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Review Article

A Review on the Role of Rodents in the Transmission of Emerging Zoonotic Bacterial Diseases

Mohammedkemal Mustefa Ame[1*], Mathewos Belina Woyessa[2], Kedir Mohammed[1], Wali Khan[3], Asma Mohamed Ziyada Farah[4]

[1]Department of Veterinary Public Health, College of Veterinary Medicine, Haramaya University, Ethiopia
[2]Department of Veterinary Public Health, College of Veterinary Medicine, Wollega University, Ethiopia
[3]Department of Zoology, University of Malakand, Lower Dir, Pakistan
[4]College of Applied Medical Sciences, Jazan University, Jazan, Saudi Arabia

Abstract

Emerging infectious diseases (EIDs) are those that are either newly discovered in a community or those that are already there but are rapidly spreading geographically or becoming more frequent. Bacteria are considered to be the source of 54% of newly EIDs, and 175 pathogenic species are connected to diseases that are suspected of emerging. Emergent infectious diseases are those that have either not yet been identified and are impacting a population, or those that are currently present but are rapidly expanding to new regions or generating a high number of new cases within an existing population. Emerging diseases also include infectious diseases that once affected a region, declined, or were under control but are returning more frequently. Moreover, EIDs are infections that were formerly limited to a particular area, declined, or were under control but are now manifesting more frequently.

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Introduction

The rodent order, which makes up roughly 43% of all mammalian species, is the most diverse and numerous order of living mammals (1). The directive Rodentia are found all throughout the world, and it is commonly known that rodents are the primary reservoirs of zoonotic diseases (2). Numerous investigations revealed that rats are a major factor in the spread of numerous dangerous zoonotic diseases, including salmonellosis, leishmaniasis, campiliobacteria, and murine typhus (3). Because they can increase environmental diseases and serve as reservoirs of zoonotic diseases, rodents are dangerous (4).

Due in large part to the pre-harvest harm they inflict on cereals, rodents are a significant global rival to humans for food (5). Diseases that can spread from domesticated or wild animals to humans are referred to as zoonotic diseases (6). Rodents make up the majority of zoonotic reservoir species, which are the source of about 60% of all infectious disease pathogens that infect humans (7).

It is interesting to note that a large number of hotspots for rodent reservoirs are found in areas with the highest concentration of human emerging infectious disease (EID) cases (8). Inhalation, swallowing, or skin punctures are the routes by which the bacterial, viral, and protozoan pathogens that cause zoonotic diseases enter the human body after being expelled by rodent hosts or being bitten by a bloodsucking arthropod (9).

Salmonellosis, campylobacter, listeriosis, and other bacteria are among the developing zoonotic bacteria that are spread by rats. Additionally, numerous additional disease agents may be transmitted by wild rodents (10).

The public health of the world is greatly affected by emerging bacterial zoonoses. In recent years, national and worldwide awareness of both emerging and re-emerging bacterial zoonoses has grown. There are more cases of animal-borne bacterial zoonoses due to increased contact with companion animals and quick socioeconomic changes in the food supply system (11).

The first approach is a direct one: consuming food or water that has been contaminated by the poop of rats can infect humans (12). It is also possible for humans to come into contact with surface water that has been contaminated by the urine of rats, which can lead to diseases like leptospirosis. Additionally, rats are occasionally brought up in relation to the horizontal transfer of infections that result in animal diseases, which in turn harms the reputation of animal husbandry and generates enormous financial losses (13). The purpose of this review article was to examine how rodents contribute to the spread of newly discovered zoonotic bacterial diseases.

*Corresponding Author: Mohammedkemal Mustefa Ame, Email: mohammedmustefa4@gmail.com

Literature Review

Newly Developing Bacterial Infectious Diseases

Infections that are either newly discovered in a population or that have long been present but are expanding geographically or in frequency quickly are referred to as "emerging infectious diseases" (14). A number of conditions that facilitate the spread of infections lead to their appearance as emerging or re-emerging diseases. Emerging foodborne diseases are no different, as they are disproportionately zoonotic (15). Furthermore, a large number of these diseases still have no known cure, and those who work in healthcare are also frequently affected by them. Over the last 3 decades, more than 30 new species have been recognized globally, with many emerging from the contact between humans and animals. Human disease is known to be caused by about 1415 different types of bacteria. Of this amount, the majority (72%) originates in wildlife, with 60% of the species being zoonotic (16).

EIDs are linked to about 175 pathogenic species, and bacteria, or rickettsia, are responsible for about 54% of these infections (17). A large number of newly discovered and rediscovered diseases have zoonotic origins, which means they originated in animals and then spread to people across species boundaries. It is evident that a complex web of interrelated elements plays a role in the disease's progression from natural reservoirs into human hosts (18). As infectious agents are able to adapt to new hosts, propagate more readily among the new hosts, and evolve into new ecological niches, a number of variables contribute to the early formation of new diseases (19).

All of these factors include microbial genetic mutation, changes in reservoir host populations or intermediary insect vector populations, changes in climate and ecosystems, urbanization, and habitat degradation that result in humans and animals living near each other (20). Therefore, even though the impact of developing diseases could be substantial, it is hard to anticipate because of people's lack of natural immunity to them (21).

Emerging Infectious Disease Mechanism

EIDs are illnesses brought on by pathogens that have lately emerged and entered a population, or illnesses that have already occurred but are predicted to rise (22). Even while the introduction of EIDs was influenced by a number of causes, including the global populations demographics, environmental changes, land use, symptoms of chronic diseases, enhanced pathogen detection, microbial evolution, the collapse of the public health system, and bioterrorism (23).

Emerging Zoonotic Diseases Transmitted by Rodents

Emerging zoonotic bacteria, which cause the majority of novel disease outbreaks globally, rely heavily on rodent reservoirs for their spread. These diseases are frequently caused by zoonotic bacteria, which can be spread from animals to people (24). Since they can harbor more than 60 different diseases that can infect humans, rodents are a significant source of zoonotic diseases (25). Nevertheless, it is challenging to establish that diseases spread by rodents are highly serious because there is a significant underreporting of these diseases. Given that they help Yersinia pestis spread, rats represent a substantial reservoir of human infections (26). Even though resistant rodent species like mice and voles are needed to generate enzootic foci, rats are fatally affected by plague. Viral epidemics and human infections are caused by this transmission. Rodent skin arthropod vectors can harbor a variety of zoonotic infections (27). These infectious diseases are a result of species jumps from animals to people in temperate zones. Many factors, including the number of rodents, the socioeconomic status of humans, conflict, and war, are linked to rodent-borne diseases (28). It is possible for rodent-borne infections to spread from one population to another through human-related activities such as migration, extensive travel, trade, urbanization, and agricultural practices (29).

The Zoonotic Ecology of Rat Populations

An understanding of the 'behavior' of zoonotic pathogens in rat populations is crucial for identifying which rats or rat populations pose the greatest health risk for people. For example, for an individual rat, the probability of infection with Leptospira spp. and the hepatitis E virus increases with age (27). However, at a population level, pathogen prevalence may decrease at the height of juvenile recruitment, which is the time when the greatest number of young and uninfected rats leave the nest and enter the population (30).

Major Zoonotic Bacterial Diseases Transmitted by Rodents

An epidemiological investigation looked into the bacterial communities of several native and invasive North Senegalese rat populations (31). Furthermore, it is well recognized that rodents serve as reservoir hosts for at least 60 zoonotic diseases, greatly aiding their spread via a variety of routes (24). Some of the most important diseases in terms of public health are rat-bite fever, leptospirosis, leishmaniasis, Lassa fever, hemorrhagic fever with renal syndrome, and hantavirus cardiopulmonary syndrome caused by the hantavirus (1). Furthermore, novel and potentially harmful bacteria are still being discovered in rats (24), the toxicity of which is unclear. Senegalese researchers have conducted a study that highlights the challenge of forecasting the correlation between biodiversity and pathogen transmission risks, particularly those of zoonotic pathogens. The study also suggests preventive measures that rely on worldwide pathogen surveillance, particularly the accurate identification of potential zoonotic agents (31).

Leptospirosis

Leptospirosis is classified as an occupational disease that primarily affects farmers who labor in flooded rice fields (32). Leptospirosis, one of the newly recognized, globally significant zoonoses caused by bacteria, varies in the severity of its symptoms (33). Agricultural labor and recreational activities that expose people to freshwater are frequently linked to outbreaks (34). The primary carriers of the bacteria are murine rats, who disperse them throughout the environment via their urine or feces (13). Contact with the urine of these diseased animals can spread to humans through food, water, or soil. There is no evidence that the disease spreads from one person to another. Rats and humans coexist in agricultural settings, with the rodents searching for food from dark to dawn and the farmers working during the day. Rodents can contaminate human areas with infectious organisms and spread diseases, such as leptospirosis (35). Leptospirosis is the most common zoonosis in the world. It mostly affects tropical and subtropical countries, where a large amount of precipitation helps the dangerous bacteria proliferate (36).

Spirochaetes of the genus Leptospira are the cause of leptospirosis and can spread from animals to people either directly or indirectly (37). Long thought to be a disease predominantly affecting rural or occupational settings, leptospirosis is also common in metropolitan areas. Farmers, butchers, veterinarians, sewage workers, miners, fish workers, and those who fish, sail, or swim are among the occupations and activities where leptospirosis is on the rise (38).

Salmonella

The world's most significant foodborne pathogens are salmonelloses (39). In order to protect consumers of animal products from diseases, it is crucial to decrease or eradicate these infections at farms, which are considered the initial stage of the food chain (40).

Campylobacter

More cases of diarrhea than foodborne *Salmonella* are caused by *Campylobacter*, the most prevalent bacterial cause of gastroenteritis throughout the world. They reach their peak in the summer and can endure for several weeks at 4 °C in the environment (41). Farm rats raise the possibility of introducing *Campylobacter* into mice's intestines and grill houses, which could contaminate feed and water. Because rodents frequently come into contact with food animals, there is a greater risk of transmission in organic farming (42).

Scrub Typhus

The obligatory intracellular gram-negative bacterium, *Orientia tsutsugamushi*, is the cause of a zoonotic disease called scrub typhus. It can spread to people when infected chiggers feed on rodents and humans (43). Approximately one million instances of the disease occur globally each year, and it is prevalent in the Asia-Pacific region (44). The disease is linked to rat exposure in rural vacation rentals, and because it resembles other tropical fevers, it may be misdiagnosed (45).

Listeriosis

L. monocytogenes, the bacterium that causes listeriosis, is frequently existent in rodents, including wild black rats (46). Particularly in the case of AIDS patients, expectant mothers, and the elderly, contaminated food can result in a serious disease or even death (47). The bacterium is a major cause of human sickness and mortality, with a case fatality rate of 20–30% during recent outbreaks (48).

Rat-Bite Fever and Haverhill Fever

Streptobacillus moniliformis is the causative agent of Haverhill fever and rat-bite fever; Spirillum minus is also found in Asia (49). Humans can contract Haverhill fever by eating, drinking, or handling contaminated food or milk. High fevers, headaches, migrating ankylosis, vomiting, and skin rashes are some of its hallmarks. Physicians rarely diagnose rat-bite fever, which has a 10–13% fatality rate (1). Even though touching or scratching an animal may spread the illness (50).

Rodents' Method of Transferring Infections to People

Human health is greatly at risk from zoonotic diseases such as murine typhus, leishmaniasis, salmonellosis, and bubonic plague, which are primarily transmitted by rodents (2). In close proximity to human communities and residential areas, they pose a special problem. Because of their closeness to food animals and resilience to rodenticides, rodents pose an even greater danger of transmission in organic farming (51). Cats are the primary source of infection from rodents and birds carrying tissue cysts, which can be spread through inhalation, direct contact, handling, bites, scratches, contaminated water, or food, and commensal rodents like rats and house mice pose a threat due to their behavior and reproduction capabilities (52).

Regulatory Rodent Control and Empired Zoonotic Disease Prevention

Controlling and getting rid of zoonotic pathogens in the food chain requires effective rodent management. Unintentional contact with wild rats, which carry numerous diseases, can result in the spread of those diseases (53-56). They are more common among immunocompromised people and pregnant women. The risk of transmission is increased because rats are known to frequent areas where these bacteria are prevalent (57, 58). Effective documentation and control of rodents require a rodent control plan. It is best for humans to avoid having direct contact with wild rodents (59). The most effective method for managing pest populations with high densities is to use rodenticides; however, judicious baiting can reduce the need for them (60-62). Trapping is another method available to organic farms. However, it should be borne in mind that using cats for this purpose may jeopardize animal welfare and food safety (63). Studies indicate that extensive one-time rodenticide application is beneficial for eliminating rodent populations from farms (64).

Conclusion and Recommendations

Infectious diseases are becoming increasingly important due to globalization and population mobility. High drug resistance in pathogenic and harmful bacteria is a serious concern. Rodents, known as reservoir hosts, play a major role in transmission and spread. Increased contact between humans and rats increases the risk of severe infectious diseases. Based on the above conclusion, the following recommendations are forwarded:

- Minimize direct contact between humans and wild rodents to prevent transmission of zoonotic agents through bites, skin contact, aerosols, or dust containing rodent excreta.
- Proper rodent management is an important preventive measure in the food chain.

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Authors' Contribution

Conceptualization: Mohammedkemal Mustefa Ame.
Data curation: Mohammedkemal Mustefa Ame, Mathewos Belina Woyessa, Kedir Mohammed, Wali Khan.
Formal analysis: Mathewos Belina Woyessa, Kedir Mohammed, Wali Khan.
Funding acquisition: Wali Khan, Asma Mohamed Ziyada Farah.
Investigation: Mohammedkemal Mustefa Ame.
Methodology: Mohammedkemal Mustefa Ame.
Project administration: Mohammedkemal Mustefa Ame, Mathewos Belina Woyessa, Kedir Mohammed.
Resources: Mathewos Belina Woyessa, Wali Khan.
Software: Mohammedkemal Mustefa Ame, Wali Khan.
Supervision: Mohammedkemal Mustefa Ame.
Validation: Mohammedkemal Mustefa Ame, Mathewos Belina Woyessa, Kedir Mohammed.
Visualization: Kedir Mohammed, Wali Khan, Asma Mohamed Ziyada Farah.
Writing–original draft: Mohammedkemal Mustefa Ame.
Writing–review & editing: Mohammedkemal Mustefa Ame.

Competing Interests

The authors declare no competing interests.

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