# The Routine Use of Antibiotics to Promote Animal Growth Does Little to Benefit Protein Undernutrition in the Developing World

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**Some persons argue that the routine addition of antibiotics to animal feed will help alleviate protein undernutrition in developing countries by increasing meat production. In contrast, we estimate that, if all routine antibiotic use in animal feed were ceased, there would be negligible effects in these countries. Poultry and pork production are unlikely to decrease by more than 2%. Average daily protein supply would decrease by no more than 0.1 g per person (or 0.2% of total protein intake). Eliminating the routine use of in-feed antibiotics will improve human and animal health, by reducing the development and spread of antibiotic-resistant bacteria.**

Protein and energy undernutrition in many developing countries remains an enormous problem [1, 2]. The increased production and consumption of animal products (meats and milk) have been seen as a solution for protein undernutrition, because meat has much higher protein content than do vegetal (i.e., plant-derived) products. Many governments have adopted policies to promote "industrialized meat" production [3, 4] (i.e., meat from animals raised in intensive production systems using prescribed feed intakes). Until recently, nearly all large-scale and intensive meat production in developed countries involved continuous administration of in-feed antibiotics because of purported growth promotion and "disease prevention" effects in animals fed continuous antibiotics. This practice was largely accepted unquestioningly in developing countries, despite the long-standing controversy surrounding it in developed countries [5–8]. Critics of the routine use of antibiotic additives in industrialized meat production have pointed mainly to the risk of spread of antibiotic-resistant bacteria to people via the food chain and wastewater [5, 7, 8]. In opposition to this position, others have argued that continuous use of in-feed antibiotics is essential for the economic viability of industrialized meat production and that, in turn, industrialized meat production is necessary to solve protein undernutrition in developing countries. There have even been suggestions that starvation would result without this antibiotic use [9, 10].

This article examines the evidence for claims that routine in-feed use of antibiotics increases the production of meat for human consumption in developing countries. We have done this by estimating the potential loss of protein production likely to occur if the in-feed use of antibiotics for growth promotion in industrialized meat production was eliminated. We also discuss some of the hazards of routine antibiotic use. Finally, we examine whether increased industrialized meat production can successfully solve protein undernutrition.

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## THE USE OF LARGE QUANTITIES OF ANTIBIOTICS AS GROWTH PROMOTERS IN ANIMALS IS A PUBLIC HEALTH HAZARD

The prolonged used of antibiotics, whether in humans or animals, creates evolutionary pressure for the development of antibiotic resistance [11]. In general, this pressure is proportional to the quantity of antibiotics used, although the class of antibiotic and the ways in which they are used are also im-

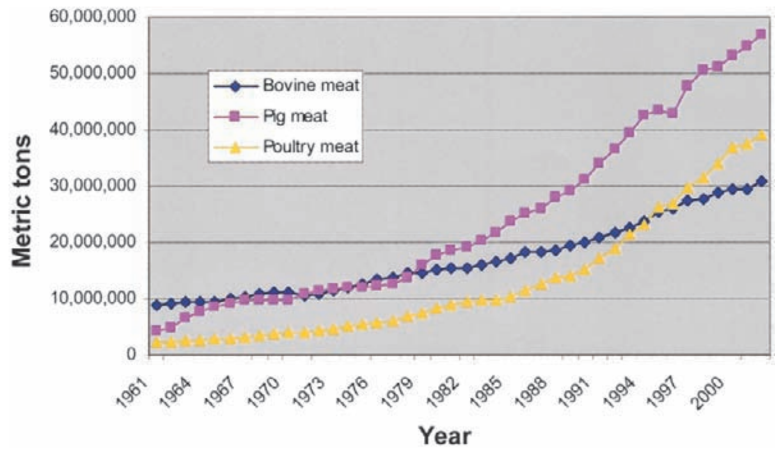


**Figure 1.** Meat production per year in developing countries (from [18])

portant. The limited data available show that very large amounts of antibiotics are used in agriculture in nearly every country, mostly as feed additives to promote animal growth in intensive, industrial ("landless") farms. In Australia (1992–1997), Denmark (1995) and the United States (late 1990s), more than two-thirds of all antibiotic use involved food animals [7, 12–14]. However, in some developed countries, the situation is changing. In 1999, the European Union banned the use of many antibiotics for growth-promotion purposes, and use of the remaining agents is to be phased out by 2006 [15]. The McDonald's Corporation [16] has recently introduced a policy similar to that of the European Union for its meat suppliers that is likely to have a global impact. It is in developing countries, however, where the largest increases in industrialized meat production (especially poultry production) are occurring, where it is harder to successfully regulate the use of antibiotics, and where "critically important" human antibiotics (such as fluoroquinolones) are used in large quantities for nontherapeutic uses in healthy animals.

Antibiotic-resistant bacteria carried by animals can enter the human food chain through the consumption of meat or other animal products, through farm runoff water, and by other pathways. Meats frequently became contaminated with antibiotic-resistant bacteria, particularly during the process of slaughtering. There are many human health problems that result from the spread of antibiotic-resistant bacteria acquired from animals [17]. Antibiotic exposure in animals also promotes the amplification of resistance genes that, once transmitted to humans, can then be transmitted within humans to more pathogenic bacteria.

Poultry, cattle, and pork are the main livestock in which continuous in-feed antibiotics are used (for purported growth promotion and disease prevention). Antibiotics are also used extensively in aquaculture, but very limited data are currently available on the extent and consequences of this practice (for this reason, aquaculture is not further discussed in this article). Most cattle and sheep in developing countries are raised on grasslands and do not receive antibiotics as in-feed additives (compared with an increasing proportion of cattle raised in feed lots in developed countries). Therefore, this article focuses on poultry and pork production, to evaluate the potential value of continuous in-feed use of antibiotics in developing countries as growth promoters. Pig and chicken meats have had the largest increases in both meat production and consumption in the past 50 years in developing countries (figure 1) [18].

## DO ANTIBIOTICS FUNCTION AS EFFECTIVE GROWTH PROMOTERS?

It is commonly assumed that significant weight gains in animals result from the in-feed use of antibiotics, especially in developing countries. However, it remains unclear how much of an increase, if any, in meat production results from routine use of in-feed additives in industrialized meat production. There are no double-blind, placebo-controlled studies of the continuous use of in-feed antibiotics for growth promotion. The limited comparative studies of in-feed antibiotic use from developed countries that are available have shown remarkably few benefits [19–21]. Even data supplied by pharmaceutical companies for their own products show very modest weight gain benefits (~2% or less for virginiamycin) [12, 22]. Consistent with this general impression of modest effect, the data presented by pharmaceutical companies for their competitors' products show even poorer performance for weight gain, compared with control animals (e.g., 0.4% for avoparcin) [22].

Danish poultry growers voluntarily ceased all routine in-feed antibiotic use in February 1998 in response to concern over the risk to public health. Chicken production has not suffered economically as a result. Meat production and chicken weights have been maintained, as has the output of chicken meat per square meter of pen size [21, 23]. In this nationwide intervention in Denmark, the only economic parameter that decreased after cessation of antibiotic use was that feed intake increased, as indicated by a 1% increase in Feed Conversion Efficiency (FCE). However, the savings from not purchasing antibiotic additives substantially offset this small increase in feed cost.

Furthermore, routine in-feed antibiotic use does not decrease mortality among food animals in developed countries. In studies reported by Pfizer, neither virginiamycin use nor avoparcin use reduced mortality among meat chickens (the mortality rate was 3.9% for control animals and 4.8% for broilers that received virginiamycin) [12]. In Denmark, no increase in mortality was observed after the cessation of in-feed antibiotic use in poultry [21, 23]. Similarly, in a study involving close to 7 million chickens in the United States, no statistically significant effects were seen on mortality (or weight gain) after the routine use of in-feed antibiotics in poultry was stopped [19].

Data from developing countries are far more limited. Because animals may be under greater stress (for such reasons as poorer food quality or greater ambient temperature), it is often assumed that benefits will be commensurately larger. However, the limited data available question this assumption. Unpublished studies by poultry producers in Brazil that involved >5 million chickens were submitted in response to a "call for data" before the World Health Organization (WHO) meeting on antibiotic use in food animals in Oslo, Norway, in 2001 [24]. These data showed that the weight gains associated with antibiotic use are variable, and the change in weight is, at most, only ~2%. One small study from India attributed a 9% weight gain to antibiotic use [25]. However, in this study, the final weight of the chickens after 6 weeks of antibiotic use (1141 g) was only approximately one-half of the weight of chickens reared without continuous antibiotic administration in developed countries (e.g., Denmark) or in Brazil.

## THE GLOBAL PRODUCTION AND DISTRIBUTION OF CALORIES AND PROTEIN

In the developing world, calorie and protein consumption has increased markedly in the past 30 years. In most countries, foods available for consumption now exceed the recommended minimum daily intake for an individual [3, 4]. However, despite this seeming abundance, protein-energy undernutrition remains seemingly intractable in many developing countries, especially in sub-Saharan Africa and parts of South Asia [1, 2].

It has long been noted by writers who comment about famine, hunger, and undernutrition that food insecurity is more likely to be caused by the maldistribution of food and food "entitlement" (e.g., income) than deficiencies in the total food supply [26]. Globally, the present is a time of ample total food supply, yet the distribution of consumption of different kinds of food remains markedly unequal and appears to be becoming more unequal [27–29]. Urban populations are consistently more affluent and better fed than are rural populations.

The maldistribution of the food that is grown and produced harms the overnourished as well as those who remain undernourished. Obesity, well recognized to increase the risk of diabetes, cardiovascular disease, and some forms of cancer, is increasing in many developing countries and may even lead to a decline in life expectancy in some developed countries [3, 4, 29].

There is increasing recognition that excessive quantities of animal-derived foods may be suboptimal for a healthy diet. These concerns also relate to the composition of saturated fats and dietary cholesterol, abundant in many fatty products of animal origin. Indeed, the WHO has cautioned authorities in developing countries against the blind imitation of agricultural and farming techniques from developed countries that are based on nutritional knowledge that is becoming outmoded [3, 4].

## THE POOR RARELY—IF EVER—EAT MEAT PRODUCED WITH CONTINUOUS IN-FEED ANTIBIOTICS

The majority of the world's poor live in rural areas. These areas are usually characterized by poor infrastructure, limited food distribution networks, and minimal means of refrigeration. Together, these factors restrict the distribution and sale of industrialized meats. More importantly, the poor generally lack the financial means (the "entitlement") [26] to purchase meat, even if it were available or culturally permitted (e.g., to vegetarians). The poor prefer cereals as the staple energy source because of its far lower cost per calorie (it is ~15% less expensive, compared with the cost per calorie for meat). On a population level, significant quantities of meat are not consumed until the majority of people have already passed a minimum intake of protein and calories through the consumption of cereal and other vegetal products. Most of the limited quantity of chicken and pork that the poor do consume in rural areas are grown locally with animals that rely on scavenging and thus would not receive routine in-feed antibiotics.

Most industrialized meats consumed in developing countries are sold and eaten in or near cities and are increasingly consumed by a population whose major nutritional problem is obesity. Therefore, even if the continuous in-feed use of antibiotics in these countries were discontinued and were to cause an (unlikely) fall in production of 10%, undernutrition in any segment of the population is unlikely to result.

**Table 1. Sources of dietary protein intake in "all developing countries," 2002.**

| Protein source | Consumption, capita/day | | |
|---|---|---|---|
| | No. of calories | Fat, g | Protein, g |
| Butter/ghee | 19.3 | 2.2 | 0 |
| Whole milk | 58.3 | 3.4 | 2.9 |
| Bovine meat | 29.5 | 2.1 | 2.5 |
| Fish/seafood | 23.2 | 0.7 | 3.8 |
| Freshwater fish | 9.8 | 0.4 | 1.5 |
| Pig meat | 109.4 | 10.5 | 3.5 |
| Poultry meat | 33.1 | 2.4 | 2.6 |
| Poultry and pig meat combined | 142.5 | 12.9 | 6.1 |
| All meats | 184.1 | 15.8 | 9.6 |
| Vegetal products | 2307.6 | 47.4 | 38 |
| 10% of poultry and pig meat produced | 14.3 | 1.3 | 0.6 |
| Total[a] | 2666 | 65.2 | 68.5 |
| Total if 10% of pork and poultry is removed[a] | 2651.70 | 63.9 | 67.9 |

**NOTE.** From [18].

[a] Total is for all dietary sources of protein, including minor sources that are not listed.

## THE USE OF IN-FEED ANTIBIOTICS MAY HARM THE POOR IN DEVELOPING COUNTRIES

The increase in the total production of meat may harm the poor in other ways. The economies of scale permitted by large-scale industrial meat production (often in tandem with government subsidies, many of which may be hidden) leads to market distortion. Roads and other subsidized infrastructure can sometimes allow the long-distance transportation of animals produced by the industrialized sector to central markets. Thus, as supply increases, prices will usually fall. These lower prices allow increased meat consumption by many middle-class consumers, yet they depress the price received for animals grown for sale by the poor.

## HIGHER PRICES FOR CEREALS

In recent years, the worldwide production of cereals (and soy) has decreased on a per capita basis [27]. At the same time, increasing amounts of these crops are being used as animal feed. The available "supply" of grain and soy for human consumption is thus likely to be relatively smaller, and this is a plausible cofactor for the increased maldistribution of energy intake observed since 1990 [28]. These competing demands will also have an influence on price.

## LITTLE EXTRA EMPLOYMENT

Increased employment in the industrialized meat sector is unlikely to significantly reduce poverty levels. Although some individuals will find jobs in this sector, overall rates of employment in the farm sector are decreasing (including in many developing countries) as that sector becomes increasingly capital and energy intensive [27].

## THE CONTRIBUTION OF INDUSTRIALIZED MEATS TO IMPROVED NUTRITION IN DEVELOPING COUNTIES IS NEGLIGIBLE

Poultry and pork are the main industrialized meats produced in developing countries. We used Food and Agriculture Organization of the United Nations statistical databases data to evaluate the contribution of each of these meats to national nutrition (table 1) [18]. These data have been used to model the effect of removing antibiotics as growth promoters in developing countries. We have assumed (optimistically) that 10% of all poultry and pork produced can be attributed to the growth promotion effects of antibiotics in animal feed, consistent with the highest figure claimed by proponents of this practice. However, other evidence we have presented suggests that $\leq$2% is a more realistic estimate; this latter figure has also been modelled.

Because most protein available in developing countries is of vegetal origin, a decrease in the fraction of the industrialized production of pork and poultry by 10% represents only a trivial decline of 0.6 g/day in total daily protein supply (table 1). This represents a mere 0.9% reduction in the average available total daily protein intake of 68.5 g/day. Fat intake would also fall but by a larger amount (1.3 g/day, or 2%). Furthermore, there is no developing country where even a loss as high as 10% in industrialized meat production shifts the protein intake to less than levels that are deleterious to a population's nutrition (table 2). The largest effects were seen

**Table 2. Changes in availability of dietary protein in selected developing countries if continuous in-feed antibiotics were not used in pork and poultry production, 2002**

| Region | Protein intake by source, g/day | | | Change with 2% less pig and poultry production | | Total protein intake with 10% less pig and poultry production, g/day[a] | Difference in total protein intake if 2% of pig and poultry intake is removed, % |
|---|---|---|---|---|---|---|---|
| | Total[a] | Poultry | Pig meat | Total dietary protein loss, g/day | Total protein intake, g/day[a] | | |
| Africa | | | | | | | |
| Angola | 44.8 | 2.2 | 1 | 0.1 | 44.7 | 44.5 | 0.1 |
| Chad | 64.7 | 0.2 | 0 | 0 | 64.7 | 64.7 | 0.0 |
| Congo | 24.7 | 0.2 | 0.2 | 0 | 24.7 | 24.7 | 0.0 |
| Egypt | 95.4 | 3.2 | 0 | 0.1 | 95.3 | 95.1 | 0.1 |
| Eritrea | 45.3 | 0.2 | 0 | 0 | 45.3 | 45.3 | 0.0 |
| Liberia | 30.8 | 1.1 | 0.5 | 0 | 30.8 | 30.6 | 0.1 |
| Mozambique | 39.5 | 0.9 | 0.2 | 0 | 39.5 | 39.4 | 0.1 |
| Rwanda | 48.5 | 0.1 | 0.1 | 0 | 48.4 | 48.5 | 0.1 |
| Zimbabwe | 42.9 | 0.9 | 0.6 | 0 | 42.9 | 42.8 | 0.1 |
| Americas | | | | | | | |
| Argentina | 96 | 8 | 1.8 | 0.2 | 95.8 | 95 | 0.2 |
| Bolivia | 59.3 | 5 | 3 | 0.2 | 59.1 | 58.5 | 0.3 |
| Brazil | 82.8 | 10 | 3.4 | 0.3 | 82.5 | 81.5 | 0.3 |
| Haiti | 46.1 | 1.2 | 1.3 | 0.1 | 46.1 | 45.9 | 0.1 |
| Mexico | 90.8 | 7.1 | 3.8 | 0.2 | 90.6 | 89.7 | 0.2 |
| Asia/Pacific | | | | | | | |
| Bangladesh | 48.1 | 0.3 | 0 | 0 | 48.1 | 48.1 | 0.0 |
| Barbados | 94 | 15.8 | 4.1 | 0.4 | 93.6 | 92 | 0.4 |
| China | 81.5 | 3.4 | 10.4 | 0.3 | 81.2 | 80.1 | 0.3 |
| India | 57.3 | 0.4 | 0.2 | 0 | 57.3 | 57.2 | 0.0 |
| Indonesia | 64.2 | 1.3 | 0.7 | 0 | 64.2 | 64.1 | 0.1 |
| The Philippines | 56.1 | 2.8 | 5.3 | 0.2 | 55.9 | 55.3 | 0.3 |
| Solomon Islands | 51 | 0.4 | 1.5 | 0 | 51 | 50.8 | 0.0 |
| Thailand | 57 | 4.9 | 2.5 | 0.1 | 56.9 | 56.4 | 0.2 |
| Vietnam | 62.3 | 1.7 | 6.2 | 0.2 | 62.3 | 62.1 | 0.1 |

**NOTE.** From [18].

[a] From all protein sources.

in countries with high average daily protein and fat intakes (e.g., China and Argentina) and where obesity is a major problem [3, 4]. In countries with relatively low per capita protein intakes (50–60 g/day), the protein supply remains at >50 g/day in all countries where this was the case prior to our modelling exercise. Pork and poultry intakes are usually very small in countries with very low (<50 g/day) per capita protein availability. In these countries, a decrease of 10% in the supply of pork and poultry makes almost no change to the population's average daily protein intake (table 2).

In reality, the weight gain in animals fed antibiotics is likely to be much less than 10%, and not all animals will receive in-feed antibiotics (e.g., animals on small family farms). If we assume that antibiotic use increases weight by 2%, then the decrease in protein intake for "all developed countries" combined is only 0.1 g/day, or 0.2%. Thus, the resultant loss of protein intake in malnourished people if antibiotics were not used routinely in poultry and pigs is likely to be extremely small.

The use of in-feed antibiotics may paradoxically harm national nutrition. The segment of the population that currently consumes most of this industrially produced meat (and, thus, a high content of saturated fats) faces a greater problem with obesity than with protein-energy undernutrition [3, 4]. Decreasing the supply of industrialized meat by 10% should lead to a decrease in overall consumption of meat by a similar amount in the population. Where pork is a major component of this industrialized meat production, a 10% decrease in meat intake will generate a far larger decrease in fat intake rather than in protein intake. For instance, in China, in 2002, the average daily intake of fat from pork was 31.8 g, compared with a protein intake of 10.4 g [18]. Therefore, every 1-g of protein intake from pig meat is associated with a much larger 3.1-g intake of fat.

## WHO BENEFITS FROM INDUSTRIALIZED MEAT PRODUCTION IN DEVELOPING COUNTRIES?

Manufactures and sellers of antibiotics benefit from current practices because they derive income from selling these products. Consumers appear to gain because they can afford to buy increased quantities of industrialized meats, which are often made to be cheaper by government subsidies.

It might be anticipated that meat producers (usually large corporations) would profit from antibiotic use because of the increased production claimed by its proponents claim. However, a recent economic analysis performed by the US Department of Agriculture [30] casts doubt on this assumption. This report concluded that, overall, meat producers reaped minimal or no financial benefits. It was calculated that the US hog industry would have a net saving of $7 million if the use of antibiotic growth promoters ceased.

## CONCLUSIONS

Some proponents of the routine feeding of antibiotics to animals in industrial farms claim that animal weight increases by as much as 10%. This has led to assertions that in-feed antibiotics increase meat production and protein consumption by the poor in developing countries and that starvation will result if this practice ceases. However, we have shown that animal weight gains are likely no more than 2% (or would be nonexistent). Furthermore, "industrialized meat" production in developing countries offers little benefit to the vast majority of the poor, who for entrenched structural reasons lack access and "entitlement" to these meats. Those who do consume these industrialized meats are more affluent and are, paradoxically, experiencing substantial rates of obesity.

We are not arguing that meat should not be consumed in developing countries or that it should not be produced as efficiently as possible. Meat is a valuable contributor to nutrition, although it can be harmful if eaten in excess. However, any loss of production of industrialized meat because of the withdrawal of in-feed antibiotic use is unlikely to have any adverse nutritional effect, including for the poor. Instead, the public health effects are likely to be strongly beneficial, particularly by protecting the public good of reduced bacterial resistance to antibiotics.


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