Are Pig Parasites a Human Health Risk?

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▪ Introduction

The safety of foods we obtain from animals for human consumption has become a public health concern. Because animal fecal waste is distributed on farmland, it is considered a potential source of environmental contamination and therefore a public health risk. Parasites of pigs and their potential to infect humans have recently become a major issue among the public because of recent outbreaks of waterborne parasitic diseases. This article will discuss parasitic diseases of pigs, which have the potential to infect humans and provide reasonable risk assessments for zoonotic transmission (infection from animals to humans).

▪ Giardiasis

Giardia in Humans and Animals

Giardiasis is caused by a microscopic protozoan called *Giardia duodenalis* (syn. *Giardia lamblia*). It has worldwide distribution and is the most common pathogenic intestinal parasite of humans. The parasite colonizes the small intestine of humans and animals leading to moderate to severe diarrhea. Children and immunosuppressed individuals are the most vulnerable. The prevalence of giardiasis in humans is 2-7% in Europe and North America, but it can be as high as 40% in developing countries. *Giardia* is predominantly transmitted through oral-fecal routes (usually between humans) but waterborne and foodborne zoonotic transmission have been reported. Giardiasis is the most frequently diagnosed waterborne disease of humans. Water contamination is associated with human sewage effluent and runoff of agricultural manure. *Giardia* cysts can survive for months in water and are resistant to chlorination, which is used to remove pathogens in water. *Giardia* cysts can be removed from water through filtration or inactivated by boiling

water or powerful chemical agents (e.g. ozone). The World Health Organization recommended that *Giardia* infection be considered as a zoonoses.

Giardia Infections in Pigs

Giardia duodenalis is a common parasite of wild and domesticated animals. *Giardia* has been demonstrated in pigs in Canada, the United States and in Europe. *Giardia* was reported in 4 of 6 hog operations with an overall prevalence of 9% (Olson et al., 1997). In a large Alberta study involving 1602 animals and 50 farms, *Giardia* was documented in 70% of farms and in 8.5% of fecal samples collected (Guselle & Olson, 1999). *Giardia* cysts were identified in 3.8% of piglets, 9.8% of weaners, 10.8% of growers, 15% of finishers, 5.7% of boars and 4.1% of sows (Guselle & Olson, 1999). A significant proportion of feral pigs (7.6%) in California have been shown to be infected with *Giardia* which may pose a serious health risk to humans and a source of infection for domestic pigs (Attwill et al., 1997). *Giardia* cysts are have been shown to be degraded in hog liquid manure holding tanks and therefore it is unlikely that distribution of liquid manure poses a serious threat for contamination of surface water (Guselle & Olson, 1999).

Zoonotic Transmission

There is strong evidence to show that at least some *Giardia* isolates are not host specific (will infect more than one animal species) while others are host adapted (only infect one animal species). Thus some strains have a higher potential for human infection than other strains. Although few porcine *Giardia* strains have been bio-typed, most isolates that have been characterized are pig specific and therefore unlikely to cause human infections (Ey et al., 1998, Guselle & Olson, 1999). Clearly more work is required to compare human and pig *Giardia* isolates.

▪ Cryptosporidiosis

Cryptosporidium in Humans and Animals

Cryptosporidium parvum is a small protozoan coccidian parasite that colonizes the small intestine of many animals, including man. This parasite has intestinal forms that multiply within the intestine and environmentally resistant oocysts and which are shed in the feces. Until the 1970's *Cryptosporidium* was considered unimportant. Over the past 30 years this parasite been identified in severe intestinal disease in both humans and animals. *Cryptosporidium parvum* infects humans and a wide variety of domestic (e.g. cattle, pigs, horses, sheep, dogs, cats) and wild mammals. Other species of *Cryptosporidium* infect birds (*C. baileyi* and *C. meleagridis*) fish (*C. nasorum*), reptiles (*C. serpentis*)

and small rodents (*C. muris*). Animals and humans can be infected, but not show any symptoms. In young and immuno-suppressed individuals, severe watery diarrhea may develop. The clinical signs usually coincide with oocyst excretion and usually persist for 1-2 weeks. In immuno-compromised humans the infection is usually more severe and longer. It is frequently life threatening in humans undergoing immuno-suppressive chemotherapy (transplantation, cancer) or with infections which damage the immune system (e.g. human immuno-deficiency virus - HIV).

Cryptosporidium is transmitted by the oral-fecal and waterborne route. Poor hygiene leads to transmission between humans and from animals to humans. Fecal contamination of water by animals and humans may lead to waterborne outbreaks of cryptosporidiosis. Such an outbreak occurred in Milwaukee, Wisconsin and led to the infection of over 5,000 humans.

Cryptosporidosis in Pigs

Although there are few studies, *Cryptosporidium* has been demonstrated in pigs throughout the world. Cryptosporidiosis may be responsible for diarrhea in piglets. In a Canadian study, *Cryptosporidium* was identified in 3 of 4 sampling sites with an overall prevalence of 11% (Olson et al., 1997). In a larger Alberta study, *Cryptosporidium* was demonstrated in 32% of 50 farms sampled with a 2.8% overall prevalence (Guselle & Olson, 1999). Infection was predominately in weaners (10.4%). Oocysts were demonstrated in only 1% of hog liquid manure samples and no oocysts were found in soil samples where liquid hog manure had been spread. These data indicate that this parasite in hogs is not an environmental concern provided that manure is handled responsibly (Guselle & Olson, 1999).

Zoonotic Transmission

Most human infections are acquired by person to person transmission (day care centres, hospital acquired infections) and through consumption of drinking water contaminated by human sewage. Zoonotic infections have been attributed to contact with infected calves. There are several reports of veterinary students, farm workers and researchers developing infections after exposure to animals shedding large numbers of cysts (Coop, 1998). There are no reports of humans being infected with *Cryptosporidium* from pigs. Most likely the strain of *Cryptosporidium parvum* that is carried by pigs is not infective to humans.

▪ Toxoplasmosis

Toxoplasma in Humans and Animals

Toxoplasmosis is a protozoan disease caused by the microscopic parasite *Toxoplasma gondii*. It is prevalent in humans and animals throughout the world. There are three infective stages of *T. gondii* which include tachyzoites (multiplies within the host), bradyzoites (in tissue cysts) and sporozoites (in oocysts). Cats are the definitive hosts but oocysts excreted by cats can infect a wide variety of mammalian hosts (cattle, goats, sheep, pigs, chickens) where cysts containing bradyzoites develop within their tissue. Ingestion of these bradyzoites can lead to infections in humans.

Infection with *T. gondii* is widespread in human and animals. In North America it is estimated that 16-40% of people are infected. Most infections in humans and animals are asymptomatic but parasite can occasionally cause devastating congenital infections leading to abortions and birth defects. Postnatally acquired infection may be localized or generalized. Fever, muscle pain, enlarged lymph nodes, headache and stiff neck are the most common symptoms in humans. Toxoplasmosis is frequently the cause of death in severely immuno-suppressed individuals (eg. AIDS).

Toxoplasmosis in Pigs

Toxoplasma has been demonstrated in pigs worldwide. Serological testing of pigs in the United States and Canada have shown sero-prevalences between 3.5 to 48% (Gajadhar et al., 1998, Gamble et al., 1999). In the Canadian study involving 2,800 market hogs, 8.5% were seropositive (Gajadhar et al., 1998). When tissue collected from seropositive animals was examined, only 25% of the positive animals had evidence of Toxoplasma RNA and none successfully infected mice (Gajadhar et al., 1998). *Toxoplasma* was not found on farms where pigs were raised under total confinement. Infection in pigs is associated with exposure to cats and contaminated soil (Gajadhar et al., 1998, Davies et al., 1998).

Zoonotic Transmission

The frequency of infection through the consumption of contaminated raw meat and that due to ingestion of food contaminated by fecal oocysts from cats is not known. Tissue cysts are killed by cooking meat to over 67 ^{o}C or cooling to less than -13 ^{o}C. Tissue cysts in pork can be eliminated by raising pigs in the absence of cats and ensuring that cat feces does not contaminate pig food. Pork produced under modern contained production systems is considered an extremely low risk of containing *Toxoplasma* oocysts. The majority of human

infections are probably associated with their contact with fecal oocysts shed by cats (Dubey, 1998).

▪ Sarcocystosis

Sacrocystis in Humans and Animals

There are two known species of *Sacrocystis* that can infect humans. *Sarcocystis hominis* produces diarrhea, stomachache and nausea following consumption of raw beef that contains muscle cysts. *Sacrocystis suihominis* produces more severe but similar clinical signs following ingestion of uncooked pork containing muscle cysts.

Sacrcocystis in Pigs

No survey of *Sacrocystis* in pigs has been conducted. It is believed to be rare in North America (Dubey, 1998).

Zoonotic Transmission

These infections are rare but have been reported in humans from Asia, Europe South America and North America. To prevent infections, meat should be cooked before human consumption. Infection in pigs can be prevented by avoiding the feeding of human feces or effluent to pigs. Obviously, this practice is not a component of modern hog production systems.

▪ Blastocystosis

Blastocystis in humans and animals

Blastocystis is a microscopic protozoan parasite, which has been shown to be present in a wide variety of mammals, reptiles and birds. *Blastocystis hominis*, the parasite of humans, has not yet been proven to cause clinical disease in either humans or animals. There is speculative data on the prevalence, mode of transmission and the importance of animal reservoirs. It is proposed that *B. hominis* is transmitted by the oral fecal route but waterborne and foodborne transmission have been suggested.

Blastocystis in pigs

Blastocystis have been demonstrated in hogs worldwide. Molecular and serological typing of *Blastocystis* have shown that there are distinct differences between pig and human isolates (Boreham et al, 1998).

Zoonotic transmission

It is not determined that *B. hominis* is a zoonoses but certainly the a parasite with similar morphology to *B. hominis* has been identified in many domestic and wild animals. There is minimal data to support zoonotic transmission but in one study 44% of 121 patients with *B. hominis* had a history of exposure to farm animals. Pigs are an unlikely source of this disease in humans.

▪ *Taenia solium* (Tapeworms)

Taenia infection in Animals and Humans

The adult tapeworm exists in humans while the metacestodes exist in domestic and wild pigs as well as humans. This disease exists under conditions where pigs have access to tapeworm eggs and segments. Inadequate cooking or consumption of raw meat containing metacestodes (measly pork) may lead to infection in humans. When humans ingest eggs, metacestodes develop within the muscle, under the skin, in the intestine, brain and spinal cord. The human to human transmission of disease results in the most clinically serious forms of the disease. Cystercystosis (metacestodes within tissue) can lead to pain at the site of the cysts, swellings, fibrosis, granulomas and calcification. When the metacestodes are located within nervous tissue, patients can experience paralysis and seizures that can be fatal.

Taenia infection in pigs

Taenia solium has not been reported in Canadian pigs for over 2 decades. In Canada, *Taenia solium* infection is a reportable disease. It is a common parasite of pigs in developing countries throughout the world.

Zoonotic Transmission

Zoonotic transmission of *Taenia solium* occurs in countries were pigs have access to human feces. Prevention of animal to human transmission is achieved by thorough meat inspection and adequate cooking contaminated meat. Zoonotic transmission of *Taenia solium* has not been reported in Canada for over 20 years because pigs in modern production systems are not in contact with human feces.

▪ Trichinellosis

Trichinella spiralis in Humans and Animals

Trichinella spiralis is a nematode parasite of humans, some domestic animals (pigs, horses) and carnivorous wild mammals (eg. bears). *Trichinella* is unusual because the worm undergoes complete development from larva to adult to larva in the body of a single host. Infective larvae are found encapsulated within cysts in the muscle. Ingestion of meat with viable larvae leads to digestion of the cyst by the host digestive enzymes thus releasing the larvae. The larvae invade the lining of the small intestine where it matures into an adult. After mating with a male, the female worm releases larvae. The newborn larvae enter the blood stream and penetrate into muscle fibres where the larvae become a cyst. The unusual life cycle restricts transmission to carnivores with cannibalistic and scavenger habits. In domestic animals, the deliberate or unintentional feeding of rats and pig tissue leads to infections. Humans become infected when they consume uncooked wild or domestic meat containing viable larvae. The severity of clinical signs depends upon the number of ingested larvae. During the intestinal phase patients may be without symptoms or develop diarrhea or abdominal cramps. The extraintestinal stage of infection is characterized by fever, muscle tenderness, weakness and urticaria (allergic rash).

Trichinella spiralis in pigs

Trichinellosis in pigs is a reportable disease and Agriculture Canada conducts an extensive monitoring program of animals at slaughter. Testing of over 30,000 market hogs per year between 1980 and 1997 yielded only 3 cases which were localized to the same area of Nova Scotia (Gajadhar et al., 1997). In this case, eradication programs were initiated by Agriculture Canada.

Zoonotic Transmission

Human consumption of contaminated meat can lead to infection. Prevention of zoonotic transmission in hogs can be achieved by:

- strict adherence of garbage feeding regulations
- rodent control
- preventing the exposure of pigs to dead pigs and other animal carcasses
- prompt disposal of dead pigs and other animal carcasses
- provision of barriers between pigs and other wild and domestic animals.

Pigs as a source of *Trichinella* has declined over the past years and the last reported case of trichinellosis in Canada which occurred from consumption of domestic pork was in 1980 (Gajadhar, 1997). Over the past decade, trichinellosis has resulted from the consumption of wild mammals (eg. bear, walrus) or wild boar. In the latter case 28 people developed clinical trichinellosis after consumption of improperly cooked wild boar meat from 2 animals.

▪ Ascariasis And Visceral Larval Migrans

Ascaris in humans and animals

Ascaris lumbricodes is the largest intestinal roundworm of man and is especially common in the tropic and subtropics. *Ascaris suum* is the common roundworm of pigs. Pigs and humans become infected by ingestion of eggs, which have developed to an infective stage in the environment. *Ascaris* eggs are environmentally resistant. After hatching the larvae penetrate the gut wall, pass through the liver and migrate to the lung. The larvae are coughed up and swallowed to develop to mature worms in the small intestine. Ascariasis in both species produces ill thrift, stunting, pot belly and diarrhea.

Ascaris infection in pigs

In Saskatchewan examination of up to 50% of abattoir pig livers demonstrated scarring associated with migration of ascarid larvae (Wagner & Polly, 1997). *A. suum* eggs under dry conditions survive for 2-4 weeks while under a moist and cool environment they can survive for over 8 weeks (Gaasenbeek & Borgsteede, 1998). The routine use of anthelminths (eg. Ivermectin) and containment, which breaks the parasite life cycle, have dramatically reduced the prevalence of *Ascaris* infection in pigs. *Ascaris* was identified in 60% of 50 Alberta farms but only 8.5% of 1602 animals were infected (Guselle & Olson, 1999). *Ascaris* was only identified on farms that kept dry sows outdoors on soil.

Zoonotic transmission

The larvae of *Ascaris suum* can migrate into the tissues of many animals including man. Under certain circumstances *Ascaris suum* can produce infections in man. Because *Ascaris suum* cannot be differentiated from *Ascaris lumbricoides* it is often difficult to determine the source of human infections. It is generally accepted that humans are infected by expose to infective eggs from human feces. Human infection from pigs is rare (Anderson & Jaenike, 1997). Because *Ascaris* eggs were identified in only 1% of samples from manure storage lagoons, there is a minimal risk of human infection from

environmental contamination of water or soil by hog manure (Guselle & Olson, 1999).

▪ Conclusion

Although parasites can be identified in some pigs, the prevalence of these parasites are generally low or absent. Some pig parasites such as *Taenia* and *Trichinella* have been virtually eradicated from Canada. Some parasites such as *Cryptosporidium*, *Blastocystis*, and *Sarcocystis* are infrequently found in Canada and the strains found in hogs are most likely not infective to humans. *Ascaris suum* is occasionally identified but only in hog operations that house dry sows outdoors on contaminated soil. In these operations *Ascaris* infections can be controlled by anthelminthic therapy. Environmental contamination is not a major concern because *Ascaris suum* eggs have not been identified in soil after distribution and incorporation of manure. *Ascaris suum* larval infection in humans has not been reported in over 20 years. Human infections from ingestion of *Toxoplasma* contaminated meat have not been reported but infections in pigs need to be controlled by separation of pigs from cats and cat feces. *Giardia* in pigs may pose a minor threat to humans but *Giardia* strains may be specifically adapted to pigs. In conclusion, throughout Canada, pigs, pork products and waste generated by pork production have a minimal to no risk of transmitting parasitic diseases to humans. This may not be the same in other countries

▪ Acknowledgement

The Canada-Alberta Hog Industry Development Fund is gratefully acknowledged for funding the survey of parasites on Alberta hog farms.

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