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Prevalence of canine infectious diseases in Gujarat, India: A brief review

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Abstract
Dogs are one of the most common and well-liked pets in Gujarat, India. People have a different perception and are more open to the idea of having a pet as a companion. Interactions between humans and dogs, as well as close living, pose a significant risk for the development of zoonotic diseases, including diseases that can be carried by dogs. There are many diseases of dogs have been reported from Gujarat state but not concisely reviewed. Having rich natural resources habitant in wildlife sanctuaries and national park and wild animals, it always under the risk of disease outbreaks. The correct knowledge of vaccination, education on health management, and knowledge of diseases affecting pets are required in order to prevent and control diseases not only in dogs but also important for wild animals. The focus of the current review is on describing dog diseases that are prevalent specifically in Gujarat and southern part of state.

Keywords: Canine infectious, diseases in Gujarat, zoonotic diseases

Introduction
Many infectious diseases are widespread among dogs in India and the rest of the world, but a few serious illnesses are more common in Gujarat and the southern parts of the state. These diseases include canine distemper virus infection, canine gastroenteritis, canine parvovirus infection, canine leptospirosis, canine babesiosis, rabies, and other Infectious diseases seen in dogs pose considerable danger not only to the health of the dogs but also to the human population. Even though veterinary medicine has come a long way in recent years, infectious diseases continue to be a major concern for zoonotic transmission and for dog populations. These diseases have a negative impact on the health of dogs, and many of them are fatal. Several factors contribute to the occurrence of major infectious diseases in canines in the Gujarat and south region of state. These factors include a high population density, poor hygiene, inadequate vaccination, and a lack of awareness regarding zoonotic diseases among both pet owners and the general population. Outbreak of different diseases in pet are preventable, treatable but fatal, too. Due to climatic favoring conditions, there are many disease have been reported from dog population. Various, Bacterial, viral, protozoal, fungal and other diseases are often reported despite of vaccination. Deadly diseases like canine distemper and rabies seen in stray dogs as they are devoid of vaccination. There is no any state policy or social organization set up that covers vaccination to stray dogs. Dog owners should vaccinate their pets annually to avoid the worst possible situation in India (Desai *et al.*, 2021) [9]. As a consequence of this, it is extremely essential to have an understanding of the epidemiology, clinical manifestations, and treatment of these diseases in order to successfully prevent and manage these diseases. The purpose of this review article is to provide an overview of the most common canine diseases that are frequently reported from Gujarat and the southern part of state. This overview will cover the diseases' etiologies, clinical signs, diagnostic methods, treatment options, and some prevention strategies.

Canine Distemper (CD)
Canine distemper virus is a highly infectious and fatal virus (Desai *et al.*, 2021) [9]. It has a worldwide distribution with wide range of hosts which includes members of the families Canidae, Ailuridae, Hyaenidae, Mustelidae, Procynaidae, Ursidae, Viverridae, and felidae (Quinn *et al.*, 2011) [30].

Occurrence of CD has also been reported in several wildlife species including foxes, skunks, racoons, black footed ferrets and lions. (Appel and Sumners, 1995) [2]. CDV belongs to the genus Morbillivirus, Subfamily paramyxovirinae, and family paramyxoviridae and in order of mononegavirales. (Desai *et al.*, 2021) [9]. It is a single stranded, non – segmented, negative sense RNA that has an envelope and having a size of 150-300 nm size (Murphy *et al*. 1999.) [39] The CDV genome is made up of seven structural proteins: haemagglutinin (H), large protein (L), phosphoprotein (P), nucleocapsid protein (N), fusion protein (F), and matrix protein (M), in addition to one non-structural protein (C) produced via an alternative open reading frame in the P gene (Joshi *et al.*, 2022[a]) [14]. The virus is relatively labile and it is transmitted by direct contact or by aerosols, Infection of CDV spreads most commonly in young dogs, usually between 3 to 6 months of age because in this age maternally derived immunity declines. (Quinn *et al*., 2011) [30]. CDV usually occurs in winter season, and it causes disease mostly in non-vaccinated pet puppies and dogs. (Desai *et al*., 2021) [9]. The virus primarily replicates in the upper respiratory tract, spreads to the tonsils and bronchial lymph nodes, and later reaches to various organs including ocular, brain, lymphoid organs, urinary bladder, respiratory system and GIT (Pardo *et al*., 2005) [25]. CDV is a highly immunosuppressive virus, and it causes immunosuppression. The main reason behind it is lymphocytolysis and leukopenia upon viral replication. (Quinn *et al*., 2011) [30]. In CNS, viruses infect both neurons and glial cells and may persist there for very long periods. Dogs with adequate humoral and cellular immunity might show clinical signs but will clear the virus from most tissue within 3 weeks. However, from CNS, lungs and skin viruses can be shed for several months. If there is inadequate immune response, severe clinical disease is seen at 2-3 weeks with death by 3-4 weeks. Recovered dogs can shed viruses for 2-3 months. Initial clinical sign of the disease is pyrexia. Though pyrexia is biphasic, usually initial elevation of temperature may not be noticed. During the second period of pyrexia, oculo-nasal discharge, pharyngitis, and tonsillar enlargement become evident (Quinn *et al*., 2011) [30]. Coughing, vomiting and diarrhea are often consequences of secondary infections. Skin rashes and pustules may be present on the abdomen. Dogs with neurologic signs may develop hyperkeratosis of the footpads and nose due to the epithelial damage referred to as “hard pads”. Common neurological signs include paresis, myoclonus & seizures. Chronic distemper encephalitis, also called old dog encephalitis condition is marked by ataxia, compulsive movements such as head pressing also known as “chorea”. (Kahn and Line, 2010) [16]. One of the most consistent postmortem findings of CDV is Thymic Atrophy (Kahn and Line, 2010) [16]. Diagnosis of CDV can be done by clinical signs observed in affected animals, viral antigen can be done by immune fluorescence. Eosinophilic inclusions can be demonstrated in nervous and epithelial tissues. Sensitive molecular methods for the detection of CDV RNA in clinical samples include one step, nested and real-time RT PCR and lateral flow essay. Prevalence of canine distemper in south Gujarat was reported 14/18 (77.77%) in the research conducted by Desai *et al.* (2021) [11] in the year 2020. Prevalence of canine diseases in Gujarat presented in Table 1.

Table 1: Prevalence of Canine disease in Gujarat

Sr. No.	Diseases	Place	Prevalence	References
1	Canine parvoviral infection	Navsari	63/145 (43.44%)	Mehta *et al*., 2017 [22]
		Navsari	62.29%	Pandya *et al*., 2017 [40]
		South Gujarat	35/73 (47.94%)	Sharma *et al*., 2018 [34]
		Navsari	37/109 (33.94%)	Desai *et al*., 2020[a] [7]
		Navsari	34/50 (68%)	Mehta *et al*., 2020 [21]
		Anand	145/1540 (9.42%)	Patel *et al*., 2022 [29]
2	Canine distemper	Navsari	14/18 (77.77%)	Desai *et al*., 2021 [9]
		Anand	08/12 (66.66%)	Joshi *et al*., 2022[b] [15]
		Ahmedabad	07/09 (88.88%)	
		Vadodara	01/02 (50%)	
3	Canine leptospirosis	Navsari	26/56 (46.42%)	Desai *et al*., 2020[c] [10]
4	Canine corona viral infection	Navsari	05/109 (4.58%)	Desai *et al*., 2020[a] [7]
5	Canine babesiosis	Gujarat	15.81%	Jadhav, 2015 [13]
		Anand and Surat	16/79 (20.25%)	Bilwal *et al*., 2017 [5]
		Junagadh	61/375 (16.27%)	Murabiya *et al*., 2018 [23]
6	Hepatozoon infection	Junagadh	21/317 (6.62%)	Kumar *et al*., 2018 [17]
7	Canine demodicosis	Ahmedabad	04/177 (02.26%)	Anikar *et al*., 2021 [1]
		Saurashtra region	23/430 (5.34%)	Satasiya *et al*., 2022 [32]
8	Canine pyoderma	Ahmedabad	09/177 (05.08%)	Anikar *et al*., 2021 [1]
9	Dermatophytosis		56/177 (31.64%)	
10	Canine scabies		05/177 (02.82%)	
11	Tick infestation		24/177 (13.56%)	

Rabies

One of the most fatal viral diseases that can infect mammals, including people, dogs, wild dogs, and cats, is rabies (Desai *et al*., 2018[b]) [12]. Since that, it is the deadliest disease for domesticated animals, preventing the disease must follow the "One Health" principle (Desai *et al*., 2018[a]) [11]. By public awareness programs, rabies deaths can be prevented globally (Desai *et al*., 2018[b]) [12]. One of the most severe viral infections to affect mammals, including dogs and people, is rabies. It is a lethal illness brought on by rabies virus infection. All around the planet, including North America, Central and South America, Asia, Africa, the Middle East, and some regions of Europe, the rabies virus is present. When one infected animal bites another, the virus is spread. Transmission by a different method is uncommon. In North America, the skunk, fox, raccoon, coyote, and bat are significant carriers of the disease, whereas foxes are the primary reservoir in Europe. The primary reservoir is not

animals but rather stray canines in Asia, Africa, and Latin America. Human infections and mortality are more frequent in these regions. Following the bite, the rabies virus enters the host animal's peripheral nerves, reproduces, and travels to the salivary glands. Peripheral nerves are any nerves outside of the brain and spinal cord. In this instance, saliva contains the virus. The rabies virus is short lived outside of a mammal's body. The incubation period (the stretch of time before clinical symptoms manifest) can last anywhere from ten days to a year or more. The incubation period in dogs normally lasts between two and four months. The following factors affect how quickly clinical symptoms appear: 1). The infection location - the virus spreads more quickly to neural tissue the closer the bite is to the brain and spinal cord. 2). How bad the bite was. 3). The quantity of virus that the bite released. The illness develops gradually after being bitten by a rabid animal. The dog's attitude changes noticeably during the prodromal phase (Initial phase). Active pets grow anxious or timid, whereas quiet animals become irritated. This stage can last two to three days. Following this stage, the clinical disease might take one of two known forms: When a rabid dog exhibits signs of a depraved appetite, such as devouring and chewing on rocks, dirt, and trash, it develops furious rabies (Pica). The rabid animal eventually goes into paralysis and might not be able to eat or drink. Fear of water, or hydrophobia, is not a symptom of canine rabies. It is a characteristic of human rabies. Finally, the dog has a massive seizure and dies. In dogs, dumb rabies is the more prevalent kind. The face is distorted, the limbs gradually become paralyzed, and swallowing is difficult. Dog owners frequently believe their pets have an obstruction in their mouth or throat. Examining should be done carefully because saliva can spread rabies. The dog eventually goes into a coma and passes away. Only a thorough examination of the brain can determine if someone has rabies. This illness cannot be detected in a living animal. Your veterinarian may advise sending the proper brain samples for testing if there is a strong suspicion that the animal has rabies or if an animal exhibiting rabies signs passes away suddenly. This may be necessary if there has been human exposure. The mainstay of rabies prevention is vaccination. Although vaccination encourages the formation of antibodies, it only works if it is administered prior to the virus invading the nervous system. Dog, cat, horse, and ferret rabies immunizations now are very secure and efficient. The dog should have a rabies vaccination and be placed in a rigorous quarantine (no direct contact with people) for many months as stipulated by local public health rules if there is a potential exposure in an unvaccinated dog but no human exposure. An unvaccinated exposed dog that has bitten or scratched a human would typically not receive a vaccine due to the possible risk to people, as it could result in a rare adverse reaction that could mirror the symptoms of infection. The safest course of action is to euthanize the animal if there is a high likelihood of exposure; the other is a rigorous quarantine for several months. If the exposed dog has already received vaccinations, a booster shot is advised. This should be followed by a quarantine of at least thirty days, which will be governed by local public health standards and will involve close monitoring.

Canine Parvoviral infection

The most common cause of illness and mortality in dogs worldwide is canine parvovirus enteritis (PVE), which is brought on by one of three types of canine parvovirus type 2 (CPV-2; family Parvoviridae, Genus Parvovirus) (Desai *et al*., 2020[a]; Desai *et al*., 2020[b]) [7-8]. Parvo virus replicates only in the nuclei of dividing host cells. (Kahn and Line, 2010) [16]. After entering a cell, the virion is uncoated and its single stranded DNA genome is converted to double stranded DNA by cellular DNA polymerases in the nucleus. Following viral replication cell lysis occurs as virions are released. Parvovirus of vertebrates agglutinate erythrocytes therefore haemagglutination inhibition (HAI) by specific antisera is widely used for the identification of these viruses (Quinn *et al*., 2011) [30]. Transmission occurs mostly by the feco-oral route. Furthermore, infected dogs shed large numbers of viruses in their feces. After entering the body virus initially replicates in the pharyngeal lymphoid tissue and Peyer's patches. Once viremia develops the main target tissue are those with rapidly multiplying cell populations, during the first 2 weeks of life there is active division of cardiac myocytes allowing viral replication which causes necrosis and myocarditis and ultimately it leads to Acute heart failure and pups died. In conclusion, in parvovirus infection pups died mostly due to acute heart failure. While in older pups, the virus invades the actively dividing epithelial cells of the crypts in the small intestine which leads to diarrhoea because loss of cells from the intestinal crypts leads to blunting of villi and absorptive and digestive capacity may be reduced. Although it has a stronger affinity for the digestive, respiratory, and central nervous systems, it nevertheless has significant negative effects and clinical symptoms (Joshi *et al*., 2022[b]) [15]. The virus is extremely immunosuppressive and increases the host's vulnerability to secondary infections, which are the main cause of death (Joshi *et al*., 2022[a]; Joshi *et al*., 2022[b]) [14-15]. In severely affected pups there may be extensive hemorrhage occurs in the intestinal lumen. Therefore, the main clinical signs of CPV infection include sudden onset of vomiting and anorexia, fever may also be observed, blood stained diarrhoea, feces have a fetid smell. Severely affected dogs die within 3 days. Diagnosis of the CPV infection can be done by presence of basophilic intranuclear inclusions in cardiac myocytes that is confirmatory. ELISA & HA test may be used to demonstrate viral antigen. LFA test was used to detect canine parvovirus in the research conducted by Desai *et al*. (2020[a]) [7]. Prevalence of canine parvovirus in the south Gujarat was reported about 33.94% (Desai *et al*, 2020[a]) [7]. Similarly the age wise prevalence of CPV are found to be 41.26% in < 3 months of dogs, 25% in the 3 to 6 months of dogs while only 20% in the 6 to 12 months of dogs. (Desai *et al*., 2020[a]) [7]. Prevalence of canine diseases in Gujarat presented in Table 1.

Canine Leptospirosis

Leptospirosis is one of the major globally concern disease due to its increasing incidence in both developing and developed countries (Desai *et al*., 2020[c]) [10]. It is caused by pathogenic spirochetes, which is motile and affects numerous hosts all over the world. It is re- emerging as an important zoonotic disease. Different serovar of leptospira interrogans are ubiquitously present in sub-clinically infected wild and domestic animal reservoir hosts (Desai *et al*., 2020[c]) [10]. In 1886, Adolf weil reported clinical syndrome characterized by splenomegaly, nephritis and jaundice commonly referred as 'weil's disease' that became synonyms of leptospirosis. Leptospirosis is endemic in south Gujarat because the environmental factors such as the high percentage of rainfall leading to water logging and high humidity favors the

occurrence of leptospirosis in these regions. Pathogenic leptospires can persist in the renal tubules or in the genital tract of carrier animals. Though indirect transmission can occur whenever environmental conditions are favorable, these organisms are transmitted mostly by direct contact. Leptospires invades tissue through moist, softened skin or through the mucous membrane as this is the motile organisms motility aid the tissue invasion. After entering into the body, they spread throughout the body via blood stream. Following appearance of antibodies at about 10 days after infection, organisms are generally cleared from the circulation. However, some organisms evade the immune response and persist in the body. Principally these persisted organisms found in renal tubules but also in the uterus, eye or meninges. The most common presentation for canine leptospirosis in recent years is acute kidney injury. It also causes hepatocellular injury, which produces hemolytic anemia, Jaundice, hemoglobinuria and hemorrhage. Diagnosis of leptospirosis can be done by dark field microscopy (DFM), microscopic agglutination test (MAT), ELISA & PCR. (Desai *et al*., 2020[c]) [10]. Though DFM is the most economic and rapid technique used to demonstrate organism under the microscope it is less sensitive in detection (Desai *et al*., 2020[c]) [10]. The gold standard test for the detection of different serovars from the samples either organisms or antibody detection is MAT. Prevention of leptospirosis in domestic animals depends primarily on the use of vaccine. As immunity is serovar specific vaccine should contain the prevalent leptospiral serovar present geographical region. Treatment of cases where there is a higher likelihood of treatment evasion, which could result in the development of antibiotic resistance, is highly challenging (Bhinsara *et al*., 2018) [4]. Pets as well as domesticated animals (Tumlam *et al*., 2022) [36] are the focus of the main problem, which is antimicrobial resistance and antimicrobial residue (Patel *et al*., 2019; Patel *et al*., 2020) [28, 27]. The intimate contact between dogs and people may operate as a conduit for the transmission of resistant germs in the opposite direction. The risk of occupational injury to humans can be decreased by using protective equipment and avoiding swimming in contaminated water sources. Since vaccination is the most effective method of preventing disease from occurring, testing a rodent control culling program and vaccinating pets can both contribute to a decrease in the animal population (Makwana *et al.*, 2018) [18]. Leptospirosis is endemic in coastal area of south Gujarat (Desai *et al.*, 2020[c]) [10]. Humans and domestic animals like cattle, buffalo, sheep, goat and dogs are affected. Prevalence of leptospirosis in dogs in south Gujarat was reported 46.42% by testing urine and serum sample in research conducted Desai *et al.* (2020[c]) [10] in 2020. Furthermore, among all samples collected from male and female, female dogs (55.55%) affected more than the male dogs (42.10%) (Desai *et al*., 2020[c]) [10]. Prevalence of canine diseases in Gujarat presented in Table 1.

Canine Babesiosis

Canine babesiosis is a clinically significant and geographically widespread haemoprotozoan disease of dogs. (Bilwal *et al*., 2017) [5]. *Babesia canis* and *Babesia gibsoni* are the most common occurring species of babesia in the dog. As it is a tick borne protozoan disease *Babesia canis* is transmitted by *Dermacentor reticulatus* in Europe, *B. vogeli* by *Rhipicephalus sanguineus* in tropical and subtropical countries. *Babesia gibsoni* is transmitted by *Haemaphysalis longicornis*. The disease has been reported in various states of India including Gujarat (Bilwal *et al*., 2017) [5]. The lifecycle of *B. gibsoni* includes two stage, inside the host RBCs, in which the sporozoite converts into piroplasm and other inside the tick vector. (Uilenberg, 2006) [37]. A small form of Babesia is seen in Geimsa stained peripheral blood smear which is small and of around 1-3 micrometer diameter, ring-,oval-,or comma shaped piroplasm which is indicative of *B. gibsoni* which can be further confirmed by PCR (Bilwal *et al*., 2017) [5]. The parasite can also be transmitted by blood exchange and transplacental transmission. This parasite generally destruct circulating erythrocytes. Typical clinical sign of canine babesiosis include anemia, thrombocytopenia, leukocyte abnormality, increased liver enzymes and hyperbilirubinemia, hypokalemkia, hyperglobulinemia, azotemia, metabolic acidosis, and abnormalities of urinalysis may be observed in some severely affected dogs (Bilwal *et al*., 2017) [5]. Naturally, occurring cases of *B. gibsoni* are having variety of clinical signs ranging from anorexia to hepatomegaly or splenomegaly. Supportive treatment is usually given, and it includes fluid therapy, anti-inflammatory and antipyretics, gastroprotectants, oxygen supplementation and blood transfusion should be employed. However, *Babesia gibsoni* required specific drug, which is known as atovaquone (a quinone antimicrobial medication) and azithromycin. Prevalence of canine babesiosis in south Gujarat was reported 20.25% in the research conducted by Bilwal *et al.* (2017) [5] while 15.81% was reported by Jadhav (2015) [13]. Prevalence of canine diseases in Gujarat presented in Table 1.

Other Diseases

Other important disease that are of kennel cough, herpes virus infection, canine ehrlichiosis, and other protozoal and parasitic infection are common like canine demodicosis, canine pyoderma, dermatophytosis, canine scabies, and tick infestation (Anikar *et al*., 2021) [1]. The detail of the reported diseases are presented in Table 1. These diseases can be diagnosed by various ways and commonly treatable. Hepatozoonosis is a tick-borne disease of dog caused by *Hepatozoon* parasite and one of the important disease of dogs. The improved sensitivity of antibody-based serology assays like direct fluorescent antibody test (Patel *et al*., 2018) [26], ELISA based detection kits and nucleic acid– based polymerase chain reaction (PCR) assays (Vala *et al*., 2020) [38] has increased our clinical investigation of bovine, equine, canine herpesvirus and other canine pathogenic pathogens. Canine coronavirus disease, also known as CCoV, is a very contagious intestinal infection that mostly affects puppies (Desai *et al*., 2020[a]) [7]. Human and animal gastrointestinal pathogens include group A rotaviruses (Tumlam *et al*., 2019; Makwana *et al*., 2020[a]; Makwana *et al*., 2020[b]) [35, 19, 20]. For collecting epidemiological information and determining the origin of unusual rotavirus strains, sequence analysis of the genes encoding the two outer capsid proteins VP7 and VP4, the inner capsid protein VP6, and the nonstructural protein NSP4 is helpful (Makwana *et al*., 2020[a]; Makwana *et al*., 2020[b]) [19-20]. There is a high probabilities of disease occurrence when animal transported from one place to other, movement of animals, or confine them together at one place as organized farm (Sakhare *et al*., 2019; Sharma *et al.*, 2019) [31, 33]. Therefore, it causes spreading of disease among dog population as well as other animal population. It also contributes to the spread of viral and bacterial pathogens between species. Along with mast cell tumors, basal cell

carcinomas, histiocytomas, and lymphomas, TVT is currently classed as a round cell neoplasm. However, there have also been reports of other tumor cases, such as perianal gland adenoma (Chaudhari *et al.*, 2017) [16]. Especially among stray and breeding dogs, TVT is naturally infectious and sexually transmissible among dogs. Therefore, canine tumors like TVT and canine memory glad tumors are also common in the Gujarat and southern part of state.

Conclusion

The current review of diseases presented the percent positivity of diseases and reviewed. Canine diseases are preventable through the vaccination; however, every year dog is infected and treated. Many diseases like, canine parvoviral infection, canine distemper, canine leptospirosis, canine corona viral infection, canine babesiosis, hepatozoon infection, canine demodicosis, canine pyoderma, dermatophytosis, canine scabies, tick infestation have been reported from different part of Gujarat. There are still many diseases might prevalent in Gujarat but not reported through literature. Due to the stray dog population and not having any vaccination policies, there may be the possibilities in rise of diseases outbreaks.

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