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Critical Issue Report: Antibiotic Resistance

Organic Food and Farming as a Tool to Combat Antibiotic Resistance and Protect Public Health

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ANTIBIOTIC RESISTANCE has been described as one of the most pressing" human health concerns today and contributes to thousands of deaths each year. While the use of antibiotics in conventional agricultural practices has been implicated as an important contributor to this growing crisis, research also demonstrates that livestock production without the use of antibiotics, such as in organic agriculture, is an important part of the solution.

This review paper takes an in-depth look at the role of antibiotic use in conventional agricultural livestock production in contributing to the development of antibiotic-resistant bacteria. It covers everything from mechanisms by which resistance develops in bacteria and the role that modern day agricultural practices play in exacerbating the problem, to how organic agriculture provides a simple and effective means to combat the rise of antibiotic-resistant bacteria and to protect the health of consumers. Furthermore, because organic production methods are available to all farmers, they can be incorporated into any livestock operation to combat resistant bacteria.

The Organic Center thanks the many researchers and livestock producers who have reviewed our report, providing valuable comments and information that we have incorporated into this final publication. We appreciate your support, and our report is stronger because of your input.

We hope this report acts as a tool to educate livestock producers, policymakers, consumers, and industry members about how reducing on-farm antibiotic usage can be used to combat antibiotic resistance and improve human health.

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Executive Summary

The best choice that consumers can make to combat antibiotic resistance and protect themselves from antibiotic-resistant bacteria is to choose organic. Antibiotics are widely administered to conventional livestock raised for food consumption. Of particular concern is the use of antibiotics not to treat infections or prevent diseases but to simply increase the growth and feed efficiency of the animals being raised. This practice has been implicated as a direct contributor to the emergence of antibiotic-resistant bacteria.

Numerous studies have demonstrated that resistant bacteria originating in livestock can be transmitted to humans. Transmission has been documented via direct contact with animals and feces, environmental contamination, and through the food supply chain resulting in serious public health concerns. Organic livestock production, which prohibits the use of antibiotics for growth promotion or prophylactic purposes, provides a compelling example of successful, profitable operations, demonstrating the ability of livestock farms to operate without substantial antibiotic use and providing a model for how agriculture can contribute to a solution.

THIS REVIEW COVERS:

- Mechanisms by which resistance develops in bacteria
- The role that modern-day agricultural practices play in exacerbating antibiotic resistance
- How organic agriculture, which prohibits antibiotic use, combats the rise of antibiotic-resistant bacteria
- How organic protects the health of consumers

As science demonstrating the effects of imprudent antibiotic use in conventional agriculture continues to accumulate, policymakers are beginning to implement regulations designed to curb irresponsible practices. Unfortunately, change takes time and current regulations are easily skirted. While best practices utilized by organic farmers are available to everyone, they are not widely utilized within the U.S. agricultural system. Until our agricultural system undergoes a major paradigm shift, organic offers a simple and effective means to combat the rise of antibiotic-resistant bacteria and to protect the health of consumers.

Index

INTRODUCTION

The discovery of antibiotics revolutionized modern medicine by allowing physicians to reliably reduce the death toll caused by bacterial infections. Unfortunately, over time, bacteria have evolved to tolerate or resist the antibiotics that were designed to kill them. Prolonged and frequent use of antibiotics has further accelerated this natural process, making many medically important antibiotics ineffective at combating infection and leading to what the World Health Organization has dubbed an emerging global crisis.[1] In the United States alone, two million people are infected annually with antibiotic-resistant bacteria, and at least 23,000 people die each year as a direct result of those infections.[2]

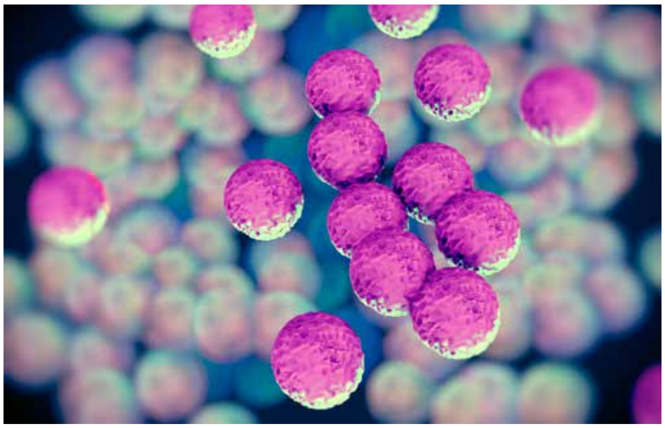
The use of antibiotics in any setting can lead to the proliferation and spread of antibiotic-resistant bacteria. However, low-dose administration of antibiotics in livestock is now considered by many to be an unnecessary driver of bacterial resistance with significant public health impacts.

Resistant bacteria were initially found in hospitals and health care centers where they were able to survive in an environment in which antibiotics are frequently administered. More recently, however, they are becoming prevalent and spreading throughout community settings. This disturbing trend is primarily attributed to the fact that antibiotic usage is growing worldwide, with much of this increase occurring outside of healthcare facilities.[3] Direct links have been established not only between overall rates of antibiotic usage and the presence of antibiotic-resistant bacteria but also with bacterial exposure to antibiotics in low doses or over long periods of time.[4–7] While the development of new antibiotic therapies and curbing antibiotic over-use in humans have an important role to play in combatting resistance,[8] there are also a number of facets by which we can make drastic reductions in antibiotic usage outside of the human health system.[8] Antibiotic usage in livestock production is virtually unregulated. It has been estimated that worldwide, more than twice as many antibiotics are administered to livestock as they are to humans.[9]

Industrial conventional livestock operations are notorious for their imprudent use of antibiotics, commonly utilizing them in a number of ways that are known to directly drive the proliferation of antibiotic-resistant bacteria.[10] These practices include administering low-doses of antibiotics over long periods of time, mass treatment of livestock with antibiotics when only a small number of animals are sick, and the use of antibiotics that are similar to those used to treat human infections.[11, 10] The majority of antibiotic administration in livestock is not intended to treat bacterial infections or even to prevent infection. Instead, antibiotics are fed to livestock as growth promoters.[12, 13] This low-dose, long-term administration of antibiotics to large groups of animals creates the perfect environment for the selection and propagation of antibiotic-resistant bacteria.[8]

Organic livestock production, on the other hand, provides one of the simplest and most effective ways to reduce the proliferation of antibiotic-resistant bacteria, because the

National Organic Standards prohibit the use of any antibiotics in livestock production.[14] Here we take an in depth look at how antibiotic resistance develops, the role that antibiotic usage in livestock production plays in driving the rise of antibiotic-resistant bacteria, and the science behind organic production methods as a means to combat bacterial resistance and protect human health.



MECHANISMS BY WHICH RESISTANCE DEVELOPS

Antibiotic resistance in bacteria evolves naturally via random mutation and natural selection. Natural selection is the process by which an individual with an adaptive trait is better able to survive and reproduce in its environment than individuals lacking the adaptive trait. As a result, the trait becomes common in the population.

No two individuals are exactly alike. Just as each human has a unique fingerprint, there are genetic differences among every species, every population, and every individual, even among individual bacteria. These differences in DNA are naturally occurring and constantly changing. As cells divide and DNA is replicated, changes known as mutations occur by chance in the genetic code. While most of these genetic mutations have no negative or positive impact on an individual or even result in any trait change at all, sometimes they do. When a random mutation does lead to an observable change in an individual, the new traits are often detrimental and the individual will not survive. However, sometimes, such as in the case of antibiotic resistance, new traits can also be advantageous, allowing that individual to ultimately produce more offspring over the course of their lifetime than individuals without the trait. If an advantageous trait is heritable, offspring that inherit the genes that code for that trait will continue to survive and reproduce at greater rates than other individuals until the trait becomes common in the population.[15]

Traits that confer resistance to antibiotics in bacteria arise via random mutation. In a typical antibiotic-free environment, these traits are not likely to provide bacteria with any survival disadvantage or advantage and will likely remain in the population at very low rates. However, if we place those bacteria in an environment where antibiotics are common, the trait becomes advantageous and the tables are turned. The resistant bacteria are able to survive in the new environment better than bacteria that are not antibiotic resistant. As non-resistant bacteria die off, the resistant bacteria have easy access to food and resources that they once may have had to compete for. The resistant bacteria survive and reproduce, passing on their genes for antibiotic resistance to the next generation. Transfer of resistance genes among bacteria is particularly troubling because they not only have the ability to pass their genes on to their offspring via reproduction, they can also share genetic material within and among bacterial species in a process known as horizontal gene transfer.[16] Furthermore, because bacteria are able to reproduce very quickly, advantageous new traits are able to spread swiftly through the population.[10]

ANTIBIOTIC USE IN CONVENTIONAL LIVESTOCK PRODUCTION

The use of antibiotics in conventional livestock production is extremely common. In fact, 80% of antimicrobials used in the United States are administered to livestock raised for food.[17] Their uses can be broken down into four main categories (a comprehensive review on the subject is provided in McEwen & Fedora-Cray).[11]

- **Therapeutic treatment:** Therapeutic treatments are typically high doses of antibiotics given over a set duration of time as prescribed by a veterinarian. Therapeutic treatment is generally intended to treat and cure diseased animals. While ideally only sick animals should be treated, it is often less efficient and sometimes impossible to do so (such as in fish or poultry-rearing operations). In these cases, therapeutic doses of antibiotics are mass administered through medicated feed or water, and delivered to large groups of animals, only some of which require treatment.

- **Metaphylaxis:** Metaphylaxis is the practice of medicating sick animals as well as surrounding healthy animals with therapeutic doses of antimicrobials. In this way, producers aim to treat sick animals while simultaneously preventing new infections from occurring in an otherwise healthy herd.

- **Prophylaxis:** Prophylaxis is the practice of administering antimicrobials to healthy animals in order to prevent bacterial infections from occurring. Antimicrobials for prophylactic treatment are typically administered at non-therapeutic levels (doses at low enough levels that they would be ineffective in treating an actual infection) for extended periods of time.

- **Growth promotion:** Livestock producers often administer non-therapeutic doses of antimicrobials to food animals to promote growth. It is worth noting that because many of the antibiotics approved for growth promotion are also approved for prophylactic treatment to prevent infections in livestock, there is often little difference in administration practices for prophylactic and growth promotion purposes.

The expansion of intensive industrial animal production has led to the adoption of two primary animal husbandry practices directly tied to on-farm increases in antibiotic use: (1) The practice of housing large numbers of animals in extremely close confinements—such as used in concentrated animal feeding operations—which unavoidably exposes livestock to their own waste and the waste of other animals, greatly increasing the risk of disease contraction and spread, and (2) the formulation of feed to include non-therapeutic doses of antimicrobials for prophylactic and growth promotion purposes, creating an environment that strongly selects for the proliferation of antibiotic-resistant bacteria.[18]

While the rise of intensive industrial livestock production is directly responsible for the increase in antibiotic administration in feed animals over the years,[19] a number of studies suggest that the growth differential between animals treated with antibiotics and those not treated with antibiotics becomes negligible as animal care improves. For instance, research has suggested that when simple improvements in animal husbandry practices are are made, such as improved hygiene and the implementation of vaccination schedules, antimicrobial growth promoters can be removed from livestock diets with little to no effect on production efficiency.[20, 21] In spite of these promising results, total antibiotic use in food-animal production remains high and is only expected to increase in the U.S. and worldwide, exacerbating human health concerns.[22]

IMPLICATIONS FOR HUMAN HEALTH

Widespread antibiotic use in livestock production has significant public health implications for a number of reasons. Many classes of antibiotics that are important for use in the human health system such as penicillin are also approved for use in livestock production.[23, 10] As imprudent use of antibiotics in agriculture drives increases in antibiotic-resistant bacteria, important human health therapies are rendered useless. Indeed, antibiotic-resistant bacterial infections account for many of the newly emerging infectious diseases globally.[24, 25] Furthermore, excessive use of antibiotics in agricultural systems greatly increases the number of environmental pathways by which human exposure to resistant bacteria occurs.

Antibiotics and antibiotic-resistant bacteria can be transmitted to the environment via a number of pathways. Once established, resistant bacteria create reservoirs of resistant bacteria and the antibiotics themselves in the air, water, and soil. From there, humans and wildlife may be exposed and livestock-associated bacterial resistance may be transferred to unrelated bacterial isolates via horizontal gene transfer.[26, 27, 28] Evidence also suggests that resistant bacteria can also be transmitted to humans through contact with infected animals on the farm or in the slaughterhouse as well as contaminated retail food products—a particular concern for the everyday consumer.

TRANSMISSION VIA ENVIRONMENTAL CONTAMINATION

Livestock animal waste is largely unprocessed upon disposal, leading to significant contamination of air, soils and waterways.[10] The United States agricultural system generates approximately one billion tons of manure, sewage, sludge, and other waste byproducts per year, 335 million tons (dry

Organic in Action: **Preventing Contamination**

Livestock manure disposal is one of the biggest ways that antibiotic residues and resistant bacteria enter the environment. Organic production methods reduce contamination of the air, water, and soil because the organic standards prohibit the use of antibiotics in livestock unless medically necessary.

weight) of which are made up of manure produced by livestock.[29] The majority of all animal waste is recycled back into agricultural land as fertilizer. Unfortunately, a number of studies have also implicated this practice as an important entry route for antibiotic-resistant bacteria into the environment. Once they've entered the broader landscape, humans can be exposed to resistant bacteria through crops that are contaminated after being fertilized or irrigated with animal waste, inhalation, or through contact or consumption of water from streams and aquifers inadvertently contaminated by farm runoff.[10]

Air Contamination

A number of studies have isolated antibiotics and antibiotic-resistant bacteria from the air within and surrounding cattle, swine and poultry confinements.[30–34] For example, Friese *et al.*[35] investigated the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in the air inside of hog barns. They found that 82% of all barns sampled tested positive for MRSA, suggesting that farm workers who spend time inside swine confinements may experience significant exposure risks simply through inhalation.

While studies demonstrating the prevalence of antibiotic-resistant bacteria in the air of animal confinements are common, it has been suggested by some that bacteria are unlikely to survive once that air has been exhausted to the outside due to inhospitable climatic conditions.[36] However, more recent studies have demonstrated that it is possible for antibiotic-resistant bacteria to survive and be transferred via air pathways. A study by Laube *et al.*[33] detected living *E. coli* up to 50 meters from the poultry housing exhausting air. McEacharan *et al.*[34] further confirmed that antibiotic-resistant bacteria remained viable after being carried away from livestock housing via air. The research team tested particulate matter from cattle feedlots as well as with air samples from upwind and downwind of the operations. They found that samples collected on the feedlots contained antibiotics and antibiotic-resistant bacteria. What's more, their results indicated that air samples collected downwind of feedlots contained significantly more antibiotics and antibiotic-resistant bacteria than samples collected upwind of the feedlots, and included some strains known to infect humans. These findings strongly imply that the feedlots had a direct impact on measured results.

Soil and Water Contamination

Untreated manure and waste are often applied to soil both as a disposal method and as a fertilizer. Unfortunately, numerous studies have demonstrated that these practices are the primary route by which soils are contaminated with antibiotic-resistant bacteria and residual antibiotics, creating an environment where resistant genes can then be transferred to unrelated soil bacteria.[37, 38]

Soil contamination is typically followed by subsequent contamination of streams and rivers through runoff, and groundwater can be contaminated via seepage from poorly constructed waste storage lagoons, or other waste storage facilities.[39–42] In 2002, the U.S. Geological Survey published results from the first nationwide reconnaissance for pharmaceuticals, hormones and organic wastewater contaminants in U.S. waterways. One hundred thirty-nine streams across 30 states were sampled between 1999 and 2000 and tested for 33 different antibiotics. All but eight of the 33 antibiotics were detected in the waterways sampled. Another study by West *et al.*[43] tested water quality, bacterial load, and bacterial resistance upstream and downstream of confined animal feeding operations. They found that the majority of bacteria collected at all sites were resistant to at least one antibiotic, and that bacteria collected from natural waterways near the farms were significantly more likely to contain bacteria resistant to multiple antibiotics.

Groundwater contamination is also commonly associated with industrial livestock operations.[44, 45] For instance, Anderson and Sobsey[46] sampled two hog farms and two crop farms to quantify the extent to which livestock operations could be linked to the presence of antibiotic-resistant E.coli in groundwater. Groundwater collected near the hog farming operations had higher levels of *E. coli* than crop farms, and 68% of the 90 bacterial strains isolated exhibited antibiotic resistance. In contrast, only one *E. coli* strain collected from each of the crop farms was antibiotic resistant.

TRANSMISSION TO FARM WORKERS AND SURROUNDING COMMUNITIES

Farm personnel, those who work closely with livestock such as veterinarians, and workers in livestock slaughter houses and processing plants are often at the greatest risk for contracting livestock-associated antibiotic-resistant bacteria.[47–56] The type of livestock that farmworkers come into contact with can also increase the risk of exposure to resistant bacteria. For example, Wardyn *et al.*[57] tested 1,342

Iowans for the presence of *S. aureus* in their nose, throat and on their skin, and found that swine livestock workers were six times more likely to be carriers of the drug-resistant bacteria than farmworkers who did not have contact with swine. While research dating back to the 1970s has demonstrated that livestock workers are more likely to be carriers of resistant antibiotic strains of bacteria than the general public,[51, 55] it wasn't until more recently that researchers were able to demonstrate that the transmission of resistant bacteria from livestock can actually increase the risk of infection and illness in humans. Casey *et al.*[58] was able to do so by associating the rate of MRSA infections that required medical treatment with proximity to conventional pig farms in Pennsylvania. They found that people who lived near pig farms or agricultural land where pig manure was spread were 30%–38% more likely to contract community-resistant strains of MRSA infections than individuals who were not exposed to conventional pig farms, suggesting a link between exposure to pig manure and infection.

TRANSMISSION VIA FOOD

Livestock and meat handlers aren't the only people at increased risk due to imprudent use of antibiotics in livestock production. Consumers may also be exposed to resistant bacteria through contact with or consumption of animal products. Antibiotic-resistant bacteria have been isolated on a wide range of retail meat products sampled across the U.S.[59–68, 3]. For example, Zhao et al.[69] sampled over 11,000 retail meats from four different U.S. states between 2002 and 2008 as part of the National Antimicrobial Resistance Monitoring System's Retail Meat Program. Over the course of the study, approximately 3,000 samples each of chicken breast, ground turkey, ground beef and pork chops were tested for antibiotic-resistant *E. coli*. They found that the majority of meat samples were contaminated with resistant bacteria isolated on 84% of chicken samples, 82% of turkey samples, 69% of beef samples and 44% of pork samples. Furthermore, a large number of the *E. coli* isolates were resistant to more than one class of antibiotic.

Indirect evidence also suggests that antibiotic resistance can be transferred from bacteria in contaminated foods to bacteria in humans via food handling or consumption[70]. For example, Donabedian *et al.*[71] found that antibiotic-resistant genes in bacteria collected from humans were closely related to the antibiotic-resistant genes in bacteria collected from pork meat. They also found a similar pattern of relatedness between resistance genes in resistant bacteria collected from humans and grocery chicken. These results suggest that antibiotic resistance may have been transferred from bacteria colonizing supermarket meat to bacteria in consumers. Another study by Klare *et al.*[72] investigated how the discontinuation of the antibiotic avoparcin as a feed additive for chickens and turkeys in Germany affected the presence of antibiotic-resistant bacteria in supermarket poultry products and humans. Vancomycin-resistant bacteria were frequently detected in samples collected from supermarket poultry samples and humans from 1994–1995, when avoparcin use was widespread. However, samples collected at the end of 1997—2 years after the use of avoparcin had been discontinued—showed not only a striking decrease in the presence of vancomycin-resistant bacteria present on poultry products but also in humans. In fact, the average detection rate for vancomycin-resistant bacteria in humans decreased from 12% in 1994 to only 3% in 1997. These results not only suggest that antibiotic additives in livestock feed drive the proliferation of antibiotic-resistant bacteria, but drives home the important role that retail meat products may play in the transmission and spread of resistance to bacteria in humans.

Organic in Action:
Reducing Consumer Exposure

While cooking meat at the proper temperature will kill antibiotic-resistant bacteria, consumers are still at risk due to cooking preferences—for instance, a medium-rare steak—or through cross contamination of kitchen surfaces and cooking utensils. Organic production directly reduces consumer exposure to antibiotic-resistant bacteria via contact and consumption of supermarket meat products. Surveys of retail meat products have demonstrated over and over again that organic chicken, turkey, pork, beef and even eggs are much less likely to be contaminated with antibiotic-resistant bacteria than conventional meat products.

Organic in Action: **Preventing Pathogens**

While many organic and conventional operations utilize raw manure as a fertilizer source, organic is the only production method with regulations in place to protect consumer health from inadvertent contamination of crops with pathogens. Unlike conventional production, organic standards have safety measures in place, requiring a three- to four-month waiting period between the application of raw manure and the harvest of crops. This ensures that consumers are protected from potential pathogens that could be present in raw manure.

Crop contamination

Food crops that have been irrigated with surface waters contaminated by runoff containing animal waste or that have been fertilized with untreated manure from animals receiving antibiotics can also pose a food safety risk.[73, 24] For instance, some crops can directly uptake antibiotic residues from manure into their tissues[74] or their surfaces can become contaminated with antibiotic-resistant bacteria coming in contact with animal waste. Micallef *et al.*[75] investigated the degree to which retail tomatoes were contaminated with *Enterococci* prior to harvest. Tomatoes, leaves, groundwater, pond water, irrigation ditch water and soil from farms across the mid-Atlantic were tested for bacterial contamination. The results found that almost all samples were contaminated with Enterococcus species that were resistant to a number of antibiotics including some used to treat infections in humans.

ELIMINATING EXCESSIVE ANTIBIOTIC USE WITHOUT HARM TO THE LIVESTOCK INDUSTRY

It has been well established that reduction in non-therapeutic antibiotic use for growth promotion purposes is a key step in combatting antibiotic-resistant bacteria. As early as 1976, Dr. Stuart Levy, a medical doctor and microbiologist at Tufts University, found that while the introduction of poultry food that contained the antibiotic oxytetracycline led to a proliferation of antibiotic-resistant bacteria in both poultry and farm worker guts, subsequent removal of the antibiotic from poultry feed reversed this trend within six months after which poultry and farm workers were found to no longer be carriers for antibiotic-resistant bacteria.[51] Studies from across Europe have demonstrated that banning various antibiotics for non-therapeutic use in livestock production can lead to a significant reduction in resistant bacteria in both humans and animals.[76, 77, 78] In spite of the clear effectiveness of reducing non-therapeutic antibiotic use to combat the rise of antibiotic-resistant bacteria, critics continue to argue that elimination of non-therapeutic antibiotic use in livestock production will decrease productivity, lead to increased infections and reduce overall profitability for farmers.[79]

While widespread and indiscriminate administration of antibiotics to livestock is commonplace in conventional farming systems, evidence from a number of countries demonstrates that it is possible to successfully reduce agricultural antibiotic use with little to no impact on the productivity and profitability of the livestock industry.[20, 21, 80] In 1998, the poultry industry of Denmark agreed to discontinue the use of all antibiotics for growth promotion purposes. Emborg *et al.*[20] assessed the effects of these actions on the productivity of poultry production using data collected from almost 7,000 chicken flocks between 1995 to 1999—before and after the self-imposed ban. The weight of poultry produced per area of land, the amount of feed used in production and the mortality rate of birds prior to slaughter were assessed. Results demonstrated that overall poultry production did not decrease after antibiotic use for growth promotion was discontinued, and that feed use increased only marginally (less than 1%). The authors concluded, "Despite a fear of decreased productivity and increased mortality, it was possible to withdraw all use of antimicrobial growth promoters from broiler production without productivity decrease for the producers."

Another study by Laine *et al.*[21] monitored infection rates on piglet-producing farms in Finland after the European Union banned the use of the antimicrobial growth promoters carbadox and olaquinodox in 1999. They found that illness in piglets after weaning did not increase significantly once growth promoters were eliminated, demonstrating that "antimicrobials can be withdrawn from piglet production, and that it is possible to produce pigs without them."

Finally, a study by Aarestrup *et al.*[80] analyzed data collected from hog farms in Denmark between 1992 and 2008 to assess how changes in antimicrobial usage in the swine industry influenced productivity. Their team found that while antibiotic use dropped by more than 50% over that time period due to the implementation of bans on antibiotics for growth promotion, overall pork production increased by 47%, providing clear evidence that non-therapeutic use of antibiotics is not necessary to maintain productivity.

ORGANIC LIVESTOCK PRODUCTION AS A MODEL FOR REDUCING ON-FARM ANTIBIOTIC USE

Organic methods can serve as a model for successfully eliminating the non-therapeutic use of antibiotics in livestock production in the United States. Certified organic production is also the best way to combat antibiotic resistance and protect the health of farm workers, communities and consumers because the National Organic Program (NOP) is the only national standard that strictly regulates antibiotic administration in livestock and is backed by the force of law.

The National Organic Standards prohibit the use of antibiotics in organic certified livestock for any reason. As a result, organic livestock production contributes to reductions in overall antibiotic usage, particularly at non-therapeutic doses, and relieves the selective pressure that drives the proliferation of antibiotic-resistant bacteria.

In addition to prohibiting antibiotic use, NOP standards require organic producers to follow animal husbandry practices that support the health of the animals. For instance, they must develop a healthcare plan for their animals that focuses on disease prevention. Livestock feed must be 100% organic and cannot contain plastic pellets, feces, or slaughter byproducts. Living conditions must accommodate the natural behavior of the livestock and provide access to outdoors, fresh air, and sunlight. Animals must be supplied with adequate nutrition and when kept

Organic in Action: **Reducing the Use of Non-Therapeutic Antibiotics**

Choosing organic is currently the only way that consumers can play a role in reducing antibiotic use in livestock production. In spite of recent FDA efforts to reduce antibiotic use in livestock, production data indicate that the sale of antibiotics for livestock production in the U.S. is still rising, and that the sale of antibiotics that are medically important for human health but also approved for use in livestock are also rising. The Organic label is the only system regulated by USDA to ensure that producers are not using antibiotics.

indoors, they must have dry, clean bedding and substantial ventilation. Furthermore, manure produced by organic livestock must be handled to ensure that it will not contaminate crops, soil, or water with heavy metals, or pathogenic organisms, and managed in a way that maximizes nutrient cycling back into the environment. These measures drastically reduce the risk of infection and transmission within organic operations.

The organic standards also have regulations in place to reduce the risk of crop contamination when manure is used as a source of fertilizer in organic crop production. For instance, compost livestock manure or apply it 90–120 days before crop harvest. This ensures that crops are not contaminated with animal feces at time of harvest or when they undergo subsequent processing.

It is also important to note that because organic farming methods are based on practices that support the health of both humans and animals, organic producers do not withhold antibiotic treatment from sick animals when it is medically necessary. However, once an animal has been treated, it can no longer be marketed as certified organic.

The practices applied in organic livestock production simultaneously increase the overall health of livestock and reduce the need for broad-scale antibiotic administration. Organic farmers also commonly experience additional benefits associated with good animal husbandry practices such as increased herd and flock health and longevity. While the regulations set forth in the organic standards are required in certified organic operations, organic farming methods are available to any livestock producer and can serve as an example of responsible livestock production practices that can combat antibiotic resistance.

ORGANIC PRODUCTION: COMBATING ANTIBIOTIC-RESISTANT BACTERIA ON THE FARM

Because the organic standards prohibit the use of antibiotics in any livestock raised for consumption (including animal products such as eggs and milk), it alleviates the selective pressure that drives the proliferation of antibiotic-resistant bacteria. Numerous studies have demonstrated that organic farms harbor fewer antibiotic-resistant microbes than their conventional counterparts.[81–84] For instance, Aerestrup *et al.*[82] sampled manure from chickens and pigs raised on conventional and organic farms in Denmark prior to the implementation of widespread regulations on non-therapeutic antibiotic use in Europe. They found that 80% of chickens sampled on conventional farms tested positive for vancomycin-resistant bacteria. No resistant bacteria were found in the chicken raised on organic farms.

Another study by Sapkota *et al.*[81] demonstrated that by transitioning from conventional to organic production practices, poultry farms were able to drastically reduce the amount of antibiotic-resistant bacteria present on the farm. Researchers collected samples from poultry litter, feed and water from ten conventional poultry houses and ten poultry houses that had recently transitioned to organic production. Each sample was tested for the presence of *Enterococcus* species, and their susceptibility to 17 different antimicrobials. While all sources tested positive for some *Enterococcus* species, the number of isolates exhibiting antibiotic resistance was significantly higher on the conventional farms. 42% of *Enterococcus faecalis* isolates detected in conventional poultry houses were multidrug resistant, compared with just

Organic in Action: **Keeping Animals Healthy without Antibiotics**

Organic's prohibition on use of antibiotics in livestock relies on the establishment of practices that prevent disease like supplying a nutritious and complete diet, choosing breeds naturally resistant to pests and diseases, maintaining strict levels of hygiene cleanliness in housing, and reducing stress. When these preventive practices have failed, organic farmers and ranchers turn to natural disease control measures, like botanical extracts and minerals. However, when illness necessitates treatment with antibiotics, organic producers cannot withhold treatment to preserve the organic status of an animal, and, if treated, the animal and its products must be diverted from the organic marketplace.

10% of isolates from newly organic poultry houses. Even more startling, 84% percent of the *Enteroccocus* species *E. faecum* exhibited resistance to multiple antibiotics compared with only 17% of isolates from the newly organic houses.

ORGANIC PRODUCTION: PROTECTING CONSUMERS

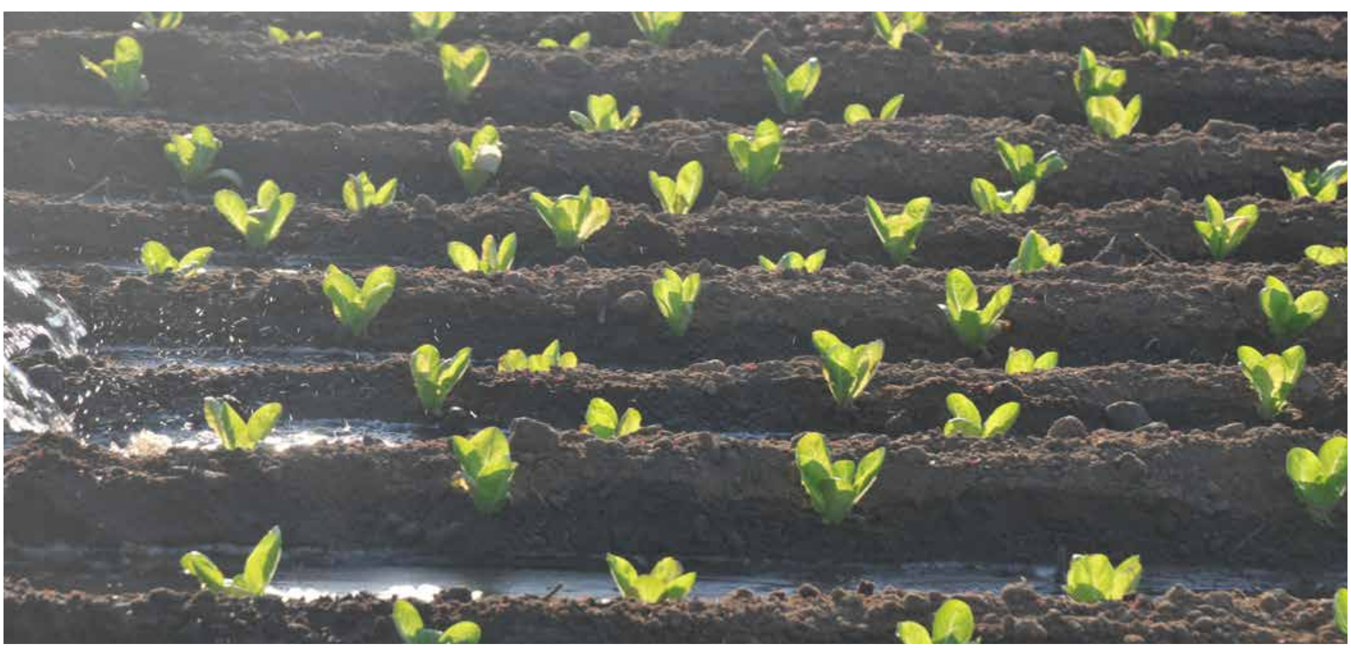
Numerous studies have demonstrated that the benefits of organic production in protecting human health extend the length of the farm-to-fork continuum, directly reducing consumer exposure to antibiotic-resistant bacteria via contact and consumption of supermarket meat products. Surveys of retail meat products have demonstrated over and over again that organic chicken, turkey, pork, beef and even eggs are much less likely to be contaminated with antibiotic-resistant bacteria than conventional meat products.[85–90] For instance, a survey of chicken sold in Maryland retail stores found that all of the *Salmonella* bacteria found on conventional chicken were resistant to five or more antibiotics while almost none of the bacteria collected from organically raised chicken were resistant to antibiotics.[85]

While the U.S. Food and Drug Administration (FDA)[91] has implemented new policies over the past three years designed to combat antibiotic resistance by regulating antibiotic use for growth promotion in livestock production, it has been criticized for relying on voluntary actions by drug companies that stand to lose money from reduced antibiotic sales. Furthermore, while the policy has effectively made it illegal to administer non-therapeutic doses of antibiotics for growth promotion, livestock producers may still use those same low doses of antibiotics under the guise of prophylactic treatment, creating an easy loophole to evade the ban. Indeed, the most recent report released by FDA[92] indicates that sales of antibiotics for use in livestock production has increased in spite of the new policy. The report also shows that the sale of antibiotics that are medically important for human health but also approved for use in livestock rose almost 23% between 2009 and 2014, and those same medically important antibiotics made up the majority of antibiotics purchased for use in livestock.

LESSONS LEARNED FROM THE ORGANIC FIELD

Until effective regulations are in place to reduce antibiotic use in the U.S. agricultural system, the best choice that consumers can make to combat antibiotic resistance and protect themselves from antibiotic-resistant bacteria is to choose organic. Furthermore, the success of the organic industry in maintaining healthy, vigorous populations of livestock can serve as a model for conventional operations interested in reducing their dependence on antibiotics.

By implementing methods that support animal health naturally, such as providing animals with proper ventilation, access to the outdoors, and exercise, any farmer can avoid the need for antibiotics. Additionally, practices that encourage healthy growth, such as allowing the nursing of young animals and feeding animals healthy diets, can further help conventional farmers reduce the need for antibiotic use. Finally, organic techniques not only can help maintain the health of livestock populations; they can also contribute to the health of farm workers and their surrounding community by preventing the development and spread of antibiotic-resistant bacteria.



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