CHAPTER N0.

27

Bacterial Zoonosis in Animals: Pathogenesis, Diagnosis and Therapeutic Strategies

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Summary: Bacterial zoonoses are infectious diseases that can spread from animals to humans and pose a significant threat to global health due to their widespread incidence and impact. The importance of early diagnosis cannot be overstated because it allows for quick treatment, effectively reduces the seriousness of the disease, prevents further human and animal propagation, and is necessary for implementing the proper containment measures. The "One Health" concept, which encourages collaboration across the human health, animal welfare, and ecosystem sectors, is essential to recognizing the interconnection of diseases and developing comprehensive, coordinated measures for surveillance, early identification, and control. This integrated strategy is essential for ensuring the general defense of public health and effectively combating complex zoonotic risks.
Keywords: Zoonoses, One health, Bacterial diseases

INTRODUCTION

The genesis and spread of several infectious diseases are greatly influenced by individuals, animals, and their surroundings. Animals are the source of the majority of infectious diseases that harm people. According to the "Asia Pacific approach to emerging diseases: 2010" study, approximately 60% of newly discovered infections affecting humans are zoonotic, with over 70% of these viruses originating from wildlife species. Recent decades have seen the emergence of novel human diseases that were directly linked to meals derived from animals. The Greek words "zoon," indicating an animal, and "nosos," which indicates illness, are the roots of the word "zoonoses." The World Health Organization (WHO) defines a zoonosis as any illness or infection that can naturally spread from human beings to animals or from vertebrate species to humans. Approximately 61% of human pathogens are zoonotic. Zoonoses are a serious public health issue that poses a direct risk to human life and can even be fatal. In addition to their detrimental effects on the health of people, the 13 most prevalent zoonoses worldwide have an estimated 2.4 billion cases of disease and 2.7 million human fatalities annually, with poor livestock laborers in nations with low or middle incomes being the most affected. The majority of these illnesses have an impact on animals' health and reduce livestock output (Esposito et al., 2023).

EMERGING ZOONOSIS

Emerging zoonosis is defined as a zoonosis that is either recently identified, has recently evolved, or has previously happened but exhibits a rise in incidence or an increase in host, vector, or geographic range. Over the past 70 years, more than 250 zoonoses have been identified as developing or reemerging zoonotic illnesses. These illnesses have expanded quickly across the globe, both geographically and in terms of occurrence. Proximity to animals, which serve as pools for newly emerging and reemerging zoonotic illnesses, has an impact on humans. Avian flu, spongiform encephalopathy of cattle (BSE), feline cowpox, rotavirus infection, viruses such as norovirus illness, Ebola, human hantavirus infection, diseases such as West Nile fever, canine leptospirosis, MRSA infections, cat scratches disease, high fever with syndrome of thrombocytopenia (SFTS), the Middle East respiratory syndrome (MERS), severe acute breathing syndrome (SARS), and the most recent coronavirus disease 2019 (COVID-19). However, in many regions of the world, rabies, brucellosis, Japanese encephalitis, TB (*M. bovis*), and a Schistosoma japonica infestation are thought to be reemerging zoonoses (Leal Filho et al., 2022).

REEMERGING ZOONOSIS AND WILDLIFE

Due to their close relationships with people, domesticated creatures, and the surrounding environment, wild animals are actively involved in the spread and upkeep of several infectious diseases. The ecological relationships between the one-health aspects are being disrupted by globalization, habitat degradation, climate change, and species declines in biodiversity. This eventually leads to the formation of zoonotic infections and changes in the modes of spread. Wild animals can carry pathogens that affect human and animal health, lower agricultural productivity, and disrupt wildlife (Bartlow et al., 2021). Animals such as reptiles, fish, birds, and

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amphibians are examples of wild species that serve as reservoirs for zoonotic infections that can spread to humans or other living things. It is concerning that wild animals are involved in the genesis and spread of zoonotic illnesses. The type of virus implicated and meteorological factors like temperature, humidity, and precipitation have an impact on how wildlife zoonoses spread. These viruses' patterns of transmission among people, domestic animals, and wild animals determine their emergence and reemergence. Rapid growth in populations, ease of travel both domestically and internationally, increased human contact with animals and animal products, and wildlife ranching are some of the factors influencing these processes (Cook and Karesh, 2011).

Overview of Bacterial Zoonosis

There are four types of classification based on pathogen type, transportation route, life cycle, and ecological category, which are part of our framework. Based on the disease's etiological agent, which can be bacterial, viral, protozoan, parasitic, fungal, or prion, the pathogen type describes the zoonosis. Lifecycle Depending on what the pathogen needs to finish its life cycle, it can be either direct, metazoonosis, saprozoonosis, or cyclozoonosis. Giardiasis is an example of a direct zoonosis, in which the infection can spread through creatures that are not humans to people. For the disease to complete its life cycle, cyclozoonoses like echinococcosisneed several vertebrate hosts. For a metazoonosis, like anaplasmosis, the pathogen needs both a vertebrate and an invertebrate host to finish its life cycle. For saprozoonoses like histoplasmosis to complete their life cycle, pathogens need both a host that is vertebrate and an external reservoir (Keenan et al., 2024,

Transmission

Via travel, interaction with exotic pets, work exposure, and recreational activities, Americans are becoming more and more susceptible to exotic zoonotic diseases. In order to prevent the nosocomial transmission of uncommon zoonotic illnesses in which contact between individuals has been recorded, appropriate isolation measures are necessary. The Andes hantavirus disease, anthrax, B virus infection, hemorrhagic fevers (caused by Ebola, Marburg, Lassa, Crimea-Congo hemorrhagic fever, Argentine blood-borne fever, and Bolivian blood disease viruses), monkeypox, plague, Q fever, and rabies are among the infectious diseases with reported person-to-person transmission. A number of these infections, such as anthrax, bloody fever viruses, the plague, and Q fever, may also provide bioterrorism risks. Following advised isolation protocols will enable appropriate patient care while safeguarding medical personnel who treat patients with presumed or confirmed zoonotic illnesses that can spread nosocomially (Anderson and Bokor, 2012).

IMPORTANCE OF ONE HEALTH APPROACH

Collaborative surveillance of illnesses, controlling and preventing zoonotic disease outbreaks, enhancing food safety and security, and reducing infections caused by antimicrobial-resistant bacteria to promote human and animal health are all accomplished through the One Health strategy. The One Health concept increases the diagnostic laboratory infrastructure, the network for rapid response and outbreak detection, the infection surveillance system, and the data sharing mechanism with all stakeholders by encouraging strong collaboration among pertinent sectors. This strategy undoubtedly improves staff efficiency for zoonotic control and prevention and guarantees efficient and well-coordinated public health emergency preparedness, where all tactics help to effectively reduce zoonotic illnesses. Overall, by addressing prevalent health threats like zoonoses, resistant microbes, food safety, and safety hazards, the One Health approach effectively collaborates, coordinates, and communicates information at the points of contact between pertinent sectors, strongly supporting global health security (Erkyihun and Alemayehu, 2022).

BACTERIAL DISEASES

Phantom tuberculosis and Bartonella infection were among the bacterial illnesses covered in our study's topic. The main natural reservoirs of Bartonella species, some of which are zoonotic causal agents, are rodents. Therefore, monitoring rat Bartonella sp. infections is crucial for preventing human outbreaks of bartonellosis. To detect and identify Bartonella sp. DNA, Jian et al. caught rodents and collected their spleen samples. They then used semi-nested polymerase chain reaction (PCR) to amplify the 16S rRNA, gltA, and ftsz genes. Investigations showed that although bacterial DNA was found in 31 Apodemus agrarius people, with a rate of finding of 28.4% in Handan City, Bartonella sp. DNA was found in seven rats from Norway people with a discovery rate of 6.7% in Chengde City. There was no statistically significant variation in the DNA analysis rate across the genders and ages of the rodents. Additionally, at least eight Bartonella species were found in circulation in Hebei Province, according to sequence analysis of the aforementioned three genes. Three of these species, Bartonella rattimassiliensis, Bartonella grahamii, and Bartonella tribocorum, are human pathogens, indicating the presence of an important threat to public health (Chai et al., 2023).

PATHOGENESIS OF BACTERIAL ZOONOSIS

Pathogenesis of Rabies

All of the knowledge regarding the pathophysiology of rabies has come from research conducted in experimental animals, mostly rodents. Via injuries or direct contact with the mucus membranes, the virus penetrates the body. A rabid animal's bite can inoculate muscles and subcutaneous tissues with infectious saliva. The rabies virus then begins to replicate in the affected muscle tissue by binding to nicotinic acetylcholine receptors at the junction of neuromuscular tissue (Kumar et al., 2023).

Pathogenesis of Mpox

Mpox outbreaks are common amongst rural residents who participate in ecosystem-related activities like trapping wildlife. The biggest risk factor for infection is their intimate physical touch. According to the mechanism of transmission from a wildlife source or human-to-human contact, the onset of Mpox infection begins with viral entrance through cutaneous cells or respiratory mucosa. Primary viremia is caused by the virus replicating at the site of first inoculation (skin or the respiratory tract) and then spreading to the surrounding lymph node drainage. Following its replication in lymphoid tissues, the MPXV infects the spleen and other lymph node organs. Secondary viremia results from the virus's subsequent release into the circulatory system. After entering the bloodstream, MPXV localizes once more in respiratory epithelium or skin cells, resulting in inflammation of the skin and viral transmission in drool and other body fluids.40, 41 The duration of contact with a sick animal or human, the viral density in bodily fluids and superficial wounds, and the pathogenicity of the virus all play a significant part in the host's response to infection. Therefore, the host immune response and MPXV escape pathways have a major role in the risk of transmission (Tajudeen et al., 2023).

Pathogenesis of Brucella

The pathogenesis of brucellosis involves complicated relationships between the human immune system and microorganisms. Because of their high degree of adaptability, Brucella species can elude immune responses and cause persistent infections. After entering the host, Brucella multiplies and survives inside macrophages, allowing for extensive spread. The subcellular environment is a major obstacle to successful vaccine and treatment development because of its capacity to control host processes, including autophagy and apoptosis, which is essential to survival and replication (Elbehiry and Almuzaini, 2025).

Clinical manifestations in animals

The gradual onset of symptoms includes progressive fatigue, debility, and mildly fluctuating temperature. Decreased tolerance to exercise, breathing difficulties, and a persistent, moist cough are more apparent in the early hours and in chilly conditions when the lungs are involved. Head lymph nodes may swell, and internal lymph node swelling is indicative of organ blockage. Constipation or diarrhea is caused by gastrointestinal involvement. The gradual onset of symptoms includes progressive fatigue, debility, and mildly fluctuating temperature (Qureshi et al., 2023). Animals may occasionally exhibit peripheral lymph node disease and reduce their weight (Mansfield and Fox, 2019).

Clinical Indications of Mycobacterium

NTM contamination has been identified based on ambiguous or positive subcutaneous skin test results, and infected animals frequently show no clinical symptoms. Animals may occasionally exhibit peripheral lymph node disease and reduce their weight (Mansfield and Fox, 2019). The illness has a brief incubation period; clinical symptoms show up two to four hours after eating. Abdominal cramps, either with or without constipation, nausea, vomiting, chills, headache, and mostly subnormal temperature are its hallmarks, but there is no fever. The most frequent symptoms are nausea, vomiting, and cramping in the abdomen. Particularly vulnerable people, such as youngsters and the elderly, can occasionally die (Abebe et al., 2020).

Clinical Indications of Bovine Tuberculosis

The signs and symptoms are determined by the afflicted organ systems: In the early stages, animals with tuberculosis are clinically healthy and show no signs. The gradual onset symptoms include progressive fatigue, debility, and mildly fluctuating temperature. Decreased tolerance to exercise, breathing difficulties, and a persistent, moist cough are more apparent in the early hours and in chilly conditions when the lungs are involved. Head lymph nodes may swell, and internal lymph node swelling is indicative of organ blockage. Constipation or diarrhea is caused by gastrointestinal involvement. Mammary TB can cause hypertrophy and chronic mastitis in different animal populations. Infertility and abortion are possible outcomes of tuberculosis metritis, which can also cause persistent purulent discharge from the genitals. Hematogenous military tuberculosis can cause immediate or subacute mortality from primary as well as secondary lesions (Qureshi et al., 2023).

Clinical Signs of Leptospirosis

Leptospirosis usually takes 7 to 14 days to incubate, while it can take anything from 2 to 30 days. Roughly 90% of diseases in humans are either subclinical or exhibit mild flu-like symptoms. Severe forms, however, can happen and may result in potentially fatal consequences such as meningitis, pancreatitis, encephalitis, liver and renal failure (Weil's disease), or bleeding from the lungs. Abortion or stillbirth may also arise from transplacental transfer. Septospirosis can result in a variety of pathological alterations and clinical signs in animals. Infection can cause late-term miscarriage in cows and blood loss and hemoglobinuria in calves, followed by interstitial nephritis (mixed for clarity). Mastitis condition and sporadic miscarriages are possible in dairy cows. The biggest losses in pigs are caused by stillbirths, abortions, infant mortality, and interstitial nephritis (Basiouni et al., 2025).

Clinical Signs of Brucellosis

A variety of clinical symptoms are displayed by infected animals, especially those associated with reproductive difficulties such as abortion and the birth of feeble progeny that act as carriers within the herd. The reproductive system is the primary site of brucellosis's clinical symptoms and other consequences in several animal species. The incubation period of the disease might range from two weeks up to several months. Although calves can contract the infection at a young age, clinical symptoms might not show up until they are older. Weak calves, decreased fertility, fetal membrane retention, endometritis, and decreased milk production are all consequences of prolonged abortions in pregnant animals. In vulnerable herds, the abortion rate might vary between 30 and 80% (Arero, 2022).

DIAGNOSIS OF BACTERIAL ZOONOSIS

Diagnostic Tests

In LMICs, accurate and quick field detection of zoonotic and infectious animal diseases has numerous advantages. The well-being and livelihoods of rural communities, and resourceconstrained government services can be improved by early detection and management (e.g., therapy, isolation, or culling) of infected animals, which can prevent future medical expenses associated with chronic illnesses in people as well as animals. From a global standpoint, such prompt detection and treatment choices can stop infectious pathogens from spreading further, safeguarding the health and welfare of human and animal populations everywhere and possibly containing epidemics the fact that would otherwise have grave and extensive repercussions (Gaballa and Shoulah, 2021). This study examined the clinical utility of fecal bacterial enteric pathogen cultures (FBEPC) results in the context of following clinical actions in which its use could be justified after adjunct use of fecal cytology as a first-line method of diagnosis to ascertain the diagnostic value of FBEPC as part of regular preventive medicine methods in terrestrial mammal species housed in a zoological collection (Gaballa and Shoulah, 2021). A wide range of diseases, including bacteria, viruses, and parasites, can cause zoonoses. These pathogens frequently have intricate life cycles that include definitive hosts, intermediary hosts, arthropod carriers, and ecological reservoirs. The failure to identify numerous organisms with standard microbiologic investigations, vague clinical symptoms, and gaps in physician understanding about these rare illnesses can all lead to diagnostic problems. Nonetheless, radiologists encounter imaging findings in numerous patients with these illnesses.

Anthrax is regarded as a sickness that is resurfacing. Laboratory tests that search for anthrax germs or antibodies in the animal's blood or other tissues are used to diagnose anthrax in animals. The majority of anthrax strains are responsive to first-line antibiotics; some strains are resistant to them, according to a review of vulnerability assessments (Alam et al., 2022). When an animal passes away unexpectedly without showing any signs, especially in ruminants, anthrax may also be suspected. A fast-decaying carcass, bloody secretions from the mouth, nose, or anus, a lack of death, dark, tar-like, unclotted blood, or a large spleen that has the consistency of "blackberry jam" are other indicators of anthrax. Care must be used when gathering samples to prevent environmental contamination and bacterial exposure. In the past, stained streaks of blood, pleural or peritoneal fluid, or lesion exudate, based on the route of illness, edema fluid in pigs, and blood in other animals can be examined under a microscope to confirm the diagnosis. Animal blood or fluids aspirated from pustules might be used to cultivate the bacilli. Fresh stains or blood smears can be treated using the fluorescent antibody method. Another study employed serum samples and an enzyme-linked immunosorbent test to find the bacilli's IgG titers (Faccin et al., 2023).

The diagnosis of Tb is mostly dependent on microscopic analysis for acid- fast staining (AFS) bacilli in sputum or tissue, such as using the Ziehl-Neelsen stain. AFS does not distinguish between different kinds of mycobacteria. Additionally, it is not sensitive enough to detect tissue samples and sputum smears. The sputum smears and extracted tissue can be made more sensitive by staining them with auramine and using an LED fluorescence microscope to detect fluorescence, which is comparable to the method used for FISH tests. The Xpert® MTB/RIF system, also known as Xpert (Cepheid, Sunnyvale, CA, USA), is a PCR-powered nucleic acid amplification (NAA) method that finds certain MTB DNA sequences (Shah and Ramasamy, 2022).

Benefits and Limitations of Diagnostic Tests

The results of a PCR or serological test are not the only factors used to diagnose Lyme disease. When interpreting the test, clinical and epidemiological features should be taken into account. This is true for any illness, including Lyme disease. The intrinsic qualities of the test (specificity and sensitivity) and the probability of having the illness in question (prevalence), which is dependent on the tested sample, determine the predictive ability of the serological test. As an illustration, the predictive value of a positive serology test in a patient who does not reside in or have visited an endemic area and does not exhibit any objective lesions diagnostic of Lyme disease is nearly negligible. For instance, when conducting seroprevalence investigations on people who have been overexposed to the disease (such as forest rangers in Alsace, France), up to 14% of the subjects may have a positive serology without exhibiting any symptoms of the illness. The percentage of persons who get Lyme disease after coming into contact with Borrelia burgdorferi varies, but the presence of the bacteria is not always linked to the development of the illness in all cases after tick inoculation. Because of this, biological outcomes cannot be understood independently. To analyze biological results in the context of the patient's clinical features, doctors must possess the necessary knowledge (Eldin et al., 2019).

Therapeutic Strategies

Tan et al. (2025) investigate the antimicrobial and antibiofilm properties of a blend of essential oils from cinnamon and star anise against drug-resistant Salmonella Thompson. These multidrug-resistant bacteria, which originate from Bellamya quadrata, which is a freshwater snail that is frequently eaten in Guangxi, represent a serious risk to food safety. The discovery presents a possible substitute for traditional antibiotics by showing that the synergistic combination of these natural chemicals effectively hinders both bacterial development and biofilm formation. This strategy emphasizes the possibilities of using natural materials in antimicrobial therapy while simultaneously addressing the crucial problem of antibiotic resistance.

ANTIBIOTICS' IMPORTANCE

Zoonoses are a serious issue everywhere in the world. Antibacterial resistance in zoonotic diseases can be managed with a single health approach. Early in the 20th century, the discovery of antibiotics led to a significant improvement in human health that has saved many lives. Antibiotics are complex substances that prevent germs from growing in a number of ways. Cell membrane alteration, cell wall synthesis inhibition, antimetabolite action, nucleic acid synthesis blockage, protein synthesis suppression, and competitive antagonism are some of these processes.

Antibiotics play a vital function in human health, but they are also used in the breeding of animals and cattle to protect against infectious diseases and boost the production of meat and dairy products. They are used extensively to encourage animal weight and growth. Antibiotics have many advantages, but their over use and environmental contamination cause major problems (Parmar et al., 2018).

ANTIBIOTIC MECHANISM OF ACTION

Antibiotics work through five different mechanisms: It prevent the synthesis of bacterial proteins; prevent the synthesis of bacterial nucleic acids; halt the creation of cell walls; interfere with the operation of cell membranes; and disrupt the bacterial metabolic pathway (Ahmad et al., 2023). The overuse of antimicrobial drugs in medical, farming, and veterinary contexts has led to the global problem of antimicrobial resistance (AMR). Resistant microbes have emerged as a result, endangering food safety and public health. Numerous modes of susceptibility gene transfer and developing evolution in the genetic composition of resistant bacteria aggravate the situation. Antimicrobial resistant genes (ARGs) can be prevented from spreading by keeping an eye on AMR in agricultural, companion, and wild animals (Cheng et al., 2024).

By attaching to the overexpressed infected macrophages and delivering antimicrobial medications in a targeted and regulated manner, nanotechnology has transformed medicine with its diverse potential for identifying and curing zoonosis. Using poly(ethylenimine)-conjugated particles, modified thiolated chitosan (MTC)-coated particle-loaded PLGA NPs, the mannose linked thiolated nanocarriers adjuvanted pDNA hydrogel, arginine-containing nanocarriers, and quantum dots to treat and diagnose a variety of zoonotic diseases, such as infectious influenza, salmonellosis, leishmaniasis, rabies, Lyme disease, and other infections caused by emerging coronaviruses (SARS, MERS, COVID-19). It has been demonstrated that recently created anti-pathogen-laden nanoformulations with improved cellular absorption, biocompatibility, and hemocompatibility can pass through biological barriers when orally administered (Arshad et al., 2022)

Prevention and Control Measures

Public health services are particularly burdened by the prevention and management of zoonotic illnesses, especially in settings with low resources. Healthcare and veterinary health organizations have a significant interest in illness surveillance and control efforts because many zoonotic infections have a profound impact on both humans and animals. Agency cooperation is essential, but it takes time and requires careful planning and skillful activity coordination. Even with the best of intentions, one-sided disease prevention (implemented by both the human and animal health sectors) frequently fails to stop the spread of zoonotic illnesses. For instance, a rabies prevention program that focuses mostly on preventing human deaths by expanding access to postexposure prophylaxis (PEP) vaccines with little to no concurrent investment in dog vaccination will surely save lives in developing nations where canine rabies is still ubiquitous, but it is not as inexpensive as putting money into mass canine vaccination intended to eradicate the disease from the primary reservoir (Shiferaw et al., 2017).

Attempts to break the spreading circuit of vector-associated zoonoses (VZB) and vector-borne illnesses with animal reservoirs (VBIAR) are complicated by their intricate transmission characteristics. Insecticide use may be difficult in some situations to control and eradicate VZB and VBIAR, especially for illnesses with sylvatic transmission cycles. Consequently, different strategies have been taken into consideration for managing these infections' vectors. From the viewpoints of VZB and VBIAR, we emphasized the distinctions between the ecological, chemical, and biological prevention strategies in vector management in this review. In accordance with the combined vector management strategy (IVM) created by the World Health Organization (WHO) since 2004, concerns and knowledge gaps regarding the available control approaches were discussed to gain an understanding of the possibility of integrating these vector prevention approaches to work together break the transmission of VZB and VBIAR in humans (Wong et al., 2023).

The trafficking of wild creatures, which can lead to the emergence of contagious diseases, is also fueled by culinary customs that involve the intake of wildlife meat or traditional medicine. A spillover event that leads to an effective and durable spread between individuals can spread swiftly in a world growing more interconnected by the day. The continuing coronavirus disease (COVID-19) pandemic, which has caused an unparalleled global healthcare, social, and unable to stop the emergence of new zoonotic diseases (EZDs) that originate from animals, despite our experiences with Ebola, highly pathogenic H5N1 avian influenza, and Severe Acute Respiratory Syndrome (SARS), as well as improved national and international surveillance systems (Magouras et al 2020).

CONCLUSION

Due to their frequent occurrence and extensive effect, bacterial zoonoses, infectious illnesses that can transmit from animals to humans pose a serious threat to world health It is impossible to overestimate the significance of early diagnosis since it enables rapid treatment, effectively lessens the severity of the disease, stops additional human and animal transmission, and is essential for putting appropriate containment measures into place. In order to acknowledge the interdependence of diseases and create all-encompassing, coordinated approaches for surveillance, early detection, and control, the "One Health" concept, which promotes cooperative efforts across the human health, welfare of animals, and ecosystem sectors, is crucial. Effectively controlling complex zoonotic hazards and guaranteeing the general safety of public health depend on this integrated approach.

REFERENCES

Abebe E, G Gugsa and M Ahmed, 2020. Review on major food-borne zoonotic bacterial pathogens. Journal of Tropical Medicine 2020:4674235.

Ahmad S, M Rizwan and S Mahmood et al., 2023. Status of chemical antibiotics against bacterial zoonosis. International Journal of Agriculture and Biosciences 3:67–81.
Alam ME, MM Kamal, M Rahman et al., 2022. Review of anthrax: A disease of farm animals. Journal of Advanced Veterinary and Animal Research, 9:323.
Anderson PD and G Bokor, 2012. Bioterrorism: pathogens as weapons. Journal of Pharmacy Practice 25:521–9.
Arero GB, 2022. Major reproductive health disorders in dairy cows. Journal of Animal Biology and Veterinary Medicine 2:1-11.
Arshad R, S Sargazi and I Fatima et al., 2022. Nanotechnology for therapy of zoonotic diseases: a comprehensive overview. ChemistrySelect 7:202201271.
Bartlow AW, C Machalaba, WB Karesh et al., 2021. Biodiversity and global health: intersection of health, security, and the environment. Health security 19:214-22.
Basiouni S, AJ Rodriguez-Morales and AA Shehata et al., 2025. Silent carriers: the role of rodents in the emergence of zoonotic bacterial threats. Pathogens 14:928.
Chai H, Q Liu and NN Gaudreault et al., 2023. Zoonotic diseases originating from wildlife: emergence/re-emergence, evolution, prevalence, pathogenesis, prevention, and treatment. Frontiers in Microbiology 14:1165365.
Cheng G, LX Fang and J Feng et al., 2024. Antimicrobial resistance in zoonotic bacteria. Frontiers in Microbiology 15:1362380.
Cook RA and WB Karesh, 2011. Emerging diseases at the interface of people, domestic animals, and wildlife. Fowler's Zoo and Wild Animal Medicine 22:136.
Elbehiry A and AM Almuzaini, 2025. Unraveling brucellosis: advances in pathogenesis, diagnostic strategies, therapeutic innovations, and public health perspectives. Frontiers in Medicine 12:1629008.
Eldin C, B Jaulhac and O Mediannikov et al., 2019. Values of diagnostic tests for the various species of spirochetes. Medecine et Maladies Infectieuses 49:102–11.
Erkyihun GA and MB Alemayehu, 2022. One Health approach for the control of zoonotic diseases. Zoonoses 2:963.
Esposito MM, S Turku, L Lehrfield et al., 2023. The impact of human activities on zoonotic infection transmissions. Animals 13:1646.
Faccin M, DJ Wiener, RR Rech et al., 2023. Common superficial and deep cutaneous bacterial infections in domestic animals: A review. Veterinary pathology 60:796-811.
Gaballa MM and SA Shoulah, 2021. Canine bacterial zoonosis. Veterinary Pathobiology and Public Health:239.
Keenan S, D Niedziela and V Morera-Pujol et al., 2024. Zoonotic disease classification in wildlife: a theoretical framework for researchers. Mammal Review 54:63–77.
Kumar A, S Bhatt and A Kumar et al., 2023. Canine rabies: an epidemiological significance, pathogenesis, diagnosis, prevention, and public health issues. Comparative Immunology, Microbiology and Infectious Diseases 97:101992.
Leal Filho W, L Ternova, SA Parasnis et al., 2022. Climate change and zoonoses: a review of concepts, definitions, and bibliometrics. International Journal of Environmental Research and Public Health 19:893.
Magouras I, VJ Brookes and F Jori et al., 2020. Emerging zoonotic diseases: should we rethink the animal–human interface? Frontiers in Veterinary Science 7:582743.
Mansfield KG and JG Fox, 2019. Bacterial diseases. In: The Common Marmoset in Captivity and Biomedical Research. Academic Press, pp:265–287.
Parmar BC, JB Nayak and MN Brahmbhatt et al., 2018. Prevalence of dermatophytosis in animal and human population with special reference to its zoonotic significance. International Journal of Pure and Applied Biosciences 6:687–91.
Qureshi MA, Z Fatima and SM Muqadas et al., 2023. Zoonotic diseases caused by mastitic milk. Zoonosis 4:557–72.
Shah JS and R Ramasamy, 2022. Fluorescence in situ hybridization tests for identifying protozoan and bacterial pathogens in infectious diseases. Diagnostics 12:1286.
Shiferaw ML, JB Doty and G Maghlakelidze et al., 2017. Frameworks for preventing, detecting, and controlling zoonotic diseases. Emerging Infectious Diseases 23:71.
Tajudeen YA, HJ Oladipo and AO Muili et al., 2023. Monkeypox: a review of a zoonotic disease of global public health concern. Health Promotion Perspectives 13:1-9.
Tan L, M Ma and Z Zhu et al., 2025. Exploring zoonoses: therapeutic strategies and drug mechanisms. Frontiers in Cellular and Infection Microbiology 15:1581340.
Wong ML, Z Zulzahrin and I Vythilingam et al., 2023. Perspectives of vector management in the control and elimination of vector-borne zoonoses. Frontiers in Microbiology 14:1135977.