



Zoonoses Associated with the Canines in India

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Abstract

India has approximately 6.2 cores of community dog population and it is estimated that the population of pet dogs will be around 31 million by the end of year 2023. Despite this huge dog numbers in India, the knowledge regarding the zoonoses transmissible from dogs to human is highly lacking. Moreover, the climatic conditions in India are also very much conducive for a wide variety of zoonotic pathogens and for most of them canines including community and pet dogs serve as the reservoir host. This literature reviews some of the important zoonotic diseases prevalent in dogs of India that can be passed to humans.

Keywords: Canine, Zoonoses; Dogs, Rabies; India; Campylobacter; Cryptosporidiosis; Lyme; Dipylidiasis; Giardiasis; Ancylostomiasis; Echinococcosis; Ringworm; Toxocara Canis; Scabies; Dirofilariasis; Leptospirosis

Introduction

Man has developed an emotional attachment for variety of pet animals but amongst them all, the dog has clinched a special position. The dog is perhaps the first animal to be domesticated and ever since then it remains a true companion of the man. Although, the man-dog friendship has proven to be beneficial for physical and psychological well beings of humans but there is dearth of awareness among the owners about the zoonotic diseases that could transmit from dogs to human.

Dogs closely share the domestic environment with human and are potential reservoir of many zoonotic diseases. The infection can be routed to human through the faeces, urine, saliva, nasal discharge, nails etc. Hence, it is important for the dog owners to gain the knowledge about canine zoonoses, their possible routes of transmission and preventive measures. The wide range of infections with bacterial, viral, fungal agents and infestations with parasites often pave their ways to humans from unhealthy pet animals. Some of these diseases are unique within the species or to closely related species, while others may be of zoonotic concern which often goes underappreciated. Hence, this review is focused on the canine diseases of zoonotic importance in India.

The dog population in India is broadly comprised of four type viz., pet dogs, family dogs, stray/community dogs and feral dogs. In India the stray/community dogs remarkably outnumber the other dog population. Approximately 60% - 80% dogs in India are either community or feral type compared to only 40% - 20% pet dog population [1,2]. Both pet and stray dogs are reservoirs for many zoonotic agents and therefore may pose substantial public health risks to the people dwelling very close to infected dogs. In India, wild canines such as foxes, jackals and wolves are also the potential reservoir of zoonotic pathogens and community dogs probably bridge the gap for the transmission between the wildlife and human [3]. Various zoonotic agents can be transmitted to human through direct contact with infected dogs or by their contaminated excretion and secretion. Though many of these zoonotic diseases are preventable but the knowledge, awareness concerning the prevalence and epidemiology of canine zoonoses in India is very scarce. This review discusses some of the important canine zoonotic diseases prevalent in India.

Rabies

Rabies is one of the deadliest and oldest endemic zoonoses in India. Rabies has its mention in the ancient Indian scripture *Athar-*

va veda, wherein Yama, the mythical 'God of Death' is accompanied by two dogs 'the death ambassadors'. Mammals, particularly carnivores and bats are the potential reservoirs of rabies virus that can transmit the infection to other animals including man. Human contracts rabies either through the direct contact with the saliva or through the bites of rabid dog. It is the only communicable disease of man that is practically 100% fatal even today but easily preventable. In India, human rabies cases are mainly attributed to dog bites. Dogs serve as the key reservoir of rabies in most parts of the country. According to the World Health Organization, dogs contribute up to 99% of all rabies transmitted to humans. Dog bites accounts for approximately 92% of all the animal bites in India, of which about 60% are by stray dogs and 40% by pet dogs [4]. India accounts for 36% of rabies deaths globally and 56% in Asia annually. The global burden of endemic canine rabies in India has been reported to be highest in the world accounting for 20,800 rabies deaths every year [5].

The incubation period for rabies virus usually varies between 2-3 months however, depending upon the site of bite and the amount of inoculated virus it may take one week to one year to become clinically overt in human patients [6]. Rabies typically manifests two forms depending upon the route virus takes to reach the brain. Classical signs of "furious rabies" comprise anxiety, hypersensitivity, hydrophobia and aerophobia leading to death within two to three days. Lesser dramatic form of rabies i.e. "paralytic/dumb rabies" terminates into death due to muscular paralysis. Public education, dog vaccination and correct WHO recommended pre and post-bite measures can preclude the incidences of rabies deaths worldwide. Immediate wound washing with soap under running water can dramatically reduce the viral load and prevent subsequent possibility of rabies infection. WHO, the World Organization for Animal Health (OIE), the Food and Agriculture Organization of the United Nations (FAO) and the Global Alliance for Rabies Control (GARC) have established a global "United Against Rabies" collaboration to provide common strategy to achieve "zero human dog-mediated rabies deaths by 2030 [6].

Leptospirosis

Leptospirosis is an emerging zoonotic disease caused by spirochete excreted in the urine of an infected animal. Major public health concern arises during natural disasters when endemic cases of leptospirosis may peak to epidemic proportions owing to the poor sanitary conditions [7]. Disease is mostly implicated by pathogenic strains of *Leptospira* species harbored in primary reservoir host,

the rodents. However, dogs may also disseminate infection as secondary hosts. Man contracts infection through broken skin contact with water or soil and consumption of food/water contaminated with infected urine. Carrier dog may shed organisms into the environment for months to several years. The disease is still widely ignored due to non-specific clinical symptoms similar to influenza-like illness in man. Rare availability of laboratory tests and non-reliable rapid diagnostic assays further adds to the investigative negligence of an infection. As per the estimates of royal tropical institute, Amsterdam, leptospirosis in the WHO's south-east asia region accounts for an annual incidence from 0.1-1 per 100,000 in temperate climates and from 10-100 per 100 000 in the humid tropics. An incidence can sour up to more than 100 per 100 000 during disease outbreaks and in high-exposure risk groups [8].

Transmission to dogs is either through direct contact with infected urine, or indirectly through drinking, swimming in contaminated water bodies. Dogs may express the infection in the form of fatigue and depression, colic, liver damage and even death. Infected dogs acquire the carrier stage and continue to shed the spirochetes in urine. Occupational risk to human can be prevented by protective clothing and avoidance of swimming in contaminated water bodies. Control in animal population can be achieved by vaccination of pet animals and by 'a testing a culling programme for rodent control.

Lyme disease

Borrelia burgdorferi is a spirochete that causes Lyme disease in humans. Disease is typically spread through the bite of an infected Ixodes ticks. In India, Lyme disease is highly underreported due to its non-specific symptoms, non-availability of reliable diagnostic testing facility and unawareness among the medical practitioners and pet owners. The dog are 'the sentinels' for the risk of disease transmission to humans as the Ixodid ticks feeding on dog blood can transmit *Borrelia* spirochetes to human through bite [9,10]. Despite, the paucity of scientific documentation on lyme disease, the available scanty literatures are sufficient to confirm existence of lyme borreliosis in India.

In India, the first human case was identified in a teenage boy from Shimla. The available literatures indicate the stretch of Lyme *Borrelia* in India from Arunachal Pradesh, Assam, Meghalaya, Nagaland and Manipur regions in North-East to an extent of 17.8%, 9.6%, 9.09%, 8.46% and 8.46% respectively [11]. In southern India, this bacterium is important criterion for the differential

diagnosis of neuroretinitis among the patient hailing from a forest area [12]. While in north India, sero positivity for *Borrelia* has been observed among the patients with monoarthritis [13]. Lately, in the year 2013, Kerala witnessed a Lyme disease casualty in a 50-year-old woman [14] while in the year 2014, four cases of Lyme borreliosis were identified in Haryana with classical bull's eye lesion [15]. A study by [16] also confirmed first case of multi-system Lyme disease from north India. The disease has already gained a status of notifiable disease way back in early 90s in India [17].

Campylobacter infection

Campylobacteriosis is an acute bacterial gastroenteritis affecting most part of the urbanized world. The bacteria has gained a particular concern in the developing countries like India due to thirty nine times higher incidence in immune-deficient patients [18]. Among *Campylobacter* species, *C. jejuni* and *C. coli* has earned a public health importance due to their zoonotic potential. This spirochete is the natural inhabitant of the gastro-intestinal tract of domestic and wild animals [19]. Domestic animals are known carriers with incidences as high as 92% in stool samples [20]. Evidences have linked the dog ownership with significant risk for pet-associated human campylobacteriosis [21]. Approximately 6% of human campylobacteriosis cases are due to contact with pets [19]. Dogs have been identified as asymptomatic carrier for shedding *Campylobacter* spirochetes in their faeces. The prevalence in dogs varied from 4.81% to 87% [22,23] with higher prevalence in younger pets than older ones [20,24]. Kennel dogs are reported to carry heavy load of bacteria compared to other dogs [23,25,26]. Even the healthy dogs have showed 56% positivity for *Campylobacter* organism [27-29]. Humans are commonly susceptible to enteritis causing *C. jejuni* and septicemia causing *C. fetus* species. *C. fetus* being an opportunistic human pathogen mainly causes systemic infections and neonatal sepsis. Other zoonotic species have rarely been implicated in human infection. Clinical infections tend to be common in immune-suppressed people with debilitating illnesses. Although *Campylobacter* abortion in human is very rare but occasional incidences have been noted with *C. jejuni*. Among the other zoonotic *Campylobacter* species, *C. lari* causes mild diarrhea in children. *C. upsaliensis* is an emerging diarrheal cause whereas; *C. hyointestinalis* is associated with bacteremia in immune-compromised individuals. Unlike animals, humans do not usually become long term carriers of the bacterium.

Cryptosporidiosis

Cryptosporidium is an intracellular zoonotic protozoa causing parasitic diarrhoea in humans and domestic animals. The dis-

ease is a health concern in both immune-compromised and immunocompetent individuals. It is transmitted through faeco-oral route by ingestion of oocyst contaminated water and food. Dogs acquire *Cryptosporidium* infection when ingest oocysts from soiled environment. *Cryptosporidium canis* is specifically a canine pathogen causing severe diarrhoea, malabsorption and weight loss. Among the other species, *Cryptosporidium parvum*, is zoonotically important due to its potential to cause serious human health complications. The role of dogs in transmission of human cryptosporidiosis is perhaps marginal however, it has been speculated that persons with compromised immunity can readily be infected with zoonotic species other than *C. parvum*. Evidences supporting such transmission were documented in a study from Peru, highlighted the possible passage of *C. canis* in two children from dogs sharing same household [30]. Conversely, a study from Italy detected zoonotic *Cryptosporidium* species (*C. parvum*) in a few dogs [31]. Moreover, few reports have also established common association of *C. canis* and *C. felis* with diarrhoea and *C. parvum* with chronic diarrhoea and vomiting in humans [30].

Scabies

Among the various zoonotic dermatological afflictions in dogs, canine scabies and dermatophytosis are two major causes which can pass on to the people handling them. Sarcoptic mange also known as canine scabies is a highly contagious skin disease which can affect a variety of wild, domestic and farmed animals. The *Sarcoptes scabiei* mite can be transmitted to humans on close contact with infected dog causes intense pruritis and irritation. An infection runs a prolonged course in immune compromised individuals and in patients under immuno-suppressants therapy. The infestation, although is self-limiting, can be intensely itchy and bothersome. There are reported cases of sarcoptic mange in humans that are not self-clearing and require months of treatment to control.

Ringworm

The ringworm infection in dogs is caused by the dermatophytes species namely *Microsporum canis*, *Microsporum gypseum* and *Trichophyton mentagrophytes* which are also the zoonotically important dermatophytes. These species primarily infects dogs but can pass on to humans while handling the infected dogs. Carrier dogs transmit infection to humans and other domestic animals residing in shared environment through direct contact and contaminated objects. The name "ringworm" is a misnomer, as the infection is not caused by worm, but it is rather a fungal infection of the superficial keratinous layers of tissues. The infection

has acquired its name 'Ringworm' from its classical 'ring shaped' marking around the boundary of an inflammatory lesion.

Healthy individuals are usually resistant to infection but immuno-compromised individuals are often susceptible. Dogs are the sentinel host for human dermatophytosis. The fungal spores are resistant and remain viable for months on grooming brushes, bedding, carpet and flooring etc. Most disinfectants do not kill the dermatophytes but a solution of chlorine bleach in water can be a suitable disinfectant for floors and other hard surfaces. Fabrics should be treated with steam or hot water dip. Avoiding sharing of grooming equipment, bedding and kennels etc will help prevent fungal spread. People should wear gloves and protective clothing while handling an infected dog. Dogs suspicious of ringworm infection should be separated and provided veterinary attention.

Toxocara canis

Canines are the definitive host for the dog roundworm *T. canis*. The puppies less than one year old are often vulnerable to *Toxocara* worm infestation. The incidence tends to decrease with advancing age of the dog and among well domesticated pet dogs compared to their stray counterparts [32-34]. The parasitic worms colonize in the intestinal tract of infected canids and excrete the eggs in faeces. The parks and playgrounds are seldom contaminated with the eggs of *T. canis* voided by the infected dogs. Toxocarasis in dogs was documented as early as in 1940s in India. *T. canis* prevalence in dogs ranged from 10-80% [35]. High prevalences was observed in dogs from Calcutta (82%), Miraj (55.8%), Nagpur (38% - 45%) and Uttar Pradesh (24.3%) [33-36]. In contrast, Madhya Pradesh, Himachal Pradesh, Chandigarh and Assam reported low prevalence as 2.7%, 5.93%, 9.6% and 11% respectively in dog [32,37,38].

Evidence of high prevalence in stray dogs raised health risks to people visiting public places contaminated with dog faeces. This helminth parasite is a perfect example of a parasite moving from wild canids to their domestic counterparts and to humans. Humans are the accidental host who restrict the further development of *Toxocara* larvae into adult worms. The first human case was evident in 1993 in India [50]. Ever since then, sporadic incidences of human toxocarasis have been reported from different parts of the country. Human toxocarasis, primarily is a soil-transmitted zoonosis acquired from contaminated grounds. Geophagia, poor personal hygiene, playing with non-dewormed puppies and consumption of raw contaminated vegetables increases the risk of toxocarasis in Human. Human disease flared up as visceral larva migrans (VLM)

due to migration of larvae through the liver, heart, lung, muscle, eye, and brain.

Ancylostomiasis

Dog harboring hookworm parasite *Ancylostoma* can pass on the infection to the people dwelling in their surroundings. Dogs carrying adult parasite, excrete the eggs in the faeces which hatch to larvae in environment. Hookworms cause haemorrhagic diarrhoea in puppies and chronic microcytic hypochromic anaemia in adult dogs. The place where dogs defecate get contaminated with eggs and larvae voided in the faeces. Human may acquire an infection by touching or walking barefoot on contaminated soil and by accidental ingestion of contaminated soil or water. This soil transmitted hookworm infection is one of the most common roundworm of humans. Infected human develop a skin condition called Cutaneous Larva Migrans (CLM). The species of dog hookworms capable of parasitizing humans are *Ancylostoma braziliense*, *A. caninum* and *A. ceylanicum*. Based on the studies from various parts of India, two hookworm species, *A. caninum* and *A. ceylanicum* have been identified in dogs in India [3]. Prevalence of *Ancylostoma* has been reported higher among the rural dogs with a prevalence range of 19- 91% in dogs from various parts in India. Control measures need to be implemented to prevent shedding of infected parasite eggs in dog faeces.

Echinococcosis

Echinococcosis is parasitic zoonoses causing serious public health problems worldwide. The disease is caused by the dog tapeworm of genus *Echinococcus* and its larval stage (hydatid cyst). Carnivores, especially dogs are the definitive host harboring a mature tapeworm of *Echinococcus* in their intestine. Parasite eggs are shed in the environment, contaminating fruits, vegetables or water bodies, and can stick to the fur of animals and can transfer on hands to the mouth of human handlers. Zoonotic genotype of *Echinococcus* is principally maintained in a dog-intermediate host-dog cycle. The definitive hosts are infected through the consumption of viscera of intermediate hosts that contain the parasite larvae. Wide range of herbivorous and omnivorous species acts as intermediate hosts of *Echinococcus*. Intermediate hosts become infected while grazing on the pasture contaminated with dog feces laden with parasite eggs. Eggs develop into larval stages in the viscera of intermediate hosts. Humans are accidental intermediate hosts, acquire infection by ingestion of the parasite eggs in contaminated food and water, but are not involved in further transmission of the infection.

According to WHO, human cystic echinococcosis ranges from < 1 per 100,000 to > 200 per 100,000 in rural populations in close contact with domestic dogs while alveolar echinococcosis is usually < 0.5 per 100,000 but may be >100 per 100,000 in certain communities [51]. Worldwide, there may be in excess of 1 million people living with echinococcoses at any one time, experiencing severe clinical symptoms which are life-threatening if left untreated. The 2015 WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) estimated 19 300 deaths and 871 000 disability-adjusted life-years (DALYs) due to echinococcosis of globally each year. Echinococcosis accounted for an estimated annual cost of US\$ 3 billion for treating cases and losses to the livestock industry.

Dipylidiasis

Dipylidiasis is a neglected parasitic zoonosis caused by a dog tapeworm, *Dipylidium caninum* also known as cucumber tapeworm, or flea tapeworm. Definitive hosts dog/cat harbor the adult worm and gravid proglottids in their small intestine. Gravid proglottids are expelled in the faeces of dogs. Expelled proglottids dehydrate and rupture to release parasite egg. The eggs are ingested by the larvae of dog or cat fleas (*Ctenocephalides felis*, *Ctenocephalides canis*) where eggs develops into the infective cysticercoid finally metamorphosed into the adult stage. Humans acquire infection by accidental ingestion of the infected dog or cat fleas. Although, the human infections with *D. caninum* are rare, but it is more likely to occur in young children who kiss or are licked by their infected pets.

In India *D. caninum* is predominantly transmitted by flea intermediate hosts, *Ctenocephalidis felis orientis* (40.42%) and *C. canis* (10.63%) [41]. Prevalence of dipylidiasis in stray and pet dogs revealed 12.5-16.10% in north, 10.25% in central and 0.56% in north-eastern parts of India [37,42,43]. Survey data revealed lower prevalence in pet dogs as compared in stray dogs of India. Proper flea control measures and regular deworming of dogs can help to restrict the occasional human cases.

Giardiasis

Giardiasis has got the public health importance due to its potential to infect millions of people worldwide. Within this genus, *Giardia duodenalis* is zoonotically important infecting humans and animals. *Giardia* is an intestinal parasite of domestic animals including dogs that can be transmitted to the susceptible hosts by drinking water contaminated with infected feces. Infected dogs excrete the microscopic cysts in their faeces and infect other animals or per-

son if ingested. Unlike many other infectious organisms, *Giardia* cysts are very resistant and can persists longer in the environment under the favorable circumstances. Illness in humans is usually self-limited characterized by diarrhea, abdominal cramps, bloating, weight loss, and malabsorption, however, in infected children it disturbs the growth and cognitive functions. Dogs in tea-growing communities of India have shown a prevalence of 3% - 20% for *Giardia duodenalis* [38].

Dirofilariasis

Dirofilariasis is a nematodal infection transmitted between humans and animals through the bite of infected mosquitoes. Disease is caused by the filarial worm *Dirofilaria immitis* popularly known as dog heartworm. Dogs and cats are the reservoir host of this parasite. An adult worm residing in the right ventricle of heart liberates microfilariae in the blood stream of infected dog. Microfilariae siphoned by mosquitoes from infected animals mature to the infective third-stage larvae within the mosquito and transmitted to healthy human or animal during next blood meal. The parasite in cutaneous tissue molts and reaches the heart via bloodstream to mature into an adult worm. Worms reaching pulmonary arterial circulation cause thrombosis, infarction, inflammation, eventually producing a granulomatosis of fibrous tissue.

In India dirofilariasis is an emerging zoonosis accounting for at least hundred subcutaneous or ocular cases and three pulmonary cases [44]. The common filarial species associated with dirofilariasis in India are *Dirofilaria immitis* and *D. repens*. Studies have reported the prevalence of *D. immitis* to be 1% in Sikkim, 34% in Mizoram, 57% in Orissa, 3% in Kolkata and 4% in Delhi [45-48], whereas, *D. repens* was found to prevalent to an extent of 7%, 21%, 14%, 17% and in 5% in Kerala, Karnataka, Delhi, Orissa, Mumbai and Delhi respectively [47,49,50].

Conclusion

Benefits of man-dog bond have been well recognized in an entire world. Increasingly, dogs are intimately tied to the human experience. They no longer are confined outside the house but are rather an integral member of families sharing home pace with man. Such relationships are undoubtedly beneficial for the social and mental health and well-being of human. Although this relationship between animals and people are beneficial, we also need to be aware of the zoonotic diseases transmission between these domains.

Prevention is the first line of defense against any disease. Regular immunization, deworming, appropriate chemical disinfectant, personal and environmental hygiene can protect canine friends and owner from various infections exchanging between them. Early diagnosis and owner awareness are important for curtailing the zoonotic spread of these diseases.

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Conflict of Interest

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