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ENTERIC PATHOGENS OF DOGS AND CATS WITH PUBLIC HEALTH IMPLICATIONS

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ABSTRACT

Dogs and cats play an important role in modern society, enhancing the psychological and physiological well-being of many people. However, there are well-documented health risks associated with human animal interactions. More specifically, enteric pathogens of zoonotic risk which are transmitted by feces of dogs and cats can be grouped as follows: (a) Parasites such as *Toxocara canis*, *T. cati*, Ancylostoma sp, *Uncinaria* sp, *Strongyloides stercoralis*, *Echinococcus granulosus*, *E. multilocularis* and Dipylidium caninum (b) Protozoa including *Toxoplasma gondii*, *Giardia duodenalis* and *Cryptosporidium* spp. (c) Bacteria of the genera *Clostridium*, Campylobacter, Salmonella, Escherichia, Yersinia and *Helicobacter* and (d) Viruses mainly *Rotaviruses* and *Coronaviruses*. Among them, Salmonella, Campylobacter, *Rotaviruses*, *Toxoplasma gondii*, *Echinococcus* have been reported to be of considerable importance for many countries including Greece. Even though official records of the cases in humans and livestock in Greece continuously decline, cystic echinococcosis is considered to be a serious problem for public health and livestock economy. Regarding other parasites, the overall prevalence of parasitism was 26% in owned shepherd and hunting dogs examined in Serres. Furthermore, seroepidemiological studies revealed the presence of antibodies against *T. gondii* in a considerable percentage of hospitalized children. *Rotaviruses* were confirmed as a major cause of acute gastroenteritis in children. Finally, bacterial zoonotic enteropathogens were identified in a notable number of pediatric cases. Most of these zoonoses are associated with the exposure of immunodeficient people or children to pets and/or conditions of poor hygiene. Studies on the presence of all these pathogens in animals are required to identify the extent of problem, to define control strategies and evaluate their effectiveness.

Keywords: Dog, Cat, Enteropathogens, Public Health, Zoonoses

1. INTRODUCTION

The relationship between humans and dogs began 12,000-15,000 years ago and with cats nearly 5,000 years ago (Morey, 1994). Nowadays, the number of dogs worldwide has been estimated to be more than 500 million. Apart from the psychological advantages, pet ownership has physiological benefits for many members of the society, such as a reduction in blood pressure (Wilson, 1991), reduced medication (Headey and Krause, 1999) and increased one year survival after an acute myocardial infarction (Friedmann and Thomas, 1995).

Owning a dog or cat is a common phenomenon throughout the world: In the USA 61% of households have a pet and more than half of families that have a dog also have a child (Macpherson, 2005). Similarly in Europe percentages of companion animals including birds in households varies and the average is 52% for all

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the 17 European countries (Macpherson, 2005). Unfortunately, the owners may abandon their pets which results in large numbers of unwanted stray dogs, mostly in countries without dog population well-established control programs, such as Greece (Macpherson, 2005).

Although human interaction with pets has been proven beneficial for pet owners, the risk of interspecies transmission of pathogens cannot be passed by when certain hygienic rules are not followed. Nowadays, control of zoonotic diseases is even more important due to the increasing number of immunocompromised people but the distribution of pets around the world and their differences modify their role in zoonotic disease transmission. The risk of pathogen transmission from pet to the owner is relatively small, when simple precautions are taken. Therefore, the role of veterinarians is essential since they have to provide pet owners with accurate information. This review focuses on zoonotic important enteropathogens, particularly these encountered in Greece and suggests preventive measures.

2. ENTEROPATHOGENS OF COMPANION ANIMALS

Numerous enteropathogens are detected in feces of dogs and cats but they do not all have the potential for transmission to humans (Bugg *et al*., 1999). Consequently, this review refers mostly to the enteropathogens with high risk of zoonotic transmission which can be classified as parasites, protozoa, bacteria and viruses, as summarized in **Table 1**.

2.1. Intestinal Parasites

The intestinal parasites with high risk of zoonotic transmission from animals to humans are divided in the following categories.

2.1.1. Nematodes

2.1.1.1. *Toxocara Canis*/*Toxocara* Cati

The prevalence of *T. canis* and *T. cati* has decreased during the last twenty years (Overgaauw, 1997; Bugg *et al*., 1999), probably due to the regular administration of broad-spectrum anthelmintics in companion animals. However, in USA, the most common zoonotic parasitic infestation acquired from companion animals was human toxocariasis (Schantz, 1994). People become infected when they accidentally ingest eggs containing L_2 larvae. It has been shown (Holland *et al*., 1995) that *Toxocara* was present in the intestine of 80% of dogs younger than 6 weeks, although the results of fecal examination were often negative.

Table 1. Zoonoticenteropathogens; the most important zoonotic agents for Greece are marked

Parasites	
I. Nematodes	II. Cestodes
*Toxocara*canis (Greece)	*Echinococcusgranulosus* (Greece)
*Toxocara*cati	*Echinococcusmultilocularis*
Ancylostoma	*Dipylidiumcaninum*
Uncinaria	
Strongyloidesstercoralis	
Protozoa	
Toxoplasma gondii(Greece)	
Giardia duodenalis	
Cryptosporidium spp.	
Viruses	
Rotavirus(Greece)	
Coronavirus	
Bacteria	
Clostridium spp	
Salmonella spp. (Greece)	
Campylobacter spp. (Greece)	
E. coli	
Yersinia spp.	

The host becomes infected with *T. cati* by swallowing embryonated eggs of the parasite. It should be assumed that all young animals are infected with *Toxocara* and should be treated accordingly. In the external environment, the eggs survive for months and consequently toxocariasis represent a significant public health risk (Overgaauw, 1997).

2.1.2. Ancylostoma/*Uncinaria*

The larvae of hookworms (Ancylostoma and *Uncinaria*) can penetrate the skin of humans as well as the skin of canine or feline host. This disease is more common in areas of higher humidity (tropical and subtropical regions). Particularly, sunbathers or people who walk around barefooted are at higher risk of acquiring this infestation. It is probable that this condition is under-diagnosed, as the worm could be overlooked in pathological specimens and may be more common (Walker *et al*., 1995). If there are many larvae, they can penetrate into deeper tissue and cause pulmonary or intestinal symptoms (Robertson *et al*., 2002).

2.1.3. Strongyloides *Stercoralis*

Infection of dogs and cats with *S. stercoralis* is generally rare (Bugg *et al*., 1999). Infected animals may be asymptomatic; however, severe clinical illness can also occur. Severe diarrhea and bronchopneumonia can be caused by *S. stercoralis*. When massive infection occurs, the migration of the worm through the body may result in fever, nausea, vomiting and severe diarrhea. The disease can easily be confused with viral diseases, more common in young companion animals. In immunocompromised people, it can cause a life-threatening disease (Siddiqui and Berk, 2001).

2.2. Cestodes

2.2.1. *Echinococcus granulosus*/ E. multilocularis

The life cycle of *Echinococcus* involves two mammalian hosts. The definitive hosts are carnivores (dogs in the case of *E. granulosus*, foxes and dogs for *E. multilocularis*) while the intermediate hosts (usually herbivores or humans) become infected by the accidental ingestion of eggs (Deplazes and Eckert, 2001). Playing with dogs without adult supervision could become risky for children, as eggs adhere to dog's hairs and children may accidently shallow them. After ingestion of the eggs the larvae develop into cysts (hydatid cysts-hydatid disease). Alveolar hydatid disease which is caused by *E. multilocularis* is an emerging infection in the USA, Western Europe and Japan and the cysts of *E. multilocularis* can invade internal organs leading to potentially life-threatening consequences (Deplazes and Eckert, 2001). Naturally, transmission of *Echinococcus* spp. results from a predator-prey relationship. However, human activities (i.e., feeding the viscera of home-butchered sheep to dogs or rabies vaccination through baiting of fox population in Europe) have resulted in establishment of wild animal cycles that serve as reservoirs (Thompson, 1992). The carcasses of animals close to urban areas are also potential sources of infection for companion animals.

2.2.2. *Dipylidium Caninum*

D. caninum is another intestinal tapeworm which can affect both dogs and cats. It is rarely found in humans. Fleas and lice are its intermediate hosts and final host becomes infected by ingesting cysticercoids (Raschka *et al*., 1994). Humans, especially children, become infected through accidental ingestion of infected fleas. This infection is usually asymptomatic. The symptoms from this infection are self-limiting and they disappear with time (Robertson *et al*., 2002).

2.3. Protozoa

2.3.1. *Toxoplasma Gondii*

Humans and other animals are frequently infected with *T. gondii* (Cook *et al*., 2000). Cats are the only definitive host for this parasite and they excrete oocysts (Tenter *et al*., 2000). In a study in the USA, less than 1% of cats examined have been shown to be shedding oocysts (Dubey, 1994). Humans become infected with *T. gondii* by ingesting soil contaminated by cat feces or more frequently by eating meat not properly cooked which contains bradyzoites or tachyzoites (Angulo *et al*., 1994; Cook *et al*., 2000). Infection with *T. gondii* is relatively common in humans and in most cases it is asymptomatic. The symptoms can vary from person to person when illness occurs. However, when an immunocompromised person or an unborn child becomes infected in utero, the clinical condition is far more dangerous. Also, humans can be infected with toxoplasmosis by organ transplant, but this is very rare (Robertson *et al*., 2002).

2.3.2. *Giardia Duodenalis*

G. duodenalis is considered to be the most common pathogenic intestinal parasite of humans and its prevalence has been found to be 2-7%. Humans are likely to be the main reservoir of human giardiasis according to epidemiological evidence and person-to-person transmission is probably more important than zoonotic transmission (Schantz, 1991). However, dogs and cats can carry strains of Giardia which may be able to infect humans as well (Hopkins *et al*., 1997).In a recent study, the prevalence of *Giardia* spp. in stray dogs was found to be 7.14% (Mirzaei, 2010). Consequently, zoonotic transmission cannot be excluded, especially for immuno compromised people. Clinical giardiasis usually concerns kennels or catteries, which are overcrowded. These places are important sources of new pets for households, but these animals may be infected (Robertson *et al*., 2002). It is crucial to treat properly Giardia-infected dogs, even if they are not clinically ill, because of the potential for zoonotic transmission (Robertson *et al*., 2002).

2.3.3. *Cryptosporidium*

Cryptosporidium is a genus of protozoan pathogens and induces diarrhea in humans and domestic animals. Infection with *Cryptosporidium* is one of the most common non-viral causes of diarrhea (Current and Garcia, 1991). Most often *Cryptosporidium* affects children, particularly those who attend childcare centers. People may become infected with *Cryptosporidium* from their pets (Sargent *et al*., 1998). Among the eight different genotypes of *C. parvum* that have been reported only two appear to be capable of infecting immunocompetent humans (Morgan *et al*., 1997). However, it is possible for other genotypes, including the genotype found in dogs, to infect individuals, whose immune system does not function properly, as in HIV infected individuals (Pieniazek *et al*., 1999). Most infections of dogs with *Cryptosporidium* are asymptomatic. Clinical cryptosporidiosis appears to be most severe in children. Risk factors of acquiring cryptosporidiosis are stress, overcrowding and immune suppression (Robertson *et al*., 2002). In immunocompromised people infection can lead to a serious, life-threatening illness. Thus, early diagnosis and treatment is crucial.

2.4. Bacteria

2.4.1. *Campylobacter* Spp

Campylobacter spp. are gram-negative motile rods. There are 37 species and subspecies in the genus, but most of them are considered to be nonpathogenic. Many pathogenic *campylobacter* species such as *C. jejuni* ssp. *jejuni* and *Campylobacter* coli induce diarrhea in dogs, cats and humans (Marks *et al*., 2011). The association between diarrhea and the presence of *Campylobacter* in the feces has been investigated in many studies. However, it has been found that the isolation rates were similar in healthy and diarrheic animals (Sandberg *et al*., 2002; Rossi *et al*., 2008). In puppies and dogs younger than 12 months of age, it was observed that *C. jejuni* and *C. upsaliensis* had a prevalence rate in diarrheic animals over two times that of non diarrheic animals. This association was not observed in animals of older age (Burnens *et al*., 1992). When puppies were experimentally infected with *C.* jejuni, mild clinical disease occurred; therefore *Campylobacter* was considered potentially pathogenic (Makartney *et al*., 1988). It may be transmitted from dogs to humans, as a relationship between *C. jejuni* enteric diseases in humans with the ownership of a puppy has been found in epidemiologic analyses (Stafford *et al*., 2007). Children and immunocompromised individuals who own young pets are at greater risk of becoming infected by contact with dogs or cats while other sources of infection such as food products are the most commonly incriminated (Marks *et al*., 2011).

2.4.2. *Salmonella* Spp

Salmonellae are microorganisms that can infect mammals, birds, reptiles. *Salmonellae* are pathogenic for dogs and cats, but not all *Salmonella* strains can induce disease depending also on the infectious dose. The prevalence of *Salmonella* spp. in healthy dogs and cats was found to be equal as in animals with diarrhea in a study (Marks and Kather, 2003). In animals with diarrhea the prevalence of *Salmonella* spp. ranges from 0 to 3.5% in dogs (Van Duijkeren and Houwers, 2002; Hackett and Lappin, 2003) and from 0 to 8.6% in cats (Immerseel *et al*., 2004). The prevalence of *Salmonella* spp. in stray or shelter dogs and cats is 0-51.4% (Spain *et al*., 2001; Kocabiyik *et al*., 2006). Furthermore, the prevalence of *Salmonella* spp. was found to be much higher in dogs that are fed raw food diets and it was also isolated from 30% of the stool samples in greyhounds fed raw chicken diets (Joffe and Sclesinger, 2002). Salmonellosis is a disease of major zoonotic importance. All *Salmonella* microorganisms infect both animals and humans except for those causing human typhoid fever. More frequently, people become infected due to foodborne outbreaks after consuming contaminated products of animal origin that have been improperly stored or handled. It has been also observed (Gradel *et al*., 2008) that patients with malignancy in the hematopoietic system are at increased risk of being infected with Salmonella.

2.4.3. *Clostridium* Spp

Clostridium spp. are gram-positive anaerobic spore-forming bacilli. *Clostridia* are among the most widespread pathogenic bacteria and they are part of the natural micro flora of the gastrointestinal tract. *C. perfringens* and *C. difficile* are two of the most common enteropathogens which cause diarrhea in dogs. They are not considered pathogens of high zoonotic risk. However, they can be found in feces of the animals and spores survive in feces or decomposed tissues. People more often acquire this infection after consumption of contaminated food (Jhung *et al*., 2008; Songer, 2010) or during hospitalization. It was found that *C. difficile* was the cause of 10-21% of cases of diarrhea in dogs in the general population (Cave *et al*., 2002). In several studies *C. difficile* was found in 0-58% of healthy animals and especially in younger animals that visit human hospitals (Marks *et al*., 2002; Clooten *et al*., 2003). Consequently, it is safer for public health to consider *C. difficile* as potentially zoonotic (Arroyo *et al*., 2005; Weese *et al*., 2010). *C. perfringens* can be isolated from more than 80% of diarrheic and non-diarrheic dogs (Weese *et al*., 2001), whereas it is found more rarely in healthy cats and the isolation rates range between 43 and 63% (Marks *et al*., 2011). *C. Perfringens* Enterotoxin (CPE) is found in 34% of diarrheic dogs (Weese *et al*., 2001). Animals may be responsible for transmission of the pathogen among species.

2.4.4. *Escherichia Coli*

E. coli are gram-negative, non-spore-forming rods belonging to the family Enterobacteriaceae. *E. coli* are part of the normal intestinal microflora, but they can cause gastroenteritis when local or systemic immunity does not function properly. Enteropathogenic strains of *E. coli* (EPEC) have been found in human patients and dogs that live in the same household (Rodrigues *et al*., 2004). In a more recent study, feces from 70 cats with diarrhea and 230 without diarrhea were collected and 15 enteropathogenic strains were isolated from 14 of them, whereas none enterotoxigenic *E. coli* (ETEC) or enterohemorrhagic *E. coli* (EHEC) were not found (Morato *et al*., 2009). Those strains include serotypes known as human pathogens. So, we should consider the possibility of zoonotic transmission in cases of disease outbreaks (Marks *et al*., 2011).

2.4.5. Yersinia *Enterocolitica*

Y. *enterocolitica* is a species of gram-negative coccobacillus-shaped bacteria, belonging to the family Enterobacteriaceae. It infects many animal species and it is resistant to the external environment (Wang *et al*., 2010). It has been isolated from feces of healthy dogs and cats. Domestic animals excrete *Y. enterocolitica* in their feces for many weeks and may be a source of infection for humans. In a survey in China from 2004 to 2008, 326 strains of *Y. enterocolitica* were isolated from people with diarrhea and it was demonstrated that there is a close relationship between strains of domestic dogs and of humans' strains (Wang *et al*., 2010). Nevertheless, the direct zoonotic transmission of *Y. enterocolitica* has not been proven until now (Robins-Browne, 1997). However, people who have come into contact with infected animals suffered from enterocolitis, indicating possible zoonotic transmission (Wang *et al*., 2010).

Other pathogens have also been reported as being responsible for causing zoonotic diseases such as *Helicobacter* spp, *Anaerobiospirillum* spp.

2.5. Viruses

2.5.1. *Rotaviruses*

Rotaviruses are pathogens which induce acute watery diarrhea in various host species, including birds and mammals. *Rotaviruses* are classified into a genus within the family Reoviridae. Their genome consists of 11 segments of double-stranded (ds) RNA (Estes, 2001; Kapikian, 2001). They are resistant to conditions of external environment. Until now, seven serogroups (A to G) of rotavirus have been defined. Mainly group A *Rotaviruses* (GARVs) induce diarrhea in humans, mammals as well as poultry. GARVs infect individuals mainly via fecal-oral route. Their resistance in the environment may be responsible for water- or food-born transmission and outbreaks. Non-GARVs are not considered to be of importance for public health. GARVs are not considered as major enteric pathogens for companion animals but rotavirus-like particles were found in stool samples from both symptomatic and asymptomatic pets (Marshall *et al*., 1987). *Rotaviruses* usually affect particular species for which they have been defined as the homologous strains. However, heterologous rotavirus may infect other species in natural and experimental conditions. It has been proven that human GARV strains exist in stool samples from newborn animals with diarrhea (Kapikian, 2001). Nowadays there are plenty evidence for interspecies transmission and for genetic reassortment between human and animal *Rotaviruses* (Martella *et al*., 2009). The results of a recent study demonstrate that canine-like *Rotaviruses* may be responsible for interspecies transmission and also to induce severe forms of gastroenteritis in children. As most Rotavirus infections in pets may not be detected, the chance of complete epidemiologic surveillance is reduced . In conclusion, improving epidemiological surveillance in both animals and humans is crucial for understanding virus evolution, examining the results of the vaccines on reducing Rotavirus impacts and planning novel vaccine strategies.

2.5.2. *Coronaviruses*

Coronaviruses belong to family *Coronaviridae* and they are large, single stranded positive-sense RNA viruses. They infect many animal species and they cause enteric and respiratory disease (Enjuanes *et al*., 2000). *Canine Coronavirus* (CCoV) is an important enteropathogen of dogs, as it has caused many outbreaks (Decaro and Buonavoglia, 2008). CCoV is widespread in canine population, mainly in kennels and shelters, which are overcrowded, according to serological and virological investigations (Naylor *et al*., 2001; Schulz *et al*., 2008). Infection with *Canine Coronavirus* is characterised by high morbidity and low mortality and it is transmitted via the fecal-oral route (Tennant *et al*., 1991). It rarely infects people. However, The Severe Acute Respiratory Syndrome (SARS) is common and this fact has enhanced the suspicion that *Coronaviruses* may be responsible for zoonotic transmission. Besides that, in China, there were found SARS virus like *Coronaviruses* in a masked palm civet and a raccoon dog, two wild carnivore species. Following sequence analysis, the human and civet viruses' origin presented 99% homology although placed in different clusters (Bhardwaj, 2013). Also, changes in virulence, tissue tropisms and interspecies transmission of CCoVs have been found and they occur due to genetic variations in structural and non-structural proteins of the virus (Guan *et al*., 2003; Vijgen *et al*., 2005). In conclusion, zoonotic transmission cannot be excluded, as long as *Coronaviruses* are not strictly host specific.

3. PUBLIC HEALTH SIGNIFICANCE

Among all the above presented pathogens likely to cause zoonotic diseases in humans and especially in children, the most important are considered the following:

3.1.1. *Salmonella* Spp

Despite the advances in hygiene and handling of food, salmonellosis continues to be an important public health problem (Sánchez-Vargas *et al*., 2011). Salmonellosis is very common in developing countries; it affects mostly kids under 5 years old, while *Salmonella* spp. has become resistant to many antibiotics (Graham, 2002). In a recent study of 79 cases in U.S.A., a correlation was found between diarrhea due to *Salmonella* spp. and handling dry dog or cat food. In 49% of these cases, salmonellosis affected children under the age of two (Behravesh *et al*., 2010).

3.1.2. *Campylobacter Spp*

In a recent study, it was found that *Campylobacter spp*. was the most frequent bacterial cause of diarrhea in human patients during hospitalization in Great Britain (Tam *et al*., 2012), while it is one of the four most frequent causes of infectious enteritis in German patients (Epple and Zeitz, 2011). Children of age 0-35 months are more likely to be infected by *Campylobacter spp*. if they live in a household with a dog (Tenkate and Stafford, 2001).

3.1.3 Rotavirus

Rotaviruses are considered the most common cause of infectious diarrhea in young kids worldwide, especially in those of age 6-12 months (Yang and Fang, 2011) and the ownership of a pet seems to be an important risk factor (Bellido-Blasco *et al*., 2007).

3.1.4. *Toxoplasma Gondii*

Ocular toxoplasmosis is very common worldwide and it affects people in developing countries (Petersen *et al*., 2012). In a study in Brazil, it was found that 89 mothers were infected with *T. gondii* and their children had symptoms of the eyes (nystagmus, strabismus and retinal choroiditis) (Soares *et al*., 2012).

3.1.5. *Echinococcus Granulosus*/E. multilocularis

Echinococcosis is an important parasitic zoonosis found frequently at rural regions (Macpherson *et al*., 2003). In Europe, hunting, pet ownership and farming are important risk factors (Macpherson, 2005). From 2003 to 2010, 5483 persons were examined and 235 of them were found positive for echinococcosis in Poland (Wnukowska *et al*., 2011).

4. UPDATE ON THE SITUATION IN GREECE

In Greece, cystic echinococcosis is also considered a very important disease. It was a serious problem for public health in the 1970s and since then, there is increased epidemiological surveillance: Strict controls on meat and other food products and management of stray animals. The prevalence of parasite has been reduced in human and in animal population, as human hydatidosis has decreased from percentage 14.8 per 100,000 inhabitants during the years from 1967 to 1971 to 0.3 per 100,000 in 2008 (Sotiraki and Chaligiannis, 2010). A survey in northern Greece, found that the prevalence of *Echinococcus* was 100% in sheep, 56.6% in cattle, 15.4% in goats and 9.3% in pigs and during the years from 1988 to 1999, it was found that the seroprevalence for specific IgG was 29% in human population (Sotiraki *et al*., 2003). It seems that the parasitosis is still endemic in Greece.

In a recent study, stool samples from 232 healthy owned dogs from Serres were examined and it was found that the overall prevalence of parasitism was 26%, with *T. canis* present in 12.8% of the cases, *Giardia spp*. in 4.3%, *T. leonina* in 0.7%, *D. caninum* in 0.3% (Papazahariadou *et al*., 2007).

In another study in northern Greece, seroprevalence for IgG and IgM specific to *T. gondii* was 1.25 and 1.1% in 1984 respectively, 1.05 and 0.93% in 1994, 0.85 and 0.8% in 2004, while the intrauterine infections were estimated at 90-200 cases (Diza *et al*., 2005). Another study demonstrated that 11.1% of the 486 sera of children examined were positive to IgG antibodies against *T. gondii* (Frydas *et al*., 2000). Furthermore, a research which took place simultaneously in 5 pediatric hospitals, showed that rotavirus was the main cause of gastroenteritis in 166 of 393 children with gastroenteritis, i.e., 42.3% of non-hospitalized and in 47.8% of hospitalized patients, while 78.6% of the cases occured during winter and spring months (Koukou *et al*., 2010), as it is presented in **Table 3**. Finally, a study in Crete, which lasted from 1993 to 2010 included 33.032 stool samples which were tested and demonstrated that the 2912 samples were positive to enteropathogenic bacteria, with *S. enterica* (42.3%) and *Campylobacter spp*. (33.6%) to be the most frequently detected (Maraki *et al*., 2011).

5. PREVENTIVE MEASURES

Simple procedures and practices may prevent the transmission of pathogens from feces via the oral route (fecal-oral route):

- Regular deworming of young and pregnant animals which may excrete a great number of parasites and other enteropathogens (Juckett, 1997)
- Washing hands carefully after playing with pets (Macpherson, 2005)
- Supervision of children during playing with companion animals or visiting public places
- Veterinarians should inform the owners about the risks of pet ownership and help them to avoid zoonotic transmission (Schantz and Glickman, 1983). Moreover, they should take the same precautions when handling animals since it is well known that they are also at great risk as well as breeders, groomers, veterinary nurses to become infected with zoonotic enteropathogens (Robertson and Thompson, 2002)
- Programs should be implemented to reduce stray animals' numbers: A major reservoir of enteropathogens (Macpherson, 2005)

Apart from contact with pets, other sources of infection should not be ruled out because of the presence of animals in a household. Improper preparation of food products and contamination of water or the environment are other common ways of acquiring a zoonotic infection (Smith *et al*., 2007).

Table 2. Population groups at higher risk of acquiring zoonotic infections caused by enteropathogens

Population groups susceptible to enteropathogens
Children
Elderly people
Pregnant women
Immunocompromised individuals
Persons professionally involved with animals

Table 3. Zoonotic diseases caused by enteropathogens of major importance in Greece

Zoonoses	
Echinococcosis	29% seropositivity in human population of Greece
Toxocariasis	
nothern greece	12.8% prevalence in healthy owned dogs in
Toxoplasmosis	90-200 cases of children's inautrerine infections
Rotaviruses	Main cause of children's gastroenteritis in Greece

6. CONCLUSION

The most susceptible groups to enteropathogens are usually children (due to insufficient hygiene habits, geofagia) and the elderly, due to inadequate immune reactions. Also, pregnant women and immunocompromised individuals are at higher risk than other individuals. Finally, it is more common for people who are professionally involved with dogs or cats including veterinarians to become infected with zoonotic enteropathogens and this is summarized in **Table 2**. Changing habits is expected to contribute to the reduction of zoonotic transmission of enteropathogens (Macpherson, 2005). This is an important challenge for public health specialists, but results may be reached after long periods of time consuming efforts.

Presently, owners treat pets as family members and animals are free to wander in their households. Therefore, veterinarians should inform people about the risks and suggest preventive measures especially if they are parents or population at risk. Finally, surveillance is crucial to estimate the risk of infection and suggest case-specific preventive measures.

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7.1. Conflict of Interest

None of the authors of this article has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of this study.

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