PUBLIC HEALTH

CAFOs and Public Health:
The Issue of Antibiotic Resistance

EXPERT REVIEWED

Paul Ebner
Animal Sciences
Purdue University

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Introduction

The use of antibiotics in food animal production remains one of the more controversial agricultural practices in the United States. Most concerns revolve around the fact that administration of an antibiotic often leads to increases in antibiotic-resistant bacteria. Very little consensus exists, however, as to whether the development of antibiotic-resistant bacteria on the farm poses a risk to human health, and what, if any, measures should be taken to minimize this risk. What follows is a review of the science behind antibiotic resistance, specifically highlighting the issues that make decision making difficult.

How do bacteria become resistant to antibiotics?

In nature, antibiotics are produced by certain bacteria and molds to eliminate other bacteria and molds that compete for limited resources. For the antibiotic producing organisms to benefit, however, they must have some means to withstand the killing effects of the drug. This often comes in the form of the ability to produce a protein that inactivates the drug. Thus, the mold that produces penicillin also produces a protein that will degrade penicillin if its concentration becomes too high for the mold cell.

If the only antibiotic-resistant organisms were those that produced the antibiotics, there would not be a problem with antibiotic resistance. Bacteria, however, are very adept at acquiring foreign genes; and over time, some bacteria that do not produce antibiotics have acquired the genes necessary for antibiotic resistance. Administration of antibiotics, in turn, allows these organisms to flourish by killing off their antibiotic-susceptible competitors. The cycle feeds itself as higher concentrations of antibiotic-resistant bacteria with antibiotic resistance genes increase the likelihood of more bacteria acquiring antibiotic resistance.

How could the agricultural use of antibiotics affect human health?

One manner in which the agricultural use of antibiotics could affect human health is through the generation of antibiotic-resistant foodborne pathogens. Organisms such as *Salmonella, Campylobacter*, and pathogenic *E. coli* are easily spread among large groups of animals yet often do not cause any disease. In contrast, these organisms cause illness in humans, but generally do not transmit well from person to person. As such, it is widely accepted that antibiotic resistance in foodborne pathogens develops on the farm; the organisms do not persist long enough in humans for resistance to develop. Antibiotic resistance in foodborne pathogens could be problematic if an infected person seeking treatment is administered the drug to which the pathogen is resistant. The result could be a treatment failure, an increased illness time, or an extended hospital stay. While antibiotics are not routinely prescribed for foodborne illnesses, the drugs are sometimes necessary in severe cases and infections in individuals with compromised immune systems.

On-farm development of antibiotic resistance could affect human health through non-pathogenic bacteria as well. These are organisms that are in the digestive tracts of both animals and humans, but are not usually involved in the development of disease. Humans can ingest these organisms through the consumption of animal products. Unlike most foodborne pathogens, many non-pathogenic bacteria can easily be transmitted among human populations, and once established, could share their antibiotic resistance genes with more dangerous organisms such as *Staphylococcus* or *Pseudomonas*.

Do these scenarios really happen?

Although this issue has been debated for over four decades, there is still little agreement as to whether the use of antibiotics in food animal production poses a serious human health risk. There are several obstacles impeding any consensus. Foremost is the ecology of antibiotic resistance, or more precisely, the complexity of the ecology of antibiotic resistance. Determining whether someone is infected with an antibiotic-resistant organism is an easy task. Determining how that person became infected is also relatively easy. Determining how the antibiotic resistant organism acquired the genes responsible for antibiotic resistance is very difficult. There are too many culprits—most notable is the human use of antibiotics. Antibiotic therapy in humans directly amplifies the number of antibiotic resistant bacteria, both harmful and non-harmful. It creates an immediate and large reservoir of antibiotic resistance genes available to bacteria of all types. This is the trade-off in using the drugs.

There are only a few examples where a clear cause and effect relationship between antibiotic use in livestock production and antibiotic resistance in humans has been established. The case most often cited involved the antibiotic avoparcin. Avoparcin was indicated for use in poultry, but not in human medicine. Bacteria that are resistant to avoparcin, however, are also resistant to vancomycin, one of only a few remaining drugs available to treat methicillin resistant *Staphylococcus aureus* (MRSA) in humans.

In Europe, avoparcin was widely used in the early 1990s in the poultry industry. Vancomycin, however, was not, as MRSA was not yet a big problem. The converse was true in the United States where avoparcin was not used in poultry, but vancomycin was widely used in hospitals due to MRSA. In the United States, vancomycin-resistant bacteria were only found in individuals who were either patients or frequent visitors of hospitals. In Europe, vancomycin-resistant bacteria were regularly isolated from healthy individuals who were not linked in any way to a hospital. Therefore, rather than acquiring these infections in hospital settings, Europeans acquired vancomycin-resistant bacteria from the community at-large with the only community source able to drive increases in resistance being the use of avoparcin in birds[1].

Risk assessment models

Such clear cases are very rare. As such, several research groups in recent years have attempted to predict the impact of agricultural use of antibiotics on human health with models or risk assessments. Like more traditional studies, these models are also somewhat limited by the complexity of the ecology of antibiotic resistance. Seemingly, no two organisms, or two genes, or two environments behave alike. For instance, a model predicting the impact of ampicillin resistance may not be useful in predicting the impact of tetracycline resistance, or resistance to other antibiotics. Nevertheless, several such studies have been published in the past decade, but with varying predictions. Some models predict that the use of antibiotics in food animal production significantly contributes to the problem of antibiotic resistance in humans while others say that the contribution is minimal to non-existent[2,3]. However, as more data become available and more models are created and refined, a consensus should emerge as to which models are the most accurate in gauging the impact of the agricultural use of antibiotics on public health.

Conclusions

Because the ecology of antibiotic resistance is so complex, it is difficult to say definitively whether the use of antibiotics in food animal production negatively impacts human health. It is widely accepted that the use of the drugs, whether therapeutically or subtherapeutically, results in increases in the proportion of antibiotic-resistant bacteria. It is not clear, however, as to how much antibiotic resistance generated on the farm contributes to the problem of antibiotic resistance in human medicine. In recent years, many researchers have developed risk assessment models to address the problem but with contradictory results. As our knowledge of the ecology of antibiotic resistance grows, it will be easier to come to some consensus as to what measures, if any, should be taken to ensure that our meat, dairy, and poultry products continue to be produced in the safest manner possible.

References and Further Reading:

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3 Smith DL, Harris AD, Johnson JA, Silbergeld EK, Morris JG. 2002. Animal antibiotic use has an early but important impact on the emergence of antibiotic resistance in human commensal bacteria. *Proc Natl Acad Sci USA.* 99:6434-9.

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