

The Medical Impact of Animal Infectious Disease

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A significant non-political crisis we are facing in the world today is the widening gap in the rate of human population increase and the rate of increase in the production of food. The most critical food need is for high quality proteins as evidenced by the disease kwashiorkor (protein hunger) which takes the lives of large numbers of children in many countries and drains the resources of all nations to one degree or another. Although there has been much said about the availability of new food sources or synthetic proteins, protein hunger is essentially and practically a problem of a deficit in animal protein - in meat, fish, eggs, and milk. It remains obvious that diseases of animals substantially reduce the world's supply of these high quality proteins. It is equally obvious that implementing good management practices and proper therapeutic regimens to maintain optimal animal health will result in the opportunity to maintain a supply of animal origin proteins.

Just as the death of animals through various disease processes contribute to hunger in humans, some of these same diseases are also of great importance for their direct effects on human health, zoonotic diseases. The World Health Organization defines Zoonoses as those diseases and infections which are naturally transmitted between vertebrate animals and man. Many infectious diseases of animals such as bovine tuberculosis, brucellosis, streptococcal infections, and various forms of food poisoning due to *Salmonella*, *Escherichia coli*, *Campylobacter jejuni*, *Yersinia pestis*, *Listeria monocytogenes*, etc., may be contracted by people through consumption of infected or contaminated meat, fruits, vegetables, unpasteurized milk and juices, or other foods of animal origin. Other modes of zoonotic disease transmission include feces, urine, saliva, blood, or via aerosol and oral contact with animals or their bedding. The probability of disease transmission from animals to man is influenced by many factors: 1) the length of the incubation period in animals, 2) the length of time the animal is infective, 3) the pathogen load contained in the animal product or placed into the environment, 4) the stability of the agent in the environment, 5) the population density of the animals and humans, 6) animal husbandry practices, 7) maintenance procedures and control of wild rodents and insects, 8) virulence of the microbe, and 9) the route of transmission.

The impact of zoonotic disease in humans are manifested through death, clinical and subclinical illness, personnel-hours lost, monetary losses, adverse effect on the moral of personnel, unfavorable publicity, as well as medicolegal implications. In the case of many of these zoonotic diseases of man, the only way to reduce their impact on human health is to control them in lower animals.

Eradication of the offending pathogen is often called for by those outside of veterinary medicine. It seems reasonable at first glance; however, it is truly not possible to do for such organisms as *Escherichia coli* O157:H7 or various *Salmonella* species, etc. The reasons why are listed in Figure 2. In many cases, there are reservoirs via multiple host species for the organism. It may be possible to reduce the prevalence on the farm, but the prevalence in the wildlife or domestic animal populations will go untouched; thus, allowing the organism to survive and thrive.

One focus of this symposium is to address the legitimate concern regarding the medical impact on human health of antibiotic resistant bacteria. Many questions arise regarding how we may address this multifactorial problem. It is clear that a closer look by animal agriculture at management practices can offer some possible solutions in decreasing the probability of disease transmission from animals to man by looking at such factors as the population density of animals, maintenance procedures and control of wild rodents and insects, and animal husbandry practices in the areas of housing, bedding, clean water, nutrition, vaccines and use of antibiotics on farms.

The use of antimicrobial agents can have a positive impact in reducing the probability of disease transmission from animals to man by shortening the length of time the animal is infective, and reducing the pathogen load contained in the animal product or placed into the environment through facilitating a cure of the disease. However, among several potential solutions presented by everyone involved in this discussion, is a proposal to eliminate the use of antimicrobial agents in animal agriculture. What might be the medical impact of animal disease on humans if this suggestion is implemented?

In some cases, it is reasonable to expect that an increase in pathogen load in or shedding by animals would be accompanied by a proportional increase in human illnesses arising through a given route of exposure. This is likely to be true in cases for which the current human exposure

to the pathogen is infrequent and sporadic. For example, consider a pathogenic bacterium which is shed in milk by cows with subclinical mastitis. Suppose that 1% of cows are shedders, at an average level of 1,000 organisms per ml of milk. In the bulk tank, dilution from non-shedders' milk will reduce the concentration of the pathogen to 10 organisms per ml. Assuming, for simplicity, that no multiplication of the pathogen occurs before pasteurization, the raw milk will enter the pasteurization process at the same concentration. Although pasteurization is a well proven and very effective process, 100% lethality is not achieved, and a tiny fraction of the pathogenic organisms in the milk may survive heat treatment and remain viable in the pasteurized product. A reasonable rough estimate of the surviving fraction for many pathogens in milk would be 10^{-6} , which would be considered a satisfactory reduction in *Salmonella* organisms, for example. Thus in the pasteurized product, viable pathogenic organisms would be present at a density of 10^{-5} organisms per ml, or one per hundred liters. The typical experience of a regular consumer of the pasteurized milk product would be an exposure at infrequent intervals to a single infectious organism. Someone who drank 250 ml per day, on average, would be exposed a little less than once a year on average. In most cases, of course, exposure to a single viable pathogen in this way would not result in infection or illness. The risk to an individual on a daily basis is quite small. Nevertheless, it is likely that a small proportion of these exposures would result in infection and possible illness, with less immunologically competent individuals being at greater risk than the general population.

If the prevalence of shedding of the pathogen doubled for any reason, the end result would be a density of one organism per 50 liters of pasteurized product. Our hypothetical consumer would now, on average, experience twice as many exposures to the pathogen in a given span of time. The likely outcome would be a doubling of the annual incidence of human illnesses from this route of exposure.

Whether it comes about through overuse or the failure to make appropriate use of antibiotics, failure to control pathogens in animal populations may result in increased risks to human health. Domestic animals are of particular concern because of their frequent close contact with immunocompromised humans. During the period that antibiotics have been available in animal agriculture, the rate of change in animal management practices has probably been as great as at any time in history. Today in the United States, food animals are housed in very large numbers, often reaching populations of thousands to hundreds of thousands per farm. The associated high

housing densities and intensive practices have developed together with the use of antibiotic drugs in animals. The consequences of abruptly giving up the veterinary use of antibiotics for animals raised in these conditions are unknown, but the potential for severe disease outbreaks seems real. Increased pathogen load combined with high population density creates opportunities for transmission of pathogens from debilitated to healthy hosts. This state of affairs could favor the evolution of more virulent strains of existing pathogens, because the mobility of infected animals would be less important in transmitting the organism to new hosts.

Ruminants have served and should continue to serve an essential role in sustainable agricultural systems. They are useful in converting renewable resources from rangeland, pasture, and crop residues or other by-products into food edible for humans. With ruminants, land that is too poor or too erodable to cultivate becomes productive. The need to maintain ruminants to utilize these humanly inedible foodstuffs and convert them into high-quality foods for human consumption has been a characteristic of advanced societies for several thousand years. The efficiency with which ruminants convert humanly edible energy and protein into meat or milk is highly dependent on diet, and hence, on regional production practices. Previous studies suggest that in the United States, dairy production efficiency ranges from 96 to 276% on a humanly consumable protein basis. Beef production efficiency is very dependent on the time spent in the feedlot and digestible energy and protein efficiencies range from 28 to 59% and 52 to 104%, respectively. The evidence that ruminant livestock belong in sustainable livestock production systems is convincing and the prudent use of antibiotics as a tool to ease pain and suffering of these animals through disease prevention and cure are important to the survival, health and well-being of our nation..

Figure 1. Potential zoonotic diseases that may be found on the farm

- *Salmonella* species
- *Escherichia coli* O157H7
- *Listeria monocytogenes*
- *Brucella abortus*
- *Staphylococcus aureus*
- *Nocardia asteroides*

- *Yersinia pestis*
- *Campylobacter jejuni*
- *Cryptosporidium parvum*
- *Mycobacterium paratuberculosis*

Figure 2. Criteria necessary for the eradication of a pathogen

1. A single host species with no external reservoir species
2. Identified to be present on only a small percent of the farms, ranches, dairies, feedlots, etc.
3. The pathogen of interest serves as a disease marker for detecting endemic herds
4. Appropriate assays are validated that can correctly identify carrier animals
5. An effective means of intervening in the chain of infection after carrier animals have been removed from the herd must be established
6. Substantial financing- many Billions of dollars
7. Long-term resolve by all involved to fully implement all measures necessary for eradication

Suggested Reading:

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