



The Long Road from Farm to Fork: Why Animal Health Matters to Human Health

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INTRODUCTION

How the journey of our meat, milk and eggs connects animal health with our own

A glass of milk at breakfast, an egg cracked into a frying pan, or a piece of chicken simmering for dinner may seem far removed from the farms where these foods began their journey. Yet the safety of these foods is influenced by decisions made long before they reach the supermarket or the kitchen.

It Starts with a Healthy Animal

Modern livestock farming performs an extraordinary task. Every day, animals produce large quantities of milk, meat and eggs that move through increasingly complex food systems to feed a growing population. Behind this production are advances in breeding, nutrition, housing, vaccination, disease prevention and veterinary care.

However, productivity and animal health cannot be separated. Animals living under poor nutritional conditions, overcrowding, heat stress, inadequate hygiene or repeated exposure to infection are more likely to become sick. Once an infectious disease enters a herd or flock, close contact between animals can allow it to spread rapidly.

For farmers, the consequences may include poor growth, reduced milk production, reproductive losses, mortality and increased treatment costs. The effects, however, may extend beyond the farm. Some microorganisms carried by food-producing animals can infect people, while others can contaminate meat, milk, eggs, water or soil. Animal waste may also provide a pathway through which microorganisms and antimicrobial-resistance determinants enter the environment. Keeping animals healthy is therefore about more than protecting productivity. It is one of the earliest opportunities to protect public health.

The Invisible Passengers

One of the greatest challenges in foodborne disease prevention is that contamination is not always visible. An animal may appear completely healthy while carrying microorganisms capable of causing disease in people. *Salmonella*, *Campylobacter*, pathogenic *Escherichia coli* and *Listeria* are familiar examples.

Other pathogens can reach humans through direct contact with infected animals or through contaminated animal products. The scale of the problem is substantial. According to the World Health Organization's global estimates, unsafe food causes illness in approximately one in nine people worldwide and is associated with about 1.52 million deaths each year. Children are particularly vulnerable.

Contamination can begin surprisingly early. Microorganisms may enter a farm through contaminated feed or water. Animals can acquire them from other animals, people, equipment, rodents, insects or wildlife. Transport may bring animals from different environments into close contact. During slaughter, microorganisms from hides, feathers or intestinal contents can contaminate carcasses if hygiene is inadequate.

Processing facilities, retail outlets and kitchens provide further opportunities for contamination or cross-contamination. The phrase "farm to fork" is therefore more than a description of how food travels. It represents a chain in which every link matters.

When Antibiotics Begin to Lose Their Power

Few discoveries have transformed medicine as profoundly as antibiotics. They have saved countless human and animal lives and remain essential for treating bacterial infections in veterinary practice. However, antibiotics are not an unlimited resource.

When bacteria are exposed to antimicrobials, resistant organisms may survive and multiply. Repeated, unnecessary

or inappropriate use can increase the selection pressure that favours resistance. The result is antimicrobial resistance, commonly referred to as AMR.

Resistant bacteria do not recognise the boundaries between farms, hospitals and communities. They can move through animals, food, people, manure, wastewater and the wider environment. This is why AMR is considered a challenge affecting humans, animals, plants and ecosystems, and why a One Health approach is essential.

There is some encouraging evidence. The World Organisation for Animal Health reported a 5% decrease in antimicrobial use in animals between 2020 and 2022 among countries that provided consistent data. Nevertheless, the challenge remains serious. A 2025 FAO-led study projected that, without targeted interventions, antibiotic use in livestock could increase by almost 30% by 2040 compared with 2019. The same study indicated that improvements in livestock productivity, animal health and management could substantially reduce this projected increase.

This offers an important lesson: the answer to AMR is not simply to tell farmers to use fewer antibiotics. Sick animals still need treatment. A better strategy is to create production systems in which fewer animals become sick in the first place.

Vaccination, good nutrition, appropriate housing, hygiene, biosecurity, disease surveillance and timely veterinary care can all reduce the need for antimicrobial treatment. In many situations, one of the most effective ways to reduce antibiotic use is to prevent disease before it begins.

What Leaves the Animal Does Not Leave the Story

Meat, milk and eggs receive considerable attention in discussions about livestock production. Much less attention is often given to what animals leave behind.

Manure is valuable. It contains nutrients and organic matter that can improve

agricultural soils and reduce dependence on synthetic fertilisers. With appropriate treatment, it can also be used to produce compost, biogas and energy.

Manure, however, may carry more than nutrients. It can contain microorganisms, resistant bacteria, antimicrobial-resistance genes and residues of medicines used in animals. If it is poorly managed, these materials may enter surrounding soil and water. Rainfall can carry contaminants into surface water, while inadequately treated waste can introduce microorganisms and resistance determinants into agricultural environments.

The farm-to-fork pathway therefore has another important branch:

Farm → Animal → Manure → Soil and Water → Crops, Animals and People

Manure management is consequently not simply a matter of keeping a farm clean. It is a One Health intervention. Proper collection, storage, treatment and application of manure can help retain its agricultural value while reducing potential health and environmental risks. Integrated manure management and appropriate treatment are also important components of efforts to address the environmental dimensions of AMR.

Waste can become either a problem or a resource. Management determines which.

From the Farm Gate to the Kitchen

When an animal leaves the farm, responsibility for food safety does not leave with it. It simply moves to the next link in the chain:

Farm → Transport → Slaughter → Processing → Retail → Kitchen → Consumer

During transport, stress and the mixing of animals from different sources may influence pathogen shedding and transmission. At slaughter, hygiene becomes critical because microorganisms from the animal's hide, feathers or intestinal contents can reach the carcass.

Processing facilities must control cross-contamination, while retailers must

maintain appropriate storage conditions and protect the cold chain. Consumers also have an important role. Keeping food properly refrigerated, separating raw and cooked foods, washing hands and utensils, and cooking food adequately are simple but powerful measures for preventing foodborne disease.

The consumer, however, should not have to carry the entire burden. Safe food arriving in a kitchen is the result of many people doing their jobs correctly long before the shopping bag reaches the home.

An Indian Reality

This connection is particularly important in India, where livestock are closely linked with livelihoods, nutrition and the agricultural economy. Dairy animals, poultry, sheep, goats and pigs contribute to food production and household incomes, while increasingly complex food chains connect farms with rapidly growing urban populations.

These connections can also provide pathways for microorganisms to move between animals, food, people and the environment. Evidence from India illustrates why integrated surveillance is necessary.

A large WHO-AGISAR surveillance study published in 2024 examined foodborne pathogens and antimicrobial resistance at the human–animal interface. Researchers investigated human diarrhoeal cases alongside samples from food-producing animals and meat collected from farms, slaughterhouses and retail shops across northern India. The study found substantial carriage of important foodborne pathogens in food animals and high levels of multidrug resistance among several bacterial groups.

The study also highlights a more fundamental point: human and animal surveillance cannot operate in completely separate worlds. If a resistant organism appears in a hospital, it is useful to know whether related organisms are circulating in animals, food or the environment. If resistance is increasing in livestock, public-health

authorities need to know. When a foodborne outbreak occurs, investigators must be able to trace the organism through the food chain. Microorganisms do not respect the boundaries between sectors. Our surveillance systems should not either.

One Farm, Three Kinds of Health

For much of modern history, human health, animal health and environmental health were treated as separate subjects. Nature, however, has never worked that way.

The same water may be used by animals, crops and people. The same bacterial species may occur in animals, food and humans. An antimicrobial administered to an animal may influence microbial populations beyond that individual animal. Disease may move from wildlife to livestock, from livestock to people, or through contaminated food and the environment.

This interconnectedness lies at the heart of One Health. The concept recognises that the health of people, animals, plants and ecosystems is closely connected.

For livestock farming, One Health does not need to remain an international slogan. It can be remarkably practical. A vaccinated animal is less likely to become sick. An animal that remains healthy is less likely to require antibiotics. Good biosecurity reduces the chance of infection entering a farm. Good nutrition supports both production and health. Clean water protects animals and reduces opportunities for contamination. Better manure management protects soil and water, while disease surveillance can provide an early warning before a problem becomes an outbreak.

Hygienic production also helps protect the food leaving the farm. The same intervention can therefore benefit the farmer, the animal and the consumer.

The Farm of the Future

The livestock farm of the future may look very different from the farm we know today.

Sensors can monitor movement, feeding behaviour, body temperature and rumination. Automated systems may detect subtle changes that signal disease before obvious clinical signs appear. Genomic technologies can help scientists identify and track pathogens and antimicrobial-resistance genes with increasing precision. Rapid diagnostic tests can support faster and more accurate veterinary decisions. These technologies offer enormous possibilities, but technology alone will not make food safer. A sensor cannot replace good husbandry. A sequencing machine cannot compensate for poor hygiene. A new antibiotic cannot provide a permanent solution if it is used irresponsibly.

Some of the most powerful tools remain remarkably simple: clean water, balanced nutrition, vaccination, good housing, biosecurity, hygiene, responsible medicine use and an observant farmer supported by a veterinarian.

The farm of the future therefore needs to be not only more productive. It needs to be more preventive.

The Fork in Our Hand

By the time food reaches our plate, an extraordinary number of decisions have already shaped it. Some were made by the farmer who raised the animal. Others were made by the veterinarian who protected its health, the nutritionist who formulated its feed, the worker who transported it, the people who slaughtered and processed it, the retailer who stored it and, finally, the person preparing it in the kitchen.

Public health is built through all of these decisions.

The future of livestock production cannot simply be a race to produce more meat, milk and eggs. The larger challenge is to produce enough nutritious animal-source food while keeping animals healthy, preserving the medicines on which we depend, protecting the environment and delivering safe food to consumers.

There will be no single answer. Production systems differ. Climates differ. Resources differ. Farmers and communities face different realities.

One principle, however, is universal: healthy animals raised in healthy production systems are an important foundation of healthy food.

The road from farm to fork may be long, but every step gives us an opportunity to make the next one safer. Perhaps that is the most important thing to remember the next time we sit down to a meal.

Food safety does not begin at the kitchen door.
It begins on the farm.

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