ECONOMIC EFFECTS OF A PROHIBITION ON THE USE OF SELECTED ANIMAL DRUGS

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ABSTRACT

An economic assessment is made of the impacts that might occur in the agricultural sector from the ban or restricted use of various drugs in animal feed. Attention is focused on feed efficiency, growth promotion, and mortality, and how changes in these variables affect production costs, output, and product prices. Effects on consumers and consumer response are also estimated.

KEYWORDS: Animal feed, Antibiotics, Nitrofurans, Sulfa, Human health hazard, Production costs, Output, Product prices,

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The list could go on. Suffice to say that without the help of these and many other people from other agencies and departments in Government, this report would not have been possible. Those responsible for the report believe it provides useful information on an important public policy issue.

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SUMMARY

Chemicals, once thought to be absolutely necessary for food preservation, are being implicated as causal agents directly related to human health conditions. As a result, and in an attempt to protect the inherent safety of the food supply, public policies to ban or otherwise regulate the use of a wide variety of animal feed additives are being proposed and debated.

The subtherapeutic uses of some animal drugs are being questioned, because of evidence linking resistant strains of certain organisms to the chronic intake of antibiotics. For example, the Food and Drug Administration (FDA) has demonstrated that strains of Pasteurella multocida and Pasteurella haemolytica have developed a resistance to penicillin, streptomycin, sulfonamides, and tetracyclines. The development of such resistance is a serious concern, because it makes the use of these antibiotics potentially less effective in dealing with health problems.

Proposals to restrict the therapeutic and subtherapeutic use of the nitrofurans stem from the finding that these antibacterials produce tumors in laboratory animals. Since manufacturers have been unable to produce an adequate method of analysis to assure the absence of residues in human food, there continues to be doubts whether their use in animal feeds poses a threat to human health.

A potential proposal to restrict the use of sulfamethazine in hog feeding stems from the continued high levels of sulfa residue being detected in pork tissue.

Farmers have used drugs at subtherapeutic levels in raising animals for approximately 25 years. Over the years, they have come to believe that such use (a) reduces the risk of animal disease outbreaks, (b) improves feed efficiency, and (c) reduces condemnations of the final product. In short, while limited scientific evidence is available to either support or refute the notion, the subtherapeutic use of animal drugs is now believed responsible for reducing the unit costs of animal production.

At the request of the U.S. Senate Committee on Agriculture, Nutrition, and Forestry the U.S. Department of Agriculture (USDA) initiated this study of the economic consequences of the proposed and potential retrictions on animal drug use. The study focuses mainly on the effects such a restriction would have on food availability, food and farm prices, farm production costs, and the level and distribution of farm income.

While the results of this study must be considered as merely suggestive, they do indicate that the economic system would generally be quite resilient to a more restrictive policy on animal drug use. Costs of production and, therefore, consumer prices would increase initially. However, farm prices would increase more than porportionally, because the farm-level demand for most livestock products is inelastic. As a result, total net revenue to farmers would initially be enhanced. The increased profitability would encourage farmers to expand output in subsequent years; by the fifth year following the restriction on animal drug use, production and prices of most affected species would recover to approximately their baseline levels.

These results do not take into account any changes in the structure of production agriculture that might accompany an animal drug ban. Increased risks associated with feeding poultry and livestock in confinement without the low-level use of animal drugs could make such confinement production systems less viable and change the magnitude of this result. On the other hand, the effect of changes in management practices that might occur in anticipation of or following the enactment of such a rule could not be measured. Improved sanitation and pasture rotation could reduce the magnitude of even the first-year effects as they are shown.

The Study

Basic science data are essential to a study such as this. Without good data on the effects of subtherapeutic drug use on feed efficiency, growth rates, mortality, and product condemnation rates, it is impossible to develop precise estimates of the economic effects resulting from a ban. The basic science data for this study were obtained from USDA and land-grant university scientists, veterinarians, others in private business, and professional journals. Most estimates were extrapolated from small scale test results since other data were not available. Most of the data were from tests conducted when the additives were first introduced in the 1950's and 1960's. In many instances there were wide variations in test results, making estimates of the changes in production coefficients subject to error. Despite such difficulties, however, the best available scientific data were used for this study.

As the available scientific evidence on the animal production effects of drug use are not conclusive, two levels of drug efficacy were assumed--a moderate and high level. Such a procedure provides a range of potential outcomes that likely bracket what could reasonably be expected to occur in reality.

The estimated initial effects on animal production of restrictions on the low-level use of selected animal drugs are shown in table 5. These data indicate, for example, that the first year cumulative effect of a restriction on the use of tetracyclines and sulfa in feeding hogs would be a 4.9 to 17.8 percent reduction in output, depending on what is assumed about drug efficacy.

As the data indicate, use of animal drugs within the same species was assumed to generate additive effects. That is, banning the use of all four animal drugs was assumed to be equivalent to the cumulative effect of separate bans occurring one at a time. It was also assumed that substitute drugs would not be available for use and that producers would not change management practices in order to effectively circumvent the regulations. While these assumptions admittedly do not mirror what would take place in the real world, they make the problem amenable to analysis and allow bounds on the extent of the economic impact to be set.

The economic analysis was conducted assuming both a species-by-species ban of each animal drug and an across-species concurrent ban of all the drugs. The cumulative effects of an across-species ban were estimated by taking into account the adjustments in production that would occur as a result of cross-commodity effects. For example, the increased demand for beef resulting from higher pork prices was explicitly taken into account. The net effects of an animal drug ban on prices, production, and consumption were traced for a hypothetical 5-year period following the ban to indicate whether, and to what extent, there would be long term adjustments to the changed conditions.

In order to simplify the discussion, only the effects of the moderate efficacy assumption are explicitly discussed in this summary. If the high efficacy response is assumed, the pattern of adjustment is identical to that assuming moderate efficacy. However, reductions in output for the affected species are more pronounced and, as a result, prices are relatively higher. Magnitude changes are shown in the tables attached.

The study results indicate that, at least initially, net farm income, farm and food prices, and farm production costs would all increase if the subtherapeutic use of animal drugs were restricted. Farm production costs per unit would increase, because animal production is made less feed efficient and because mortality is increased. Farm and food prices would increase, because fewer animal units are offered for sale. Net farm income would increase, because increases in aggregate costs of production

would be more than offset by increases in aggregate receipts. This result would, of course, be expected in cases where the demand for a product is relatively price inelastic.

Total net farm income in the first year following the animal drug ban would be about $1.2 billion above the baseline estimate (moderate efficacy). Increases in livestock cash receipts (2.9 percent) would more than offset the relatively small decreases in cash receipts from crops (-1.4 percent). In subsequent years, net farm income would move steadily closer to the baseline estimate. By the fourth period, net farm income would be slightly below the baseline estimate (-1.2 percent), reflecting primarily the somewhat higher costs of producing about the same total output of livestock product (table 20).

Consumer price impacts follow essentially the same pattern as the index of farm prices received. The first-year impact on the Consumer Price Index (CPI) for food is the most significant (1.2 percent above the baseline estimate). Consumer prices for the livestock products would be affected most. Retail poultry prices would be up 10 percent, beef prices up 3 percent, and pork prices up about 4 percent. By the fifth period, slightly higher prices would persist for pork and poultry products, but there would be almost no change from the baseline food CPI estimate because of the relatively low weight of these items in that index (table 21).

Under the assumption of moderate drug efficacy, a restriction on animal drug use implies about a 7-pound-per-person reduction in the availability of red meat and poultry products. Broiler consumption in the first year is reduced most (3.5 pounds per capita), followed by pork (2.8 pounds), turkeys (0.5 pound), and beef (0.25 pound). (See table 19.)

Price deviations from the base estimate for both the moderate- and high-level efficacy are shown in table 16. In the first year, broiler and turkey prices would be above the baseline estimate by about 12 percent, assuming moderate efficacy. Barrow and gilt prices would be up about 5 percent, and fed beef prices would be about 4 percent above the baseline estimate.

By the fifth year, all prices would be relatively closer to the baseline estimates. Broiler and turkey prices would still be higher than baseline, reflecting the relatively higher costs of producing poultry products without the subtherapeutic use of the chemicals and drugs.

The study also provides an estimate of the effects of a ban on the use of the four additives in producing dairy products and sheep. The impact of such a ban on dairy producers would be minimal. Such additives are now used at subtherapeutic levels only in the feeding of calves. Study results indicate that costs of producing milk would increase less than 1 cent per hundredweight if that use were banned.

Impacts of an animal drug ban on sheep and lamb production would also be minimal. Study results indicate an approximate 1-percent reduction in gross farm receipts to sheep producers if the additives had been banned in 1976. In that year, consumers would have paid about 1 cent per pound more for mutton and lamb and there would have been about 47,000 cwt less meat available.

ECONOMIC EFFECTS OF A PROHIBITION ON THE USE OF SELECTED ANIMAL DRUGS

INTRODUCTION

The Food and Drug Administration (FDA) has proposed regulations to restrict the use of several animal drugs. 1/ These proposals include restrictions on the low-level (subtherapeutic) use of penicillin and tetracycline antibiotics, alone or in combination with other drugs in animals feeds, and all animal uses of four of the five nitrofuran class of animal drugs. In addition, continued high violative levels of sulfa residue in pork tissue could result in a proposal to severely restrict or ban sulfa's use in hog feeds.

Members of the medical research community and some consumer groups regard these proposals as being very important in the broader effort to restrict the use of or remove substances toxic to humans and/or animals. However, livestock and poultry producers regard the proposals in a different light. For them, the proposals represent the potential loss of management tools that reduce costs and increase profits.

For policymakers, the issue is one of evaluating the tradeoffs involved. On one hand, the proposals represent an opportunity to realize substantial benefits in the form of less risk and lower incidences of certain diseases along with smaller economic losses and possibly higher farmer incomes. On the other hand, the consequences could be increased production costs, greater incidence of animal disease, smaller supplies of animal products at higher prices, and greater consumer expenditures for food.

The primary objective of this study is to conduct an economic assessment of the impacts that might occur in the agricultural sector from adoption of any or all of the current proposals to restrict the use of antibiotics or nitrofurans and possible restrictions on the use of sulfa products in swine feed. Attention is focused on feed efficiency, growth promotion, and mortality, and how changes in these variables affect production costs, output, and product prices. Adjustment alternatives and impacts upon feed grain utilization and animal industry structure are examined.

Effects upon consumers and consumer response to the proposal impacts upon animal production are also estimated. The specific effects investigated include: impacts on retail product prices, consumer expenditures for these products, and per capita consumption.

Public health and safety impacts are identified where possible. The assessment focuses on the incidence rates, trends, and costs for cancer, food-borne bacterial diseases, and allergy problems associated with drug residues.

Due to the broad recognition of the importance of the problem of chemical and drug usage in food production and insufficient knowledge about their side effects, a list of research projects and associated data needs is developed.

Animal species examined in this report include beef, swine, broilers, turkeys, dairy, cattle, and sheep. 2/ Other species that would be affected by a restriction on drug use, such as rabbits, horses, mink, pheasant, and quail, are not included in this analysis. The interaction effects among the several livestock and poultry industries

1/ See Federal Register, vol. 42, no. 168, part IV, August 30, 1977, vol. 42, no. 204, part IV, October 21, 1977, and vol. 41, no. 94, part V, May 13, 1976.

2/ Previous studies did not examine the impact on the dairy and sheep industries.

for the individual and combination drug proposals are estimated and analyzed. For each animal drug, a moderate and high efficacy impact is calculated. The interaction effects are calculated on an annual basis and traced for a 5-year period following the hypothetical enactment date.

The last section of the report contains a list of research and data needs identified while conducting this study and obtained from recommendations of other related reports.

ANIMAL DRUGS IN THE FOOD SYSTEM

Since antiquity, man has been plagued by the problems of how to increase his production of food. With the food supply being largely dependent upon natural conditions beyond man's influence, there were regular cycles of feast and famine. Consequently, large segments of society suffered from inadequate diets, sickness, and starvation.

In recent times, at least domestically, this cycle has been broken by a series of technological advancements. Scientists developed methods to stimulate plant and animal growth. Chemical fertilizers are used to provide plant nutrients, and animal production benefits from the use of nutritionally balanced diets that include vitamins, minerals, amino acids, and antibacterial growth stimulants. Pesticides, fungicides, and rodenticides are used to protect plants from a large variety of disease and pests. Pharmaceuticals are used to combat animal diseases while vaccines are extensively used to create immunity to other diseases.

Advancements in production, harvesting, processing and storage technology, plant and animal genetics, nutrition, and management (including the use and availability of chemicals and drugs) were the factors that contributed to the agricultural revolution. Today, largely as a result of these advances, our society is more concerned about managing a food surplus and protecting the safety and quality of food than it is about food shortages and the consequences of not having enough to eat.

Classifications and Uses of Animal Drugs

For purposes of this report, the term animal drug is used primarily to refer to those drugs intended for use in feeds. 3/ Many of these drugs are identical to those used by humans for therapeutic purposes. Animal drug use is a relatively recent phenomenon, occurring largely since World War II. While some of the naturally occurring nutritional drugs were used prior to then, the antibacterials and more exotic nutritional drugs began to appear right after the end of the war. The sulfonamide antibacterials were introduced during the 1940's--sulfamethazine in 1947. Organic arsenicals were approved about the same time along with the first nitrofuran, nitrofurazine (NF-7), in 1948. The other four nitrofuran class drugs were approved for use later. Furazalidone (NF-180) was approved for use in 1957.

The use of antibiotics at low levels in animal feeds first occurred in 1949, and commercialization followed in 1950. Since then, 14 antibiotics, along with other antibacterials, have been approved by FDA for routine use either singly or in various combinations in animal feeds.

3/ For the legal definition of animal drugs, see Federal Food, Drug and Cosmetic Act, as amended, October 1976, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Animal drugs consist of a variety of substances that can be classified into three broad categories and several subcategories. The three main categories are feed additives, pharmaceuticals, and biologicals.

Feed additives, the category with which this report is concerned, consist of antibacterial compounds such as antibiotics and nutritional additives such as vitamins, minerals and amino acids. In addition, other products are used to perform a variety of functions. They include, but are not limited to, antioxidant and antifungal feed preservatives, flavorizers, hormones, and coccidiostats. Antibacterial compounds and hormones are used at subtherapeutic levels for stimulating animal growth and improving feed efficiency. The antibacterials also suppress subclinical infections and/or prevent disease when used in small dosages. In larger dosages they are therapeutic agents.

The widespread and routine use of antibacterials is closely identified with changes in the structure of livestock and poultry production in the United States. The ability to suppress and control many infectious animal diseases has often been cited as facilitating the development of large-scale confinement rearing operations and the realization of the scale economies. Although large-scale confinement animal production systems require large investments of capital, many argue that such systems have resulted in significant decreases in operating costs, especially costs for labor. Furthermore, the generally recognized improvements in animal growth rates and feed efficiency have reduced the ratio of feed input per unit of output.

According to the Animal Health Institute (AHI), the total value of animal drug sales in the United States during 1977 was $1.21 billion; this was nearly triple that of 1968 when sales totaled $411 million. Sales of feed additives were $808 million (nutritional products such as amino acids, vitamins, and minerals were estimated at $505 million; antibacterial sales as feed additives, including the antibiotics, sulfas, nitrofurans, and arsenicals, were $151 million; and all other feed additives, including hormones and antioxidants, totaled $152 million). 4/ Pharmaceutical sales totaled $306 million (antibacterials accounted for about a third, or $107 million, and other products, including wormers, insecticides, and coccidiostats, accounted for $199 million). Sales of biologicals totaled $92 million.

Antibacterials accounted for a significant share of the animal health products market. The 1977 combined sales of antibacterials as feed additives and pharmaceuticals totaled $258 million, or 21 percent of the total health product market. Almost 60 percent of the sales were as feed additives.

The poultry industry was the primary user of feed additives, with purchases of a little over 60 percent of the total sales dollar value. Broiler and table egg producers each accounted for about 45 percent of the total sales, and turkey producers accounted for the remaining 10 percent. The remainder of the feed additive sales was about evenly divided between swine producers and the cattle, dairy, and sheep producers.

Total annual production of antibiotics for human and animal use has increased rapidly in the United States. In 1960, antibiotic production was 4.16 million pounds; 2.95 million pounds, or 71 percent, were used for human and animal therapy. 5/ The balance was added to animal feeds for growth promotion and disease prevention. By 1970, total U.S. production of antibiotics had increased fourfold to 16.9 million pounds. Of this amount, 9.6 million pounds (57 percent) were for human and animal therapeutic purposes, and the remaining 7.3 million pounds were for use in animal

4/ Feedstuffs, Miller Publishing Co., Minneapolis, Minn., vol. 50, no. 231, July 8, 1978.

5/ Federal Register, vol. 43, no. 14, p. 3034.

feeds. According to the U.S. International Trade Commission, the 5-year annual average production of antibiotics in the United States during the 1971-75 period was 18.94 million pounds. 6/ Medicinal uses accounted for 11.16 million pounds or 59 percent. The remaining 7.68 million pounds (41 percent) were used as feed additives and for other nonmedicinal purposes.

These trends clearly indicate the rapid growth that has occurred in the use of antibiotics for both human and animal therapy, as well as for animal growth promotion and other nonmedicinal purposes. The huge and increasingly widespread use of antibiotics has to be regarded as a significant factor in explaining any possible increases in health risks associated with their use.

According to the FDA, 4.06 billion grams (8.94 million pounds) of antibiotics were used annually in animal feeds and for other nonmedicinal purposes. 7/ Of the 14 antibiotics licensed for use in animal feeds, the tetracyclines (chlortetracycline and oxytetracycline) are the most important in terms of use. FDA estimates that 1.66 billion grams (3.66 million pounds) were used in this category with 99 percent going into animal feeds. Tetracyclines represented about 41 percent of the total antibiotic use of 8.94 million pounds in animal feeds and for nonmedicinal purposes in 1975.

Tetracycline prices are estimated to average 2.5 cents a gram. On the basis of feed additive sales of 1.64 billion grams and this price, the tetracycline sales value is about $41 million annually. With 1977 feed additive antibacterial sales of $152 million, the tetracyclines represented about 27 percent of the total sales.

The quantity of penicillin used on an annual basis in animal feeds was estimated at 467 million grams (1.03 million pounds) by FDA. 8/ This is equivalent to 12 percent of the total. Of this amount, about one-third is used in poultry feeds, and the balance is used in combination with other drugs in hog feeds. Annual sales of penicillin have been estimated at $10.7 million annually by FDA.

Together, penicillin and tetracyclines represent 2.11 billion grams, or 52 percent of the annual sales in the U.S. feed additive market. However, since these antibiotics have a lower average price than the others, their sales value of about $51.7 annually is equivalent to 34 percent of the total sales value of this category.

About 97 percent of the nitrofuran compounds used by food animal producers are furazolidone (NF-180). 9/ This compound is used primarily by poultry producers and to a minor extent by swine producers.

Sulfamethazine is used in swine, cattle, and poultry feeds. In swine feeds, it is used in combination with chlortetracycline and penicillin. A typical combination generally consists of 100 grams each of sulfamethazine and tetracycline and 50 grams of penicillin per ton. FDA estimates annual sales of this combination at about 32 million pounds. 10/ Another combination is 100 grams of tylosin and 100 grams of sulfamethazine per ton of feed, but it is used less extensively. Sales of this combination are estimated at 3 million pounds a year. Combined sales volume is approximately 35 million pounds.

6/ U.S. International Trade Commission, Synthetic Organic Chemicals, United States Production and Sales (1971-75), Publication 804, Washington, D.C.

7/ Food and Drug Administration, DHEW, Economic Impact Statement, "Tetracycline-Containing Premixes," October 1977.

8/ Food and Drug Administration, DHEW, Economic Impact Statement, "Penicillin-Containing Premixes," August 1977.

9/ Food and Drug Administration, DHEW, Inflation Impact Statement, "Nitrofurans (5-NITRO) Compounds," May 1976.

10/ Food and Drug Administration, DHEW, Economic Impact Statement, "Penicillin-Containing Premixes," August 1977.

Specific Uses of Selected Animal Drugs

FDA, under the authority of the Food, Drug, and Cosmetic Act, as amended, has the regulatory authority to approve the use of animal drugs in animal feeds at subtherapeutic levels for growth promotion and disease prevention and at therapeutic levels for disease treatment. 11/ These uses are approved on the basis of substantiated claims by drug manufacturers. Recent proposed FDA rules would, however, substantially reduce the number of uses of penicillin and tetracyclines and combinations with other drugs, of nitrofurans, and possibly curb the use of sulfamethazine in swine feeds. A general description of the uses of these drugs is presented below:

Penicillin

Penicillin from procaine penicillin is used at low levels to stimulate growth and improve the feed efficiency of chickens, turkeys, and swine. It is also used to improve egg hatchability. In larger dosages, penicillin is used to prevent or treat chickens and turkeys for chronic respiratory disease (CRD) and bluecomb. Penicillin in combination with streptomycin is used for treatment of chickens and turkeys for CRD, infectious sinusitis, bluecomb, and hexamitiasis as well as for growth promotion. The combination is used for prevention of bacterial enteritis in swine. Penicillin, in combination with tetracycline and sulfamethazine or sulfathiazole, is used to reduce the incidence of cervical abscesses, treat bacterial enteritis, maintain weight gains in the presence of atrophic rhinitis, and improve feed efficiency up to 6 to 16 weeks postweaning on swine.

Tetracyclines

Tetracyclines, chlortetracycline and oxytetracycline, are broad spectrum antibiotics with a number of uses. Besides improving feed efficiency and promoting growth in poultry, chlortetracycline claims include preventing and treating CRD, infectious sinusitis, bluecomb, hexamitiasis, synovitis, treatment of coccidiosis, and reducing mortality from paratyphoid and *E. coli* infections. For use in swine, claims include promoting growth and improving feed efficiency, preventing and treating bacterial enteritis, maintaining weight gains in the presence of atrophic rhinitis, lowering the incidence of cervical abscesses, and reducing the spread of leptospirosis.

Chlortetracycline is administered singly or in combination to cattle to promote growth and feed efficiency and prevent bacterial calf diarrhea, liver abscesses, foot rot, bacterial pneumonia, anaplasmosis, shipping fever, and respiratory infections. Chlortetracycline is also administered to promote sheep growth and feed efficiency, reduce losses from enterotoxemia, and lower the incidence of vibrionic abortion.

Oxytetracycline has many of the same claims as chlortetracycline. For poultry additional claims include prevention of fowl cholera, avian infectious hepatitis, and diseases from oxytetracycline susceptible organisms. With a nitrofuran, claims include prevention of pullorum and paratyphoid and an aid in prevention of coccidiosis.

Oxytetracycline is used in swine to prevent a variety of dysentery ailments as well as satisfying other claims common to chlortetracycline. Cattle are administered oxytetracycline alone or in combination to prevent scours, reduce the incidence of

11/ The distinction between subtherapeutic and therapeutic in terms of the dosage level is difficult to define. FDA, in Economic Impact Statement, "Tetracycline-Containing Premixes," defines subtherapeutic as less than 200 grams per ton.

bloat, prevent liver abscesses and shipping fever, and increase milk production in lactating dairy cows. Oxytetracycline is administered to sheep to prevent or treat scours and reduce losses from enterotoxemia.

Nitrofurans

Nitrofurans are a class of chemicals used at low levels in animal feeds as antibacterial and antiprotozoan agents to increase an animal's resistance to disease. 12/ Nitrofurans also have prescribed therapeutic uses.

Furazolidone (NF-180) was approved in 1953 and is currently approved for prevention and treatment of fowl typhoid, paratyphoid, and pullorum in chickens and turkeys, blackhead in chickens and turkeys, infectious hepatitis in chickens, and hexamitiasis in turkeys; for prevention and control of air-sac infection, nonspecific enteritis (bluecomb), ulcerative enteritis, and synovitis in chickens and turkeys; for prevention and treatment of paracolon infection in chickens and coccidiosis in chickens; and for growth promotion and feed efficiency purposes. Swine are administered furazolidone to prevent or treat bacterial enteritis or vibrionic dysentery and for growth promotion and feed efficiency purposes.

Furaltadone (NF-260) was approved in 1962 for mastitis treatment in dairy cows. It requires administration by injection into the mammary gland.

Nihydrazone (NF-64) was approved in 1963 for use in chicken feeds for the purpose of prevention of a number of diseases similar to those listed for NF-180.

Nitrofurazone (NF-7) was the first nitrofuran approved for use. This approval occurred in 1948 for food-producing animals. It was approved for use in mastitis products for dairy cows, to treat vaginal infections in large animals; and for use in feed to treat bacterial swine enteritis and to prevent coccidiosis in chickens and turkeys and pullorum in chickens.

Sulfamethazine

This drug is approved for use in swine feed in combination with chlortetracycline and penicillin or with tylosin. Claims are that the combination with tylosin lowers the incidence and severity of Bordetella bronchiseptica rhinitis and controls bacterial pneumonia, while the other combination reduces the incidence of cervical abscesses, treats bacterial enteritis, prevents these diseases during periods of stress, and maintains weight gains in the presence of atrophic rhinitis. This combination also promotes growth and improves feed efficiency. Sulfamethazine is also approved for use in poultry and cattle feeds, but residue problems have not been a matter of concern recently.

HUMAN AND ANIMAL HEALTH HAZARDS

Numerous scientific advancements in the fields of epidemiology, toxicology, and pharmacology now provide evidence that health hazards may have evolved from the continuous use of chemicals once considered safe. As future advancements are made to more specifically identify the causes of human and animal diseases, it is likely that other, now commonly used animal drugs will be the subject of regulations further restricting their use.

12/ Federal Register, vol. 41, no. 94, pp. 19907-19921.

The extent of regulatory decisions to restrict the use of possibly hazardous additives and drugs will depend upon society's knowledge, anxieties, and willingness to make tradeoffs and amend the law. On one hand, extreme concern about the possible adverse impact of chemicals used by the food system on one's health could lead to restrictions on their use, and ultimately to higher costs to produce food, and a reduction in the variety of foods on the market. On the other hand, little expressed concern by society could be associated with further cost reductions in food production and greater food variety. However, any adverse effects that reveal themselves in the form of higher incidences of disease and increased medical expenditures could be expected to exert increased pressure for policy modifications to restrict the use of such chemicals.

Of the three major types of animal drugs addressed in this report, the nitrofuran class has caused tumors or cancer in laboratory animals and, therefore, is suspected of being carcinogenic for humans. Of further concern, the widespread use of antibiotics such as penicillin and tetracycline as animal growth stimulants is suspected of causing the development of organisms resistant to one or more antibiotics. These organisms, now known to be capable of transferring newly acquired resistance patterns to pathogens, could become the causative agents of epidemics among human or animal populations.

Finally, some researchers suggest that the sulfa drugs, especially sulfamethazine residue or sulfa metabolities in animal (pork) tissue, can cause allergic reactions to susceptible humans. The widespread use of sulfa has also been connected with development of antibacterial-resistant organisms and pathogens. In addition, administration of large dosages of sulfa to laboratory animals results in enlargement (hyperplasia) of the thyroid gland, an indication of possible cancerous growths.

Cancer Health Problems

Cancer is characterized as a rapid, uncontrolled cell metabolism. A cancer site results from the evolution of normal cells into malignant cells. Various types of cancer appear to be caused by chemicals, viruses, radiation, and/or other unknown factors. One source estimates that 60 to 90 percent of all human cancer is caused by physical and chemical agents present in the surrounding environment. 13/

Various types of cancer are responsible for about a sixth of all the deaths in the United States, and cancer currently ranks second among the leading causes of death. In 1975, 365,000 deaths were caused by cancer, and the estimate of new cases is believed to have exceeded 1 million. In 1972, the estimated annual economic loss from cancer morbidity and mortality was $17.4 billion. This was equivalent to 9.2 percent of the estimated $188.8 billion annual economic loss for all disease morbidity and mortality in the United States in that year. However, cancer's share of the total economic loss had decreased from 11.3 percent in 1963. 14/

Over the past several decades, trends in cancer incidence and mortality among humans in the United States have shown some dramatic changes. The causes of the changes are not known, but may be attributed to (1) improved means of detection and treatment, (2) changes in the number and type of factors causing cancer, (3) reduced or increased exposure to these factors, and (4) changes in human diet, longevity, and behavior.

13/ Research Highlights 1977, U.S. Environmental Protection Agency. EPA 600/9-77-044, December 1977.

14/ Cooper, B.S., and D.P. Rice, The Economic Cost of Illness Revisited, Social Security, Bulletin 39 (2): 21-26.

Although vital statistics on cancer mortality are collected on an annual basis, statistics on incidence in the United States have been collected on a far less frequent basis. In order to measure incidence, however, the National Cancer Institute conducted three surveys in certain areas of the United States during 1937-39, 1947-48, and 1969-71. These data were examined and adjusted to a comparable basis by Devesa and Silverman for the purpose of identifying incidence trends. 15/

Over the 1937-71 period, the total cancer incidence rate initially increased, but then began to subside to 277.7 cases per 100,000 population in the 1969-71 period (table 1). This decrease would have been even more drastic if the incidence of respiratory system (lung and bronchial) cancer had not tripled.

The digestive system continues to be the most frequent site of cancer accounting for about 15 percent of the total incidence. This is followed by the respiratory system and the breasts. These three sites accounted for about half of the total incidence. However, the greatest absolute decrease in primary site incidence has been the digestive system. If the trend continues, the digestive system is likely to be replaced by the respiratory system as the leading primary site.

Closer examination of cancer incidence statistics reveals considerable difference in the relative importance of cancer primary site between sex, race, and other demographic factors. For example, the three leading primary cancer sites for men are digestive, respiratory, and genital; for females the three leading primary sites are breast, digestive, and genital. Race also appears to be an important factor in explaining differences in incidence rates, especially for males. Other factors found to be important are age and type of employment. Incidence rates increase among all persons over 45 years of age and with occupations in lower skill requirement areas.

There is a generally accepted belief that diet is an explanatory factor in causing cancer at some body sites. The overnutrition problem, characterized by a high intake of meats, dairy products, fats, and refined flour and sugar, may be related to as many as half of all cancers in women and one-third in men, according to Eckholm and Record. 16/

There is also a belief that food additives or contaminants may cause cancer in humans. Some food dyes, artificial sweeteners, food preservatives, and animal drugs are either proven or suspected carcinogens. Exactly how the additives and foods interact along with mode of cooking to cause cancer is not known. The fact that there is a long delay between the stimulus that causes cancer and appearance of the disease adds further difficulty in determining this relationship.

Possible diet-related cancers are usually associated with several primary sites (table 2). These include breast, colon, uterus, prostate, stomach, ovary, and esophogus. In the United States, changes in cancer incidence rates at these primary sites have been inconsistent over the past four decades. The incidence of stomach and uterine cancer is down considerably, although diets have shifted toward more meat, fat, and sweeteners, and there is increased variety and use of food additives. However, the incidence of breast and prostate cancer has increased, while the trends in incidence rates for cancer of the ovary, colon, and esophagus are not clear. Consequently, it is not clear how diet influences the incidence rates for cancer among the several sites.

Nitrofurans, a class of animal drug, are used primarily in feed at low levels to increase disease resistance in animals and to treat mammary gland infections in dairy

15/ Devesa and Silverman, "Cancer Incidence and Mortality Trends in the U.S. 1935-74," Journal of National Cancer Institute, vol. 60, no. 3, March 1978.
16/ 1977 Yearbook, World Book Encyclopedia, Field Publishing Co., Chicago, IL.

Table 1--Cancer incidence rate per 100,000 population, selected years, 1937-71

Cancer site and period	Average	White		Nonwhite	
		Male	Female	Male	Female
			Number		
All sites:					
1937-39	259.3	247.1	286.1	153.8	243.3
1947-48	288.9	283.7	305.0	225.6	273.2
1969-71	277.7	309.0	256.8	330.2	231.5
Digestive system:					
1937-39	86.7	102.9	77.2	72.6	44.7
1947-48	87.2	102.7	75.3	89.0	57.0
1969-71	66.6	79.6	54.0	93.7	56.4
Respiratory system:					
1937-39	13.5	22.5	5.9	11.9	3.3
1947-48	22.7	38.1	8.7	28.5	5.6
1969-71	44.3	77.5	16.6	86.1	14.7
Breast:					
1937-39	32.7	.8	67.1	1.0	46.2
1947-48	36.9	.9	73.6	.2	50.4
1969-71	38.7	.8	73.3	.7	53.7
Female genital system:					
1937-39	43.0	NA	82.2	NA	121.4
1947-48	42.6	NA	80.6	NA	112.5
1969-71	29.6	NA	54.2	NA	57.4
Male genital system:					
1937-39	18.0	36.0	NA	31.9	NA
1947-48	19.3	41.3	NA	47.4	NA
1969-71	22.5	49.8	NA	71.2	NA
Urinary:					
1937-39	13.5	18.7	10.0	7.3	5.1
1947-48	15.8	22.8	10.6	10.1	8.8
1969-71	17.7	29.8	9.6	17.0	7.1
Lymphomas:					
1937-39	--	--	--	--	--
1947-48	9.6	12.0	7.6	8.7	6.2
1969-71	13.8	16.7	11.3	15.8	10.8
Buccal cavity and pharynx:					
1937-39	15.1	25.4	6.9	6.4	5.3
1947-48	14.1	22.4	7.6	9.4	5.9
1969-71	10.1	16.0	5.3	13.0	4.9
Leukemias:					
1937-39	--	--	--	--	--
1947-48	7.6	9.0	6.9	9.2	3.0
1969-71	8.4	11.0	6.7	8.7	5.3
Brain and nervous system:					
1937-39	2.5	3.2	2.2	1.2	0.5
1947-48	6.5	8.0	5.6	3.8	4.8
1969-71	4.8	5.9	4.2	4.0	3.3
Other:					
1937-39	34.3	37.9	34.6	21.5	16.8
1947-48	26.6	26.5	28.5	19.3	19.0
1969-71	21.2	21.9	21.6	20.0	17.9

NA = Not applicable, and -- = Not available.
Source: Devesa and Silverman, Cancer Incidence and Mortality Trends in the U.S., 1935-74.

Table 2--Incidence of possible diet related cancers, per 100,000 population, selected years, 1937-71

Cancer site and period	Average	White		Nonwhite	
		Males	Females	Males	Females
		Number			
Breast:					
1937-39	32.7	0.8	67.1	1.0	46.2
1948-49	36.9	.9	73.6	.2	50.4
1969-71	38.7	.8	73.3	.7	53.7
Colon:					
1937-39	--	--	--	--	--
1948-49	23.8	23.8	26.0	13.7	11.9
1969-71	26.4	29.0	24.8	22.9	23.6
Uterus:					
1937-39	35.0	NA	65.1	NA	113.4
1948-49	33.0	NA	61.2	NA	99.6
1969-71	21.0	NA	38.3	NA	44.4
Prostate:					
1937-39	16.0	32.0	NA	26.9	NA
1948-49	17.5	37.4	NA	43.8	NA
1969-71	20.4	45.2	NA	68.6	NA
Stomach:					
1937-39	32.9	41.8	25.4	37.3	18.4
1948-49	25.2	32.4	17.8	38.6	18.9
1969-71	9.1	12.1	5.8	18.6	7.9
Ovary:					
1937-39	6.2	NA	13.1	NA	5.3
1948-49	7.4	NA	15.2	NA	9.5
1969-71	6.9	NA	13.3	NA	9.8
Esophagus:					
1937-39	3.6	5.9	1.5	4.1	1.0
1948-49	4.0	6.3	1.8	6.6	1.5
1969-71	3.5	4.4	1.3	14.3	3.4

-- = Not available.
NA = Not applicable.

cattle. The class consists of nitrofurazone (NF-7), nihydrazone (NF-64), furazolidone (NF-180), and furaltadone (NF-260). Of these four, the FDA has concluded furazolidone is carcinogenic and the other three are highly suspect. Furthermore, some of the nitrofuran metabolites may be carcinogenic.

Long-term, low-level exposure to residues and/or metabolites of these drugs, via human consumption of meat, milk, and eggs of treated animals, may pose a public health hazard. However, both the amount of actual consumption of these suspected carcinogenic agents by humans and, consequently, the magnitude of the health risk remain unknown to date. Suitable detection methods to identify and measure residues and the metabolites in the animal products have not yet been developed.

The Comptroller General has recommended that the Secretary of Health, Education, and Welfare "promptly consider the need to suspend those uses of furazolidone, furaltadone, nitrofurazone, and nihydrazone where it has not been demonstrated that no residues of the drug or its active metabolites remain in food from treated animals." 17/

Antibacterial Resistance Health Hazards

The use of antibacterials in animal feeds for animal growth promotion and disease prevention purposes began in the United States about 30 years ago. For many years, scientists regarded the practice as safe for both humans and livestock and poultry, although possible evidence to the contrary began to emerge shortly after the discovery of penicillin.

Sir Alexander Fleming, the man who discovered penicillin, noted that use of the antibiotic resulted in the development of some resistant bacterial organisms. With an increase in the number and quantity of antibiotics used over time, the number and types of organisms developing antibacterial resistance have also increased. As a result, concern has mounted that many of the same antibiotics used for human and animal therapy are likely to become less effective.

By the early sixties, there was considerable concern about the consequences to human and animal health of feeding antibiotics to animals. Several committees in Great Britain and the United States were appointed to investigate the problem, and its implications for human health, and to make regulatory recommendations. 18/

These committees reviewed past and current research on the antibiotic resistance problem and identified a number of specific cases either indirectly or directly relating to the health hazards to humans. The Swann committee report suggested that there is a widespread pool of potentially infectious salmonella and E. Coli organisms in the intestinal tracts of livestock and poultry. 19/ Further, these organisms are potential infectives of the human food supply. If this occurred, food poisoning cases

17/ "Use of Cancer-Causing Drugs in Food-Producing Animals May Pose Public Health Hazard: The Case of Nitrofurans," Report of the Comptroller General of the United States, General Accounting Office, MND-76-85, February 1976.

18/ These committees included: (1) The Agriculture and Medical Research Council Committee established in Great Britain in 1960, (2) the Netherthorpe Committee that succeeded the above in 1962, (3) the Joint Committee on the Use of Antibiotics in Animal Husbandry and Veterinary Medicine (Swann committee), in 1968, and (4) the committee on the Veterinary Medical and the Non-Medical Uses of Antibiotics in 1966 and the FDA Task Force on the Use of Antibiotics in Animal Feeds, 1970, both in the United States.

19/ Joint Committee on the use of Antibiotics in Animal Husbandry and Veterinary Medicine, Report, Her Majesty's Stationery Office, London, September 1969.

might result and, less frequently, incidences of systemic salmonella infections such as human typhoid and paratyphoid fevers. It was also reported that therapeutic uses of antibiotics in animals result in the emergence of, although seldom deleterious, populations of infective bacteria.

The Swann committee subsequently recommended that antibiotics and other antibacterials be separated into a feed class and a therapeutic class. They recommended further that the tetracyclines, penicillin, tylosin, and sulfonamide antibiotics and the antibacterial nitrofurans be restricted to therapeutic use only and bacitracin, flavomycin, virginiamycin, and nitrovin be used exclusively as feed antibiotics subject only to recommendations pertaining to level of use.

The Swann committee report was adopted by the British Government in 1971. Results of that policy change indicate that the use of drugs has been more selective and effectively monitored without a sacrifice in food production. However, no documented evidence exists to indicate that there has been a reduction in disease in humans due to animal origin bacteria, that a reduction in drug-resistant bacteria has improved their therapeutic efficacy for treatment of human or animal diseases, or that bacterial contamination of food of animal origin has been reduced. 20/

Following publication of the Swann committee report, FDA appointed a task force to investigate the use of antibiotics in feed. That report, published in 1972, recognized the potential health hazard of drug-resistant bacteria and identified the means of transmission to humans, along with the larger problem of compromising the use of drugs for therapeutic purposes.

The FDA task force concluded that a potential hazard does exist. This generated development of the following guidelines:

(1) An antibacterial drug fed to animals shall not have significant effects on the ecology or the resistance characteristics of salmonella bacteria normally inhabiting food animals;

(2) an antibactierial drug fed to animals shall not increase the reservoir of enteric bacteria resistant to antimicrobic agents commonly employed for therapy of human or animal diseases; and

(3) the use of an antibacterial in feed should not enhance the pathogenicity of bacteria for animals and man.

In 1973, FDA published a statement of policy and criteria for testing antibiotics in order to answer the questions raised by the 1972 report. 21/ Special attention was focused on the use of tetracyclines, streptomycin, dihydrostreptomycin, penicillin, and sulfonamides. Their effect on the salmonella reservoir in animals was addressed explicitly. Manufacturers were given until April 1975 to provide data on the safety and effectiveness of their products. Products that continued to indicate a human health hazard would be withdrawn immediately.

Although low-level feeding of antibacterials represents only one of several major uses, this practice does provide an ideal environment for development of resistant organisms. Feeding of antibacterials results in the survival of resistant organisms in the gut which can, in turn, perpetuate themselves. The resistance of these organisms is determined by genetic elements called R-plasmids or R-factors which are

20/ Based on a statement by Dr. R. Braude, Univ. of Reading, American Society for Animal Science, annual meeting, 1976.

21/ "Task Force Report to the FDA Commissioner on the Use of Antibiotics in Animal Feeds," (FDA 72-6008), January 1972.

small lengths of DNA material separated from the bacterial chromosome. These plasmids have three characteristics that contribute to a health hazard: (1) they can reproduce themselves, (2) they can carry transferable genes for drug resistance, and (3) identical plasmid types have been found in man and animals. Consequently, plasmids apparently can transfer from one bacteria to another regardless of the strain, species, and host animal, and determine the single or multiple antibiotic-resistance pattern.

In man and animals, the normal bacterial intestinal flora, Escherichia coli, serves as the R-plasmid reservoir. With subtherapeutic feedings of antibiotics, the number of antibiotic-resistant E. coli increases in the gut and remains present long after antibiotic use has ceased. The R-plasmid-bearing bacteria and the antibiotic-resistance pattern carried can be interchanged in several ways between animals, man, and the environment. These include direct contact, on E. coli contaminated food or feed, and through the environment following discharge from the host.

Since there are numerous common strains of E. coli and salmonella infecting man and animals, there are opportunities for antibacterial-resistant strains of salmonella pathogens to be transferred to man. FDA has indicated that the number of multiple antibiotic-resistant strains of pathogenic salmonella are increasing, that resistance could come from plasmids donated from E. coli, and that the use of penicillin and tetracyclines increases the number of resistant E. coli. 22/ Consequently, increased use of antibiotics increases the probability for harm by increasing the R-plasmid reservoir.

The health hazards posed by the widespread and indiscriminate use of antibiotics at subtherapeutic levels in animal feeds and for human and animal therapy are potentially dangerous. The most serious hazard to human health is represented by the large reservoir of plasmids carrying genes for antibiotic resistance existing in humans, animals, and in the environment. The hazard is not the resistance carried by pathogens, but the therapy problems created by the resistance patterns. Once the disease is diagnosed and the treatment of choice is realized to be ineffective, considerable time may be required to find a substitute therapy to combat the disease. Practitioners would have recourse only to less effective, more expensive, and possibly more toxic antibiotics. In the meantime, the disease could spread and reach epidemic proportions. This would result in greater human suffering and greater economic losses in the form of higher medical costs and lost production of goods and services.

Another potentially dangerous situation is the increase in the number of reported urinary infections among humans that are resistant to the traditional therapy of sulfonamide drug administration. The disease is usually caused by E. coli from an individual's own intestinal flora.

More recently, a number of epidemics among human populations have been characterized by the emergence of R-plasmid-mediated pathogens. These include resistance to chloramphenicol in a Mexican typhoid epidemic. There is considerable anxiety about the possibility of development of tetracycline-resistant forms of psittacosis, ornithosis and Q-fever. There also is considerable apprehension about the recent emergence of ampicillin-resistant strains of Haemophilus influenzae and penicillin-resistant strains of Neisseria gonorrheae.

Almost three decades of low-level feeding of antibiotics in the United States, however, has not been linked to any outbreak of a disease among humans caused by pathogens that have developed antibiotic resistance.

22/ Federal Register, vol. 43, no. 14, January 20, 1978, p. 3035.

Although there is little disagreement about the development and transference of antibiotic resistance, there is considerable disagreement about how serious a health hazard subtherapeutic feeding of antibiotics represents. Considering that subtherapeutic feeding represents only one means of developing antibiotic resistance, it may not be the most crucial element. Furthermore, the widespread distribution of R-plasmids carrying antibiotic resistance throughout the environment, and lack of major epidemics, raises questions about the ease of colonization of resistant pathogens. To date, it appears that there are factors preventing widespread colonization of antibiotic-resistant pathogens. Until an assessment is made of these factors, it is impossible to determine what the true health hazard potential is or might become in the future.

Salmonellosis

The FDA has been particularly concerned about the development of antibiotic-resistant Salmonellosis pathogens from low-level feeding of antibiotics. These pathogens can spread quite easily to humans and are the cause of food poisoning. Symptoms include upset stomachs, diarrhea, fever, and other common signs of discomfort. Presumably, any significant increase in resistant salmonella pathogens would be reflected in the number of diagnosed cases reported to the Center for Disease Control in Atlanta, Ga.

Beginning in 1966, Salmonellosis has been a reportable intestinal disease. The number of cases a year ranged between 16,514 and 18,419 between 1966 and 1969. Since then, the number of reported cases has been about 22,000 a year with no evidence of a positive or negative trend. However, the reported cases are believed to be only a small fraction of the total number of cases actually occurring. The total number of cases annually in the United States is estimated between 2 and 2.5 million. Many cases go unreported because of their mildness and are attributed to the flu. Consequently, it has not been possible to determine whether there is any meaningful correlation between the increase in resistant isolates and incidences of the disease.

A recent combined economic impact assessment on proposals covering penicillin/tetracycline-containing premixes contains an estimate of losses from Salmonellosis attributable to antibiotic resistance. 23/ According to that estimate, some 15 percent of the cases are associated with meat from livestock and poultry fed these antibiotics. Using cost estimates developed by Levy, the total annual U.S. cost is estimated to be $110 million. 24/ This represents the potential reductions in human health costs that could be realized if rulemaking proposals are adopted.

Other Human Health Hazards

The low-level use of animal drugs may be the cause of some other health hazards. Animal drugs may leave residues in the tissue of the consuming animal. These residues, which chemically may be the same or a metabolite of the original form of the drug, might be toxic to consumers of the edible tissue.

Antibiotic residues in animal tissue, milk, and eggs were long suspected of being an important factor in the emergence of antibiotic-resistant strains of organisms. Additional research on drug resistance development has resulted in this being

23/ "Combined Economic Impact Assessment of Series of Proposals Regarding Penicillin/Tetracyclines Containing Premixes," Food and Drug Administration, DHEW, January 1978.

24/ Levy, B.S., "The Economic Impact of a Food-Borne Salmonellosis Outbreak," Journal of the American Medical Assocation, 23:1281-1282, 1974.

considered the least likely means of occurrance. Low-level usage of antibiotics in correctly formulated animal feeds does not contribute significantly to legal residue problems now monitored by the Food Safety and Quality Service (FSQS), U.S. Department of Agriculture (USDA). Most of the antibiotic residue problems result from therapeutic use on animals (table 3).

Nitrofuran residues present a different type of problem. Although they are suspected carcinogens, no satisfactory method of detecting the residues and metabolites in animal tissue has ever been developed. Consequently, it is not certain what kind of health hazards may result from different levels of residues and forms of metabolites in food products or what population groups are most susceptible.

Sulfa residues and metabolites in pork tissue have been a problem for at least the last 5 years. Residue testing by FSQS indicates that up to 15 percent of the slaughter hogs have had violative levels of sulfa residues, primarily in the liver and kidney tissues.

Like the antibiotics and nitrofurans, the types and seriousness of health hazards posed by sulfa resides, especially the several metabolite forms, are unclear. The sulfas may be mildly toxic causing a rash, itching, or other forms of mild illness, or tumorgenic, depending on the dosage. However, less is known about the metabolites.

The customary means of eliminating residue problems is by increasing the withdrawal time between the last treatment and slaughter or marketing of milk and eggs. However, environmental contamination and contaminated feed may be an important element in explaining continued occurrences of residue violation. Another factor is believed to be the producer not following recommended withdrawal times.

Uncertainty about the magnitude and extent of health hazards caused by animal drug residues and metabolites precludes any attempt to determine the economic impacts from their withdrawal.

Animal Health Hazards

The mode of action of antibacterials is very complex and not entirely understood. Presumably, subtherapeutic feeding of antibacterials should have little effect on prevention and control of infective diseases in animals. But there is a belief that low-level use can and does suppress subclinical infections.

Morbidity and mortality in livestock and poultry currently results in economic losses exceeding $1 billion a year. Mortality losses from disease alone exceed $600 million annually. Morbidity losses due to disease add hundreds of millions more in losses. Since disease can adversely impact quality, additional losses in the form of condemnations and downgradings amount to millions of dollars.

Infectious diseases are one of the major causes of morbidity and mortality losses of livestock and poultry. In 1976, an estimated 4 million head of dairy and beef calves had scours resulting in the death of about 700,000 head, an economic loss of about $40 million. 25/ Pneumonia and shipping fever probably afflicted over 35 million head of cattle and caused death losses of 800,000 to 900,000 head. The dollar value of the lost animals was slightly greater than $100 million. Intestinal and respiratory diseases resulted in the death loss of over 4.3 million hogs in 1976, with a dollar value of almost $90 million. Scours, influenza, and pneumonia were the major causes of losses. Over 3 million disease-afflicted sheep resulted in slightly more than 700,000 deaths, with a dollar value of almost $20 million.

25/ Doane Agricultural Service, Inc., 1976 Animal Health Market, St. Louis.

Table 3--Incidence of violations among different antibiotics in kidneys from food animals, Food Safety and Quality Service, residue monitoring program, 1973-77

Year and specie	Samples analyzed	Total violations		Penicillin		Strepto-mycin		Neomycin		Tetra-cycline		Chlortetra-cycline		Oxytetra-cycline		Erythro-mycin		Unidentified microbial inhibitor	
	No.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
1973:																			
Steers/heifers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cows	1,594	44	2.8	3	.2	31	1.9	7	.4	0	0	0	0	0	0	0	0	3	1.9
Calves	1,889	152	8.0	5	.3	45	2.4	24	1.3	7	.4	0	0	5	.3	2	.1	64	3.4
Swine	834	15	1.8	0	0	2	.2	0	0	9	1.1	0	0	0	0	0	0	4	.5
Chickens	665	4	.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	.6
Turkeys	176	1	.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	.6
1974:																			
Steers/heifers	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cows	1,301	15	1.2	1	.1	12	.9	1	.1	0	0	1	.1	0	0	0	0	0	0
Calves	2,849	94	3.3	3	.1	35	1.2	17	.6	17	.6	0	0	0	0	1	.3	21	.7
Swine	292	7	2.4	1	.3	3	1.0	0	0	1	.3	0	0	0	0	0	0	2	.7
Chickens	296	2	.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	.7
Turkeys	218	2	.9	0	0	0	0	0	0	1	.5	0	0	0	0	0	0	1	.5
1975:																			
Steers/heifers	222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cows	236	5	2.1	0	0	2	.8	1	.4	0	0	0	0	0	0	1	.4	1	.4
Calves	2,131	155	7.3	5	.2	28	1.3	58	2.7	29	1.4	1	.04	1	.04	0	0	33	1.5
Swine	150	4	2.7	0	0	0	0	0	0	2	1.3	0	0	0	0	0	0	2	1.3
Chickens	177	5	2.8	0	0	1	.5	0	0	4	2.3	0	0	0	0	0	0	0	0
Turkeys	491	17	3.5	1	.2	1	.2	5	1.0	6	1.2	0	0	0	0	0	0	4	.8
1976:																			
Steers/heifers	187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cows	353	9	2.5	1	.3	6	1.7	0	0	0	0	0	0	0	0	0	0	2	.6
Calves	1,378	88	6.4	0	0	22	1.6	44	3.2	9	.7	0	0	1	.07	0	0	12	.9
Swine	247	3	1.2	1	.4	1	.4	0	0	0	0	0	0	0	0	0	0	1	.4
Chickens	155	1	.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	.6
Turkeys	258	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977: 1/																			
Steers/heifers	198	1	.5	0	0	0	0	0	0	1	.5	0	0	0	0	0	0	0	0
Cows	755	17	2.3	1	.1	8	1.1	4	.5	3	.4	0	0	0	0	0	0	1	.1
Calves	566	28	4.9	2	.4	11	1.9	9	1.6	5	.9	0	0	0	0	0	0	1	.2
Swine	211	2	.9	0	0	1	.5	0	0	1	.5	0	0	0	0	0	0	0	0
Chickens	177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkeys	204	2	1.0	0	0	0	0	0	0	1	.5	0	0	0	0	0	0	1	.5

1/ 1977 Data are from January-June.

The poultry industry spends tens of millions of dollars annually to suppress and control a wide variety of diseases. Diseases still considered to be serious threats to the economic welfare of this industry include enteritis, coccidiosis, Mycoplasma gallisepticium, Marek's disease, Gumboro, and several respiratory diseases. Even with the large expenditures on disease control and prevention, losses are believed to exceed $300 million annually. 26/

Livestock and poultry producers are finding themselves in the midst of a serious dilemma. Proposed restrictions on animal drug use at low levels is expected to result in less efficient feed conversion and growth rates, higher incidence of diseases and mortality, and higher costs. However, continued use may also reduce the therapy value of these animal drugs in preventing or curing some potentially serious animal diseases. FDA has recently demonstrated that strains of Pasteurella multocida and Pasteurella haemolytica have developed plasmid mediated resistance to penicillin, streptomycin, sulfonamides, and tetracyclines. 27/ Consequently, production efficiency may be impaired regardless of the regulatory decisions.

FEDERAL REGULATIONS

Two Federal agencies share responsibility for assuring the safety and wholesomeness of the overall food supply. The FDA has the primary responsibility. A very important role is also performed by the USDA. USDA shares concurrent jurisdiction with FDA over meat, poultry, and products thereof which have entered the Federal meat and poultry inspection systems.

Various other Federal agencies are also involved in this regulatory task, though to a somewhat lesser extent. The U.S. Environmental Protection Agency (EPA) approves and regulates pesticide chemicals used in food production. The Department of Transportation (DOT) assures that food and feedstuffs are not transported with various classes of poisonous substances. The Public Health Service (PHS) is charged with assuring that food for consumption on commercial interstate transportation services are prepared under sanitary conditions. Finally, the U.S. Department of Commerce (USDC) conducts a voluntary inspection program to assure that proper health standards are maintained in plants preparing fish products.

While all of these agencies are involved to some extent with assuring the safety of food, the FDA and USDA maintain control over what chemicals and drugs may be used in food production. The statutory authority under which they operate are the Federal Food, Drug, and Cosmetic Act, the Federal Meat Inspection Act, and the Poultry Products Inspection Act.

Federal Food, Drug, and Cosmetic Act

The Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 et seq.) (hereinafter FFDCA) is designed to protect the public from dangerous and unwholesome products. The original statute was enacted in 1938. It included prohibitions against "any poisonous or deleterious substances in food which may render it injurious to health," but did not include provisions for premarket testing of substances such as food additives, new drugs, new animal drugs, and color additives. Subsequent amendments to this legislation have been enacted to prohibit the addition of articles to food that have not been shown to be safe by appropriate tests.

26/ A Guide for Accredited Veterinarians, USDA, APHIS, 91-81, Rev. June 1977.
27/ Federal Register, vol. 42, October 21, 1977 p. 56272.

Food Additive Amendment

The Food Additive Amendment (Public Law No. 95-929) was enacted in 1958. That amendment requires premarket testing of all substances which meet the following definition of the term food additive:

> . . . any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; and including any source of radiation intended for such use) if such substance is not generally recognized among experts qualified by scientific training and experience to evaluate its safety, as having been adequately shown through scientific procedures (or, in the case of a substance used in food prior to January 1, 1958, through either scientific procedures or experience based on common use in food) to be safe under the conditions of its intended use; . . . (21 U.S.C. 321(s)).

The 1958 legislation contains the first Delaney clause, which was added as a proviso to the bill as a committee amendment and became part of section 409(c)(3)(A) of the FFDCA (21 U.S.C. 348(c)(3)(A)):

> . . . fails to establish that the proposed use of the food additive, under the conditions of use to be specified in the regulation, will be safe Provided, that no additive shall be deemed to be safe if found to induce cancer when ingested by man or animal, or if it is found after tests that are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal, . . .

The procedures for obtaining approval of food additives are also specified in section 409. Before such an ingredient may lawfully be used, it must be the subject of an approved food additive regulation which establishes a tolerance for the use of such a substance. The substance in question must be shown to be safe under the conditions of its intended use and it must be shown to effectively perform its intended function, such as food preservation, when used at intended levels. The above-quoted Delaney clause dictates that approval cannot be granted for the use of a food additive that has been shown, through appropriate testing, to induce cancer in man or animal.

There are two important limitations on the scope of the term food additive. The first applies to substances generally recognized as safe by experts in the field. Products such as sugar and salt which have a long history of use in foods are consequently excluded from the complexities of premarket review and from the blanket prohibitions of the Delaney clause. However, the FFDCA includes no provisions which clearly establish the distinction between such traditionally accepted substances and other food additives. As a consequence, since any testing of a generally-recognized-as-safe ingredient which indicates carcinogenic potential will have the effect of destroying the expert consensus regarding its safety, this exemption does not substantially limit the scope of the Delaney clause.

The Food Additives Amendment also contains a grandfather clause for ingredients that either the FDA or the USDA had granted a sanction or approval prior to the effective date of the amendment. Prior to the 1958 amendment, FDA activity had primarily been limited to the issuance of informal opinions regarding the safety of food additives. USDA issued regulations describing the permitted use of many ingredients used in meat and poultry products pursuant to legislation predating the current Federal Meat Inspection Act (FMIA) (21 U.S.C. 601 et seq.) and the Poultry Products Inspection Act Act (PPIA) (21 U.S.C. 451 et seq.). Thus, a decision

to limit or prevent the use of such a prior-sanctioned ingredient would require determination by one of these agencies that it renders a food adulterated within the more general meaning of that term as defined in section 402 of the FFDCA (21 U.S.C. 342), or, if applicable, section 1 of the FMIA (21 U.S.C. 601), or section 4 of the PPIA (21 U.S.C. 453).

Color Additive Amendments

The Color Additive Amendments (Public Law No. 86-618) were added to the FFDCA in 1960. These Amendments require a demonstration of the safety of such substances before FDA approval for their use is granted in accordance with the provisions of section 706 of the Act (21 U.S.C. 376). The amendments also added another Delaney clause to the FFDCA, virtually identical to the first, which is included in section 706(b)(5)(B) (21 U.S.C. 376 (b)(5)(B)).

Under the FFDCA, the term color additive means a material which:

(A) is a dye, pigment, or other substance made by a process of synthesis or similar artifice, or extracted, isolated or otherwise derived, with or without intermediate or final change or identity, from a vegetable, animal, mineral, or other source, and

(B) when added or applied to a food, drug, or cosmetic, or to the human body or any part thereof, is capable (alone or through reaction with other substance) of imparting color thereto; . . . (21 U.S.C. 321(t)(1)).

The safety and testing procedures regarding color additives parallel those required for food additives. The sponsor of such a substance has the burden of establishing its safety, and the FDA is expressly precluded from permitting the use of any color additive that has been found to have induced cancer in man or animal.

The Color Additive Amendments do not contain an expressed grandfather clause, but do contain a transitional provision which allows for the continued use of commercially established additives pending completion of further scientific investigation. While this provision was originally drafted to expire on January 12, 1963, the FDA has repeatedly extended the expiration date while establishing certain testing and reporting requirements for such substances.

Animal Drug Amendments

The Animal Drug Amendments of 1968 (Public Law No. 90-399) were a consolidation of various provisions of the FFDCA governing the premarketing approval of drugs intended for use in animals. The term new animal drug means:

> . . . any drug intended for use for animals other than man, including any drug intended for use in animal feed . . . (21 U.S.C. 321 (w)).

Procedures for obtaining approval for use of such substances, similar to those required for obtaining approval for food and color additives, are included in section 512 of the Act (21 U.S.C. 360b). These amendments included another reiteration of the Delaney clause directing FDA to disapprove new animal drug applications if:

> . . . such drug induces cancer when ingested by man or animal or, after tests which are appropriate for the evaluation of the safety of such drug, induces cancer in man or animal, except that the foregoing provisions of this subparagraph shall not apply with respect to such drug if the Secretary finds that under the

conditions of use specified in proposed labeling and reasonably certain to be followed in practice (i) such drug will not adversely affect the animals for which it is intended, and (ii) no residue of such drug will be found . . . in any edible portion of such animals after slaughter or in any food yielded by or derived from the living animals; . . . (21 U.S.C. 3606(d)(1)(H)).

Under these amendments, approvals are granted for the use of such substances, which are used in the livestock industry for the treatment and prevention of disease and as growth promoters, after a two-part evaluation by FDA. First, there must be a determination that the drug is safe and effective for use in animals. Secondly, the safety data must be reviewed to assess the safety of potential residues which might occur in food derived from such animals (21 U.S.C. 360b(d)(1)).

As the statutory language indicates, this third enactment of the Delaney clause differs from its predecessors in that its application in the new animal drug area is not absolute, assuming that the drug will not adversely affect the animals involved, and that no residues will be found in the edible portions of such animals.

Pesticide Chemical Amendments

Pursuant to the original 1938 act, the FDA exercised regulatory authority over the amount of pesticide residues that remained in or on food, since such chemicals were considered poisonous or deleterious. This area was regulated primarily through a system of unofficial and information tolerances until the enactment of the Pesticide Chemical Amendment of 1954 (Public Law No. 85-791). This amendment created a category of poisonous substances known as pesticide chemicals and authorized their use in or on raw agricultural commodities unless they were unsafe within the meaning of newly enacted section 408 of the FFDCA (21 U.S.C. 346a).

Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, EPA was established. This agency assumed the authority, formerly vested in FDA, for establishing tolerances for pesticide chemicals under the FFDCA. FDA continues to monitor compliance and enforces such tolerances. Pursuant to this reorganization, EPA also assumed functions vested in USDA under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. 135 et seq.). The Federal Environmental Pesticide Control Act of 1972 (FEPCA) (7 U.S.C. 136 et seq.) substantially amended FIFRA to provide for more complete regulation of pesticides and gave EPA additional power to prohibit misuse of a registered pesticide in addition to its existing authority to register certain pesticides and prohibit interstate commerce of unregistered pesticides.

Within this statutory framework, a pesticide chemical is deemed unsafe by FDA as follows:

(a) Any poisonous or deleterious pesticide chemical which is not generally recognized, among experts qualified by scientific training and experience to evaluate the safety of pesticide chemicals, as safe for use, added to a raw agricultural commodity shall be deemed unsafe, (thereby rendering the commodity adulterated) for the purposes of the application of clause (2) of section 402(a) of this Act unless--(1) a tolerance . . . has been prescribed (by regulations promulgated) by the Administrator of the Environmental Protection Agency under this section and the quantity of such pesticide chemical in or on the raw agricultural commodity is within the limits of the tolerance so prescribed; or (2) . . the pesticide chemical has been exempted from the requirement of a tolerance (by regulations promulgated) by the Administrator under this section (21 U.S.C. 346(a)).

The term raw agricultural commodity is defined as follows:

Any food in its raw or natural state, including all fruits that are washed, colored, or otherwise treated in their unpeeled natural form prior to marketing (21 U.S.C. 321(r)).

These statutes establish a regulatory system regarding pesticide chemicals which is essentially the same as that established for food additives, color additives and new animal drugs. However, three important distinctions should be made. Firstly, the FDA jurisdiction in this area does not extend to all foods, but only to raw agricultural commodities. Secondly, another Federal agency, the EPA, has been vested with the authority to prescribe tolerances. Finally, the Delaney clause does not apply to pesticide chemicals used on raw agricultural commodities.

Federal Meat and Poultry Inspection Acts

The Federal Meat Inspection Act (FMIA) (21 U.S.C. 601 et seq.) and the Poultry Products Inspection Act (PPIA) (21 U.S.C. 451 et seq.) are designed to protect the public from unwholesome, adulterated, or misbranded meat, poultry, or products thereof. While many of the provisions of these acts are complementary to provisions in the FFDCA, the FMIA and PPIA also provide for ante mortem, post mortem, and processing inspection by Federal inspectors of certain livestock, poultry, meat, and products thereof prepared for commerce. Such inspections are required by sections 3, 4, and 6 of the FMIA (21 U.S.C. 603, 604, 606), section 6 of the PPIA (21 U.S.C. 455), and regulations promulgated thereunder. Federal inspection is also required in any State which has not developed or is not effectively enforcing requirements, with respect to operations and transactions solely in intrastate commerce within the State, at least equal to the requirements under the Federal acts. Under these statutes, the USDA shares concurrent jurisdiction with the FDA over meat, poultry, and products thereof which have entered the Federal meat and poultry inspection system, but the FDA does not conduct continuous inspection of meat, poultry, or any other food products under its jurisdiction.

The FMIA and PPIA prohibit the sale, transportation, and offer for sale or transportation of meat, poultry, and products thereof which are adulterated within the meaning of these statutes (21 U.S.C. 60, 458). The definitions of the term adulterated included in these acts are similar to those contained in the FFDCA and encompass products which bear or contain any poisonous, deleterious substance which may render them injurious to health (21 U.S.C. 601(m)(1)), 21 U.S.C. 453(g)(1).

The term adulterated may be applied to meat, poultry, or a product thereof:

(A) if it bears or contains...any added poisonous or deleterious substance (other than one which is (i) a pesticide chemical in or on a raw agricultural commodity; (ii) a food additive; or (iii) a color additive which may, in the judgment of the Secretary, make such article unfit for human food;

(B) if it is, in whole or in part, a raw agricultural commodity and such commodity bears or contains a pesticide chemical which is unsafe within the meaning of section 408 of the Federal Food, Drug, and Cosmetic Act;

(C) if it bears or contains any food additive which is unsafe within the meaning of section 409 of the Federal Food, Drug, and Cosmetic Act; or

(D) if it bears or contains any color additive which is unsafe within the meaning of section 706 of the Federal Food, Drug, and Cosmetic Act. Provided, That an article which is not adulterated under (B), (C), or (D) shall nevertheless be

deemed adulterated if use of the pesticide chemical, food additive, or color additive in or on such article is prohibited by regulation of the Secretary in establishments at which inspection is maintained under this title 1 of this Act; (21 U.S.C. 601(m)(2), 21 U.S.C. 453(g)(2)).

Under the FMIA and PPIA, the USDA has been granted the statutory responsibility to conduct inspections of meat, poultry, and products thereof to determine adulteration, and adulteration has been defined to include products containing any residues of food additives, color additives, and pesticide chemicals in excess of tolerances established by the FDA or the EPA. Pursuant to the proviso in section 1(m)(2)(D) cited above, USDA is authorized to conduct its own inquiries into the safety of such substances. Nevertheless, the bulk of USDA's activity in this area is concerned with enforcing determinations regarding the safety of such substances which have been reached by other Federal agencies. The FMIA and PPIA do not include similar provisions for deference to the FDA in determinations on the safety of new animal drugs. These statutes were enacted prior to the New Animal Drug Amendments of 1968 and have not been substantially modified since that time. However, under normal circumstances, it is USDA's policy to defer to the FDA expertise in this area.

Federal inspection of meat, poultry, and products thereof is conducted in approximately 7,300 plants with a field inspection force of approximately 9,200. On the average, USDA conducts daily inspection of 456,000 head of livestock, 13 million head of poultry, 287 million pounds of domestic product, and 7 million pounds of imported product. Ante mortem inspection consists of an examination of an animal just prior to slaughter for the detection of any disease or abnormal condition. When such conditions are detected, the animal is diverted from human food channels. Post mortem inspection includes inspection of each animal slaughtered and involves a specific examination of its head, viscera, and carcass. Processing inspection includes the inspection of all further processing of meat and poultry into a variety of products, and includes an examination of materials such as preservatives intentionally added, as well as an examination of products to detect items unintentionally added and which might be harmful or deleterious.

The meat inspection system was developed and implemented long before the modern era of strict regulation of substances such as food and color additives, and before the development of increasingly sophisticated technology to detect the residues of such substances. While visual inspection during slaughter and processing is effective in locating signs of disease and other forms of adulteration which may be apparent to trained USDA personnel, residues of various additives which may also render the product adulterated are not so readily detectable.

The USDA is authorized by regulations promulgated pursuant to the FMIA and PPIA to retain livestock and poultry suspected of having been treated with, or exposed to, a substance that may impart a biological residue which would make the edible tissues unfit for human food or otherwise aulterated, and may condemn carcasses and edible organs containing such unlawful residues (9 CFR 309.16(d)(e), 381.74, 381.80). Pursuant to this authority, USDA conducts a residue monitoring program through which random samples of meat and poultry carcasses are submitted to laboratory analysis for the detection of various residues. When residue levels in excess of FDA and EPA tolerances are detected, suspect livestock or poultry brought to slaughter at Federal establishments are retained pending further testing. Upon receipt of satisfactory laboratory results which indicate that such retained products are not adulterated, the producer of the animals is removed from the suspect category and may market the animals in a normal fashion.

Since USDA does not assume jurisdiction over livestock and poultry until it is brought to slaughter in a Federally inspected establishment and has no jurisdiction over articles such as animal feed, its ability to control or monitor residue problems

at their source--the farm or the feedlot--is limited. The USDA is authorized to conduct voluntary programs to obtain information about such problems, but has no enforcement authority regarding livestock feeding and management practices.

Relationship of Laws to Drugs and Chemicals under Study

Three classes of drugs are currently at issue under the previously described laws. They are the nitrofurans, sulfonamides, and antibiotics (specifically penicillin and the tetracyclines). This section will discuss the various parts of the laws and their interpretations which have resulted in the current interest in these chemical compounds. An issue in all of these instances is the question of whether and to what extent the continued use of these products constitutes a risk to human health.

Nitrofurans

Five nitrofurans have been used in food-producing animals. Four of them either have current FDA actions pending or may be subject to subsequent action. Nitrofurazone, approved in 1948, was the first to be approved by FDA. Approval was later granted to furazolidone in 1953, furaltadone in 1962, and nihydrazone in 1963. A fifth nitrofuran, furamazone, is not at this time the subject of contemplated agency action. At the time these drugs were approved, applications for approval did not require inclusion of a method to detect residues remaining in the tissue or organs of the treated animals after slaughter.

The Animal Drug Amendments of 1968 provide for the withdrawal of approval of a new animal drug application if:

> Such drug induces cancer when ingested by man or animal or, after tests which are appropriate for the evaluation of the safety of such drug, induces cancer in man or animal, except that the foregoing provisions of this subparagraph shall not apply with respect to such drug if the Secretary finds that, under the conditions of use specified in proposed labeling and reasonably certain to be followed in practice (i) such drug will not adversely affect the animals for which it is intended, and (ii) no residue of such drug will be found (by methods of examination prescribed or approved by the Secretary by regulations, which regulations shall not be subject to subsections (c), (d), and (h)), in any edible portion of such animals after slaughter or in any food yielded by or derived from the living animals; . . . (21 U.S.C. 360b(d)(1)(H)).

This means that a drug is not automatically in violation of the law by virtue of its carcinogenicity, provided it does not adversely affect the health of the animal and no residue of the drug remains in any edible product of the animal as determined by an acceptable method of examination.

Thus, when FDA concluded that furazolidone was a carcinogen, the drug not in violation of the above-quoted section on that fact alone, but rather because no acceptable method for detecting residues had been devised. While no such analytical method was required for the initial approval, the later determination of its carcinogenicity made such a method mandatory. When no acceptable method was forthcoming, the proposal to withdraw approval was initiated.

Sulfonamides

Late in 1973, USDA's residue monitoring program began sampling swine for sulfonamide residues. By the end of 1974, there was evidence of a sulfonamide residue

problem in swine. The estimated range of the violation rate was 6.7 to 13.6 percent. Products containing such violative residues are considered to be adulterated within the meaning of the Federal Meat Inspection Act (21 U.S.C. 601 et seq.) and unfit for human consumption. The health risk associated with consuming animal tissue containing sulfonamide residues is unclear at present. Despite corrective efforts, the violation rate has remained near 10 percent. Meat inspection data indicate that sulfamethazine has been the sulfonamide drug found in 99.9 percent of the cases. The problem is nationwide, although certain geographic areas have slightly more serious sulfonamide residue problems than do other areas.

Efforts to correct this problem have been made more difficult, since contamination can occur at many points along the production line. At the farm, these can include residual sulfa dust in hog feeders, farm-feed grinding, mixing, and conveyer systems, pen manure packs, and hog waterers. A large therapeutic dose of sulfonamides for disease control near market time may carry over enough to leave a residue. In addition to sulfa control at the point of feeding, it is possible for cross-contamination to occur at commercial feed manufacturing plants despite efforts to keep such contamination to a minimum.

A further compounding factor in this situation is the shared responsibility of FDA and USDA in residue monitoring and followup investigation. USDA's responsibility begins when the animal is presented for inspection at the slaughterhouse. If no violations are detected, the carcass is processed. If violations are detected, the FDA is notified of the violation. At this point, an on-farm investigation may be conducted by FDA.

Granting USDA quarantine authority against violators and requiring mandatory identification of all swine going to slaughter could help. At the present time there are no such requirements, and it is sometimes difficult to trace the violative animals back to their origin. Also, while the producer is required to have no violations in the next two lots brought to slaughter, it is possible for him to sell hogs at a terminal market where they lose their identity and may move on through to slaughter undetected.

FDA, in an attempt to reduce the problem, has recently required firms marketing sulfamethazine-containing products for use in swine feed or drinking water to increase the withdrawal time on their labels to 15 days. The success of this measure has yet to be determined.

Antibiotics

On August 30, 1977, FDA proposed the withdrawal of new animal drug applications for all penicillin-containing premixes intended for use in animal feed. This was followed on October 21, 1977, by a proposal to withdraw new animal drug applications for tetracycline (chlortetracycline and oxytetracycline)-containing premixes intended for certain uses in animal feed.

Both actions were taken on the grounds that (1) new evidence has shown that the affected products have not been shown to be safe for subtherapeutic use as required by section 512(e)(1)(B) of the Federal Food, Drug, and Cosmetic Act, (2) affected applicants have failed to establish and maintain records and make reports as required by section 512(e)(2)(A) of the Act, and (3) new evidence has shown that there is a lack of substantial evidence that the affected premixes are effective for certain sub-therapeutic uses for tetracycline-containing premixes and therapeutic uses for penicillin-containing premixes under section 512(e)(1)(C) of the act.

FDA bases this action on a concern over the health hazards that may arise through an increase in the pool of R-plasmids (small lengths of DNA carrying transferable

genes for drug resistance and the capacity to reproduce) in the animal population and the potential transfer of these R-plasmids and R-plasmid-bearing organisms to the human population and surrounding environment. A second issue involves the FDA request that holders of approved new animal drug applications submit data to resolve the safety questions raised. In FDA's opinion, the results of the studies submitted fail to establish the safety of the drugs. A third issue involves the validity of certain efficacy claims made for the premixes. The National Academy of Sciences/National Research Council Drug Efficacy Study Group evaluated effectiveness claims for the premixes and concluded that there was a lack of substantial evidence that the premixes were effective for certain of their labeling claims.

PROPOSALS TO CHANGE THE USE OF ANIMAL DRUGS

During the past 2 years, the FDA has published several proposals to reduce the use of penicillin and tetracycline antibiotics and nitrofuran antibacterials. In response to continued high violation rates of sulfa residues in the tissue of slaughtered hogs, FDA increased the withdrawal time between the last treatment with sulfamethazine-containing drugs and slaughter. This section of the report reviews these proposed rulemakings and provides a historical perspective to the issue.

Antibiotics

Of the three types of animal drugs addressed in this report, the antibiotics have been subject to the most intensive and longest investigation concerning potential health risks.

The recent publication of proposals to restrict the low-level use of antibiotics in animal feed is a result of evidence publicized over 20 years regarding emergence of resistant strains of organisms during chronic intake of antibiotics. 28/ In 1960, interest in the hazards to humans or animals from use of antibiotics in animal feeds was evident in the United Kingdom with the appointment of the Agricultural and Medical Research Council. The Council was later renamed the Netherthorpe Committee. In 1962, the Committee reported that it had found no evidence that antibiotic feeding posed any hazard to animal health. 29/ In 1967, following the 1964-66 S. typhimurium epidemic that began with infected calves and was transmitted to humans who could not be effectively treated by commonly used antibiotics, the committee released a statement regarding their concern about the discovery of transferable antibiotic resistance and the phenomenon of multiple antibiotic resistance. The committee further recommended a study to investigate its implications for public health and to develop recommendations. 30/ This resulted in the appointment of the Swann committee in 1968.

During that period, the FDA Commissioner had also appointed a committee to consider the veterinary medical and nonmedical uses of antibiotics. The FDA committee report was released in August 1966. 31/ That committee focused primarily on the pharmacological and toxicological hazards of antibiotic residues in tissues of animals, milk, and eggs, and on the use of antibiotics as direct food preservatives.

28/ Byerly, T. C., "Proceedings of the First International Conference on the Use of Antibiotics in Agriculture," National Academy of Science/ National Research Council, Washington, D.C.

29/ "Netherthorpe Report of the Joint Committee on Antibiotics in Animal Feeding," Agriculture Research Council and Medical Research Council, London, 1962.

30/ Kiser, J. S., "A Perspective on the Use of Antibiotics in Animal Feeds," Journal of Animal Science, vol. 42, no. 4, April 1976, p. 1059.

31/ Lepper, Mark H., "Report of the Committee on the Veterinary Medical and the Nonmedical Uses of Antibiotics," FDA, DHEW, Washington, D.C., May 1966.

They also expressed some concern about the emergence of resistant organisms. No hazards to humans or animals were identified as a result of using antibiotics in feeds. Shortly after the report was issued, regulations permitting the use of antibiotics as direct food additives were revoked.

In 1969, the Swann committee completed and presented their report to the British Parliament. 32/ The recommendations were adopted and implemented in 1971.

The Swann committee recommendations established the animal drug policy for Great Britain. Since they appear to have a significant influence on the general and specific policy controls for antibiotics in the United States, their recommendations are quoted below. For purposes of definition, the term antibiotic includes the true antibiotics, synthetic sulfonamides and nitrofurans. The recommendations for general aspects of control were:

(1) Permission to supply and use drugs without prescription in animal feed should be restricted to antibiotics which (a) are of economic value in livestock production under UK farming conditions, (b) have little or no application as therapeutic agents in man or animal, and (c) will not impair the efficacy of a prescribed therapeutic drug or drugs through the development of resistant strains or organisms;

(2) when a particular antibiotic is under consideration as a feed antibiotic, account should continue to be taken of the possible dangers to human health which might result from consumption of the residues of the antibiotic in the tissues of the animals fed;

(3) allocation of a particular antibiotic to the classes of feed antibiotic and therapeutic antibiotic should not be regarded as permanent;

(4) a therapeutic antibiotic, i.e., an antibiotic which is not a "feed" antibiotic within the criteria set out in paragraph (1), should be available for use in animals only if prescribed by a member of the veterinary profession who has the animals under his care;

(5) one committee should have overall responsibility for the whole field of use of antibiotics and related substances whether in man, animals, food preservation, or for other purposes; and

(6) this committee should be empowered to demand on a basis of confidentiality such returns as it considers to be necessary.

Recommendations for the control of feed antibiotics were as follows:

(1) The maximum permitted level of a feed antibiotic in animal feed should continue to be 100 ppm, although in most cases lower levels will be more economically beneficial;

(2) feed antibiotics which meet the criteria established in paragraph (1) should be available for use in calves up to 3 months of age and in growing pigs and poultry;

(3) feed antibiotics conforming to paragraph (1) should be withheld from laying poultry and from adult breeding stock of all species;

32/ Joint Committee on the Use of Antibiotics in Animal Husbandry and Veterinary Medicine, Report. Her Majesty's Stationery Office, London, November 1969.

(4) concentrates of feed antibiotics should continue to be permitted for use by farmers who prefer to mix their own feeds rather than to buy ready-compounded feeds;

(5) any advertisement, order form, and label for feed containing antibiotics should be required to display clearly the amount and official name of the constituent feed antibiotic, and can be advertised and promoted without restriction;

(6) chlortetracycline and oxytetracycline do not satisfy the criteria established in paragraph (1) and (2) legislation permitting their supply and use without prescription should be revoked;

(7) penicillin does not satisfy the criteria, and legislation permitting its supply and use without prescription should be revoked;

(8) tylosin should not be available without prescription for use as a feed antibiotic and should be available only on the same terms as a scheduled antibiotic, i.e., only on prescription;

(9) sulfonamides should be available only on the same terms as a scheduled antibiotic, i.e., only on prescription;

(10) nitrofuran drugs should be available only on prescription--this restriction need not, in our view, apply to any nitrofuran derivative which is shown to be devoid of antimicrobial activity, shown not to cause drug resistance to its own action, nor to cause cross-resistance to any therapeutically useful antibiotics (including other nitrofurans); and

(11) the veterinary profession should retain the use of chloramphenicol for special situations, but distinctive labeling should be considered--the use of this drug and the prevalence of resistance to it should be monitored in human and veterinary medicine and prompt action taken if either increases significantly.

In April of 1970, the FDA Commissioner appointed a task force on the Use of Antibiotics in Animal Feeds. 33/ The report of this task force was made public in January 1972 and contained a statement of policy on antibiotic and sulfonamide drugs in animal feeds. The task force had reached the conclusion that:

(1) The use of antibiotics, especially in subtherapeutic amounts, favors the selection of R-factor-bearing bacteria;

(2) animals which have received either subtherapeutic and/or therapeutic level of antibiotics in feed may serve as a reservoir of antibiotic-resistant pathogens or non-pathogens--these reservoirs of pathogens can produce human diseases;

(3) the prevalence of multiresistant R-factor-bearing bacteria in animals has increased and has been related to the use of antibiotics;

(4) organisms resistant to antibacterial agents have been found on meat and meat products; and

33/ Van Houweling, C. D., "Report of the FDA Task Force on the Use of Antibiotics in Animal Feeds," FDA, Rockville, Md., January 1972.

(5) there has been an increase in the prevalence of antibiotic resistant bacteria in man.

In terms of policy recommendations on use, the task force submitted five. These were: 34/

(1) Any antimicrobial agents used in human clinical medicine that fail to meet task force established guidelines in regard to safety and/or efficacy should be prohibited from growth promotion and any subtherapeutic use in animals by the following dates:

(a) tetracyclines, streptomycin, dihydrostreptomycin, sulfonamides and pencillins in poultry--January 1, 1973, and in swine, cattle, and sheep--July 1, 1973; and

(b) All other approved antibiotics--December 31, 1973.

(2) the drug industry begin immediately to develop other agents that do meet the criteria established by the task force and can be used to replace those agents to be withdrawn;

(3) that the tetracyclines, streptomycin, dihydrostreptomycin, neomycin, spectinomycin, penicillins, and sulfonamides can be reserved to therapy following the dates in (1) above unless they meet the task force criteria for safety and growth promotion efficacy--they should be used only by a veterinarian or on a veterinarian's prescription and at therapeutic levels, but only for short-term treatments;

(4) antibiotics which select for bacteria resistant to the antibiotics most critically needed for therapy of man and animals be prohibited from use in animal feeds, including chloramphenicol, semi-synthetic penicillins, gentamicin and kanamycin--those that are effective and essential for therapy of certain animal diseases, but select for R-factor mediated multiple resistance should be available for short-term therapeutic use by a veterinarian or on a prescription basis; and

(5) labeling for medicated feeds be required to state the amount of antibiotics in the final feed for all levels, including levels of 50 grams/per ton or less currently undeclared.

A comparison of these recommendations with those of the Swann committee reveal considerable similarity but some differences, especially in the types of antibiotics that should be restricted. The Swann report was adopted, but the FDA Report generated considerable opposition and was modified and re-released in April 1973. 35/ This version differed in several respects: (1) it specifically recognized the value of low-level feeding of antibiotics, (2) it recognized salmonella as the organism of concern, and (3) it required proof that no hazard to health existed due to (a) colonization of R-factor transfer from animals to humans, (b) increased pathogenicity due to toxin linkage with R-factors, and (c) required a statement that the drugs had been shown to be safe under present conditions of use when they were approved. The statement required that all manufacturers of antibiotics for use in animal feed provide information showing their products met conditions of not increasing the quantity, prevalence, or duration of shedding or resistance

34/ Van Houweling, p. 10.

35/ Gardner, S., "Statement of Policy and Interpretation Regarding Animal Drugs and Medicated Feeds," Federal Register, vol. 38, no. 67, April 20, 1973.

characteristics of salmonella. Data for submission were due by April 20, 1974, and the safety and efficacy data were due a year later.

In February 1976, manufacturers not submitting the required data had the approval to market their products revoked. This action affected a number of products either not then being used or used in very limited quantities.

As FDA neared the decisionmaking phase on antibiotics, a subcommittee of the National Advisory Food and Drug Committee (NAFDC) was formed to review and make recommendations on the continued use of antibiotics and sulfonamides in animal feeds. The subcommittee was charged with examining the health risks involved, whether or not alternatives to the use of these drugs existed, if continued use of the drugs is allowed along with acceptance of the risks, and what restrictions should be imposed. After conducting hearings during 1976 and reviewing all the evidence submitted, the subcommittee sent its conclusions to the full committee. Conclusions were based on FDA policy to reduce and/or eliminate risks to the extent possible, and to weigh the risks or potential risks against the benefits derived from the use of antibacterial drugs in animals feeds.

The conclusions were: 36/

(1) Antibiotics in feed should not increase the quantity, prevalence, or duration of shedding of sensitive salmonella in animals fed subtherapeutic dosages;

(2) feeding of antibiotics in animal feeds presents no hazards to man from drug residues in tissues when good manufacturing practices are observed by the feedmixer and established withdrawal times are adhered to by the animal producer;

(3) both therapeutic and subtherapeutic use of antibiotics will result in the selection of antibiotic-resistant strains of microflora in animals;

(4) there is an increase in the pool of R-plasmid-bearing organisms which may represent a risk of unknown and presently indeterminable magnitude;

(5) there may be a potential hazard associated with an increase in the gene pool of R-plasmid-bearing organisms, and there is the possibility of introducing transmissible single or multiple antibiotic resistance into one or more colonies of highly dangerous pathogens;

(6) antibiotic resistance can transfer from animals to man, either by way of drug-resistant organisms passing directly from animals to man, or by way of transfer of drug resistance from organisms derived from animals to sensitive recipient organisms in man--the extent to which animals are a source of antibiotic resistance for the general human community is unknown;

(7) in most cases, alternates do exist for promotion of feed efficiency and growth rate in food animals, but satisfactory alternates do not exist in all cases for the use of specific antibacterials in the prevention of certain animal diseases;

(8) the loss of benefits from a total ban of the use of antibiotics in feeds would result in (a) increased cost and/or a diminished supply of foods of animal origin and (b) reduced health status of animals with subsequent effect on food products of animal origin entering the Nation's food supply; and

36/ "Report, Subcommittee on Antibiotics in Animal Feeds, National Advisory Food and Drug Committee," FDA, DHEW, 1977.

(9) the total and abrupt stoppage of the use of tetracyclines and penicillin for prevention and control of animal diseases would cause undue disruption of production in our livestock and poultry production industries, significant increases in livestock and poultry diseases, and would create a lesser supply of quality animal protein with increased consumer costs.

The subcommittee proceeded to make several specific recommendations:

(1) Discontinue use of penicillin in all species for purposes of growth promotion and/or feed efficiency and use for disease prevention when effective substitutes are available;

(2) for sulfaquinoxaline, no action is necessary for growth promotion and/or feed efficiency purposes since they are not approved uses--use for disease prevention, as approved, for chickens, turkeys, and rabbits should be continued, but limited to the extent possible; and

(3) for tetracyclines, discontinue use for growth promotion and/or feed efficiency where effective substitutes are available, and continue use for disease prevention where alternatives are not available.

Several general recommendations were also made, the most important of which would restrict sale of products with penicillin or tetracyclines by feed mills with approved medicated feed applications and/or prescriptions from licensed veterinarians. Also, it reaffirmed the policy of eliminating from low-level use in animal feeds all drugs used for therapy of disease in humans.

In January 1977, the NAFDC rejected the recommendations on tetracyclines on the basis that no judgment could be reached. In April, the FDA Commissioner concurred with the subcommittee recommendations and issued a proposal to restrict the use of penicillin and tetracyclines in animal feeds, but stated that they would continue to be available on a prescription basis for animal disease treatment and in a few instances, at lower dosages, for disease prevention. The proposal would include combination drugs with pencillin or tetracyclines.

Penicillin

In June 1977, the first formal proposal to restrict usage of penicillin was published in the Federal Register. 37/ Animal feeds containing penicillin-streptomycin combination premixes were affected. The basis for the action was that no evidence had been presented to demonstrate the effectiveness of these premixes as required under section 512(d)(3) and (e)(1)(c) of the Federal Food, Drug, and Cosmetic Act. 38/ Interested parties were also notified that they could request an opportunity for a hearing on the proposal.

On August 30, 1977, FDA published a second proposal to withdraw approval of all animal drug applications for all premixes containing penicillin. 39/

Reasons stated for this action include: (1) evidence shows that products containing penicillin have not been shown safe for subtherapeutic use as required by section 512 (e)(1)(B) of the Federal Food, Drug, and Cosmetic Act, (2) applicants have

37/ Federal Register, vol. 42, no. 112, June 10, 1977, pp. 29999-30002.
38/ This proposal would effectively end the low-level use of streptomycin as well, since the drug is approved for use only in combination with pencillin. See 21 CFR 558.460.
39/ Federal Register, vol. 42, no. 168, part IV., August 30, 1977, pp. 43770-43771.

failed to establish and maintain records and make reports as required by section 512 (e)(2)(A) of the act, and (3) there is a lack of substantial evidence that premixes containing penicillin are effective for therapeutic uses under section 512 (e)(1)(C) of the act. 40/

Tetracycline and Tetracycline-Containing Premixes

On October 21, 1977, FDA published a proposal in the Federal Register to restrict the use of premixes containing tetracycline and tetracycline premixes at subtherapeutic levels in animal feeds. 41/ The proposal followed earlier recommendations by restricting chlortetracycline and oxytetracycline uses in animal feeds except when adequate substitutes for disease prevention are not available. No therapeutic restrictions were suggested. The reasons given for the proposal were the same as those given in the penicillin proposal issued earlier.

This proposal, in accordance with the recommendations of the Animal Feeds Subcommittee, NAFDC, listed the exceptions where adequate substitutes are considered to be unavailable and a list of available substitutes. 42/ This list includes both antibiotics and antibacterials. However, no claim is made that these drugs are as effective or will not result in development of antibiotic resistant organisms.

Another step to reduce use of penicillin and tetracycline in animal feeds was proposed in the Federal Register January 20, 1978. 43/ By bringing their distribution under the control of feed mills with medicated feed licenses and veterinarian prescriptions, this proposal would establish a control mechanism as well as a recordkeeping procedure.

The approach elected by the FDA Commissioner is a supplemental course of action. On one hand, the Commissioner could attempt to terminate all penicillin and tetracycline uses in animal feeds under the imminent hazard provision of section 512(e)(1) of the act. On the other hand, he could continue to pursue the current course of action of withdrawing approval of all uses that have not been shown to be safe or effective by continuation of the typical hearing and review process. The third course of action would be to limit distribution of the antibiotics to the order of a licensed veterinarian from feed mills holding approved medicated feed applications allowing the manufacture of such feed. This action could be implemented before or after the hearing opportunities being allowed under the other proposals on pencillin and tetracycline. If implemented before the final rulings on the other proposals, all approved tetracycline and pencillin uses in animal feed would be subject to the distribution restrictions. If made effective after the other final rulings, only the remaining uses would be subject to distribution control. Consequently, timing is recognized as a crucial factor, and comments on the appropriate effective date for the proposal were also requested.

In the informal public hearings held during the spring of 1978 together with submitted comments, concern has been repeatedly expressed about the availability and geographic distribution of veterinarians specializing in large animal practice. Analyses suggest that distribution is quite uneven, and some livestock and poultry producers might have difficulty obtaining veterinary services in an emergency situation.

40/ Federal Register, vol. 42, no. 168, August 30, 1977, p. 43772.
41/ Federal Register, vol. 42, no. 204, part IV, October 21, 1977, pp. 56254-56263.
42/ Federal Register, vol. 42, no. 204, October 21, 1977, p. 56287.
43/ Federal Register, vol. 43, no. 14, part III, January 20, 1978, pp. 3032-3045.

Under this proposal, medicated feeds may be distributed by veterinarians, feed stores, and other distributors. However, certain conditions were also proposed to prevent unnecessary use.

On August 8, 1978, the Commisssioner proposed to postpone final action on this proposal until previously published proposals discussed above have been resolved. 44/

Other Antibacterials

Nitrofurans

Proposed rules have been published for several nitrofurans, along with final rulings for some of these drugs.

Nitrofurans consist of five specific agents, four of which have been subject to withdrawal proposals (NR-7, NF-180, NF-260 and NF-64). The safety of these agents became suspect with the completion of toxicological studies in 1965, 1966, and 1967 indicating that nitrofurans are tumorogenic and might induce cancer in laboratory animals. In 1964, FDA established an ad hoc committee to determine whether the nitrofurans were carcinogenic. Reports submitted by committee members were not conclusive.

In 1971, two manufacturers submitted requests for supplemental new animal drug applications for the nitrofurans that proposed to eliminate some uses and increase the withdrawal time for other food producing animals. Agency policy prevented approval, and FDA proceeded to publish proposals to withdraw approval of nihydrazone (NF-64) and nitrofurazone (NF-7) in March 1971. 45/

The grounds for withdrawal were that the drugs produce tumors in laboratory animals and, therefore, are considered unsafe for use in the absence of appropriately sensitive methods of analysis to establish residues in food derived from treated animals.

In August 1971, FDA published additional proposals to withdraw approval of furazolidone (NF-180) and furaltadone (NF-260) for the same reasons. 46/ Additional evidence submitted to FDA on NF-180 resulted in FDA determining that it is carcinogenic in laboratory animals. Furthermore, manufacturers failed to submit an adequate method of analysis to assure the absence of residues in food for humans. Consequently, FDA proceeded to issue a proposal to withdraw use in May 1976. 47/ In August, a similar notice was published proposing withdrawal of all uses of the other three nitrofuran drugs. 48/ Reasons cited for withdrawal are the same as those for NF-180.

On April 1, 1977, the final rule to withdraw approval for use of NF-260 was made official with publication of the notice in the Federal Register. 49/ A week later, approval for use of NF-64, nihydrazone, was officially withdrawn as a result of publication of the notice in the Federal Register. 50/ For NF-180 and NF-7, additional evidence to support continued approval of use and requests for hearings have been filed with FDA. These materials are still being reviewed, and it is not known when a final ruling or hearings will be announced.

44/ Federal Register, vol. 43, no. 153, August 8, 1978, pp. 35059-35060.
45/ Federal Register, vol. 43, pp. 5926-2927.
46/ Federal Register, vol. 36, August 4, 1971, p. 14343.
47/ Federal Register, vol. 41, no. 94, part V, May 13, 1976, pp. 19906-19921.
48/ Federal Register, vol. 41, part II, August 13, 1976.
49/ Federal Register, vol. 42, no. 63, April 1, 1977, p. 17526.
50/ Federal Register, vol. 42, no. 68, April 8, 1977, p. 18619.

Sulfamethazine

Sulfa residue monitoring of slaughtered hogs began in 1973. Since this program was initiated by USDA, violative rates for sampled slaughtered hogs have been considered unnecessarily high. For the 6-month period through December 1977, the percentage of the sampled hogs found in violation of the 0.1 ppm tissue residue tolerance level averaged 14.2 percent.

Probable cause of the residue violation was long thought to be the producer's failure to abide by the recommended withdrawal time of the drug between last treatment and slaughter. However, a recent FDA study indicated that there are several possible causes. 51/ Over half of the sample of violations, 57 percent, was caused by contamination of the withdrawal feed. This problem is apparently the result of insufficient cleanout of feed manufacturing, distribution, and storage equipment at feed mills and farms. 52/ Other causes include failure to observe the withdrawal period, 25 percent; accidents, 12 percent; and miscellaneous causes, 6 percent.

Since November 1977, the incidence of violations has been decreasing, suggesting greater awareness and effort to solve the problem on the part of hog producers. Furthermore, both FDA and USDA are actively involved in a program to determine the causes and means of reducing residue levels.

On May 5, 1978, FDA published a final ruling in the Federal Register that all firms marketing products containing sulfamethazine for swine feed and drinking water, including premixes and complete medicated feed, must change labeling to reflect an increase to a new 15-day pre-slaughter withdrawal time. 53/ The previous withdrawal time, 10 days, recommended in the product's labeling was considered too short to prevent violative levels of drug residue in pork tissue from occurring.

The rule should have some beneficial effect in terms of reducing the incidence rate, but that portion caused by contamination of feed may not be affected at all.

ECONOMIC IMPACT OF THE WITHDRAWAL OF SELECTED ANIMAL DRUGS NOW FED AT SUBTHERAPEUTIC LEVELS

The objective of the analysis is to evaluate the economic impact on producers and consumers of banning the subtherapeutic use of selected chemicals and animal drugs.

The specific economic impacts considered are: (1) the changes in production and price at the farm level for the animal products directly affected, (2) the effect on prices and production of other livestock products and on grain, and (3) the impact on consumption, expenditures, and prices at the consumer level. In some instances, possible changes in industry structure resulting from the ban have been identified. The animal species and the animal drugs considered are presented in table 4. Animal drugs are listed by groups, not by specific names.

Several crucial assumptions are made during the course of the analysis.

(1) The effect from banning each drug or chemical was assumed to be additive. Data were not available to determine the interactions that might exist. If adequate basic science research were made available, this assumption would not be necessary.

51/ U.S. Dept. of Health, Education and Welfare, Memo, HEW, Publ. No. (FDA) 78-6028, February 1978.

52/ Feed containing as little as 1 ppm of sulfamethazine carryover can cause a residue level in excess of the established tolerance level in pork tissue.

53/ Federal Register, vol. 43, no. 88, May 8, 1978, p. 19385.

Table 4--Animal species and chemical and drug additives analyzed 1/

Animal Species	Penicillin	Tetracyclines	Nitrofurans	Sulfa	Combination
Beef		X			
Pork	X	X	X	X	X
Laying chickens	X	X			X
Broilers	X	X	X		X
Turkeys	X	X	X		X
Dairy		X			
Lambs		X			

1/ An X indicates the additive considered for each animal species based on industry patterns of use.

(2) The physical effects on mortality, rate of gain, and other physical coefficients were, in many instances, estimated from very limited test data. Also, it was assumed that commercial animals would react to drugs in the same manner as test animals.

(3) It was assumed no new technologies would replace the banned drugs for at least 5 years after the ban. This assumption implies that there would be no change in management practices that would allow the ban to be effectively circumvented (for example, prescribing as therapeutic, drugs and dosages formerly administered subtherapeutically). It was also assumed that changed management practices would not substitute for the drugs. To the degree improved management can substitute for drugs, the effects are overestimated.

(4) Methods of analysis are not now available to measure the effects of a ban with certainty. Those available for use are based on production technologies utilizing drugs at subtherapeutic levels. These historic relationships could be altered by banning the subtherapeutic use of animal drugs.

Limitations in the data and methods of analysis do affect the ability to develop precise magnitude estimates of economic effects. In order to at least partially compensate for this shortcoming, results were generated using two assumed levels of drug efficacy. This approach provides a range that should bracket the actual changes resulting from a ban on the subtherapeutic use of animal drugs, although it is not as complete or definitive as might be desired. It is believed that the magnitude of estimates reported here do represent the best information available at this time.

Procedure

The economic concepts for and the general method followed in the analysis is presented here. Data and methods are discussed in detail in a later section for each of the animal species considered.

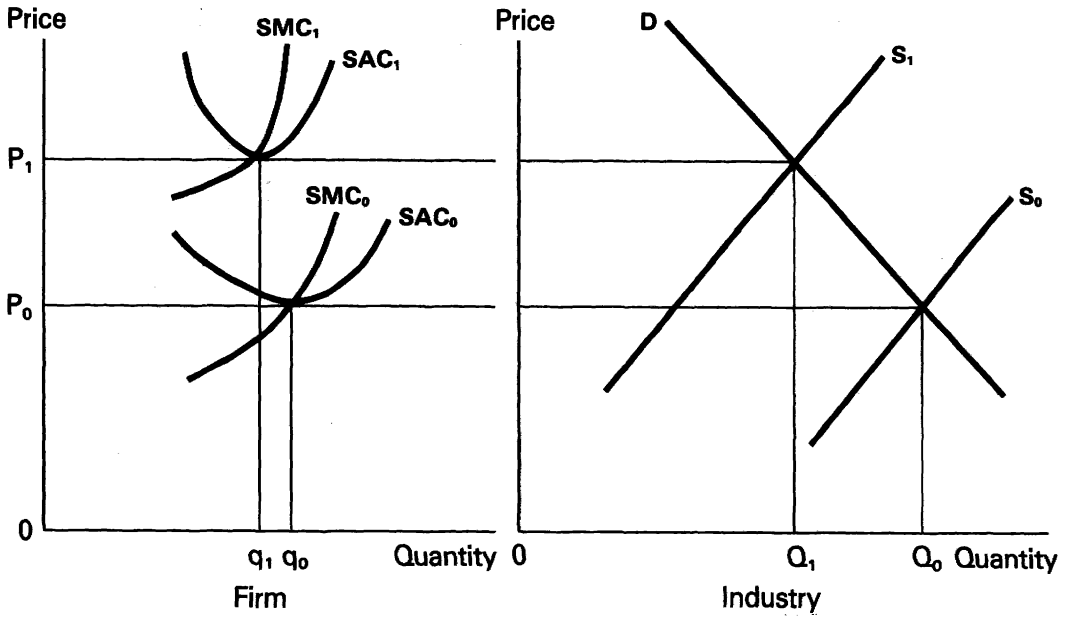
Concepts

Subtherapeutic use of animal drugs is generally assumed to minimize the amount of conventional inputs needed to produce a unit of output and to reduce condemnations in the final product. Assuming this is correct, figure 1 illustrates the economic relationships for a firm and the industry before and after a proposal affecting use of an animal drug is implemented. Under competitive conditions, both are initially in a state of equilibrium. The firm is producing quantity, Q_o, at P_o, the lowest point on its average cost curves, SAC_o. Summation of the individual firm marginal cost curves, SMC_o, results in the supply schedule for the industry, S_o. With the demand schedule, D, given, the industry is supplying quantity, Q_o, and the equilibrium price is P_o.

Implementation of a restriction on the subtherapeutic use of animal drugs results initially in a state of disequilibrium and the need for firms to adjust output to the new cost conditions. Firm managers find that more resources per unit of output are required, because of increased death loss and poorer feed conversion. This results in higher costs. Costs will also increase if the increased demand for inputs results in higher input prices. Each firm finds that its cost functions are now located above the previous ones as illustrated in figure 1.

Figure 1

Longrun equilibrium diagrams for an industry and firm affected by restrictions on the use of animal drugs



Horizontal summation of all the new short run marginal costs results ultimately in a leftward shift in the aggregate supply curve to S1. A new equilibrium market price and quantity result.

A ban on the subtherapeutic use of the animal drugs results in a higher average cost and price, P_1, and a smaller quantity produced, Q_1. Depending on the price elasticity of demand, total revenue to producers increases, decreases, or remains the same. Since the demand for most food commodities is, on average, inelastic, (i.e., a large positive or negative percentage change in price for a small, but opposite change in quantity) the reduced output would generally be expected to increase the total expenditures of buyers and increase total revenue for producers.

Changes in Production Coefficients

To determine the extent of the cost increase for each animal subsector (species), estimates of changes in mortality, growth rate, condemnations, and other production coefficients associated with the use of specific drugs were obtained. The primary source of the estimates for these changes were scientists in the Science and Education Administration (SEA), USDA, with additional assistance from scientists in land-grant universities, veterinarians, private businesses, and various publications. Most estimates were extrapolated from small-scale test results, since other data were scarce for many species and drugs. In many instances, wide variations in test results made estimates of changes in production coefficients more difficult and subject to error. Most of the data were taken from tests conducted when additives were first introduced in the 1950's and 1960's.

As indicated at the outset, the changes were estimated assuming no substitute drugs were available. Although this assumption may result in some overstatement of impacts, it was necessary because the data are not available on the efficacy of many of the substitute drugs. 54/ Another assumption is that the reaction of animals grown under commercial conditions would duplicate those of the test animals. This, too, may be a source of error, because test animals are generally carefully selected with much less variation in size and general health than commercial animals. Also, laboratory tests are usually conducted under controlled environmental conditions, including controlled disease exposure not found in the field.

The experts supplying estimates of changes in production coefficients were asked to estimate the extent of the use of each drug and to differentiate between the rates of use if they vary with the stages of production. Records compiled by drug companies supplied additional information on the rates of drug use. Two sets of coefficients were generated representing both a moderate and a high efficacy for the drugs. A low drug efficacy was assumed to be identical to the baseline projections. If use of animal drugs were banned, the assumption of a moderate change would require less adjustment in production than the higher change, since the moderate drug efficacy would result in less of a shift in the supply schedule.

Changes in production coefficients were then converted to changes in output for a given animal unit. These changes were combined with the estimated prevalence of drug use to establish an estimate of the change in output for each animal species for base year 1976. The estimated percentage changes in production from the 1976 output levels for each species and each additive are given in table 5.

54/ Efficacy refers to the power of the drug to produce the desired effects.

Table 5--Estimated percentage change in livestock product output from banning selected drugs in subtherapeutic uses, moderate and high drug efficacy, first year (1976) 1/

Animal Species	Penicillin		Tetracyclines		Nitrofurans 2/		Sulfa 3/		Cumulative effect	
	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate	High
	Percent									
Fed beef cattle	NA	NA	-0.4	-0.8	NA	NA	NA	NA	-0.4	-0.8
Hogs	NA	NA	-3.4	-15.6	NA	NA	-1.5	-2.2	-4.9	-17.8
Broilers	-2.1	-3.8	-6.4	-11.5	.2	-5.7	NA	NA	-8.3	-21.0
Egg production	-.6	-1.0	-1.2	-2.3	.1	-.3	NA	NA	-1.7	-3.6
Turkeys	-1.4	-2.8	-2.8	-4.6	-1.9	-8.7	NA	NA	-6.1	-16.1

NA = Not applicable.

1/ The higher the expected response to a feed additive, the greater the reduction in output if the additive is banned.

2/ In poultry, it is possible to get a slight increase in output when nitrofurans are removed from the feed.

3/ The major effect would be the sulfa drugs, but would also include the effects attributed to penicillin and the tetracyclines.

Method of Analysis

These coefficients were first used to determine the year-one effects of an animal drug ban on each animal industry when considered as an independent subsector. Then, the coeficients were used to establish an estimate of the intersubsector effects which would occur if the animal drugs were banned for use in all livestock subsectors simultaneously. These intersubsector effects were traced for 5 years following the ban.

A cross commodity model of the livestock, wheat, and feed grains sector developed in the Economics, Statistics and Cooperatives Services (ESCS), USDA, was used as the basis for assessing the economic impacts resulting from changes in production levels after the drugs were withdrawn, regardless of the species. Use of this model makes it possible to develop specific estimates of changes in prices and quantities resulting from a sudden and substantial change or shock introduced in one or all subsectors specifically analyzed.

An advantage of the linked model is that it gives deviations in prices and quantities from a projected baseline and shows these changes in succeeding time periods after the initial shocks are introduced.

The livestock subsectors analyzed include beef, hogs, broilers, turkeys, laying chickens, sheep, and dairy cattle. The dairy cattle and sheep subsectors were analyzed separately since the sheep sector is not yet built into the model and the major effect in dairy cattle would be on replacement calves not directly affecting current milk production. Since not all female dairy calves produced are needed for replacement, the estimated reduction in the number of calves from banning feed additives should place no meaningful restriction on the size of the dairy herd. However, milk production could be affected through the indirect effects of banning drug additives in the other subsectors.

Changes in production coefficients for each species of livestock were converted to an expected percentage change in production with banning of a drug or combination of drugs. This percentage change was calculated based on the given number of animals in 1976 and assumed that producers in the base year did not try to maintain output by increasing breeder replacement rates. 55/ The initial change in production, introduced as a leftward shift in the supply function, was maintained throughout the time periods analyzed. The analysis did not allow for changes that might occur from substituting different drugs.

The results of the analysis are presented in two sections. The first contains results from the analysis of selected animal drug bans on a species-by-species basis. The effects on each animal subsector (species) are considered independently (no cross impacts) and for only the first year after the ban. The second presents the results of an animal drug use ban across selected animal species. The intersubsector impacts are traced for 5 years after the initial ban.

Species-by-Species Ban

Fed Cattle Subsector

Cattle feeding has increased rapidly since 1955. Feeding has shifted geographically from small farmer-feeder lots in the North Central to large commercial

55/ This percentage decrease in production was introduced into the model as an absolute change in the intercept which shifted the supply curve to the left. This is a proxy for the actual shift that would occur from increased costs resulting from the ban on drugs as feed additives.

feedlots in the Plains States and Southwest. With this shift has come a need to transport increasing numbers of feeder cattle from areas where they were fed high roughage, corn silage based rations to the feed lots where they are finished on grain rations.

The movement of feeder cattle over long distances and the direct placement on full feed has been associated with an increased use of antibiotics. Some cattle are given subtherapeutic levels of antibiotics for a period prior to being shipped and are fed subtherapeutic levels of some drugs in the feedlot while they are regaining the weight lost during shipping and are becoming adjusted to the feedlot condition. In addition, cattle on feed are often fed subtherapeutic levels of antibiotics to increase feeding efficiency and reduce morbidity. Feeder cattle showing distinct signs of disease are treated with therapeutic levels of the antibiotics.

A ban on the subtherapeutic use of antibiotic feed additives in livestock production would likely: (1) increase the length of feeding period needed to achieve a specified increment of weight gain (or reduce the weight gain during a specified feeding period), because daily gains are normally lower in the absence of antibiotic feed additives; (2) increase the quantity of feed required to produce a given increment of weight gain, because more feed is usually required per pound of gain when antibiotics are not included in the feed ration; and (3) perhaps increase the morbidity and mortality rate among feeder cattle replacements and cattle on feed.

Tetracyclines are the primary antibiotics used at subtherapeutic levels in fed-beef rations. It was estimated that 60 percent of the cattle in feedlots receive tetracyclines in their feed.

Even with an animal drug ban, some antibiotics could still be used at therapeutic levels; hence, morbidity and mortality rates would likely be less affected than rates of gain and feed efficiency. The longer time periods required for cattle on full feed in feedlots to reach desired slaughter weights and grades would reduce efficiency. In addition, cattle on feed would require more feed per pound of gain.

Economic effects.--The economic effects of such a ban, aside from the effects it would have on net revenues of manufacturers and distributors of antibiotics, would depend largely on the reaction of producers. For this part of the study, production changes were analyzed under the assumption that all livestock and poultry production practices would continue the same as without a tetracycline ban. It was assumed that cattle started on feed as 700-pound yearlings would be fed the same period as before the ban--156 days. The major effect of a ban on the use of tetracyclines at subtherapeutic levels in feed this assumption would be a reduction in fed cattle average slaughter weights.

Cattle reflecting the moderate level of response to antibiotic feed additives for 156 days grade mostly choice (optimal feeding goal under the present grading system) and are marketed at 1,050 pounds. High response to antibiotic feeding results in marketing weights of 1,062 pounds with more cattle grading choice. A tetracycline ban would result in lighter slaughter weights (1,038 pounds) and possibly fewer cattle grading choice.

Banning subtherapeutic levels of tetracyclines would, thus, result in a reduced marketing weight of 12 pounds and 24 pounds per head, respectively, at the moderate and high drug efficacy levels. Best estimates available indicate that 15 million cattle (60 percent of the number of fed steers and heifers slaughtered in 1976) received subtherapeutic antibiotics giving a reduction in total production of 180.3 and 360.7 million pounds of liveweight depending on the efficacy assumption. This amounts to 0.42 and 0.83 percent reductions in beef production from the 43,442 million pounds produced in 1976 without a feed additive ban.

General implications.--Restricting feeding to no more than 156 days and holding fed cattle numbers to the base year level resulted in the initial reductions in output from banning the tetracyclines in feed. This is consistent with the method for estimating production changes in all other animal subsectors, and the production shifts are probably more comparable than if they had been based on cost calculations. However, while it would not change the essence of the result, beef producers might react in a different manner in actual practice.

Beef is priced under a fairly well established set of grades and yields. In the fed beef subsector, prices and feeding efficiencies clearly dictate the optimal feeding strategy as choice grade and a low yield grade. Banning tetracyclines would clearly not force feeders to market cattle at lighter weights. Instead, they might increase the feeding period until the choice grade is reached. Given the assumptions, the 156-day feeding period would need to be increased to 162 days for the cattle to reach 1,050 pounds, the previous marketing weight. Additional feeding time required to reach optimal market weight would reduce the number of cattle which could be fed during a given period of time. Assuming perfect turnaround, 2.34 lots of antibiotic-fed cattle could be fed a year (365 ÷ 156).

To maintain production at pre-ban levels, feedlot utilization would have to be increased by 4 percent to market 15 million head of fed cattle under the lengthened feeding period. The result is an additional 90 million animal days of feeding required. Consequently, both feed and nonfeed costs would increase. Antibiotic costs would decrease because of the subtherapeutic ban (table 6).

Production costs of the 15 million head fed tetracyclines would increase by over $80 million per year with the ban. In addition, increased condemnations at slaughter would likely occur (primarily livers), decreasing revenues, at constant prices, by $4.8 to $7.8 million per year.

Hog Subsector

Most hogs are produced in farrow-to-finish enterprises where the feeder pigs are born, raised, and fed out on the same farm. The remaining production is from separate units in which feeder pigs are produced by one firm and purchased and fed out by another firm. This analysis focuses attention on the farrow-to-finish enterprises.

The structural trend has been toward fewer and larger hog enterprises with increased capital investment. Facilities, in these larger total confinement units, are used rather intensively. Consequently, movements between the farrowing, nursery, and finishing units must be closely coordinated. Use of antibiotics helps keep down the incidence of disease susceptability, resulting in improved coordination and full use of facilities.

Antibiotics and other drugs are fed at subtherapeutic levels in hog feed through all stages of the growth cycle, but the practice is most prevalent during the preweaning, pig starting, and pig growing stages. Prevalence of subtherapeutic use of drugs is shown table 7.

A combination drug generally containing tetracycline, sulfa, and penicillin is widely used in hog foods. This makes it very difficult to isolate the response to the individual drug. Tetracycline, and to a much smaller extent nitrofurans, are fed singly, but even in these instances the effects may be difficult to isolate if they are alternated with other additives. Tetracyclines contribute the largest benefit of all the additives used in combination. Sulfa would have the greatest effect of the remaining drugs.

Table 6--Estimated per head cost of feeding cattle in feedlots, with and without subtherapeutic tetracycline use

Item	Drugs banned	Drugs Used	
		Moderate efficacy	High efficacy
		Dollar per head	
Feed cost	$186.90	$182.23	$177.55
Antibiotic	1/.21	.43	.45
Nonfeed cost	25.11	24.18	23.40
Total cost	212.22	206.84	201.40

1/ Therapeutic use only.

Table 7--Estimated percentage of hogs receiving drugs in feed at subtherapeutic levels

Production	Tetracyclines	Nitrofurans	Combination drugs 1/
		Percent	
Gestating sows	7.5	3.2	7.5
Preweaning	60.0	7.5	60.0
Pig starting	60.0	4.5	60.0
Pig growing	40.0	3.0	40.0
Pig finishing	25.0	0	25.0

1/ Combination drugs include tetracyclines plus penicillin and/or sulfas.

A subtherapeutic drug ban is considered under two alternatives (moderate and high efficacy) with comparisons to the 1976 base. The alternatives differ in that the high drug efficacy option considers estimated increases in mortality or death loss that might be expected in the absence of antibiotic feed additive in addition to the moderate alternative consideration of reduced efficiency and increased morbidity. This analysis assumes producers would react initially to the subtherapeutic ban by maintaining preban feeding periods and, thus, marketing the hogs at lighter weights.

Economic effects.--Hog producers could respond to a ban on subtherapeutic use of antibiotics by attempting to maintain the current flow of hogs through their system. Under the moderate efficacy alternative, the number of hogs produced would remain essentially the same; however, efficiency of gain would be reduced. To maintain a coordinated flow through the farrowing, nursery, and finishing facilities, the market weight of hogs would be reduced due to the slower rate of gain. Days spent in the enterprise between the farrowing and finishing phases would remain the same, but less weight would be produced.

Hogs are not marketed under a rigid set of grade and price relationships as found in the fed beef sector. Consequently, feeding to a particular weight and/or grade is not as important. Since larger farrow-to-finish enterprises tend to operate more intensively, higher capacity utilization might not be possible without increased capital investment.

Banning subtherapeutic use of all drugs from hog feed would have reduced liveweight output during 1976 by 860 million pounds (moderate efficacy) and 3,175 million pounds (high efficacy).

Marketing the hogs at lighter weights, even though gains are less efficient, results in reduced total feed usage and lower total feed costs. However, feed costs per pound of gain are increased slightly due to the lower efficiency of gain (table 8).

The study results indicate a reduced total cost for producing hogs. However, producers would also have less pork to market due to the lighter marketing weights. Consumers, faced with lower pork quantities available, would bid up the price. Assuming that the price elasticity of demand for pork is about unitary, total revenue for hog producers would be unchanged to slightly higher than without the ban. However, any increased net revenue would serve as inducement for hog producers to increase capital investment, increasing future pork production. Hesitancy on the part of producers to expand, given further assumed Government involvement in the livestock sector, might reduce the expected increase in output over the years.

Table 8--Estimated effect of banning the subtherapeutic use of selected animal drugs on the quantity and cost of feed used in producing hogs

Item	Unit	Drugs banned		Drugs used
		High efficacy	Moderate efficacy	
Feed:				
Quantity	1,000 tons	1/21,563	24,682	25,344
Cost	1,000 dol.	2,479,757	2,838,373	2,914,537
Cost per pound of gain	Dol./lb.	.170	.168	.164

1/ Lower feed use results from lower total production.

Poultry Subsector

Poultry feeds have been supplemented with feed additives for about 25 years. These additives have been credited with reductions in morbidity and mortality and improvements in growth rates and feed use efficiency.

Penicillin, tetracyclines, and nitrofurans are the animal drugs most often added to poultry rations. Among the tetracyclines, chlortetracycline and oxytetracycline are the most commonly used. Among the nitrofurans, the most commonly used agent is furazolidone (NF-180).

This analysis estimates the impact of banning these additives in rations at subtherapeutic levels, including a ban on NF-180. Documentation of the frequency of use by species and stage of production is not available. Good data are not available on estimated rates of response in flock performance to the administration of specific additives.

For this study, estimates of frequency of use and response rates for the additives considered were obtained from a survey of poultry scientists, a review of literature with emphasis on recent issues of the Poultry Science Journal, and data compiled by a private research firm. These estimates of drug use frequency are summarized in table 9. Base performance data are from several sources, including the 1974-1975 (New England) Poultry Management and Business Analysis Manual, Turkey Production, (ARS Agriculture Handbook 393), and Selected Topics Related to the Poultry and Egg Industries, (ERS-664).

Table 9--Estimated percentage of various classes of poultry receiving drugs in feed at subtherapeutic levels

Class of poultry and age	Penicillin	Tetracyclines	Nitrofurans
		Percent	
Breeder chickens, 5 months and older	10	40	20
Broiler chickens, 0-8 weeks	20	40	30
Egg-type replacement chickens, 0-5 months	20	30	20
Table egg laying hens, 5 months and older	10	20	1/
Turkey breeders, 24 weeks and older	15	15	15
Turkey poults, 0-8 weeks	30	30	90
Growing turkeys, 8 weeks to market	10	20	20

1/ Illegal to use nitrofurans in feed of table egg laying hens.

Performance coefficients were calculated for turkeys, broilers, and layers for both a moderate and high level of drug efficacy. These performance coefficients were weighted by the proportions of birds using and not using the additives in the base year (1976). At each of the two response levels, output was calculated assuming 1976 basic breeder input levels were maintained.

Economic effect.--Assuming the high drug efficacy level and that the basic breeder input levels were maintained, egg output would decrease 2.3 percent if tetracyclines were removed. Broiler meat output would decrease 11.5 percent. A ban on nitrofurans would have the greatest impact on turkey output. With base input levels maintained and high drug efficacy, it would account for an 8.7-percent decrease in turkey output. A summary of the percentage changes in output for layers, broilers, and turkeys from banning selected animal drugs is shown in tables 10, 11, and 12. Data were not available on the effect of removal of additives on the incidence of bird morbidity and, thus, the quality of the final product. Impacts of other changes in final product also were not accounted for in the price calculations. For example, average body weight for broilers marketed would be less if these animal drugs were not used, and this could affect product values.

Changes in the cost of producing poultry resulting from a ban on feed additives are shown for each of two assumptions: (1) that breeder replacement rates would not be changed to maintain output, and (2) that replacement rates would be increased to maintain output at pre-ban levels.

Summaries of feed use, total production, and unit production costs under the various sets of assumptions are presented in tables 10, 11, and 12.

Data in table 10 show that at 1976 breeder replacement rates, a ban on nitrofurans at the moderate response rate would have been accompanied by an increase in total egg production of about 40 million eggs. The increase was accounted for by an increase in average rate of lay in the breeding flock. The increase would have been an additional production cost of 0.1 cent per dozen and increased feed use of about 40,000 tons due to decreased feed efficiency among breeders and replacement growout. Decreases in total feed use, egg output, and average costs were associated with the ban on nitrofurans, assuming the high efficacy. This is accounted for by higher mortality among the less feed-efficient pullets.

The largest impact estimated for egg production at 1976 breeder replacement rates was associated with a ban on tetracyclines, (high efficacy). The number of eggs produced decreased about 1.4 billion (2.4 percent), feed use increased by about 50,000 tons, and production cost increased 1.2 cents per dozen.

The estimated impacts on broiler output and production costs are shown in table 11. At 1976 breeder replacement rates, the estimated impacts on broiler output varied between an increase of about 20 million pounds for the nitrofuran ban (moderate efficacy) to a decrease as high as 1.03 billion pounds for the tetracycline ban (high response). Estimated feed use increased about 110,000 tons, and production costs increased 0.2 cent per pound with the nitrofuran ban (moderate response). Feed use decreased about 290,000 tons, but production costs increased 3.8 cents per pound of broiler with the tetracycline ban (high response). At 1976 output rates, estimated increases in feed use and costs were lowest at 80,000 tons and 0.2 cent per pound, respectively, under the nitrofuran ban (moderate response). They were highest under the tetracycline ban (high response) at 1.66 million tons and 3.3 cents per pound, respectively.

The estimated impacts on production of turkey meat were highest with the nitrofuran ban and lowest with the penicillin ban (table 12). With the nitrofuran ban (high response) at 1976 breeder replacement rates, estimated turkey production

Table 10--Egg production and costs: Estimated impacts of banning selected drugs, moderate and high efficacy

Item	Unit	1976 base	Ban on subtherapeutic levels				Ban on nitrofuran	
			Penicillin		Tetracycline			
			Moderate	High	Moderate	High	Moderate	High
			Assuming 1976 breeder replacement rates maintained					
Feed used 1/	Mil. tons	12.36	12.39	12.43	12.36	12.41	12.40	12.28
Percentage change	Pct.		.23	.60	.03	.40	.31	-.66
Eggs 2/	Bil.	59.71	59.36	59.09	58.97	58.31	59.75	59.51
Percentage change	Pct.		-.58	-1.03	-1.25	-2.35	.07	-.33
Production costs	Cents/doz.	44.2	44.60	44.90	44.80	45.40	44.30	44.10
Percentage change	Pct.		.90	1.58	1.32	2.76	.23	-.23
			Assuming 1976 egg output maintained					
Feed used 1/	Mil. tons	12.36	12.64	12.91	12.93	13.51	12.36	12.41
Percentage change	Pct.		2.30	4.47	4.66	9.31	.03	.40
Eggs 2/ 3/	Bil.	59.71	59.75	59.77	59.78	59.86	59.71	59.74
Production costs	Cents/doz.	44.2	45.30	46.30	46.40	48.70	44.20	44.50
Percentage change	Pct.		2.47	4.76	5.07	10.09	0	.60

1/ Excludes feed for broiler breeders.
2/ Includes broiler hatching eggs not used for hatching.
3/ Varies because of changes in numbers of breeders.

Table 11--Broiler production and costs: Estimated impacts on banning selected animal drugs, moderate and high efficacy

Item	Unit	1976 base	Ban on subtherapeutic levels				Ban on nitrofuran	
			Penicillin		Tetracycline			
			Moderate	High	Moderate	High	Moderate	High
			Assuming 1976 breeder replacement rates are maintained					
Feed used	Mil. tons	15.32	15.36	15.26	15.15	15.03	15.43	14.94
Percentage change	Pct.		.24	-.45	-1.10	-1.93	.68	-2.53
Broiler meat 1/	Bil. lbs.	8.97	8.78	8.63	8.40	7.94	8.99	8.46
Percentage change	Pct.		-2.12	-3.79	-6.35	-11.48	.21	-5.67
Production cost	Cents/lb.	34.20	35.10	35.50	36.20	38.00	34.40	35.50
Percentage change	Pct.		2.63	3.80	5.585	11.11	.58	3.80
			Assuming 1976 broiler meat output level maintained					
Feed used	Mil. tons	15.32	15.69	15.93	16.18	16.98	15.40	15.83
Percentage change	Pct.		2.41	3.96	5.58	10.81	.47	3.33
Production costs	Cents/lb.	34.20	35.00	35.40	35.90	37.50	34.40	35.30
Percentage change	Pct.		2.34	3.51	4.97	9.65	.58	3.22

1/ Poundage in ready-to-cook weight. Does not include breeder salvage.

Table 12--Turkey production and costs: Estimated impacts of banning selected animal drugs, moderate and high efficacy

Item	Unit	1976 base	Ban on subtherapeutic levels				Ban on nitrofuran	
			Penicillin		Tetracycline			
			Moderate	High	Moderate	High	Moderate	High
			Assuming 1976 breeder replacement rates are maintained					
Feed used	Mil. tons	4.15	4.14	4.11	4.13	4.12	4.14	3.94
Percentage change	Pct.		-.33	-1.01	-.43	-.74	-.28	-5.04
Turkey meat 1/	Bil. lbs.	1.96	1.93	1.90	1.90	1.87	1.92	1.79
Percentage change	Pct.		-1.37	-2.83	-2.80	-4.60	-1.87	-8.71
Production costs	Cents/lb.	47.2	47.70	48.20	48.40	49.20	48.00	49.70
Percentage change	Pct.		1.05	2.12	2.54	4.24	1.69	5.30
			Assuming 1976 turkey meat output level is maintained					
Feed used	Mil. tons	4.15	4.19	4.23	4.25	4.32	4.22	4.32
Percentage change	Pct.		1.10	1.97	2.52	4.13	1.62	4.19
Production costs	Cents/lb.	47.2	47.60	48.00	48.20	48.90	47.90	49.00
Percentage change	Pct.		.85	1.69	2.12	3.60	1.48	3.81

1/ Poundage in ready-to-cook weight.

decreased almost 200 million pounds. Most of the loss was accounted for by increased young poult mortality; thus, feed use also decreased over 200,000 tons. Production costs increased about 2.5 cents per pound. It was estimated that to maintain 1976 output rates with the same ban, about 170,000 additional tons of feed would have been used and costs would have increased 1.8 cents per pound of turkey.

Dairy Subsector

Subtherapeutic use of animal drugs as feed additives for milk-producing dairy cows is effectively precluded by sanitary regulations which bar the presence of any such substances in market milk. Detection technology has progressed rapidly, and dairy farmers generally cannot afford to risk losing their milk market due to drug residues in their milk. Thus, a ban on antibiotic feed additive would not impact directly on the aggregate milking herd, but only indirectly through its impact on the calf crop of replacement heifers.

This analysis is confined to the effects of a ban on the use of antibiotic feed additives in milk replacers fed to dairy calves. Milk replacers are milk substitutes that are fed to calves from 2 to 3 days of age to about 6 weeks of age. The major antibiotics that are used as additives to this type of feed are chlortetracycline and oxytetracycline.

Presently, antibiotics are included in almost all marketed replacers. Levels of antibiotics contained in milk replacers range from a low of 25 grams per ton to a high of 200 grams per ton. Milk replacers store easily and may be purchased at most feed stores. The supply of milk replacer does not depend on milk from cows just calving, sick, and/or treated.

The addition of subtherapeutic levels of antibiotics to milk replacers has been an accepted practice since the mid-1950's. Most of the research done during that period investigated rates of gain of calves with and without antibiotics. A general consensus has emerged that the subtherapeutic levels of antibiotics probably help reduce the incidence of scours. In some instances, these additives have probably become a substitute for good management. Since there is a widespread acknowledgment of the benefits of antibiotics used as low-level feed additives, there has been little tendency for Agricultural Experiment Stations or private research laboratories to conduct additional studies concerning their performance. Consequently, there exists little data comparing milk replacers with and without antibiotics using current technology.

A review of the existing literature on antibiotic additives in milk replacer reveals three key areas where performance was measured: growth rates, morbidity, and mortality.

Subtherapeutic levels of antibiotics in milk replacers enhance the growth rate of calves. Some feel this increased rate of gain in the first 4 to 6 weeks has little effect in the calf's size even in as short a time as 3 months. For a much longer time period, rates of gain in dairy replacements are of little importance to the animal's milk production over its herd life.

Studies comparing milk replacers with and without antibiotics have produced inconclusive evidence concerning scours reduction when antibiotics are used. Amid an apparent contradiction of experimental findings, most of the manufacturers and animal nutritionists contacted in the preparation of this study felt that the antibiotic additives had some positive effect in decreasing morbidity rates in calves.

Few studies reviewed dealt with calf mortality. Of the studies concerned with mortality rates, only one reported that mortality rates among calves fed antibiotics decreased significantly as opposed to calves not fed antibiotics. Again, most professionals contacted for this study felt that mortality rates were decreased with the inclusion of antibiotics in milk replacers, although none would attempt to quantify the relationship. The most likely impact assumes a 3-percent increase in mortality with 10 percent of the calves being shifted from milk replacers to milk.

Economic impact.--Numbers of calves fed milk replacers, rate of feeding, and quantities fed are shown in table 13. The estimated increased mortality following a ban on feed additives results in fewer calves fed. Milk replacer expenditures increase by $374,300, and antibiotic costs are reduced by $269,100 (table 14). The additional animals lost through increased mortality were valued at $34 per head. The additional losses associated with mortality were $1,611,600 for calves fed for 1 week (for veal) and $2,832,200 for animals fed for 6 weeks (for replacements). Calf morbidity was assumed to increase 5 percent for calves fed 1 week and 10 percent for calves fed 6 weeks. Antibiotics, at an average farmer-administered cost of $3 per calf, increased cost by $341,100 for animals fed 1 week and $782,700 for animals fed 6 weeks.

The removal of 10 percent of the calves from milk replacer and their shift to milk increased costs for calves fed 1 week by $674,800 and calves fed 6 weeks by $3,202,900.

Under the assumption of increased calf mortality, genetic culling possibilities are reduced. Since the genetic impact was estimated to reduce the average annual increase in milk production per cow by 2 pounds, costs would be expected to increase by $2,135,800 based on a 1976 milk price of $9.66 per cwt.

In total, the impact of such a ban is a cost increase of about $11.7 million per year. On a per-cow basis, that represents a cost increase of $1.06 per cow per year. On a cost per cwt of milk production, the increase is $0.01.

Sheep Subsector

Over 6 million lambs and sheep were slaughtered in the United States in 1977. Per capita consumption of lamb and mutton was 1.7 pounds. Although the sheep industry is declining, it continues to be an important source of income to farmers in many States. Ninety-three percent of the sheep slaughtered in 1976 were lambs. For the United States, 69 percent of the lambs are produced in feed lots. In the Mountain States, the lambs run with the ewes until about 6 months of age, when they are slaughtered without being placed in feedlots.

Subtherapeutic feeding of drugs in feed is confined primarily to lambs in feed lots and consists primarily of tetracyclines. Breeding ewes may receive some medication in feed lots, but the practice is not widespread. Also, some lambs on the range may receive tetracyclines if they are creep fed, but the percentage would be small. Virtually all lambs in feedlots receive tetracyclines in the feed. This analysis, then, is based on the impact on lambs from feedlots.

Economic impact.--The impact on sheep producers, consumers, and the industry was calculated for the moderate efficacy and for only 1 year, 1976. The calculated impacts on production, farm receipts, prices, and consumer expenditures are shown in table 15. The effect on the lamb and yearling industry would be relatively small; gross farm receipts would have declined about 1 percent from 1976 levels if subtherapeutic use of antibiotics had been banned. Gross consumer expenditures for lambs and mutton would have declined slightly (1.2 percent), but consumers would have paid almost a cent more per pound and there would have been 47,060 cwt less available.

Table 13--Average number of dairy calves fed milk replacer, feeding rate, and total amount fed after a ban on tetracyclines

Item	Unit	Female		Male	
		Veal	Replacement	Veal	Replacement
Calves fed 1/	Number	25,200	2,441,400	2,248,200	167,900
Milk replacer per calf	Pounds	5	40	5	40
Total milk replacer	1,000 pounds	126	97,656	11,241	6,716
	Tons		57,869.5		

1/ Calves for veal fed to 1 week, calves for replacement fed to 6 weeks.

Banning of the subtherapeutic use of antibiotics should not affect the feedlot industry significantly or the sheep industry in total. As with all the analyses, there could be unforeseen problems that would change the situation.

Summary of the Species-by-Species Ban

The major purpose of the species-by-species ban was to describe the animal drugs used, indicate the extent of their use, and to describe the initial effects on production from a ban on their subtherapeutic use. The initial shifts in supply described in this section were used to shock the cross-commodity model and determine the effects of an across-species ban--the major thrust of the study. Although some changes in cost components were calculated, changes in farm and consumer prices were not estimated for each species. This aspect of the research is left for the cross-commodity analysis.

Tetracyclines are the primary antibiotics used at subtherapeutic levels in beef cattle. They were fed to an estimated 60 percent of the 15 million cattle in feedlots in 1976 and, if banned, would have reduced production 180 million pounds carcass weight, or 0.4 percent, (moderate efficacy) and 361 million pounds carcass weight, or 0.8 percent (high efficacy).

Tetracyclines, nitrofurans, penicillin, and sulfa are used singly or in combination in hog production. The drugs are most important in the preweaning and pig starting stage; tetracyclines are the most important to production, followed by sulfa. Banning the subtherapeutic use of all these drugs would have reduced 1976 hog production by about 600 million pounds carcass weight, or 5 percent, (moderate efficacy) and 2,270 million pounds, or 18 percent (high efficacy).

Penicillin, tetracyclines, and nitrofurans are the animal drugs most often used in poultry rations. Banning tetracycline would most affect production of eggs, with a ban on all drugs reducing egg production about 85 million dozen, or 2 percent, (moderate efficacy) and 179 million dozen, or 4 percent (high efficacy). Banning tetracylines would reduce broiler output more than any of the other drugs. A total ban on all drugs would have reduced 1976 broiler output 800 million pounds, or 8 percent, (moderate efficacy) and 1.9 billion, or 21 percent (high efficacy). Banning all drugs in turkey production would have reduced 1976 output by 120 million pounds ready-to-cook weight, or 6 percent (moderate efficacy). Nitrofurans are fed to an estimated 80 percent of all turkeys from 0 to 8 weeks of age; banning nitrofurans would account for more than half the reduction from banning drugs.

Table 14--Changes in dairy calf feeding costs due to ban on subtherapeutic tetracycline use

Item	Unit	Base (1976)	With ban	Change from base year: Quantity	Change from base year: Value	Net cost change
Total milk replacer fed	Ton	58,626	57,870	-756	NA	
Total milk replacer cost 1/	Dol.	29,312,800	29,687,100	NA	374,300	374,300
Total antibiotic cost 2/	Dol.	272,600	0	NA	3/-269,100	-269,100
Mortality: 4/						
Calves for veal, fed for 1 week	No.	2,226,000	2,178,600	-47,400	NA	
	Dol.	75,684,000	74,072,400	NA	-1,611,600	1,611,600
Calves for replacement, fed for 6 weeks	No.	2,526,000	2,442,700	-83,300	NA	
	Dol.	85,884,000	83,051,800	NA	-2,832,200	2,832,200
Additional morbidity cost: 5/						
Calves for veal, fed for 1 week	No.	0	113,700	113,700	NA	
	Dol.	0	341,100	NA	341,100	341,100
Calves for replacement, fed for 6 weeks	No.	0	260,900	260,900	NA	
	Dol.	0	782,700	NA	782,700	782,700
Additional milk feeding cost: 6/						
Calves for veal, fed for 1 week	No.	0	417,700	417,700	NA	
	Cwt.	0	125,310	125,310	NA	
	Dol.	0	674,800	NA	674,800	674,800
Calves for replacement, fed for 6 weeks	No.	0	482,000	482,000	NA	
	Cwt.	0	843,500	843,500	NA	
	Dol.	0	3,202,900	NA	3,202,900	3,202,900
Additional genetic impact	Cwt.	0	221,100	221,100	NA	
Milk/cow effect 7/	Dol.	0	2,135,800		2,135,800	2,135,800
Total cost change due to ban	Do.	NA	NA	NA		11,686,300
Cost change per cow 8/	Do.	NA	NA	NA		1.06
Cost change per cwt.	Do.	NA	NA	NA		.01

NA=Not applicable. 1/ Assumes 10 percent of 1976 milk replacer production had high vegetable sources of fat and protein and low fat and protein content. The 1976 prices for milk replacers were estimated to average about $500 per ton. Elimination of the low quality 10 percent (at $375 per ton) raised the average price to $513 per ton. 2/ The antibiotic cost was estimated at $4.65 per ton based on 150 grams of antibiotic at 3.1 cents per gram. 3/ Cost based on tonnage of milk replacer fed after ban. 4/ Assumed U.S. average price of $34 per cwt. with calves averaging 100 pounds as basis for loss. Calves raised for replacement (6 weeks) valued at beef/cull prices rather than replacement price. 5/ Morbidity assumed to be 5 percent on calves fed 1 week for veal purposes and 10 percent on calves fed 6 weeks for replacements. The average cost for farmer-administered medicines was assumed to be $3 per calf. Calf numbers are average number fed. 6/ With the loss of antibiotics, it was assumed that 10 percent of the total calves would be shifted from milk replacer feeding to milk. Calves fed to 1 week were assumed to receive 30 pounds of milk and those to 6 weeks 175 pounds of milk. The milk was valued at the U.S. 1976 average price of $9.66 per cwt. However, these calves were formerly fed milk replacer. Calves fed to 1 week were assumed to receive 5 pounds and those to 6 weeks 40 pounds of milk replacer. This was valued at $513 per ton. The dollar value is the net change in cost associated with the shift from milk replacer to milk. 7/ It was estimated that the 3-percent additional loss in female replacements in which to cull for genetic milk production improvement would result in a reduction of 0.9 percent in the annual average increase in production per cow. The average increase in production per cow was 220 pounds per year, 1968-77. A 0.9-percent reduction would represent a loss of about 2 pounds per cow per year. The 1976 U.S. average milk price was $9.66 per cwt. 8/ The 1976 cow numbers were estimated to be 11,055,000, with 1,202,690,000 cwt. milk production.

Table 15--Estimated effects of withdrawing tetracyclines from use in lamb feedlots, moderate efficacy, annual rates, 1976

Item	Unit	Amount
Total lambs and yearlings slaughtered: 1/		
With antibiotics	Head	6,472,000
Without antibiotics 2/	do.	6,459,000
Difference	do.	-13,000
Total liveweight lambs and yearlings slaughtered: 3/		
With antibiotics	Cwt.	7,054,000
Without antibiotics	do.	6,937,000
Difference	do.	-117,000
Total retail weight of lambs and yearlings: 4/		
With antibiotics	Cwt.	2,837,260
Without antibiotics	do.	2,790,200
Difference	do.	-47,060
Annual average farm level price choice slaughter lambs:		
With antibiotics 5/	Dol/cwt.	47.74
Without antibiotics 6/	do.	48.08
Annual average retail price:		
With antibiotics 7/	do.	156.82
Without antibiotics 8/	do.	157.62
Gross farm value live animals:		
With antibiotics	Dol.	336,757,960
Without antibiotics	do.	335,530,960
Difference	do.	-3,227,000
Gross retail value (carcass weight basis):		
With antibiotics	do.	444,939,100
Without antibiotics	do.	439,791,300
Difference	do.	-5,147,800

1/ Assumes 93.6 percent of total sheep and lamb slaughter of 6,915,000 head as reported in Livestock and Meat Statistics, 1976, pp. 61 and 80. It is assumed that yearlings are an insignificant proportion of slaughter, and that feedlot lambs, which receive the antibiotics, amount to 4,452,000 head with the remainder going directly to slaughter of the ewe. 2/ The reductions in number without antibiotics assumes an increase in death loss from 2.75 percent to 3.025 percent. 3/ Slaughter weight with antibiotics is 109 pounds, without antibiotics it is 107.4 pounds, reflecting a reduction in gain per day from 0.43 pounds to 0.4085 pounds. Total reduction in liveweight reflects increased death loss as well as reduced gains. 4/ Assumes carcass weight at 0.476 of liveweight, and retail weight at 0.845 of carcass weight. 5/ Price as reported in Livestock and Meat Statistics, 1976, p. 142. 6/ Assumes a farm level price flexibility of 0.42 as estimated by Usman and Gee in Prices and Demand for Lamb in the U.S., Col. Sta. Univ. Exp. Sta. Tech. Bul. 132, 1977. 7/ Price as reported in Livestock and Meat Statistics, 1976, p. 142. 8/ Assumes a retail price flexibility of 0.30 (source as indicated in footnote 6).

Animal drugs are not used subtherapeutically in dairy herds, but tetracyclines are used in milk replacers fed to replacement calves. The cost increase in milk production from a ban on tetracyline is estimated to be $0.01 per cwt.

Subtherapeutic feeding of lambs is confined primarily to those in feedlots where virtually all received tetracyclines. Banning tetracylcines would decrease total liveweight by 12 million pounds and gross farm value by $3.2 million (1 percent). Gross consumer expenditures for lambs would have declined slightly for almost 5 million less pounds of lamb, with prices increasing about a cent per pound.

Across-Species Ban

The previous section dealt primarily with the most likely result of banning the use of feed additives by each subsector in isolation. The cross-subsector effects were ignored. In real situations the economic system would incorporate the effects of these sector interrelationships explicitly. For example, price increases for pork products would increase the consumer demand for beef, broilers, and turkeys and, in so doing, reduce the effect of the ban on the ultimate production of these products.

In order to capture the effects of these intersubsector relationships, ESCS commodity analysts relied heavily on the results from a computer model of the U.S. agricultural economy. This approach makes it possible to treat explicitly the many interdependent effects occurring simultaneously. Thus, the final results reported here represent a combination of econometric model simulations and analyst expertise.

The estimated percent changes in production from banning animal drugs (table 5) for fed beef, hogs, broilers, turkeys, and laying chicken were introduced as leftward shifts in the supply of each animal species. Changes in price and quantity in other subsectors, such as feed grains, are also considered and show the cross-commodity or intersubsector effects.

The results of the intersubsector analysis are shown as deviations from a base projection. The base itself projects what would be expected if the banning of additives were not introduced.

Price Deviations

Price deviations from the base are shown for 5 years after banning all drugs for both the moderate and high response (table 16). First-year deviations (moderate drug efficacy) show that broiler prices would increase about 13 percent (5 cents per pound), turkey prices 12 percent (3.4 cents per pound), barrow and gilt prices 5 percent ($2.32 per cwt), and fed-steer prices 4.3 percent ($1.68 per cwt). By the fifth period, all prices would be considerably closer to the base projections.

Price increases would be more severe if the animal drugs were banned and one assumes a high level of drug efficacy. Deviations in pork prices would more than triple (from moderate efficacy) to more than $7 per cwt and the deviation in fed beef prices would increase from $1.68 to over $6 per cwt.

The effects on prices from banning the specific additives vary. Banning of tetracyclines would have the greatest impact on prices of any additive because they are used in all animal species. Penicillin is used primarily in poultry feed and its ban would likely have considerable impact on turkey and egg prices. A ban on the use of sulfamethazine used only for hogs would have a slight effect on broiler prices, because of the cross effects between commodities. Turkey prices would be those most affected by withdrawing nitrofurans.

Table 16--Price deviations and percentage changes from base projections resulting from a ban on the subtherapeutic use of selected animal drugs, moderate and high efficacy 1/

Commodity	Units	Year 1	2	3	4	5
		Moderate Efficacy				
Hogs (barrows and gilts, liveweight price)	Dol./cwt.	2.32	1.62	1.11	.72	.54
Percentage change	Pct.	5.02	3.83	2.34	1.59	1.14
Broilers (wholesale price) 2/	Cents/lb.	5.03	2.75	1.77	1.46	1.34
Percentage change	Pct.	12.99	6.94	3.09	2.67	2.25
Turkeys (liveweight farm price)	Cents/lb.	3.39	1.90	1.32	1.19	1.19
Percentage change	Pct.	11.61	6.70	3.42	3.51	3.54
Fed beef (steer price, Omaha)	Dol./cwt.	1.68	1.33	1.06	.60	0
Percentage change	Pct.	4.30	3.30	2.00	1.00	0
		High Efficacy				
Hogs (barrows and gilts, liveweight price)	Dol./cwt.	7.45	5.49	3.80	2.37	1.67
Percentage change	Pct.	16.13	12.97	8.00	5.24	3.53
Broilers (wholesale price) 2/	Cents/lb.	13.80	7.91	5.15	4.08	3.60
Percentage change	Pct.	35.65	20.00	8.98	7.46	6.04
Turkeys (liveweight farm price)	Cents/lb.	7.49	4.66	3.43	2.98	2.98
Percentage change	Pct.	25.64	16.42	8.88	8.79	8.88
Fed beef (steer price, Omaha)	Dol./cwt.	6.02	4.55	2.65	1.20	.60
Percentage change	Pct.	15.34	11.27	5.03	2.00	.96

1/ Drugs considered banned were penicillin, tetracyclines, and sulfa at subtherapeutic levels and nitrofurans at all levels. 2/ Ready-to-cook weight.

Quantity Deviations

Percentage changes in the production of animal products from the base are shown for the moderate drug efficacy in figure 2. These data indicate the reductions in output that might be expected from withdrawing all animal drugs considered. With the exception of fed beef, which exceeded the base projections, production of all species recovered most of the loss from the initial shock. Actual quantity and percent deviations for both the moderate and high efficacy are shown in table 17.

Changes in production for each subsector are described in detail only for the moderate response to drugs. However, the pattern of the high response shown in the deviations in table 17 is much the same as the moderate response. The exception is production in the fifth period after the ban is much farther from the base projection than the moderate response, reflecting the greater increase in per unit cost associated with the higher response.

Poultry.--Broiler production would decrease initially, but the more than 5-cents-per-pound increase in broiler prices would provide an incentive to increase production during the second year. About half of the broiler production loss would be recovered in the second year. In normal years, the industry should be able to make this response; but if present conditions (August 1978) of relatively high prices and output prevailed, a shortage of hatching capacity could slow the first 2 years of recovery. By the third period, the broiler subsector would have recovered to a point where additional output would not be profitable. With no changes in technology, broiler production would not recover any closer to base projections.

Figure 2
Quantity deviations from base projections from banning all animal drugs at subtherapeutic levels for 5 years after ban, moderate efficacy

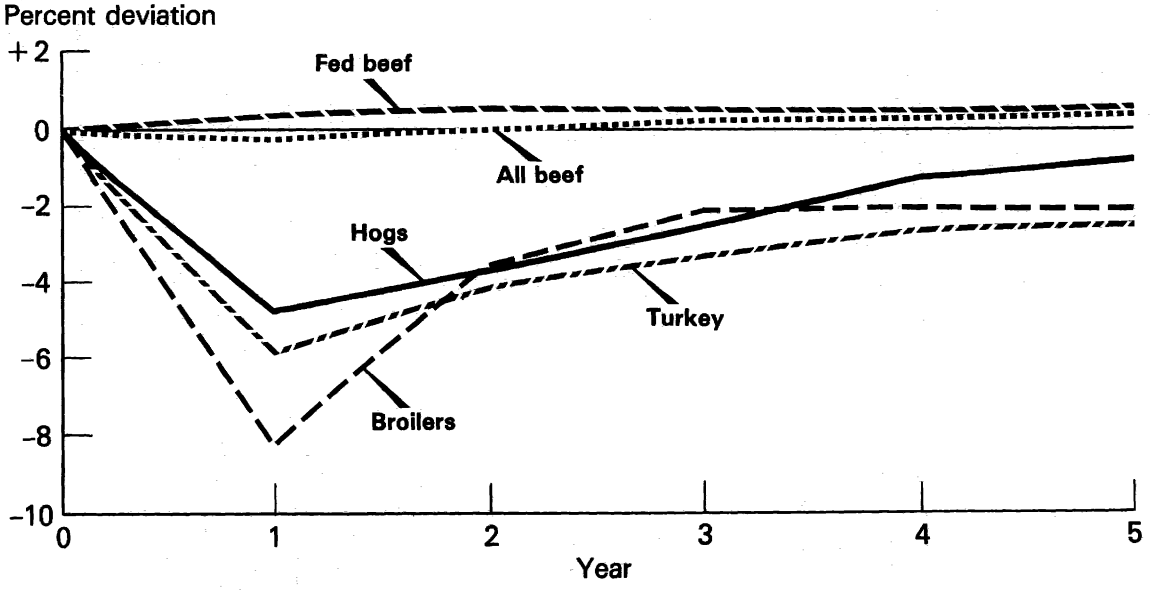


Table 17--Quantity deviations and percentage changes from base projections resulting from a ban on the subtherapeutic use of selected animal drugs, moderate and high efficacy 1/

Commodity	Units	Year 1	2	3	4	5
				Moderate Efficacy		
Hogs (barrows and gilts, carcass wt.)	Mil. lbs.	-598	-517	-370	-204	-125
Percentage change	Pct.	-4.86	-3.86	-2.68	-1.40	-.84
Broilers 2/	Mil. lbs.	-739	-330	-192	-191	-191
Percentage change	Pct.	-8.24	-3.61	-2.27	-2.15	-2.16
Turkeys 2/	Mil. lbs.	-127	-92	-73	-61	-61
Percentage change	Pct.	-5.98	-4.23	-3.54	-2.71	-2.62
Fed beef (carcass weight)	Mil. lbs.	63	106	88	81	104
Percentage change	Pct.	+.35	+.58	+.47	+.40	+.50
All beef (carcass weight)	Mil. lbs.	-50	-13	+25	+38	+83
Percentage change	Pct.	-.19	-.04	+.10	+.14	+.30
				High Efficacy		
Hogs (barrows and gilts, carcass wt.)	Mil. lbs.	-2,200	-1,900	-1,360	-750	-450
Percentage change	Pct.	-17.90	-14.17	-9.86	-5.15	-3.02
Broilers 2/	Mil. lbs.	-1,870	-837	-487	-485	-485
Percentage change	Pct.	-22.70	-9.10	-5.75	-5.46	-5.50
Turkeys 2/	Mil. lbs.	-312	-227	-180	-150	-150
Percentage change	Pct.	-14.70	-10.45	-8.74	-6.66	-6.44
Fed beef (carcass weight)	Mil. lbs.	209	309	228	190	256
Percentage change	Pct.	+1.17	+1.70	+1.21	+.93	+1.24
All beef (carcass weight)	Mil. lbs.	-73	+10	+66	+65	+155
Percentage change	Pct.	-.28	+.04	+.25	+.24	+.56

1/ Drugs considered banned were penicillin, tetracyclines, and sulfa at subtherapeutic levels and nitrofurans at all levels. 2/ Ready-to-cook weight.

Turkey production would move back toward the base, but at a slower rate than broilers, because there would not be as strong a profit incentive. The production cycle for turkeys is longer, and the potential loss per bird from disease would be much greater in turkeys than either broilers or layers.

Hog production.--Hog production during the first period following the antibiotic feed additives ban would deviate from the base projection by almost 5 percent (almost 600 million pounds, carcass weight) (moderate efficacy) as shown in figure 2. This reduction in hog output, in combination with the production changes for competing products, would cause the price of barrows and gilts to increase 5 percent, or $2.32 per cwt liveweights, (table 16). This price increase, plus the reduction in feed prices during the first period, would enhance producer net revenues considerably, providing incentive for producers to expand production in subsequent years.

Hog production during the second period would recover relatively little; output would still be about 500 million pounds (about 4 percent) below base projections. The reason for this rather slow recovery is that producers would be motivated to withhold gilts from the slaughter market in order to expand their breeding herds to increase future output. Feeding hogs to heavier market weights would be the only practical way that producers could respond during the second period to the economic incentive to expand production. Increases in the unit costs of gain for heavier hogs and market resistance to significantly heavier pork cuts would limit this output expansion.

The moderate rebound in production during the second period would reduce the hog price deviation from base projectives to $1.62 per cwt (4 percent). The economic incentive to expand output would remain, however, and with their larger breeding herds, producers would increase production to within 3 percent (370 million pounds) of baseline output during the third period.

The recovery in production would continue at a slower rate during the fourth and fifth periods, because of the declining price incentive, resulting in a return to within about 125 million pounds (0.8 percent of base projections by the end of the fifth period). The increase in production costs attributable to the loss of antibiotic feed additives would likely keep production slightly below the baseline output after the fifth.

Beef production.--Beef production would be affected relatively little by the ban on animal drugs, but beef prices would increase about 4 percent ($1.68 per cwt), because of reduced supplies and higher prices for pork, broilers, and turkeys. Fed-beef production would increase in the first year due to the increase in fed-steer prices and a decrease in the cost of feed. Nonfed-beef production would decline, which might indicate a slight shift from nonfed to fed-beef production. Production of all beef is essentially the base projection after the ban.

Effect on Feed Subsector

Price deviations from the base projections are shown for selected feed sources in table 18. Initially, prices for corn, soybeans, and soybean meal decline and then come back toward base and are only slightly below base projections by the fifth period. Initially, feed usage would decline by around 700,000 tons (moderate response). The initial decrease in feed use is the result primarily of the reduction in total animal numbers being produced, because of greater death loss and feeding to lighter weights. These decreases more than offset the increase in feed use resulting from poorer feed conversion. The poultry subsectors would about balance out in feed use with most of the initial decrease in feed coming from the hog subsector. After the ban, more feed would be needed per unit of output, and eventually the demand for feed would probably exceed the base projections due to the increased inefficiency in feed conversion.

Table 18--Price deviations and percentage changes of selected feeds from base projections for 5 years after banning all animal drugs, moderate and high efficacy

Item	Units	Year 1	2	3	4	5
		Moderate efficacy				
Corn, farm	Dol./bu.	-0.06	-0.02	-0.01	-0.01	-0.01
Percentage change	Pct.	-2.83	-.91	-.44	-.44	-.44
Soybean meal	Dol./ton	-7.00	-3.00	-3.00	-2.00	-1.00
Percentage change	Pct.	-4.00	-1.67	-1.62	-1.05	-.51
Soybeans, farm	Dol./bu.	-.13	-.07	-.50	-.04	-.03
Percentage change	Pct.	-2.20	-1.14	-.79	-.62	-.48
		High efficacy				
Corn, farm	Dol./bu.	-.18	-.05	-.03	-.02	-.02
Percentage change	Pct.	-8.49	-2.27	-1.33	-.89	-.88
Soybean meal	Dol./ton	-20.00	-10.00	-8.00	-6.00	-4.00
Percentage change	Pct.	-11.43	-5.56	-4.32	-3.16	-2.05
Soybeans, farm	Dol./bu.	-.40	-.20	-.16	-.12	-.08
Percentage change	Pct.	-6.77	-3.26	-2.54	-1.87	-1.27

Implications for Producers and Consumers

The material presented in the previous sections is rather specific with respect to both magnitude and direction for each of the major livestock species that would be affected by an animal drug ban. In this section, the results are generalized in order to summarize the likely effects such a ban would have on both producers and consumers of livestock products.

Implications for producers.--The analysis in this study treats each major livestock industry as one homogenous unit. As the demand for these products at the producer level is generally price inelastic, the initial reduction in supply generated increases in total revenue for producers.

Why then do producers use additives if total revenue increases from a ban? This is because the action of any individual producer has no material effect on either total production or market price. In such cases, each producer can be expected to use the available technologies (such as animal drugs) in an effort to minimize production costs and increase net revenues. When all producers adopt such cost-reducing and output-increasing technologies, any profit advantage gained by the early adopters is lost and all producers are in a position where none can afford to discontinue the practice on an individual basis.

The impacts on different types or sizes of production units is not addressed in this report, but likely are important in assessing the actual impacts from an animal drug ban. For example, a significant proportion of poultry production now comes from large units in somewhat concentrated production areas. Data from the 1974 Census of

Agriculture show that 70 percent of broilers in that year were from units with average output of almost 200,000 birds per year. About 45 percent of egg-producing hens and pullets were concentrated in units which averaged about 50,000 birds. Thirty-two percent of the birds were in units which averaged about 200,000 birds. About 60 percent of turkeys sold were from units selling an average of over 65,000 birds per year with over 40 percent of turkeys sold from units averaging over 200,000 birds per year. If feed additives are necessary for, or support, large-scale operations and if there are scale economies in poultry production, the costs associated with bans on additives indicated in this report may be understated.

Size of operation and production costs differ among commodity subsectors and geographic areas. These and other factors would cause unequal impacts to the subsectors in different geographic areas. The role of animal drugs in this industry may be significant even if the drugs are fed only as insurance. Without them, contractors and growers may be less willing to house large numbers of birds. Poultry, hog, and cattle producers may find it difficult to secure production capital. Additional studies of the role of feed additives in reducing risk are needed.

The uncertainty over what would happen to mortality rates in hogs and the increases in costs if feed additives are banned suggests there could be some major changes in methods of producing pork as well. For example, the smaller hog-producing units could be forced out of business if their costs were much higher than larger units. On the other hand, the relatively large increases in prices for hogs and poultry suggest new additives and new methods would be adopted to help the industry respond with increased output. Historically, these industries have responded to price increases.

Implications for consumers.--The results of this study indicate consumers would likely pay more for reduced quantities of pork, broilers, turkeys, and eggs in the short run. A summary of the changes in per capita production is given in table 19. The largest first-period reductions are in pork and broilers. By the fifth period per capita production would be down only 1.36 pounds (moderate efficacy) from base projections. Per capita production of beef would be up slightly by the fifth year after the ban. Longer run costs to consumer may be somewhat overstated, though, since producers would probably adopt new technologies to overcome problems caused by banning the animal drugs and, in so doing, respond with increased output even faster than this research shows.

The timing of any ban could be particularly crucial to consumer welfare. If, for example, a ban were imposed when red meat production was at a low point, the price increase could persist longer than indicated in the analysis. Per capita red meat production is expected to decline slightly through 1980. A ban prior to 1981 could, therefore, catch beef producers at a time when expanding output would be biologically difficult.

Effect on farm income and food prices.--In measuring the costs of this action, both the shortrun and the longrun impacts on various groups affected are of concern. To estimate this, two scenarios of likely changes were run to obtain estimates of the changes in farm income and in consumer prices. The results are summarized in tables 20 and 21 and show the different effects on producers and on consumers by the assumed efficacy levels.

In the shortrun, the first year following the action, total net farm income increases about $1.2 billion (4.7 percent). This results mainly from increases in livestock cash receipts, led by increases for broilers (8.4 percent) and cattle (3 percent). These more than offset the declines in crop cash receipts, mainly for soybeans (3 percent) and corn (3.4 percent), and increases in total farm expenses of 0.4 percent during each period. Moving into the second, third, fourth, and fifth

Table 19--Per capita production of livestock products: Estimated quantity and percentage change from base projections, resulting from a ban on the subtherapeutic use of animal drugs, moderate and high efficacy 1/

Commodity	Unit	Moderate		High	
		Year 1	Year 5	Year 1	Year 5
All beef (carcass wt.)	Lbs.	-0.23	+0.39	-0.34	+0.72
Percentage change	Pct.	-.21	+.36	-.31	+.67
Pork (carcass wt.)	Lbs.	-2.79	-.58	-10.25	-2.10
Percentage change	Pct.	-4.52	-.85	-16.59	-3.08
Broilers 2/	Lbs.	-3.44	-.89	-8.70	-2.26
Percentage change	Pct.	-7.26	-1.61	-18.37	-4.08
Turkeys 2/	Lbs.	-.59	-.28	-1.45	-.70
Percentage change	Pct.	-5.94	-2.50	-14.60	-6.26
Total net change	Lbs.	-7.05	-1.36	-20.74	-4.34
Percentage change	Pct.	-3.06	-.56	-9.01	-1.79

1/ Based on 1977 civilian population of 214.7 million.
2/ Ready-to-cook weight.

periods, however, most of the difference between the increase in cash receipts from livestock and the decrease in cash receipts from all crops disappears. By the fifth year, total cash receipts from marketings show essentially no change from the base. During this time, however, total farm expenses remain relatively constant, approximately 500 million dollars (0.5 percent) above the baseline forecast. This is mainly the result of increased death loss and reduced feed conversion. As a result, total net farm income through these periods gets steadily closer to the baseline. By the fifth year, total net farm income is approximately $500 million dollars (2.1 percent) below the baseline forecast.

For the consumer, the costs, as measured by the Consumer Price Index, are highest in the first year after the ban and decline in the longrun as consumers and producers adjust their behavior. In the first year, the CPI for food at home increased 1.2 percent above the baseline. Consumer prices for almost all livestock items are affected, with relatively larger price increases being shown for beef and veal (2.7 percent), pork (4.5 percent), and poultry (10.3 percent). By the fifth year, increases are still shown for pork (1 percent) and poultry prices (2.2 percent). However, because of the relatively small weight (less than 10 percent) that these items have in the consumers's food budget, the CPI for all food shows vitually no change from the baseline projection.

A summary of the changes in net farm income and the cost of the USDA food market basket is shown in table 22. Consumers would spend $32 more for the market basket items in the first year. By the fifth year, costs would be $5 more than the base estimate (moderate efficacy). Assuming high drug efficacy, the cost of the market basket would increase $99 in the first year and $16 in the fifth year following the ban. In no instance is the change in food costs greater than 5 percent (high efficacy, first year); by the fifth year, the percent increase is less than one percent.

Table 20--Percent deviation from base projections of selected farm income indicators resulting from a ban on the subtherapeutic use of animal drugs, moderate and high efficacy

Item	Year 1		Year 2		Year 3		Year 4		Year 5	
	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate	High
	Percent									
Cash receipts from livestock	2.9	6.7	2.0	5.2	1.5	3.1	.9	1.7	.5	1.3
Cattle	3.0	11.3	2.3	8.3	2.0	5.0	1.2	2.4	.4	1.8
Hogs	.2	-3.5	-.1	-2.6	0	-1.3	.2	.2	-.2	0
Broilers	8.4	19.1	5.9	18.3	5.5	12.2	3.9	8.9	2.9	6.2
Turkeys	2.1	1.6	1.0	1.6	.4	1.1	.4	.8	.5	1.1
Cash receipts from all crops	-1.4	-3.4	-1.1	-2.0	-.6	-1.1	-.6	-.9	-.4	-.7
Corn	-3.4	-8.9	-2.7	-3.8	-1.5	-2.4	-1.2	-1.6	-1.0	-1.5
Soybeans	-3.0	-7.2	-3.0	-5.1	-1.9	-3.7	-1.3	-2.6	-1.1	-1.9
Oil crops	-2.7	-6.7	-2.8	-4.8	-1.2	-3.4	-1.3	-2.4	-1.0	-1.8
Total receipts from marketings	.9	2.7	.5	1.9	.5	1.1	.3	.5	.1	.4
Total farm expenses	-.2	-.4	.3	.5	.4	1.0	.5	1.0	.5	1.2
Total net farm income	4.7	10.9	1.6	6.6	0	1.2	-1.2	-2.0	-2.1	-3.8

Table 21--Percent deviations from base projections of selected consumer price indexes, animal drug ban, moderate and high efficacy

Item	Year 1		Year 2		Year 3		Year 4		Year 5	
	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate	High
	Percent									
Beef and veal	2.7	10.4	2.2	7.7	1.4	3.4	0.7	1.4	0	0.7
Pork	4.5	14.7	3.5	11.8	2.1	7.3	1.4	4.8	1.0	3.2
All red meats	3.2	11.7	2.6	8.9	1.6	4.6	.9	2.4	.3	1.4
Poultry	10.3	27.6	5.7	15.9	2.6	7.4	2.4	6.5	2.2	5.6
Total, meat, poultry and fish	3.4	11.0	2.4	7.7	1.3	3.9	.9	2.3	.5	1.6
Total livestock and products	2.6	8.1	1.8	7.1	1.0	2.8	.6	1.6	.3	1.2
Food at home CPI	1.2	3.8	.9	2.7	.4	1.3	.3	.7	.2	.6
Total CPI	.2	.5	.1	.3	.1	.2	.04	.1	0	.04

Table 22--Summary of changes in net farm income and USDA food market basket from banning all subtherapeutic use of animal drugs

Item	Unit	Year 1	Year 5
Farm income:			
Moderate drug efficacy--			
Value change	Bil. dol.	+1.2	-.5
Percentage change	Pct.	+4.7	-2.1
High drug efficacy--			
Value change	Bil. dol.	+2.8	-.9
Percentage change	Pct.	+10.8	-3.8
Food market basket: 1/			
Base	Dol.	2,132	2,530
Moderate drug efficacy--			
Value change	Dol.	+32	+5
Percentage change	Pct.	+1.5	+.2
High drug efficacy--			
Value change	Dol.	+99	+16
Percentage change	Pct.	+4.6	+.7

1/ The market basket is the average quantities of domestic-farm-origin foods purchased annually in retail food stores per urban household.

RESEARCH NEEDS

In the process of evaluating the problems associated with animal drug use, reviewing research results, and conducting the analysis for this report, it became apparent that there are numerous voids in the knowledge base. These voids prevent a full assessment of alternatives to the problems associated with the safe use of drugs and chemicals in the production of food. Although an exhaustive review of the total research needs was not within the scope of this study, this section of the report is an attempt to list some of the more important research needs. Suggestions for research are made for antibacterials in general as well as for specific compounds such as sulfonamides and nitrofurans. In addition, some research suggestions for specific diseases are made along with some for economic analysis. It should be noted that some of the research could be undertaken by either the private or public sector.

Subtherapeutic Use of Antibacterials 56/

Antibacterials

USDA scientists have worked jointly with other scientists and professional organizations in developing a list of research needs in this area. The following are areas of research with regard to the subtherapeutic use of antibacterials in animal feeds.

56/ These research needs were submitted to the Food and Drug Administration as part of the USDA response to proposed rulemaking: "Tetracyclines in Animal Feeds and Tetracycline Containing Premixes," (Docket No. 77N-0316), Federal Register, vol. 42, no. 204, October 21, 1977, pp. 56264-56289.

(1) Establish a baseline in humans of the incidence and distribution of bacteria resistant to commonly used antibacterial drugs; by systematic monitoring and controlled research, determine factors influencing any change in the reservoir of resistance.

(2) Determine whether occupational exposure to meat or animals, as in packinghouse workers and livestock producers, results in increased antibacterial resistance in enteric flora and/or health problems associated with bacterial infections refractory to antibiotic therapy.

(3) Determine conditions under which bacteria are transferred from animals to man and factors influencing their colonization in man. A study of the sequence of events in maintaining such populations and the ability of newly colonized bacteria to transfer resistance should be included.

(4) Establish a better understanding of the nature and significance of bacterial resistance to antibacterial agents. Determine if there are unrecognized concomitant mechanisms operative which equilibrate the bacterial ecosystem to prevent the evolution of entire bacterial populations (nonresponsive) to the antibiotics and which prevent the evolution of dangerous numbers of resistant pathogens.

(5) Determine the basic aspects of mode of action of different types of antibacterial agents in promoting increased growth and improved feed efficiency in animals.

(6) Over a period of time, determine what selective advantage or disadvantage resistant bacteria have in the absence of further antibacterial pressure and the nature of any change in type of resistance.

(7) Following different regimens of low-level antibacterial feeding to animals, establish more accurate measures of any compromise in therapy from such use.

(8) Conduct studies in intensive production systems to establish reliable measures of the disease prevention and control afforded by low-level feeding of antibacterial agents.

(9) Determine the total economic impact on feed use of the antibacterials using controlled field studies extending over several generations of production.

(10) From the standpoint of meat production, safety, and wholesomeness, determine the relative occurrence of abscesses or recognizable disease in slaughter animals from herds utilizing feeds with and without antibacterials.

(11) Carry out epidemiological studies to determine whether exposure to consumption of meat from animals fed antibiotics according to approved methods results in a significant source of transferrable antibacterial resistance in humans. Examine health and antibacterial efficacy in humans having varying exposure to meat in the diet.

(12) Compare the relative efficacy of currently available feed antibacterials in carefully controlled tests. These comparisons should include measurements of weight gain, feed efficiency, and disease control. The results would relate to the economic impacts of restrictions of certain antibacterials and their replacement in animal agriculture.

(13) Investigate extent of bacterial cross-resistance as influenced by antibacterial agents used in animals and/or man.

(14) Examine relationship between resistance in human enteric flora and antibacterial resistance in important non-enteric human pathogens such as Neisseria gonorrhea and Haemophillis influenzae.

(15) Attempt to determine whether restricted use of feed antibacterials in other countries has resulted in improved effectiveness of antibiotic therapy in humans or animals.

(16) Determine whether chronic oral exposure to antibacterials in humans compromises their health or the successful treatment of disease.

(17) Determine by field surveys or controlled tests whether various feed antibacterials affect the epidemiology of salmonella in meat animals, and determine whether a change in the use of animal feeds would influence the threat of Salmonellosis in animals or humans.

Sulfonamides

Continued high violative rates of sulfamethazine residue in the tissue of slaughtered hogs has produced considerable controversy about the possible cause or causes. Many producers have been notified of their hogs having sulfa residues, although the animal drug was not knowingly used in the rearing of the same hogs. As a result of this problem, USDA initiated a research and education program earlier this year to find the cause or causes and increase producer awareness of procedures to prevent occurrence of the problem.

There was agreement that the following 10 research projects should be considered.

(1) Determine the influence of coprophogy (feces and urine recycling) and management practices on sulfa residues in edible pork tissue.

(2) Reexamine current methods and/or develop new methods that can be used to detect sulfa residues in feed and (including metabolites) animal tissue.

(3) Identify feed manufacturing practices that may result in contamination of feed with sulfonamides.

(4) Determine the effect of level of sulfonamides in feed and water for swine upon tissue residue levels for a time sequence following such administration.

(5) Study the metabolism of sulfonamides and their metabolities, effect of dose, sex, nutrition, and physiological state on accumulation, and rate of elimination from the tissue and digestive system of the animal.

(6) Identify farm feed mixing, swine feeding, and management practices which may result in inadvertent sulfa residues.

(7) Determine the relative effectiveness and resulting tissue residues from the use of alternative sulfonamides.

(8) Develop a simple, inexpensive, reliable, and sensitive blood assay method for predicting sulfa residues in animal tissues.

(9) Conduct long-term, finite toxicology studies of 2 to 3 years duration using two animal species to determine whether the current tolerance level of 0.1 ppm of sulfa residue could be increased and still provide an adequate safety margin for humans.

(10) Conduct carefully controlled toxicology studies for each sulfonamide used in animal feeds to determine the conditions under which toxicity to low-level sulfa ingestion by humans may occur.

(Of these research projects, the first five have been initiated. Projects 9 and 10 are needed to determine whether relaxation of the current tolerance level could be justified.)

(11) Develop an identification system for swine that is simple to apply and inexpensive to use for the purpose of being able to trace ownership from point of production to time of slaughter.

(12) Establish the precise human toxicology of each sulfa drug used in livestock feed (particularly sulfamethazine). Minimum allowable residues in meat products are now based upon indirect evidence derived by interpretation from research on other species and with different forms of sulfa.

(13) Determine the species-specific nature of effects from sulfa drugs. For example, why does the same level of a sulfa drug which causes thyroid hypertrophy and hyperplasia in rats and dogs have no effect on thyroid tissue in the monkey.

Nitrofurans

Furazolidone (NF-180) is considered to be one of the most important animal drugs by the turkey industry. Consequently, revocation of its approval for use in disease prevention and treatment could prove disadvantageous to the turkey industry and to consumers of turkey products. There are several areas of suggested research.

(1) Develop a reasonable and inexpensive method to detect the nitrofuran residue and its metabolites.

(2) Determine whether the metabolites in animal tissue are toxic to consumers of those animal products.

(3) Develop an animal drug that is a close substitute and inexpensive to use.

Disease Research

Cancer

The effort to find causes and cures for cancer is strongly encouraged. However, a means of isolating causes or changes in causes and successes in treatment requires that a nationwide reporting system be operated on a continuing basis. Therefore, research is recommended to develop a nationwide system to report incidences of cancer along with other pertinent patient data to use in assessing trends in the several types of cancer, possible causes and changes in causes, and the effectiveness of various methods to prevent or treat the disease.

Salmonella

Salmonella contamination of meat and poultry feed and product supply has been a problem for decades. Although numerous attempts have been made to eliminate the problem, salmonella infections continue to occur frequently. With the recognition that the use of antibiotics can result in the development of antibiotic resistant

strains of salmonella and that these strains might prove to be a health hazard, efforts to reduce the incidence of or prevent Salmonellosis have become more urgent.

A USDA advisory committee on salmonella was authorized in November 1975 (Secretary memorandum no. 1866). The research recommendations of that committee are discussed below. 57/

(1) Research should be implemented to identify the specific parameters of time, temperature, moisture, and pressure necessary in animal feed pelleting and extruding operations to reduce salmonella contamination to nondetectable levels.

(2) Identify antibacterial agents for salmonella that can be used in feed and feed ingredients. Special emphasis should be given to the use of formaldehyde.

(3) Research should be directed toward developing a rapid test to identify the presence of salmonella in feed and feed ingredients. Research should be concentrated on finding a test that will significantly reduce the time for pre-enrichment and enrichment techniques.

(4) Studies should be made to determine the effect of stress factors on animal physiology and to determine how these stress factors can be minimized by either changes in handling practices or conditioning of the animal.

(5) Additional research on the use of chlorine in reducing salmonella contamination of poultry and red meat carcasses should be undertaken. The work should be designed to obtain optimum parameters of chlorine level, volume of wash water, pH and type of acidulent, temperature of wash water and carcass, application pressure, and synergism between chlorine and other halogens, such as bromine.

(6) Other methods of pasteurization, such as heat and irradiation, should be considered as a means of reducing salmonella and other microbial contamination on animal carcasses, raw meat, and poultry.

(7) USDA should establish a team of epidemiologists to investigate human outbreaks of Salmonellosis attributed to consumption of livestock and poultry products.

(8) A study should be made to determine the relationship between proposed sampling plans (and this microbiological criteria for meats) and prevention of food borne illnesses.

(9) Federal funds should be made available for both intramural and extramural research, field trials, and developmental studies (including the current incidence of herd and flock infection and the feasibility of producing salmonella-clean flocks and herds through application of the best practical control methods by the livestock and poultry industry) on salmonella control in live animals and poultry.

57 / Recommendations for Reduction and Control of Salmonellosis, Report of the U.S. Advisory Committee on Salmonella, USDA/FSQS, January 1978.

Economic Research

Until quite recently, proposals to approve or withdraw use of chemicals and drugs in food production and processing largely ignored the economic effects. Interest groups and society in general are concerned about the economic tradeoffs involved between reductions in health risks and the added costs implied by discontinuing the use of drugs and chemicals in food production and processing. Of equal importance are technological advancements in the form of cost reducing uses for new or existing chemicals and drugs in agriculture and food processing.

If economic considerations should become more important as a criterion for approving or disapproving the use of particular chemicals and drugs covered under the Food, Drug and Cosmetic Act, as amended, and other statutes, then the below research should be undertaken.

(1) Determine use patterns in terms of quality and purpose or function for the animal drugs.

(2) Make periodic economic assessments of animal and animal product losses from outbreaks of disease.

(3) Develop improved analytical models to evaluate the impacts of the uses of animal drugs upon production efficiency, costs, and output; upon consumer prices, expenditures, and consumption; and upon the nature and extent of production adjustments.

(4) Develop a benefit-risk model to assess the potential impacts of regulatory proposals affecting the use of animal drugs.

(5) Make an economic assessment of the impacts on animal disease incidence, animal production costs, the supply and price of affected animal products, the pool of antibiotic resistant organisms, and efficaciousness of the restricted antibiotics in treating human illnesses from implementation of the recommendation of the Swann report in Great Britain.

(6) Determine the economic impact upon the drug manufacturing industry of proposals to reduce the use of antibacterials and other compounds in food production. The study should focus on the following impacts: (a) industry structure, (b) price changes to cover higher unit costs on both human and animal drugs, (c) increased capital needs for new drug development, and (d) costs for regulatory compliance to obtain Government approval to sell new drugs.

(7) Determine the economic benefits from use of animal drugs singly or in combination at low levels in feed or water under commercial farm size conditions.