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Review on important diseases of Dogs: At glance

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Abstract
Dogs are one of the most accepted pet animals in every household. Increasing urbanization and modernization of human life has created a space where people are living in nuclear family or alone. This has created peoples' perception and acceptance of having pet for companionship. Human- dog interaction and close livelihood confinement emerge as crucial threat of outbreaks of zoonotic disease even a dog's diseases. To prevent and control diseases of dogs, it requires proper knowledge of vaccination, education of pet health management and pets' diseases. Therefore, the current review is on describing dog diseases like, Rabies, Canine Parvoviral gastroenteritis, Canine Distemper, Canine Coronaviral infection, Canine Rotavirus infection, Canine Herpesvirus infection, Canine Leptospirosis, Canine Brucellosis, Transmissible venereal tumors (TVT), Kennel cough, Pyoderma at glance which provides concise information regarding the causative agents and other relevant details.

Keywords: Canine, dog, diseases, rabies, leptospirosis, kennel cough

Introduction
Humans are emotionally attached to many different pet animals, but the dog has taken a special place among them all. The dog was maybe the first animal to be tamed, and since that time, it has remained a loyal human companion. Although the relationship between humans and dogs has been shown to be good for their physical and mental health, there is a lack of knowledge among owners about the various diseases that can infect dogs. Dogs and humans share a close household environment, making them potential susceptible for various diseases. The virus can spread to people through their nails, feces, urine, saliva, and other bodily fluids. It is crucial that dog owners learn about canine disease and zoonoses, their potential transmission routes, and preventative measures. Many bacterial, viral, fungal, and parasitic illnesses as well as parasite infestations frequently spread from sick pets to humans. Some of these illnesses are specific to the species or to closely related species, while others may be zoonotic diseases that should be taken seriously but are frequently overlooked. So, the focus of this analysis is on the canine illnesses that are significant in India. The four main categories of dogs in India are pet dogs, family dogs, stray/community dogs, and feral dogs. The number of stray and community dogs in India far outnumbers all other canine breeds. In India, between 60% and 80% of dogs are either community or wild types, while only 40% to 20% are owned as pets (Chaudhuri, 2005) [5]. Both domesticated and stray dogs can harbor a variety of zoonotic diseases, which puts the residents of proximity to sick dogs at serious risk for illness. In India, wolves, foxes, and other wild dogs are also a potential source of zoonotic infections, and community dogs likely act as a conduit for the spread of these pathogens from wildlife to people (Sharma *et al*., 2015) [47]. Through direct contact with diseased dogs or through their contaminated secretions and excretions, several zoonotic diseases can be spread to people. Important dog diseases like, Rabies, Canine Parvoviral gastroenteritis, Canine Distemper, Canine Coronaviral infection, Canine Rotavirus infection, Canine Herpesvirus infection, Canine Leptospirosis, Canine Brucellosis, Transmissible venereal tumors (TVT), Kennel cough, Pyoderma are presented in India. However, pet-dog get vaccination shot every year (Desai *et al*., 2021) [10] otherwise it could have the worst situation in India for the pet owner. Even though many of these diseases that are under vaccine coverage, every year millions of dogs get infected by those diseases.

Because there is very little information available among pet parents in India about the prevalence and epidemiology of canine diseases. Some significant canine diseases that are common in India are covered in this article.

Rabies

Rabies is one of the most lethal viral infections that can affect mammals, including humans and dogs and wild canines and felines (Desai *et al*., 2018[b]) [9]. Rabies is a deadly infection caused by the rabies virus. The rabies virus is found worldwide, including in North America, Central America, South America, Asia, Africa, the Middle East, and some parts of Europe. Yet, there are numerous rabies-free regions in the world. The infection is transferred via a bite from an infected animal to another animal. Transmission by alternate ways is uncommon. In Europe, foxes are the primary reservoir, whereas in North America, skunks, foxes, raccoons, coyotes, and bats are significant reservoirs. Throughout Asia, Africa, and Latin America, stray dogs are the primary reservoir, not animals. Human infections and mortality are more prevalent in these regions. After the bite, the rabies virus penetrates the peripheral nerves (nerves outside the brain and spinal cord), reproduces, and travels to the salivary glands of the infected animal. Here, the virus is transmitted through saliva. Rabies virus cannot survive outside of a mammal's body for long. The rabies virus can potentially be stored in mammals, especially carnivores and bats, from which it might infect humans and other animals. Either by coming into direct touch with the saliva or by being bitten by a rabid dog, a person can get rabies. It is the only human communicable disease that is still largely 100% lethal despite being easily avoidable. The majority of human rabies cases in India are linked to dog attacks. Throughout much of the country, dogs are the main source of rabies. The World Health Organization estimates that dogs are responsible for up to 99% of all human rabies transmissions. 92% of all animal bites in India are caused by dogs, 60% of which are stray dogs and 40% are domestic dogs (Sudarshan, 2003) [49]. 36% of rabies deaths worldwide and 56% of rabies deaths in Asia occur each year in India. According to reports, India has the greatest global prevalence of endemic canine rabies, accounting for 20,800 rabies deaths annually (Gupta, 2017) [16]. The incubation period for the rabies virus typically lasts between two and three months; however, depending on the location of the bite and the quantity of virus administered, it could take anywhere from one week to a year for clinical symptoms to manifest in human patients. Depending on the path the virus takes to enter the brain, rabies often presents in one of two ways. Anxiety, hypersensitivity, hydrophobia, and aerophobia are typical symptoms of "furious rabies," which typically results in death within two to three days. The less severe form of rabies, known as "paralytic/dumb rabies," results in death because of muscular paralysis. As it is deadliest disease of household pet, it must require ‘One health’ approach to prevent the disease (Desai *et al*., 2018[a]) [8] Worldwide occurrences of rabies deaths can be avoided through public awareness campaigns (Desai *et al*., 2018[b]) [9], dog vaccinations, and the proper pre- and post-bite care procedures advised by the WHO. Quick wound cleaning with soap and running water can significantly lower the viral load and limit the risk of rabies infection in the future. A global "United Against Rabies" collaboration has been established by the World Health Organization (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) to provide a common strategy to achieve "zero human dog-mediated rabies deaths by 2030 (WHO, 2022) [57].

Canine parvoviral gastroenteritis: Canine parvovirus enteritis (PVE), which is caused by three varieties of canine parvovirus type 2 (CPV-2; family Parvoviridae, Genus Parvovirus), is the major cause of morbidity and mortality worldwide in dogs (Desai *et al*., 2020[a]; Desai *et al*., 2020[b]) [8, 9]. In the mid-to-late 1970s, CPV-2 arose as a cause of acute canine enteritis, presumably from another carnivore parvovirus (cats or other hosts), spreading swiftly and causing global outbreaks. In the early to mid-1980s, CPV-2 developed into two variations (CPV-2a and CPV-2b), while in 2000, a third form (CPV-2c) was recorded in Italy and has subsequently been discovered on every continent outside Australia. These three variations are believed to have comparable pathogenicity, resulting in same clinical illness. Significantly, CPV-2a, CPV-2b, and CPV-2c strains have a greater host range than the original CPV-2 strain and may induce feline panleukopenia in cats if they arise naturally. Despite the fact that severe clinical disease mainly affects puppies younger than six months of age, adults with weak immunity may also be afflicted (Desai *et al*., 2020[a]) [8]. Breed susceptibility and seasonal occurrence of the disease are subject to substantial regional variation. CPV-2 is widespread and can remain in the environment for more than a year, allowing vulnerable dogs to be exposed to infected excrement, vomitus, or fomites (Desai *et al*., 2020[b]) [9]. The incubation time following natural or experimental exposure ranges from 4 to 14 days, and viral shedding begins a few days prior to the onset of clinical symptoms, reducing gradually 3–4 weeks after exposure.

Canine distemper

Canine Distemper virus (CDV) is a deadly virus that infects dogs, foxes, wolves, lions, and tigers (Desai *et al*., 2021) [10]. CDV is classified as a member of the genus Morbillivirus, subfamily Paramyxovirinae, family Paramyxoviridae, and order Mononegavirales. It is a 150-300 nm single-stranded, nonsegmented, enclosed, negative-sense RNA virus (Desai *et al*., 2021) [10]. Six structural proteins: haemagglutinin (H), *Large protein* (L), phosphoprotein (P), nucleocapsid protein (N), fusion protein (F), and matrix protein (M) as well as one non-structural protein (C) produced via an alternate open reading frame in the P gene make up the CDV genome (Joshi *et al*., 2022a) [22]. CDV is a virus with multiorgan tropism that causes numerous organ damage and systemic illness. The virus replicates primarily in the lymphatic system of the respiratory tract and then spreads to other organs, including as the eye, brain, lymphoid organs, urine bladder, respiratory system, and gastro intestinal tract (GIT) (Desai *et al*., 2021) [10]. Although though it has a greater affinity for the respiratory, central neurological, and digestive systems, it causes substantial harm and clinical manifestations (Joshi *et al*., 2022[b]) [23]. It is a highly immunosuppressive virus that enhances the host's susceptibility to secondary infections, the leading cause of death (Joshi *et al*., 2022a; Joshi *et al*., 2022b) [22, 23]. CDV is most lethal in young puppies, causing rapid death a few days after infection.

Canine Coronaviral infection

CCoV, or canine coronavirus illness, is a highly contagious intestinal sickness that primarily affects puppies (Desai *et al*., 2020a) [8]. Dogs infected with the canine coronavirus may have significant stomach discomfort for a few days. The virus

belongs to the family Coronaviridae. When viewed from above using an electron microscope, the virus has a ring of projections that resemble a coronet or a miniature crown composed of ornaments attached to a metal ring. There are numerous coronavirus kinds, each of which affects distinct animal species, including humans. Coronavirus transmission is caused by overcrowding and poor sanitation. One to four days pass between consumption and clinical manifestations. In most canines, the length of illness ranges from two to ten days. Secondary infections caused by bacteria, parasites, and other viruses can cause disease and recovery to be prolonged. Dogs may be disease carriers for up to six months (180 days) following infection. The majority of canine coronavirus infections are subclinical and manifest little clinical symptoms. On sometimes, an infection may result in more severe symptoms, especially in pups. The most common symptom of canine coronavirus is sudden-onset diarrhea, which may be followed by lethargy and a decreased appetite. The stool is loose, has a foul odor, and is orange in color. There may be blood or mucous present. If a puppy has a combined infection, such as coronavirus and parvovirus, the severity of the sickness will increase.

Canine rotavirus infection

Group A rotaviruses are human and animal gastrointestinal pathogens (Tumlam *et al*., 2019; Makwana *et al*., 2020[a]; Makwana *et al*., 2020[b]) [53, 27, 28]. Nonetheless, interspecies transmission or reassortment between animal and human viruses is possible (Kapikian *et al*., 2001) [24]. 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 beneficial for gathering epidemiological data and tracing the origin of uncommon rotavirus strains (Makwana *et al*., 2020[a]; Makwana *et al*., 2020[b]) [27, 28]. In human and animal group A rotaviruses, 15 VP7 genotypes (G types 1–15), 27 VP4 genotypes (P types [1]–[27]), 4 VP6 subgroup specificities (SGs I, II, I+II, and nonI/nonII), and 5 NSP4 genotypes (A–E) have been identified to far (Khamrin *et al*., 2007) [25]. A variety of strains with animal-like VP7 and VP4 genes have been sporadically found in humans, calves and dogs and have acquired epidemiologic significance in certain geographical regions (Iturriza-Gomara *et al*., 2004; Tumlam *et al*., 2019) [53, 21]. Dogs are considered vectors of viral, bacterial, or parasitic zoonoses for people of all ages, however the possibility of enteric virus transmission is largely disregarded. Early in the research of rotavirus epidemiology, however, symptomatic and asymptomatic infections by canine/feline-like rotavirus strains (HCR3A, HCR3B, Ro1845), classified as G3P5A [3], long e-type, and SGI, were detected in young infants (Santos *et al*., 1998) [41]. Due to overlook and ignorance due to dominance of parvoviral enteritis, the cases of rotaviral infection may be ignored and remain untreated.

Canine Herpesvirus infection

Canine herpesvirus (CHV) (also known as canine herpesvirus 1, canid herpesvirus 1, neonatal herpes, genital herpes, ocular herpes, and CHV-1) infections and related diseases have been recognized since the early 1960s (Hashimoto *et al*., 1982) [18], but there has been a resurgence of interest in the various clinical manifestations of the virus, making this review very timely (Ronsse *et al*., 2005) [38]. There are numerous CHV-associated infection types. In other instances, these infections were directly associated with clinical symptoms, such as acute neonatal viremia resulting in puppy mortality; systemic viremia in naive pregnant females resulting in fetal death, abortion, and mummification; and ocular-respiratory disease in dogs of varying ages (Anvik, 1991) [1]. The ability to identify the virus in its subclinical condition has altered over the past decade, allowing for a much clearer grasp of the significance of two subpopulations of dogs in the animal populations with which we work: carrier-shedder adult dogs and CHV– latently infected dogs. The improved sensitivity of antibody-based serology assays like direct fluorescent antibody test (Patel *et al*., 2018) [34], ELISA based detection kits and nucleic acid– based polymerase chain reaction (PCR) assays (Vala *et al*., 2020) [55] has increased our clinical investigation of bovine, equine, canine herpesvirus and other canine pathogenic pathogens (Ronsse *et al*., 2002) [39]. In addition to identifying CHV adult carriers in the general community, this new momentum has enabled veterinarians to screen canines undergoing invasive procedures.

Canine leptospirosis

A spirochete found in the urine of infected animals causes the growing zoonotic disease known as leptospirosis. Due to the unsanitary environment, endemic instances of leptospirosis may peak to epidemic proportions after natural catastrophes, posing a serious public health risk (Park Kasturba, 2017) [33]. Rodents serve as the principal reservoir host for pathogenic Leptospira species strains, which are mostly implicated in disease (Desai *et al*., 2020[c]) [11]. Yet, as secondary hosts, dogs can also spread illness. A man can become infected by touching his injured skin against water or soil or by consuming food or drink that has been tainted with infected urine (Desai *et al*., 2020[c]) [11]. For months to years, a carrier dog may release organisms into the environment. Due to non-specific clinical signs that resemble influenza-like sickness in humans, the disease is still largely overlooked. The lack of investigation into an infection is further exacerbated by the rarity of laboratory test availability and the unreliable nature of fast diagnostic assays. According to estimations from the Royal Tropical Institute in Amsterdam, leptospirosis has an annual incidence in the WHO's south-east Asia region of 0.1–1 per 100,000 in temperate regions and 10–100 per 100,000 in the humid tropics. In high-exposure risk groups and during disease outbreaks, an incidence can increase to more than 100 per 100 000 (Hartskeerl, 2005) [17]. Dogs can contract the disease directly by coming into touch with contaminated urine or indirectly by consuming contaminated water or swimming in contaminated bodies of water. The infection can manifest in dogs as weakness and depression, colic, liver damage, or even death. Dogs with the infection develop into the carrier stage and continue to excrete spirochetes in their urine. It is very difficult to treat the cases where there is more chances of treatment evasion which might lead for antimicrobial resistance (Bhinsara *et al*., 2018) [2]. Antimicrobial resistance and antimicrobial residue are the major concern (Patel *et al*., 2019; Patel *et al*., 2020) [35, 36] not in domesticated animals (Tumlam *et al*., 2022) [54] but also in pets. The close interaction of pets and humans might provide medium of transferring resistant bacteria vice versa. Using protective equipment and avoiding swimming in contaminated water bodies can reduce occupational danger to people. Pet animal vaccinations and the testing of a rodent control culling program can both help to reduce the animal population as vaccine is the prime measure for preventing disease occurrence (Makwana *et al*., 2018) [26].

Canine Brucellosis

The term "brucellosis" refers to a disease caused by infection with *Brucella spp.* in people and animals. Although there are significantly more genetic differences between strains of *Escherichia coli* or serotypes of *Salmonella enterica* than between Brucella species (Tsolis, 2002) [52], *Brucella spp.* are often host-restricted, which has been the standard method for designating the species. *B. melitensis*, *B. suis*, *B. abortus, B. canis, B. ovis, and B. neotomae,* for example, have small ruminants, pigs, cattle, dogs, sheep, and rodents as their favorite hosts, respectively (Xavier *et al*., 2009) [58]. Movement of animals from one region to another and confining them as organized farms are the most critical activity where occurrence and spreading of disease is highest (Sakhare *et al*., 2019; Sharma *et al*., 2019) [40, 46]. Even it causes interspecies spread of bacterial and viral Pathogens. In recent years, the genus has expanded significantly with the recognition of new species, including *B. ceti* (Ewalt *et al*., 1994, Foster *et al*., 2007) [14, 15], *B. pinnipedialis* (Foster *et al*., 2007) [15], *B. microti* (Scholz *et al*., 2008) [43], *B. inopinata* (Scholz *et al*., 2010) [44], *B. papionis* (Whatmore *et al*., 2014) [56], and *B. vulpis* (Scholz *et al*., 2016) [45], which have as their preferred hosts cetaceans (e.g., whales and dolphins), seals, common vole (*Microtus arvalis*), undetermined host. Brucellosis is one of the most significant zoonotic diseases in the world (Corbel, 2006; Pappas, 2010) [6, 32], and the vast majority of Brucella species are capable of infecting people, although their zoonotic potential is very variable. *B. melitensis* is the most virulent species of Brucella for humans, with just 1–10 CFU (colony forming units) required for infection, whereas *B. suis* and *B. abortus* possess intermediate zoonotic potential. *B. canis* has the lowest zoonotic potential among the traditional Brucella spp., and human infections with *B. ovis* have never been observed (Young, 1983; Xavier *et al*., 2010) [59, 60]. The pathobiology of brucellosis in livestock animals has been widely researched (Carvalho *et al*., 2010; Poester *et al*., 2013) [3, 37], primarily because of its zoonotic and public health implications (Young, 1983) [60] and because of the extremely considerable economic losses to the animal sector (Santos *et al*., 2013) [42]. In contrast, the majority of research on canine brucellosis relies on seroepidemiologic surveys (Holst *et al*., 2012) [20]. Furthermore, canine infections with *B. canis* are prevalent, which, considering the limits for correct identification in dogs and human patients (Mol *et al*., 2020) [29], makes human brucellosis associated with *B. canis* a zoonotic disease that is notably neglected.

Transmissible venereal tumors (TVT)

Canine transmissible venereal tumor (TVT), also known as canine condyloma, granuloma venereum, infectious sarcoma, or venereal lymphosarcoma, is among the most prevalent neoplasms afflicting dogs (Dagli, 2019) [7]. TVT is currently categorized as a round cell neoplasm, along with mast cell tumors, basal cell carcinomas, histiocytomas, and lymphomas. However other tumors cases have also been reported like perianal gland adenoma (Chaudhari *et al*., 2017) [4]. TVT is naturally contagious and sexually transmissible among dogs, particularly stray dogs and dogs of reproductive age (Tinucci-Costa & Castro, 2009) [51], and experimental transplantation has also been proved to be a possibility (Silveira *et al*., 2009) [48]. Although sexual actions are the most common method of TVT transmission, other methods exist, such as the habit of licking and sniffing other canines (Oliveira, 2019) [31], which can result in tumor cell implantation in the nasal and oral canals. Moreover, direct contact between locations with skin lesions might result in eye and skin lesions. Metastases occur in the skin, inguinal lymph nodes, liver, kidneys, spleen, intestine, heart, brain, and lungs, among other organs (Tinucci-Costa & Castro, 2009) [51]. However, they are uncommon and less common than extracutaneous metastases, which affect approximately 1% of dogs (Tinucci-Costa & Castro, 2009) [51]. The clinical signs reported in dogs with TVT and those with genital lesions include the presence of a single or multiple, usually friable mass on the foreskin or vulva, serosanguineous secretion, odor intensity, deformity, ulceration, and areas with or without necrosis (Oliveira, 2019) [31]. When tumors and/or their metastases originate in extragenital locations, different clinical symptoms may be present, depending on the location of the affected organ (Oliveira, 2019) [31]. These symptoms may appear as respiratory diseases, such as dyspnea, abdominal pain, and dysphagia (Tinucci-Costa & Castro, 2009) [51]. Depending on the anatomical location of the tumors, it may be more challenging to diagnose TVT in extragenital areas (Oliveira, 2019) [31]. In all instances, however, a precise diagnosis of primary or metastatic TVT can only be made through cytological or histological analysis (Tinucci-Costa & Castro, 2009) [51].

Canine infectious respiratory disease complex (Kennel cough)

Canine infectious respiratory disease complex (CIRDC), sometimes referred to as "kennel cough," is a highly contagious respiratory ailment affecting dogs. All ages and breeds are vulnerable. As the name "kennel cough" suggests, dogs exposed to environments where several canines are routinely gathered or housed, such as kennels, shelters, and daycare facilities, are at increased risk.

Several types of bacteria and viruses can cause CIRDC, and dogs can be infected by two or more of these pathogens simultaneously. *Bordetella bronchiseptica* as well as canine parainfluenza virus and canine adenovirus type 2 are among the most common organisms involved. The typical symptom of CIRDC is a sudden onset of a hacking, honking cough. This cough has also been referred to as gagging or retching, and it may be accompanied by foam that resembles vomit. Coughing is typically exacerbated by physical exertion or exercise, which can irritate the airways.

Nevertheless, not every dog with CIRDC will cough. Also prevalent are sneezing and a runny nose or eyes. In the majority of CIRDC instances, the disease is mild and dogs recover completely within 7 to 10 days. However, depending on the infecting organism(s) and the dog's ability to fight them, some dogs may develop more severe symptoms, such as lethargy, decreased appetite, fever, productive cough, and rapid or labored breathing, which may indicate that bacteria have infected the lungs (bacterial pneumonia) and require immediate veterinary care. Dogs infected with canine distemper virus may also exhibit gastrointestinal symptoms (such as vomiting or diarrhea), hardened footpads, and, as the disease develops, neurologic symptoms (e.g., head tilt or circling behavior). These dogs, as well as pups and older dogs with other health issues, are at a greater risk of contracting a severe illness or perhaps dying.

Canine skin infection/Pyoderma

Staphylococcus pseudintermedius is a gram-positive bacteria with coagulase activity that typically resides in the anterior portion of the nasal cavity of a variety of species, including

dogs, pigeons, and horses. This pathogen could also be isolated from the gingiva of healthy dogs, according to some evidence (Hoekstra and Paulton, 2002) [19]. *Staphylococcus pseudintermedius* is not a common zoonotic pathogen in humans; nonetheless, multiple investigations have established that this bacterium is a potential pathogen linked with dog bite wounds and that cellulitis can develop in humans infected with this bacterium (Tanner *et al*., 2000) [50]. This microorganism must be distinguished from *staphylococcus aureus*. Treatment with penicillin and amoxicillin-clavulanate is beneficial for this infection but increasing drug resistance might fail to treat with common antimicrobials. Methicillin-resistant *Staphylococcus aureus/pseudintermedius* (MRSA/P) is a leading cause of deadly infections. According to multiple studies, this bacteria have been isolated from a variety of animals, including pigs, horses, cattle, cats, and dogs. Conventional drugs against staphylococci are not more effective in treating infections caused by MRSA. Hence, newer medications, such as vancomycin, linezolid, and daptomycin, are frequently used to treat MRSA infections (Morgan, 2008) [30].

Conclusion

The advantages of a man-dog relationship are well known around the world. Dogs and humans are becoming more and more closely entwined. They are no longer relegated to the outside of the house but are now an important part of families who live inside with men. There is no doubt that these connections are good for people's social, emotional, and overall wellbeing. Although there are benefits to this link between people and animals, we also need to be aware of illnesses might spread between these two populations. Dog diseases like, Rabies, Canine Parvoviral gastroenteritis, Canine Distemper, Canine Coronaviral infection, Canine Rotavirus infection, Canine Herpesvirus infection, Canine Leptospirosis, Canine Brucellosis, Transmissible venereal tumors (TVT), Kennel cough, Pyoderma should need to be known by every pet owner and their family members. The first line of defense against any disease is prevention. Frequent immunization, deworming, the use of the proper chemical disinfectants, as well as personal and environmental hygiene, can guard against the spread of many infections between dogs and their owners. To stop the spread of these diseases, early diagnosis and owner education are crucial.

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