also estimated total and per capita costs incurred by consumers. Henson found increases in production costs under restrictions on adding penicillin, tetracyclines, and nitrofurans to poultry feed. Wade and Barkley found gains to both producers and consumers because of a ban on antibiotics used in pork production. The gain for consumers is due to their assumption that demand would shift outward because of increased pork consumption by health-conscious consumers. Their analysis focused on pork only, ignoring effects associated with other species. Hayes *et al.*, also found increased costs to both producers, by about $6.05 initially, and consumers, by about $11 per family of four.

The authors of the CAST report included additional equilibrium price and quantity estimates based on price and quantity changes reported in several of the studies. The combined losses to producers and consumers ranged from just over a million dollars to $28 billion over a 5-year period. Losses were higher under the assumption of no substitutes for the antimicrobial drugs banned than under partial bans.

Economic Considerations for the Animal Health Industry

The Animal Health Institute[5] (AHI) Resource Book states that one-third of the $2 billion spent on animal health products in 1992 was for commercial livestock. AHI estimates that about $600 million was spent on feed additives for all animals in the United States in 1992. Separately, the Office of Technology Assessment estimated that about 90 percent of the antimicrobial drugs used in agriculture are used as prophylactics or growth promotants. Applying this 90 percent to the AHI estimate of total dollars spent on animal health products suggest that about $667 million were spent on animal health products for commercial livestock in 1992, and about $600 million of this $667 million was for prophylactics and antimicrobial feed additives and $67 million for all other animal health products.

[5]The Animal Health Institute is a lobby group for the animal health product industries.

Veterinary Costs

Another way to estimate aggregate livestock health costs is to expand estimated costs per head from survey results. Per-head veterinary costs are available from Agricultural Resource Management Study (ARMS) data.[6] Estimates of total veterinary costs for livestock producers in 1998 were $0.39 per hundredweight (cwt) of milk produced (USDA, Agricultural Income and Finance Situation and Outlook), $1.15 per cwt gained for all hogs, $22.04 per bred beef cow, and 0.5 cent per pound of live broiler weight (table 2). Expanding these costs per unit to represent total aggregate U.S. veterinary costs of production yields estimates on the order of $613 million for dairy, $747 million for beef cows and calves, $218 million for hogs, and $105 million for broilers. In addition to veterinary expenses, another $107 million was spent for antimicrobial feed additives for hogs in 1992 (Farm Costs and Returns Survey, unpublished information). There are additional classes of livestock, like sheep, goats, horses, rabbits, and others, for which there are either no estimates for or only sporadic estimates for drug costs or veterinary costs.

[6]The Agricultural Resource Management Study (ARMS) is described on the web site listed in the References section under USDA, 2000.

Table 2—Total veterinary costs for producing livestock, per unit and aggregate, 1998

Species/subgroup	Dollars per unit	Total millions dollars for U.S.
Beef cow/calf, all, per cow	22.04	746.83
Dairy, per cow, Milk, per cwt	.39	613.47
Hogs, all, per cwt gain	1.15	218.28
	Cents per pound	
Poultry, broilers, pounds live	.50	105.00

Sources: Beef cows, dairy, hogs (USDA, < http://www.ers.usda.gov/data/costsandreturns/ > (outdated web site)) and poultry (Christensen, 1993). Quantity data were from the USDA, Livestock, Dairy, and Poultry Situation and Outlook, LDP-M-68, February 29, 2000.

An Estimated Aggregate Effect of Not Having Used Antimicrobial Drugs in Hog Production

Estimating the importance of antibiotic feed additives is significant in determining the impact of regulations or bans against feeding low levels of antibiotics to livestock. For instance, using the estimates for hogs from the foregoing, we can derive the following aggregate economic effects of feeding antibiotics and banning antibiotics.

Swine production easily ranks third in pounds of meat production behind poultry and beef, and is one of the top two livestock species in terms of antimicrobial drugs used at low levels in feed and water. In 1999, total hog production was 19.278 billion pounds (USDA 2000). To determine what effects feeding antimicrobial feed additives might have on livestock production, it is instructive to work through a basic economic assessment using assumptions about use of antimicrobial feed additives and associated feed efficiency. Assuming that a fourth of the 1999 hog production[7] was directly affected by antimicrobial feed supplements, including an improvement in feed efficiency of 5 percent, then antimicrobial feed supplements could have been directly responsible for 229 million pounds of the total 1999 U.S. hog production.

Total feed costs for all U.S. hogs were about $5 billion in 1999. Given a 1.25-percent improvement in feed efficiency from feeding low levels of antimicrobial drugs (the expected 5-percent improvement in feed efficiency applied to a fourth of total pork production), U.S. hog producers saved a total of about $63 million in feed costs.

This feed cost saving is offset by lost income from the effect of the additional hog production on hog prices. If hogs were the only commodity affected, and a supply and demand elasticities of .039 and -.48, respectively (Hahn), and assuming a supply shifter elasticity of 1.0 for hogs, the 229 million pounds of U.S. hog production lost had antimicrobial drugs not been fed would have resulted in prices about 2.3 percent higher than they were. That is, by feeding low levels of antimicrobial drugs, prices, at $34.02 per hundredweight (USDA, *Agricultural Outlook*) were $0.78 lower in 1999 than they might have been had antimicrobial drugs not been fed. A hypothetical reduction in hog production of 229 million fewer pounds from not feeding antimicrobial feed additives could have meant a price of $34.80 per cwt.[8] The lower production, about 19.049 billion pounds of total U.S. hog production had low-level antimicrobial drugs not been fed, would have been worth an extra $70 million.[9] Subtracting the extra feed costs ($63 million) from this $70 million leaves a net gain to the hog sector of $7 million. However, only $17.5 million, a fourth of the $70 million, would accrue to the producers who would have fed antimicrobial feed additives, but the entire extra feed cost of $63

[7]The assumption that a fourth of hog production was directly affected by feeding antimicrobials is conservative in view of the shares of operations feeding antimicrobials observed in APHIS data included in table 3.

[8]These results assume that the same number of hogs would have been fed the same amount of feed as was the case, but these hogs would have reached slightly lower slaughter weights because of the loss in growth and feed efficiency. It may be that producers would simply continue to feed their hogs to the same market weights, in which case, results of this thought experiment would be slightly different quantitatively, but not qualitatively.

[9]19.278 billion pounds of hog production at 34.02 per hundredweight was worth about $6.56 billion; 19.049 billion pounds at the higher price (price and quantity are inversely related) of $34.80 was worth $6.63 billion,$70 million more. This result derives from the effects of low commodity elasticities common in agriculture on total values.

Table 3--Antibiotic use on hog operations, December 1, 1994 through May 31,1995

Practice	Piglets Before or at Weaning	Market Hogs	Sows/ Gilts	Boars
	Percent of operations			
Antibiotics in feed	70.2	58.7	45.5	38.4
Antibiotics in water	16.0	12.3	6.6	4.7
Antibiotics injection	39.5	24.8	30.3	22.3

Source: Adapted from U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, Swine '95: *Part I: References of 1995 Swine Management Practices*, p. 12, October, 1995.

million would have been theirs, leaving them with a net loss of $45.5 million.

If producers as a group are better off by not feeding antimicrobials to livestock, it seems natural to wonder why antimicrobial drugs are included in feed rations to improve growth rates and feed efficiency. The justification is a result of the large number of producers in the hog markets, each making optimal decisions about increasing production and efficiency, and each of which has no discernable effect in a competitive market. Each producer is able to improve his or her net returns by feeding antimicrobial drugs. However, when all producers act in concert, feeding antimicrobial drugs, the collective result is to increase hog supplies; the increased supplies decrease hog prices.

Several factors could mitigate results for the above thought experiment. First, it is not likely that an antimicrobial ban would only affect hogs. Drug use for beef, poultry, lamb, and fish would likely have been affected by a ban, and prices for those species would have been higher as well, because of less total meat available. Higher prices for other meat commodities would also reduce the effects on final consumption of hog price increases from a ban. Feed input prices for corn, sorghum, soybeans, cottonseed, and others would likely be higher because of increased demand for these and other inputs. These supply and price effects would likely decline as production adjusts over time due to increased production by producers who hadn't been feeding antimicrobial drugs and to adjusted production by other producers who had revised production practices previously dependent on low levels of antimicrobial drugs.

Second, not feeding the low levels of antimicrobial drugs in livestock feeds could contribute to increased production risks. Death losses and reduced production from diseases that had been prevented by feeding low levels of antimicrobial drugs could be costly. In situations where livestock are concentrated, especially in hog and poultry feeding operations, diseases can spread rapidly, and disease outbreaks can take a far heavier toll if low levels of antimicrobial drugs are not fed.

Toward Developing an Economic Model of Regulated Antimicrobial Use

The issues surrounding antimicrobial use are similar to issues surrounding other pest management and damage control problems. Other authors have recognized this similarity (Lichtenberg and Zilberman; Babcock, Lichtenberg, and Zilberman; and Fox and Weersink). Many of the regulatory issues raised in the context of animal drugs have been examined for pesticides and other agricultural chemicals (Carlson; Lazarus and Dixon; Harper and Zilberman; Zilberman *et al.* ; and Zilberman and Millock). And some authors have specifically addressed the issue of the development of pesticide resistance (Hueth and Regev; Carlson; and Lazarus and Dixon).

Current antimicrobial drug use introduces several complexities into economic modeling of drug use in livestock production that are not characteristic of other pesticide-input use production models. First, low-level antimicrobial use in livestock production introduces additional complexities into the general pest management/pest resistance framework because feeding antimicrobial drugs at low levels is not only output-enhancing, but also is an input that interacts with other inputs, especially feeds.

Second, decision makers must consider tradeoffs between using and not using antimicrobial feed additives. Using antimicrobial feed additives yields productivity increases from growth and feed efficiency but increases the probability of a resistant disease outbreak and increases treatment costs due to using more expensive antimicrobial drugs to treat resistant diseases. Not using antimicrobial feed additives increases feed costs and perhaps costs associated with disease and death loss, but diseases are less likely to be caused by resistant pathogens and can often be treated with less expensive first-line antimicrobial drugs.

The welfare effects of antimicrobial feeding bans depend on assumptions about animal, producer, and consumer responses. Antimicrobial drugs are not yet part of any farm-level Hazard Analysis and Critical Control Point (HACCP) measures, but conceivably could become part of a regime to reduce pathogens at the farm level. To the extent feeding low levels of antimicrobial drugs to reduce food-borne pathogens became farm-level HACCP measures, welfare results could be complicated by conflicting policies to improve food safety and reduce antimicrobial drug use in livestock production.

Implications

The potential for antimicrobial drug-resistant pathogens to ultimately pass from animals to humans may increase with increasing levels of aggregate use of antimicrobial drugs. This is important to the extent these organisms are capable of causing disease or illness in humans. Incorporating low levels of antimicrobial drugs in livestock feeds is one factor stimulating the development of antimicrobial-resistant bacteria in livestock. Based on a precautionary principle, the practice of incorporating low levels of antimicrobial drugs in livestock feeds has been banned in some countries.

As incidents and problems involving drug-resistant pathogens increase, there will be more pressure for policies or regulations on using antimicrobial feed additives in U.S. livestock production. Economists and other scientists will be called upon to assess potential effects of these policies and regulations. Economic research in these areas of antimicrobial resistance and the use or nonuse of antimicrobial feed additives will depend on economic assessments of the effects of antimicrobial drugs in livestock feeds.

This analysis has presented a summary of literature on the economic effects of hypothetical antimicrobial bans and presented some preliminary estimates of the economic effects of using or not using antimicrobial drugs in swine feeding.

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