Zoonotic disease prevention and control strategies

Introduction

Zoonotic diseases are of major concern to both animal and human health and welfare. Zoonoses are diseases caused by pathogens capable of spreading from animals to humans and vice versa. Of the 1, 415 known human pathogens, more than 60% are zoonotic and kill over 14 million people annually (Taylor et al. 2001). Zoonotic pathogens damage biodiversity in sensitive wildlife (Daszak et al. 2000), cause tremendous loss of income in agriculture (Phiri et al. 2003), and cost millions in health care (Torgerson 2003). Since zoonoses affect humans and animals in many ways, it is important to study them. Understanding the zoonotic pathogen and animal interactions aids human health in reducing exposure, developing vaccines, and developing diagnostic and epidemiological tests.

Reducing Exposure

Zoonotic disease prevention is of critical important to humans; if zoonoses cannot infect new hosts, then the large devastation wrought by the pathogens is greatly reduced. One aspect of disease prevention is reducing exposure to the pathogen. Studying animal and zoonotic pathogen interactions can reduce exposure.

Studies on zoonotic pathogens and animal interactions can identify routes of transmission. When routes of transmission are known, then exposure to the pathogen can be avoided. A classical example, toxoplasmosis, caused by the parasite Toxoplasma gondii, is a major health concern in humans. Infections of T. gondii in humans cause abortions in pregnant women, encephalitis, retinochoroiditis and hydrocephalus in children infected while a foetus, and death of patients suffering from acquired immunodeficiency syndrome (AIDS) (Innes 2008). In studying the animal/pathogen interactions, it was found that T. gondii could exist as a protective cyst within the meat of an animal for the remainder of the animal's life (Jacobs et al. 1960). This suggested a possible route of transmission was consuming meat containing T. gondii cyst. In addition, the domestic house cat was discovered to be the definitive host for T. gondii, and that an infective form of T. gondii, not similar to the cyst, could be found in the faeces of the cat (Hutchinson 1965). Because of the knowledge gained from studying the animal/pathogen interactions of Toxoplasmosis, humans are now directed to consume only thoroughly cooked meat, and pregnant/immunocompromised humans are directed to avoid cat faeces (CDC website 2008).

Changes in animal physiology can alter the number of pathogens shed into the environment. Research on pathogen/animal interactions found that stress hormones increase an animal's susceptibility to infection by a zoonotic pathogen. Zoonotic Escherichia coli serotypes O157: H7 (E. coli O157: H7) adheres and colonizes pig intestinal walls when the stress molecule adrenocorticotrophic hormone (ACTH) is present, but non-zoonotic serotypes of E. coli do not adhere more (Schreiber and Brown 2005). E. coli O157: H7 is of great importance to human health. It is transmitted via faecal-oral route, and it causes severe haemorrhagic colitis and haemolytic-uremic syndrome (Lawson 2004). In addition, examination of swine faeces during stressful handling showed an increase of E. coli O157: H7 (Dowd et al. 2007). Swine are not alone in the potential increase in zoonotic shedding due to stress. The stressful transportation of cattle caused an increase shedding of

Salmonella spp., another food-borne zoonotic pathogen (Barham et al. 2003). Armed with this knowledge, humans can alter their behaviour to reduce stress on livestock. This will reduce the potential exposure via food-borne transmission to consumers of the meat, and direct faecal-oral transmission to the handlers.

Developing Vaccine

The study of animal immunological response to zoonotic pathogens has led to the development of vaccines. These vaccines can benefit human health in two ways: indirectly or directly. Indirectly, the vaccines are used on animals. The use of vaccines on animals in zoological pathogens reduces human exposure. Directly, vaccines could be altered for use on humans.

The study of zoological pathogen and animal interactions has led to the creation of many types of vaccines. Vaccination against zoonotic pathogens reduces human exposure. The vaccines reduce exposure in two ways: reduction of reservoir host pool, and reduction of amount of pathogen shed into the environment.

If a vaccine reduces the reservoir host pool of the pathogen around humans, it then limits the human potential exposure. A major example of this is the development of the vaccine for the Lyme disease causing pathogen, Borrelia burgdorferi. Lyme disease is tick-borne. B. burgdorferi has multiple wildlife reservoir hosts including the white-footed mouse (Peromyscus leucopus) and the white-tailed deer (Odocoileus virginianus) (Gomes-Solecki et al. 2006). As the nymph ticks feed on an infected reservoir host, they become infected with B. burgodrferi. When the nymph ticks become adults, they may feed on humans, potentially causing zoonotic transmission. Through studies of host-pathogen interactions in mice, it was discovered that there was an antigen that initiates a large specific immune response from mice (Fikrig et al. 1990). From this knowledge, an oral vaccine has been developed that reduces the amount of B. burgodrferi in wild mice substantially (Gomes-Solecki et al. 2006). It has been proposed that feed baited with this new vaccine could be spread in areas where B. burgodrferi is endemic and the wild field mice are present (Gomes-Solecki et al. 2006). This would effectively reduce the potential size of the host reservoir, thus limiting potential human exposure to zoonotic pathogens. This vaccination method could be applied to other zoonotic diseases.

Additionally vaccines can reduce the amount of pathogens shed into the environment. This method has been used with great success in the reduction of the zoonotic pathogen E. coli O157: H7. Studying the host/pathogen interactions in cattle, it was discovered that the bacterial surface protein intimin was important in intestinal colonization (Dean-Nystrom et al. 1998). Using this knowledge, a vaccine was developed that when given to cattle reduced colonization of the intestines and the amount of E. coli O157: H7 that was shed in faeces (Khare et al. 2010). This vaccine reduces the amount of bacteria present in the environment, thus limiting human exposure via direct oral contact with the environment or food contamination.

Some zoonotic pathogens have similar interactions with humans as with other animals. By studying the interactions between the pathogens and the animals, it is possible to create an animal vaccine model with which a vaccine for humans can be developed. Tuberculosis is caused by the zoonotic intracellular bacteria Mycobacterium spp. Scientist are learning a large amount about intracellular pathogens and how the animal immune responds by using multiple animal models, including bovine (Pollock et al. 2006, Van Rhijn et al. 2008). Vaccines for bovine tuberculosis, developed using knowledge gained in the aforementioned studies, provide models for human vaccines against similar intracellular pathogens (Buddle et al. 2003).

Developing Diagnostic and Epidemiological Tests

A great benefit to human health from studying animal and zoonotic pathogen interactions is the development of diagnostic test that can be used in humans. Zoonotic visceral leishmaniasis is an arthropod transmitted disease caused by the protozoan parasite Leishmania infantum (Chappuis et al. 2007). Visceral leishmaniasis is fatal without treatment in both humans and canines, the animal host. It was discovered that the presence of antigen rK39 is a strong indicator of clinical visceral leishmaniasis in dogs (Goto et al. 2009). Another antigen, L. infantum cytosolic tryparedoxin peroxidise (LicTXNPx), was described and predicted to be a great indicator of both clinical and subclinical visceral leishmaniasis in dogs (Silvestre et al. 2008). A highly specific and sensitive enzyme-linked immunosorbent assay (ELISA) was developed for dogs based on those two antigens (Santarãm et al. 2010). ELISAs are rapid and can confirm the presence of an antigen within minutes. Previous techniques of diagnostics used for leishmaniasis took hours to days to confirm infections (Chappuis et al. 2007). It is predicted that this ELISA could be used in humans (Santarãm et al. 2010), showing how a diagnostic test was developed benefiting human health by studying the interaction of animal and pathogens.

Another potential use for this newly developed ELISA that would benefit humans is using it on dogs. Because the ELISA is rapid, sensitive, and specific, it will identify subclinical infections in canines. Because canines are the major reservoir host, if many dogs in an area test positive for infection, it is an epidemiological indicator that the disease is endemic in that area. This benefits humans, because it will prompt the use of proper epidemiological control mechanism.

Another way that understanding of zoonotic pathogen interactions with animals helps develop epidemiological tests is through finding sentinel animals. A sentinel species is a species that tends to develop notable signs of an infection before humans or other animals (Racloz et al. 2006). West Nile virus (Flaviviridae: Flavivirus) is a major mosquito-borne zoonotic pathogen. West Nile virus can cause mengioencephalitis in humans, and is currently of major epidemiological concern in North America where it had spread across the continent within a matter of years (Murray et al. 2010). American crows (Corvus brachyrhynchos) are very susceptible to infection from the virus pathogen (Reisen et al. 2006). Understanding this relationship between the crow and the virus has allowed epidemiologist to utilize the American crow as a sentinel species. As a sentinel species, the American crow provides an early warning system, notifying human health profession that the virus is within the area. This warning prompts the use of emergency control strategies, benefiting human health.

Conclusion

Understanding zoonotic diseases is of vital importance to humans and animals alike. Zoonoses devalue livestock, harm humans, increase cost of healthcare, and impact wildlife. By studying the ways in which zoonotic pathogens interact with their animal hosts, scientists, doctors and veterinarians are able to benefit human health through reducing exposure, developing vaccines, and developing diagnostic and epidemiological tests.