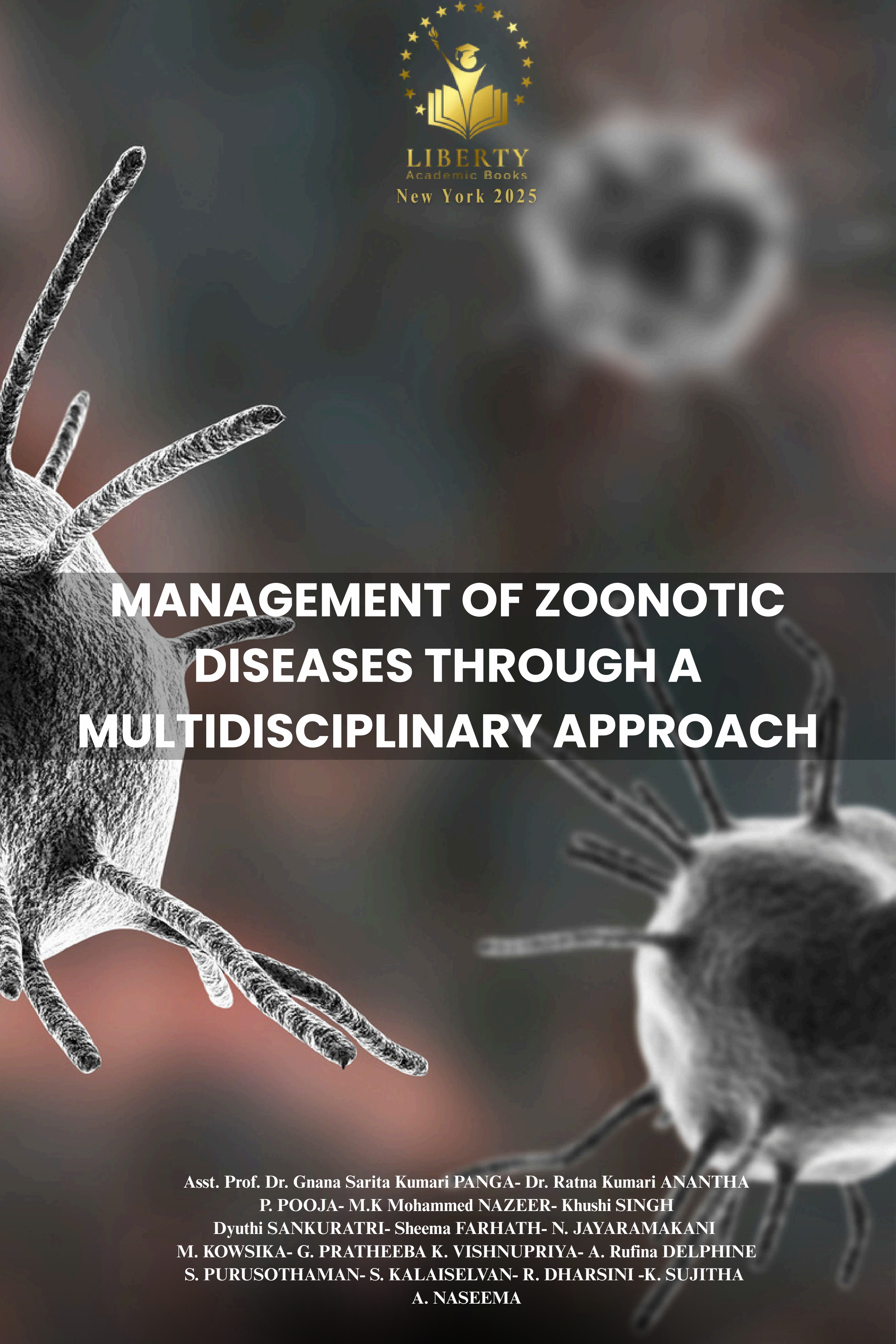

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MANAGEMENT OF ZOONOTIC DISEASES THROUGH A MULTIDISCIPLINARY APPROACH

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PREFACE

The emergence and persistence of zoonotic diseases remain among the most formidable challenges to global public health, demanding responses that transcend disciplinary boundaries. Management of Zoonotic Diseases Through a Multidisciplinary Approach offers a timely and comprehensive exploration of these complex health threats, drawing upon expertise from medicine, veterinary science, dentistry, microbiology, public health, and beyond.

By integrating perspectives from diverse scientific domains, this volume underscores the central principle of the One Health approach—that human, animal, and environmental health are inextricably linked. The chapters collectively examine critical zoonotic pathogens, from typhoidal Salmonella to rabies, with in-depth discussions on pathogenesis, prevention strategies, oral health implications, antimicrobial resistance, vaccination programs, and community engagement. Through detailed case studies and future-oriented analyses, the authors illuminate both the scientific and socio-political dimensions of zoonotic disease control.

What distinguishes this work is its recognition that effective management of zoonoses requires not only advanced research and technological innovation but also robust public health infrastructure, coordinated global policy, and culturally sensitive community education. The inclusion of emerging technologies, such as novel vaccine platforms, rapid diagnostics, and alternative therapeutic strategies, signals the book's forward-looking orientation.

This volume will serve as an invaluable resource for researchers, healthcare practitioners, policymakers, and students who seek to understand and address the multifaceted nature of zoonotic diseases. Its insights provide a roadmap for building resilient health systems capable of mitigating current threats while preparing for future challenges.

We extend our sincere appreciation to all contributing authors for their scholarly dedication and to the editorial team for bringing together such a coherent and impactful body of work. Their combined efforts reflect the spirit of interdisciplinary collaboration that is essential for advancing global health security in an era of unprecedented interconnectedness.

Dr. Mariam S. OLSSON
Director of Publishing House
August 15, 2025

CHAPTER 1

DEVELOPMENT AND IMPORTANCE OF TYPHOIDAL SALMONELLA PREVENTION IN ZOONOTIC DISEASES

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INTRODUCTION

Typhoidal Salmonella, which includes Salmonella Typhi and Salmonella Paratyphi, continues to pose a serious risk to public health, especially in underdeveloped nations with limited access to sanitary facilities, clean water, and medical care. The systemic and potentially fatal disease known as typhoid fever is caused by these pathogens and is mainly contracted by consuming tainted food or water. Typhoid fever still affects millions of people each year, despite tremendous advances in medical science. It causes high rates of morbidity and mortality, particularly in susceptible groups like children. In addition to medical treatments, comprehensive public health plans specific to endemic areas are needed to address this issue.

The battle against typhoidal Salmonella has been transformed by the creation of efficient preventive measures, especially vaccines. In the past, prevention mostly depended on enhancing sanitation and hygiene habits, which, although important, were insufficient in many environments with limited resources. Traditional approaches, like inactivated whole-cell vaccines, have given way to more sophisticated formulations, like the Vi polysaccharide vaccine, as vaccine development has progressed over time. Although these vaccinations provided some protection, their effectiveness was limited by their short-term immunity and incapacity to shield young children, who are particularly vulnerable to typhoid fever. A major turning point was reached with the introduction of Typhoid Conjugate Vaccines (TCVs), which addressed these drawbacks by offering permanent immunity and being appropriate for all age groups.TCVs have demonstrated remarkable effectiveness in clinical trials and field studies, paving the way for large-scale vaccination programs in endemic regions.

The role of better water quality, sanitation, and hygiene (WASH) practices in lowering the transmission of typhoidal Salmonella has received a lot of attention concurrent with vaccination advancements. There is ample evidence linking the spread of typhoid fever to a lack of adequate WASH infrastructure. Salmonella thrives in environments with contaminated drinking water, inadequate waste disposal systems, and inadequate food safety protocols. Community-level interventions, like building safe water supply systems and promoting handwashing campaigns, have been implemented as part of efforts to address these issues. Typhoid fever cases have been successfully decreased by these programs, but in many developing countries, their scalability and sustainability continue to be major obstacles.

The problem of managing typhoidal Salmonella has been made more difficult by antimicrobial resistance (AMR). Salmonella strains that are extensively drug-resistant (XDR) and multidrug-resistant (MDR) have emerged as a result of the overuse and abuse of antibiotics in both human medicine and agriculture. Because these strains are getting harder to treat, the emphasis needs to change from treatment to prevention. Campaigns for vaccination and advancements in WASH are essential for lowering antibiotic dependence and, in turn, the emergence of AMR.

International cooperation has been essential to the creation and application of typhoidal Salmonella prevention measures. Funding for vaccine development and distribution, especially in low-income nations, has been made possible by organizations like the World Health Organization (WHO) and the Vaccine Alliance, or Gavi. Together with strong disease surveillance systems, these efforts have made it easier to track the effectiveness of vaccines and identify outbreaks early. Additionally, communities now have the power to demand access to better healthcare resources and adopt healthier habits thanks to educational campaigns that aim to increase awareness about typhoid fever and how to prevent it.

Despite these developments, there are still many obstacles to overcome. Inadequate healthcare infrastructure, low community acceptance of vaccination programs, and logistical challenges in vaccine delivery are problems in many endemic regions. In order to overcome these obstacles, research and development expenditures must be maintained, and preventive measures must be incorporated into larger public health frameworks. New technologies like bacteriophage therapy and mRNA vaccines have the potential to further lessen the prevalence of typhoidal Salmonella.

To sum up, preventing typhoidal Salmonella infections is an essential part of international health programs. The impact of typhoid fever can be considerably reduced by combining developments in vaccine development, WASH infrastructure, and public health education. To remove current obstacles and guarantee fair access to efficient preventive measures, governments, international organizations, researchers, and communities must continue their collaboration.

1. BURDEN OF DISEASE

Typhoidal Salmonella, which is caused by Salmonella Typhi and Salmonella Paratyphi, is still a major global health concern, especially in areas with poor water, sanitation, and medical facilities. Despite advances in medical science, the prevalence of typhoidal Salmonella infections around the world underscores the serious socioeconomic and public health issues related to this systemic illness. Prioritizing public health interventions, particularly in endemic areas, requires an understanding of the disease's actual burden.

1.2 Global and Regional Impact

An estimated 9–11 million cases of typhoid fever occur worldwide each year, with a mortality rate of roughly 100,000–200,000 deaths annually. Low- and middle-income nations are disproportionately affected by the disease, as urbanization, poverty, and inadequate sanitation create an environment that is conducive to its spread. Southeast Asia, sub-Saharan Africa, and South Asia are some of the areas most severely impacted. For instance, typhoid fever incidence in South Asia is said to be as high as 500 cases per 100,000 people per year, making the region a major target for prevention and control measures.

Children are among the high-risk groups; they make up a sizable percentage of cases and are especially susceptible to complications. Typhoidal Salmonella causes acute morbidity and mortality, but it also burdens survivors over time. Chronic carrier status, intestinal perforation and hemorrhage, and long-term aftereffects like reactive arthritis are some of the complications that lead to disability and continuous medical care.

1.3 Economic Burden

The economic burden of typhoidal Salmonella is multifaceted, impacting households, healthcare systems, and national economies. In endemic regions, the direct costs of treatment, which include hospitalization, diagnostics, and medication, can be prohibitively expensive for low-income families. Indirect costs, such as loss of productivity due to prolonged illness, further exacerbate the financial strain on affected households. Additionally, typhoid fever outbreaks can cripple local economies by undermining trust in food safety and tourism industries, particularly in regions reliant on these sectors.

On a national scale, governments in endemic countries allocate substantial resources to manage typhoid fever outbreaks, often diverting attention and funding from other pressing healthcare priorities. The economic burden is compounded by the challenges posed by antimicrobial resistance (AMR), which increases treatment costs due to the need for more expensive and less accessible second-line antibiotics.

1.4 Public Health Burden

The persistence of typhoidal Salmonella as a significant public health issue is closely linked to gaps in water, sanitation, and hygiene (WASH) infrastructure. Contaminated drinking water, inadequate sewage systems, and unsafe food-handling practices are primary drivers of transmission. Urbanization and population growth in many endemic regions have further strained existing infrastructure, creating environments conducive to the spread of typhoidal Salmonella.

Typhoidal *Salmonella* is also a priority pathogen due to its growing resistance to antibiotics. The emergence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) strains poses a severe threat to global health. These resistant strains complicate treatment options, increase healthcare costs, and result in prolonged illness and higher mortality rates. The rise of AMR underlines the urgent need for preventive measures, such as vaccination, alongside the judicious use of antibiotics.

1.5 Call for Action

Addressing the burden of typhoidal *Salmonella* requires a multi-pronged approach. Vaccination campaigns, particularly with Typhoid Conjugate Vaccines (TCVs), have shown promise in reducing the disease burden in high-risk regions. Alongside vaccination, investments in WASH infrastructure, public health education, and global surveillance systems are vital for sustainable control. International collaborations, led by organizations such as

WHO and Gavi, provide essential support for funding and implementing these interventions.

In conclusion, the burden of typhoidal *Salmonella* is extensive, affecting millions of people worldwide and straining healthcare systems and economies, especially in endemic regions. Combating this burden requires sustained efforts to improve preventive measures, address AMR, and ensure equitable access to healthcare resources for vulnerable populations. By tackling these challenges, significant progress can be made in reducing the global impact of this devastating disease.

2. PREVENTIVE STRATEGIES FOR *TYPHOIDAL SALMONELLA* INFECTIONS

The prevention of typhoidal *Salmonella* infections, caused primarily by *Salmonella Typhi* and *Salmonella Paratyphi*, remains a crucial public health priority, particularly in regions with limited access to clean water, sanitation, and healthcare infrastructure. These infections, which cause typhoid fever, are associated with significant morbidity and mortality, particularly in low- and middle-income countries. Preventive strategies require a multi-pronged approach, incorporating vaccination, sanitation, public awareness, antimicrobial stewardship, and global collaboration. This section explores these strategies in detail, focusing on their development, implementation, and impact.

2.1 Vaccination: A Cornerstone of Prevention

Vaccination is one of the most effective strategies for preventing typhoidal *Salmonella* infections. Historically, vaccines such as inactivated whole-cell vaccines and Vi polysaccharide vaccines played an essential role in reducing disease incidence. However, these vaccines had limitations, including short-lived immunity, poor efficacy in young children, and the need for booster doses. To address these issues, the development of Typhoid Conjugate Vaccines (TCVs) has marked a significant breakthrough.

Development of Typhoid Conjugate Vaccines

- TCVs combine the Vi polysaccharide antigen with a carrier protein, enhancing immunogenicity and providing long-term protection across all age groups, including infants.
- These vaccines are more effective than previous formulations, with longer-lasting immunity, fewer doses required, and broader immunization potential.
- Notable TCVs, such as Typbar-TCV and PedaTyph, have shown remarkable results in clinical trials, reducing typhoid fever cases in endemic regions.

Vaccine Implementation

- Large-scale vaccination campaigns in countries like Pakistan and Bangladesh have demonstrated the real-world impact of TCVs, leading to significant reductions in typhoid fever incidence.
- Integration of TCVs into routine immunization programs, supported by organizations like Gavi, ensures high coverage in at-risk populations.

Challenges and Future Directions

- Vaccine hesitancy, inadequate cold chain infrastructure, and logistical barriers remain challenges to universal vaccine deployment.
- Research is ongoing to develop next-generation vaccines, including protein-based and mRNA vaccines, to further improve efficacy and accessibility.

2.2 Improving Water, Sanitation, and Hygiene (WASH)

Unsafe water and poor sanitation are primary drivers of typhoidal *Salmonella* transmission. Addressing these environmental factors is critical to breaking the cycle of infection.

Access to Clean Water

- Ensuring access to safe drinking water reduces the risk of ingestion of *Salmonella*-contaminated water.

- Initiatives such as community water purification systems and piped water supply projects have significantly lowered typhoid fever rates in targeted areas.

Sanitation Infrastructure

- Proper waste management systems, including sewage treatment plants and toilet facilities, minimize the contamination of water sources.
- Governments and non-governmental organizations (NGOs) are working to improve sanitation infrastructure in rural and urban settings.
-

2.3 Public Awareness and Community Engagement

Educating communities about typhoidal *Salmonella*, its transmission, and prevention measures empowers individuals to protect themselves and their families.

Awareness Campaigns

- Programs using media, schools, and community events raise awareness about the importance of vaccination, hygiene, and sanitation.
- Government partnerships with local leaders help build trust and promote behavior change.

School-Based Initiatives

- Integrating health education into school curricula ensures that children learn about disease prevention from a young age.
- Vaccination drives in schools have been successful in improving coverage rates among children.

Role of Healthcare Workers

- Training healthcare workers to educate patients about preventive measures enhances the reach and impact of public health initiatives.

2.4 Antimicrobial Stewardship

Antimicrobial resistance (AMR) in typhoidal *Salmonella* poses a significant challenge to treatment, making prevention even more critical.

Rational Use of Antibiotics

- Reducing the misuse and overuse of antibiotics in humans and livestock is essential to slowing the emergence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) strains.
- Public awareness campaigns about the dangers of self-medication and over-the-counter antibiotic sales are critical.

Alternatives to Antibiotic

- Research on non-antibiotic therapies, such as bacteriophage therapy and probiotics, offers promising avenues for managing typhoidal *Salmonella*.

Global AMR Surveillance

- Strengthening global surveillance systems helps monitor resistance patterns and guide treatment guidelines.
- Collaborations between governments and international organizations like the WHO are essential to addressing the AMR crisis.

2.5 Global Collaboration and Policy

International partnerships are vital for addressing the global burden of typhoidal *Salmonella*.

Support from Global Organizations:

- Organizations like Gavi, the Vaccine Alliance, and the WHO play crucial roles in funding vaccine development and distribution.
- The Global Typhoid Control Initiative has been instrumental in coordinating efforts to combat typhoid fever.

Policy Development:

- Governments must prioritize investments in WASH infrastructure, vaccination programs, and public health education.
- Policies promoting equitable access to preventive measures, particularly for marginalized communities, are essential for reducing disparities.

Research and Innovation:

- Funding for research on novel vaccines, diagnostics, and therapies ensures continuous progress in prevention and control efforts.

- Public-private partnerships can accelerate the development and implementation of new technologies.

2.6. Emerging Technologies and Innovations

Innovative approaches offer new opportunities for preventing typhoidal *Salmonella* infections.

Advanced Diagnostics

- Rapid diagnostic tools facilitate early detection and treatment, reducing the spread of the disease.
- Molecular techniques, such as polymerase chain reaction (PCR), improve the accuracy of diagnoses.

Vaccine Innovations

- Next-generation vaccines, including mRNA and protein-based formulations, aim to overcome current limitations and expand coverage.

Alternative Preventive Measures

- Bacteriophage therapy and microbiome-based interventions are being explored as supplementary strategies for typhoidal *Salmonella* prevention.

2.7 Conclusion

Preventing typhoidal *Salmonella* infections requires a comprehensive approach that integrates vaccination, improved WASH practices, public awareness, antimicrobial stewardship, and global collaboration. While significant progress has been made, challenges such as vaccine hesitancy, AMR, and infrastructural barriers remain. By investing in innovative technologies, strengthening public health systems, and fostering international partnerships, it is possible to achieve sustainable reductions in the burden of typhoidal *Salmonella*. These preventive strategies not only save lives but also contribute to broader public health and economic benefits, underscoring their importance in global health initiatives.

3. GLOBAL COLLABORATION

Global collaboration is critical in addressing the public health challenge posed by typhoidal *Salmonella*. This systemic bacterial infection, primarily caused by *Salmonella Typhi* and *Salmonella Paratyphi*, disproportionately affects low- and middle-income countries, necessitating a collective global effort to reduce its burden through prevention, surveillance, and intervention strategies.

International organizations such as the World Health Organization (WHO) and Gavi, the Vaccine Alliance, have been at the forefront of these collaborative efforts. WHO provides a global framework for controlling typhoid fever by offering guidelines, facilitating research, and fostering partnerships among nations. Meanwhile, Gavi plays an instrumental role in funding and distributing Typhoid Conjugate Vaccines (TCVs) to endemic regions. These vaccines, a breakthrough in the prevention of typhoidal *Salmonella*, are now part of immunization programs in several countries, thanks to Gavi's efforts in ensuring equitable access. This partnership has enabled vaccination campaigns in high-burden areas like South Asia and sub-Saharan Africa, significantly reducing disease incidence.

A cornerstone of global collaboration is the development and implementation of robust disease surveillance systems. These systems, supported by global health initiatives, monitor the prevalence of typhoidal *Salmonella*, track antimicrobial resistance (AMR) patterns, and evaluate the effectiveness of vaccination campaigns. For instance, the WHO's Global Antimicrobial Resistance and Use Surveillance System (GLASS) collects data on AMR trends, which is crucial for guiding treatment protocols and policymaking. Data-sharing among countries facilitates early detection of outbreaks and rapid response, preventing large-scale health crises.

Public health education and awareness campaigns also benefit from global collaboration. Partnerships between international organizations, governments, and non-governmental organizations (NGOs) have amplified efforts to educate communities on preventive measures, such as safe food handling, hygiene practices, and the importance of vaccination. Media campaigns and school-based health programs, supported by these collaborations, have been instrumental in reaching vulnerable populations, fostering behavior change, and increasing vaccine uptake.

Policy development, driven by global collaboration, is another key area in the fight against typhoidal *Salmonella*. Collaborative efforts have led to the formulation of national typhoid control programs, integrating vaccination, water, sanitation, and hygiene (WASH) improvements. Governments and global health organizations work together to secure funding, prioritize infrastructure projects, and address disparities in healthcare access.

Emerging technologies and innovative approaches also owe much to global collaboration. Research on next-generation vaccines, rapid diagnostics, and alternative therapies like bacteriophage applications has been accelerated through partnerships between academic institutions, governments, and private sector entities. These innovations hold promise for further reducing the burden of typhoidal *Salmonella* worldwide.

In conclusion, global collaboration underpins every aspect of the prevention and control of typhoidal *Salmonella*. By pooling resources, expertise, and funding, international partnerships are paving the way for a healthier future, particularly for those in endemic regions. Sustained commitment to these collaborative efforts is essential for achieving long-term success in combating typhoidal *Salmonella*.

4. CASE STUDY

4.1 Case Study 1: Community-Led Vaccination Campaign in Southeast Asia

In 2018, a rural district in Southeast Asia faced frequent outbreaks of typhoid fever due to poor sanitation and contaminated water sources. Despite the availability of typhoid vaccines, coverage remained low, primarily because of a lack of awareness and vaccine accessibility in the region.

To address this, a community-led vaccination campaign was initiated in partnership with local health authorities, non-governmental organizations (NGOs), and international donors. The campaign began with a survey to identify the most vulnerable populations, such as school-age children and pregnant women. This was followed by educational programs to raise awareness about typhoid prevention, emphasizing the importance of vaccination alongside hygiene practices.

Mobile vaccination clinics were deployed to reach remote villages, and vaccines were offered free of charge. Local community leaders and schoolteachers were trained to act as advocates, fostering trust and encouraging participation.

Over two years, vaccine coverage increased from 20% to 85% among the target population, resulting in a 70% reduction in typhoid fever cases. The initiative also had a ripple effect on sanitation practices, with communities actively working to improve water quality and waste management. This case study underscores the importance of community engagement, education, and accessibility in the success of typhoid prevention programs.

4.2 Case Study 2: Mitigating the Impact of Antimicrobial Resistance in Africa

A study conducted in Sub-Saharan Africa highlighted the alarming rise of antimicrobial-resistant (AMR) *Salmonella Typhi* strains, which threatened to undermine traditional treatment protocols for typhoid fever. To combat this issue, researchers collaborated with public health officials to launch an integrated prevention strategy.

The program focused on three key areas: vaccination, surveillance, and public education. A new conjugate typhoid vaccine was introduced, targeting regions with the highest incidence of AMR typhoidal Salmonella. Surveillance systems were strengthened to monitor the prevalence and spread of resistant strains, enabling rapid identification of outbreaks. Educational campaigns were designed to inform healthcare workers and the public about the dangers of antibiotic misuse and the importance of vaccination.

In parallel, funding was allocated to improve laboratory facilities, enabling more accurate and timely diagnoses of typhoidal Salmonella infections. These efforts led to a 50% reduction in AMR-associated typhoid cases within five years, highlighting the critical role of vaccines and coordinated strategies in addressing AMR.

5. FUTURE DIRECTIONS

As the global burden of typhoidal Salmonella remains a pressing public health challenge, it is essential to embrace innovative and integrated approaches for its prevention. While significant progress has been made in understanding its pathogenesis and developing preventive strategies, further advancements are needed to address persistent challenges and emerging threats.

5.1 Next-Generation Vaccines

The development of next-generation vaccines represents a critical frontier in combating typhoidal Salmonella. While conjugate vaccines have demonstrated efficacy, they often face challenges in affordability and accessibility, particularly in low- and middle-income countries (LMICs). Future research should focus on:

- Multivalent vaccines capable of targeting both typhoidal and non-typhoidal Salmonella serovars.
- Innovative vaccine platforms such as mRNA-based vaccines, which offer scalability and rapid adaptability to emerging strains.
- Enhancing vaccine thermostability to reduce cold chain dependency, making distribution more feasible in resource-limited settings.

5.2 Combating Antimicrobial Resistance (AMR)

The rise of antimicrobial-resistant Salmonella strains poses a significant threat to existing treatment protocols. Future efforts should prioritize:

- Strengthening global AMR surveillance systems to monitor resistance trends and guide treatment guidelines.
- Promoting the responsible use of antibiotics through public education and policy reforms to reduce misuse in both human and veterinary medicine.
- Encouraging the development of novel antimicrobials and alternative therapies, such as phage therapy, to combat resistant strains.

5.3 Integrated Public Health Strategies

Comprehensive public health approaches are vital for sustainable prevention. Future strategies should include:

- Integration of typhoidal Salmonella vaccination with other immunization programs, such as those for measles and polio, to maximize reach and efficiency.
- Expansion of water, sanitation, and hygiene (WASH) initiatives to address the root causes of transmission, particularly in LMICs.
- Leveraging digital health technologies, such as mobile applications and geospatial mapping, to enhance disease surveillance and outbreak response.

5.4 Community Engagement and Education

Building trust and fostering awareness within communities are pivotal for the success of prevention programs. Future directions should focus on:

- Tailoring health education campaigns to address cultural and contextual factors that influence vaccine uptake and hygiene practices.
- Empowering local leaders and healthcare workers to advocate for prevention measures and act as change agents within their communities.
- Incorporating behavioral science insights to design interventions that encourage sustained behavior change.

5.5 Global Collaboration and Funding

The fight against typhoidal Salmonella requires coordinated international efforts. Future initiatives should emphasize:

- Strengthening partnerships between governments, academic institutions, and international organizations to pool resources and share knowledge.
- Securing sustainable funding for research, vaccine procurement, and infrastructure development in endemic regions.
- Promoting equitable access to preventive measures through policy advocacy and global health diplomacy.

5.6 Advancing Research Frontiers

Finally, continuous investment in research is essential to uncover novel insights and solutions. Key areas for future exploration include:

- The genetic and molecular mechanisms underlying Salmonella virulence and host immunity.

- The role of environmental factors, such as climate change, in shaping the epidemiology of typhoidal Salmonella.
- Evaluating the long-term effectiveness and safety of new vaccines and interventions through robust clinical trials.

By addressing these future directions, the global health community can move closer to achieving the vision of a world free from the burden of typhoidal Salmonella and its devastating impact on public health and economies.

CONCLUSION

The prevention of typhoidal Salmonella in the context of zoonotic diseases is not merely a scientific pursuit but a moral imperative to improve public health and quality of life, especially in resource-limited settings. This chapter has illuminated the intricate relationship between humans, animals, and the environment in the transmission of typhoidal Salmonella. It has also underscored the pivotal role of preventive strategies, both traditional and innovative, in breaking this cycle.

Zoonotic diseases like typhoidal Salmonella are intrinsically linked to human activity, from improper waste management to the overuse of antibiotics in agriculture. These behaviors create an environment where pathogens can thrive, adapt, and evolve into even more formidable adversaries through mechanisms like antimicrobial resistance. As highlighted in this chapter, prevention must begin with addressing these root causes, emphasizing the importance of water, sanitation, and hygiene (WASH) initiatives. By reducing the pathways for transmission, we can dramatically decrease the prevalence of typhoidal Salmonella in endemic regions.

Vaccination remains one of the most effective tools in the prevention of infectious diseases, including typhoid fever caused by typhoidal Salmonella. However, existing vaccines are not without their limitations, particularly in terms of affordability and universal accessibility. The development of next-generation vaccines, including mRNA platforms, holds immense promise for overcoming these barriers. These advancements, coupled with efforts to ensure equitable distribution, can pave the way for widespread immunization, even in the most underserved communities.

This chapter has also brought attention to the critical challenge of antimicrobial resistance (AMR). The emergence of resistant Salmonella strains threatens to undermine decades of progress in managing bacterial infections. Addressing this issue requires a multifaceted approach that includes strengthening surveillance systems, promoting the judicious use of antibiotics, and investing in the development of novel therapeutic options. In the context of typhoidal Salmonella, prevention through vaccination and hygiene remains the most viable long-term solution to mitigate the reliance on antibiotics and curb the spread of resistance.

The successful implementation of these strategies depends heavily on community engagement and education. Health interventions are most effective when they are designed with cultural and social contexts in mind. Empowering communities to take ownership of their health through awareness programs and local leadership can create a ripple effect, fostering sustained changes in behavior and practices. This aspect of prevention highlights the human element of public health—recognizing that the fight against typhoidal Salmonella is not just a scientific battle but also a social one.

The role of global collaboration cannot be overstated. Partnerships between governments, research institutions, non-governmental organizations, and international agencies have the potential to bring together expertise, resources, and innovative solutions. Joint efforts to fund research, enhance infrastructure, and implement integrated prevention strategies are essential to tackling typhoidal Salmonella and other zoonotic diseases effectively.

Looking ahead, the future of typhoidal Salmonella prevention will be shaped by advancements in science and technology, as well as by the global community's commitment to equity and sustainability. The lessons learned from successful interventions, as discussed in this chapter, provide a blueprint for addressing similar challenges in other zoonotic diseases. At the same time, the unique complexities of typhoidal Salmonella demand continued vigilance, innovation, and collaboration.

In conclusion, the prevention of typhoidal Salmonella is both a scientific challenge and a humanitarian goal. By leveraging the synergy of vaccination, education, sanitation, and research, we can move closer to a future where the burden of typhoidal Salmonella is a thing of the past. This journey requires a shared vision, sustained effort, and unwavering dedication to the health and well-being of all populations. Together, we can turn the tide against this formidable pathogen and create a legacy of resilience and hope for generations to come.

REFERENCE

Andrews, J. R., et al. (2019). Typhoid conjugate vaccines: A new tool in the fight against antimicrobial resistance. *The Lancet Infectious Diseases*, 19(1), e26-e30. Dougan, G., & Baker, S. (2014). Salmonella enterica serovar Typhi and the pathogenesis of typhoid fever. *Annual Review of Microbiology*, 68, 317-336.

Andrews, J. R., et al. (2020). The impact of typhoid conjugate vaccines on antimicrobial resistance. *Clinical Infectious Diseases*, 71(Supplement_2), S55-S61.

Andrews, J. R., et al. (2020). The impact of typhoid conjugate vaccines on antimicrobial resistance. *Clinical Infectious Diseases*, 71(Supplement_2), S55-S61.

Bhutta, Z. A. (2014). Typhoid fever: A new challenge. In *Feigin and Cherry's Textbook of Pediatric Infectious Diseases* (7th ed.).

Bhutta, Z. A. (2014). Typhoid fever: A new challenge. In *Feigin and Cherry's Textbook of Pediatric Infectious Diseases* (7th ed.).

Bhutta, Z. A. (2022). Typhoid fever: Pathogenesis and prevention. In *Feigin and Cherry's Textbook of Pediatric Infectious Diseases* (8th ed.).

Bhutta, Z. A. (2022). Typhoid fever: Pathogenesis and prevention. In *Feigin and Cherry's Textbook of Pediatric Infectious Diseases* (8th ed.).

Bhutta, Z. A., et al. (2019). Current trends in typhoid fever epidemiology. *The Lancet Global Health*, 7(2), e210-e220.

Centers for Disease Control and Prevention (CDC). (2022). Typhoid fever: Prevention and control strategies. Available at: CDC Typhoid Resources.

Centers for Disease Control and Prevention (CDC). (2022). Typhoid fever: Prevention and control strategies. Available at: CDC Typhoid Resources.

Coalition Against Typhoid (CAT). (2023). Advances in typhoid prevention and control. Available at: Take on Typhoid.

Coalition Against Typhoid (CAT). (2023). Advances in typhoid prevention and control. Available at: Take on Typhoid.

Crump, J. A., & Mintz, E. D. (2010). Global trends in typhoid and paratyphoid fever. *Clinical Infectious Diseases*, 50(2), 241-246.

Crump, J. A., et al. (2022). Typhoid fever: Challenges and opportunities in the 21st century. *Clinical Microbiology Reviews*, 35(1), e00021-21.

Dougan, G., & Baker, S. (2014). Salmonella enterica serovar Typhi and the pathogenesis of typhoid fever. *Annual Review of Microbiology*, 68, 317-336.

Dougan, G., et al. (2021). Next-generation typhoid vaccines: Innovations and challenges. *Nature Reviews Immunology*, 21(3), 187-202.

Kirti, N., et al. (2024). Salmonella infections: An update, detection, and control strategies. *IntechOpen*. IntechOpen.

Levine, M. M., et al. (2018). Typhoid fever vaccines: A century of progress. *Nature Reviews Disease Primers*, 4(1), 1-20.

Macfadden, D. R., et al. (2016). Advances in diagnosis, treatment, and prevention of invasive Salmonella infections. *Current Opinion in Infectious Diseases*. Coalition Against Typhoid.

Macfadden, D. R., et al. (2016). Advances in diagnosis, treatment, and prevention of invasive Salmonella infections. *Current Opinion in Infectious Diseases*. Take on Typhoid.

Mandell, G. L., Bennett, J. E., & Dolin, R. (2015). Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases. Elsevier.

Mandell, G. L., Bennett, J. E., & Dolin, R. (2015). Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases. Elsevier.

Mandell, G. L., et al. (2020). Principles and Practice of Infectious Diseases (9th ed.). Elsevier.

Mandell, G. L., et al. (2020). Principles and Practice of Infectious Diseases (9th ed.). Elsevier.

Parry, C. M., & Threlfall, E. J. (2008). Antimicrobial resistance in typhoidal and non-typhoidal Salmonellae. *Current Opinion in Infectious Diseases*, 21(5), 531-538.

Parry, C. M., et al. (2021). Advances in the diagnosis and treatment of typhoid fever. *The Lancet Infectious Diseases*, 21(4), e123-e131.

Parry, C. M., et al. (2021). Advances in the diagnosis and treatment of typhoid fever. *The Lancet Infectious Diseases*, 21(4), e123-e131.

Rubin, E. J., & Baden, L. R. (2022). Messenger RNA vaccines: Lessons from typhoid conjugates. *New England Journal of Medicine*, 386(10), 890-895.

Ryan, K. J., & Ray, C. G. (2021). Sherris Medical Microbiology (8th ed.). McGraw Hill.

Ryan, K. J., & Ray, C. G. (2021). Sherris Medical Microbiology (8th ed.). McGraw Hill.

Ryan, K. J., & Ray, C. G. (Eds.). (2010). Sherris Medical Microbiology: An Introduction to Infectious Diseases. McGraw Hill.

Ryan, K. J., & Ray, C. G. (Eds.). (2010). Sherris Medical Microbiology: An Introduction to Infectious Diseases. McGraw Hill.

Talukder, H., et al. (2023). Prevalence and antimicrobial resistance profile of Salmonella in South Asia: A meta-analysis. *Journal of Epidemiology and Global Health*, 13, 637-652. Springer.

UNICEF (2016). Integrated approaches to typhoid fever prevention in rural communities.

Wain, J., Hendriksen, R. S., Mikoleit, M. L., et al. (2015). Typhoid fever. *Lancet*, 385(9973), 1136-1145.

WHO (2019). Case studies in typhoidal Salmonella prevention. WHO Library

World Health Organization (WHO). (2021). Global burden of typhoid fever: A comprehensive review. Available at: WHO Typhoid Resources.

World Health Organization (WHO). (2021). Global burden of typhoid fever: A comprehensive review. Available at: WHO Typhoid Resources.

Zizza, A., et al. (2025). Foodborne infections and Salmonella: Current primary prevention tools and future perspectives. *Vaccines*, 13(1), 29. MDPI.

Zizza, A., et al. (2025). Foodborne infections and Salmonella: Current primary prevention tools and future perspectives. *Vaccines*, 13(1), 29. MDPI.

CHAPTER 2

ZOONOTIC DISEASES AND THEIR ORAL MANIFESTATIONS: A GROWING CONCERN IN DENTISTRY

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INTRODUCTION

Zoonotic diseases are infectious conditions naturally transmitted between vertebrate animals and humans, caused by bacteria, viruses, fungi, and parasites. They represent a substantial global health challenge, with the World Health Organization estimating that over 60% of all emerging infectious diseases are zoonotic in origin (World Health Organization Regional Office for the Eastern Mediterranean, n.d.). Over 30 new human pathogens have been detected in the last three decades, 75% of which have originated in animals (Jones K E, et al., 2008). The increasing frequency of human and animal interactions, globalization, urbanization, and ecological disruption has led to a surge in zoonotic infections across diverse populations (White R J & Razgour O, 2020).

Dentistry, while primarily associated with oral health, is not immune to the effects of zoonoses. Oral tissues frequently provide the first site for systemic manifestation of these diseases, sometimes serving as critical diagnostic clues. In addition, dental practitioners are occupationally exposed to a wide range of zoonotic pathogens through saliva, blood, aerosols, and even animal-derived biomaterials. This dual relevance of oral manifestation and occupational risk underscores the need for dentists to recognize, diagnose, and participate in the prevention and management of zoonotic diseases.

The purpose of the current chapter is to provide a comprehensive review of zoonotic diseases that manifest in the oral cavity, describe their clinical implications in dentistry, highlight the role of dental professionals within the One Health framework and discuss the challenges with future directions.

1. EPIDEMIOLOGY OF ZOONOTIC DISEASES RELEVANT TO DENTISTRY

Globally, zoonotic diseases contribute to significant morbidity and mortality. Their oral manifestations, although less frequently documented, often provide the earliest or sometimes the only clue to diagnosis. Key epidemiological points relevant to dentistry include:

Global Burden: Rabies causes more than 59,000 human deaths annually, mostly in Asia and Africa (Hampson K, et al., 2015). Leishmaniasis affects 12 million people worldwide, with mucocutaneous forms showing oral involvement (Fonseca-Silva F, et al., 2016). Histoplasmosis, often linked to bat or bird droppings, remains endemic in the Americas and increasingly reported elsewhere (Benedict K, et al., 2021).

High-Risk Populations: Immunocompromised individuals including those with Human Immuno Deficiency Virus (HIV)/Acquired Immuno Deficiency Syndrome (AIDS), organ transplant recipients, and cancer patients on chemotherapy are at increased risk of opportunistic zoonotic infections with oral manifestations, such as histoplasmosis (Ajao S, et al., 2024) and cryptococcosis.

Dentist Occupational Exposure: Aerosol generating procedures, contaminated instruments, and use of animal-derived grafts or collagen membranes increase dental professionals' risk of zoonotic infection.

Geographic Variation: Endemic zoonoses vary by region: tuberculosis and leishmaniasis in South Asia, anthrax in Africa, histoplasmosis in the Americas, and Monkey pox in Central and West Africa.

Globalization and Travel: Increased mobility has blurred geographic boundaries, leading to unusual oral presentations of zoonoses in non-endemic areas.

2. ORAL CAVITY AS A SITE OF ZOONOTIC MANIFESTATION

The oral cavity provides a favorable environment for zoonotic pathogens because of its moist mucosa, high vascularity, and susceptibility to microtrauma. Oral manifestations may be nonspecific or pathognomonic. Common presentations include:

- *Ulcerations*: seen in tuberculosis, leishmaniasis, histoplasmosis.
- *Vesiculobullous lesions*: present in rabies, cowpox, monkeypox.
- *Granulomatous/pigmented lesions*: as in cryptococcosis, blastomycosis.
- *Gingival and periodontal changes*: seen in leptospirosis and viral hemorrhagic fevers.
- *Salivary gland dysfunction*: including xerostomia in viral infections such as HIV-associated zoonoses.

Dentists must maintain vigilance when encountering persistent, atypical, or unexplained lesions, particularly in patients from endemic regions or with relevant occupational exposure.

3. BACTERIAL ZOONOTIC DISEASES WITH ORAL MANIFESTATIONS

3.1. Tuberculosis

Tuberculosis is primarily a pulmonary disease, but oral involvement occurs in 0.05–5% of cases (Mignogna M D, et al., 2000). Historically, bovine tuberculosis (M. bovis) from unpasteurized milk was a significant zoonotic source, though rare today due to food safety measures.

Oral features: Painful chronic ulcers with indurated margins on the tongue, palate, gingiva, or lips, non-healing extraction sockets and osteomyelitis of the jaw, enlarged lymphnodes (Kapoor S, et al., 2014).

Dental relevance: Tubercular lesions often mimic malignancies; dentists should use biopsy and refer for confirmatory testing. Strict infection control is critical during treatment.

3.2. Anthrax

Anthrax remains an occupational hazard for people handling livestock or animal hides. It primarily affects herbivorous animals such as cattle, sheep, goat and horses but humans may acquire infection through contact with infected animals or contaminated animal products.

Oral manifestations: Oropharyngeal anthrax: painful edema of lips, tongue, or tonsils, mucosal lesions or ulcers, dysphagia and trismus due to extensive swelling.

Dental Relevance: Prompt recognition is essential due to rapid systemic progression.

3.3. Leptospirosis

A zoonotic spirochetal infection caused by the genus Leptospira and can be transmitted primarily through contact with water, soil or food contaminated by animal urine, especially rodents, cattle, pig and dogs (Haake D A & Levett P N, 2015).

Oral signs: Petechiae, ecchymoses on mucosa, gingival bleeding and jaundice-related mucosal discoloration, sore throat (Haake D A & Levett P N, 2015).

Dental Relevance: Dental professionals in endemic regions should consider leptospirosis in febrile patients with unexplained oral hemorrhages.

3.4. Cat-Scratch Disease

A zoonotic disease transmitted primarily through scratches, bites or saliva of infected cats, often presenting as localized lymphadenitis in the head and neck region.

Oral features: Rare intraoral ulcerations or lesions and submandibular lymphadenopathy mimicking odontogenic infection (Panicker P, et al., 2025).

3.5. Plague

Plaque is a highly virulent zoonotic disease caused by gram negative bacillus Yersinia pestis and is the oldest known endemic disease. Though rare today, plague historically devastated populations. It is primarily a disease of rodents, with flea bites being the most common mode of transmission to humans.

Oral findings: Necrotic gingival ulcers, hemorrhagic lesions in palate and cervical lymphadenopathy (Giuffra V, et al., 2020).

4. VIRAL ZOONOTIC DISEASES WITH ORAL MANIFESTATIONS

4.1. Rabies

Rabies is a fatal zoonotic viral disease caused by Rabies lyssavirus, transmitted primarily through the bite or saliva of infected mammals primarily dogs or bats. Clinically, it manifests as progressive encephalitis with hydrophobia, aerophobia, and hypersalivation, leading to death if untreated.

Oral relevance: Dysphagia and hydrophobia due to pharyngeal spasms, and excess salivation caused by impaired swallowing reflex (Wilson P J, et al., 2019).

Dental Relevance: For dentists, unvaccinated exposure to saliva of animals or humans poses occupational risks.

4.2. Monkeypox

A re-emerging zoonotic disease transmitted by rodents, primates, or close human contact. It is caused by Monkeypox virus, a member of Orthopoxvirus genus. It is first identified in laboratory monkeys and later in humans.

Oral signs: Painful vesiculo-pustular lesions on tongue, palate, and oropharynx, ulcers that appear before cutaneous lesions and dysphagia and odynophagia (Joseph B, et al., 2023).

Dental Relevance: Early recognition by dentists may aid outbreak surveillance.

4.3. Herpes B Virus

Herpes B virus is a zoonotic alpha-herpesvirus naturally infecting monkeys. It can be transmitted to humans through bites, scratches or mucosal exposure to monkey saliva resulting in severe fatal disease and hence considered as an occupational hazard for laboratory workers and researchers handling macaques.

Oral manifestations: Vesicular or ulcerative lesions resembling Herpes simplex virus, oral herpes can result in cold sores or blisters (Birek C, 2000).

4.4. Avian Influenza

It is commonly known as bird flu, a zoonotic viral disease caused by influenza A viruses. Certain subtypes such as H5N1, H7N9 can cross the species barrier and infect humans leading to severe respiratory illness with high mortality. It is primarily respiratory, but also include oral changes.

Oral manifestations: Gingival bleeding, sore throat and petechiae due to thrombocytopenia (Mittal N & Medhi B, 2007).

4.5. Corona Virus Disease

Coronavirus disease 2019 emerged in late phase as a novel zoonotic infection. Its origin has been traced to probable spillover from bats with potential intermediate hosts facilitating human transmission. While primarily a respiratory illness, it also exhibits multi-system involvement including oral cavity.

Oral manifestions: Taste alterations, xerostomia, oral ulcerations, mucosal erythema and petechiae, candidiasis, spontaneous bleeding, secondary fungal infections and salivary gland involvement (Iranmanesh B, et al., 2021).

Dental Relevance: For dentists, exposure to saliva of unvaccinated humans poses occupational risks.

4.6. Hand Foot and Mouth disease

It is an acute self-limiting viral infection caused mainly by the members of picornaviridae family and is highly contagious.

Oral manifestions: Oral vesicles and ulcers, gingivitis, pain and dysphagia, excessive salivation and secondary infections with candida or bacterial flora (Zhu P, et al., 2023).

Dental Relevance: For dentists, the characteristic vesicular eruptions on the palms, soles and buttocks in conjunction with oral lesions aid in diagnosis. Dental professionals must be able to distinguish between similar oral presentations such as primary herpetic gingiva stomatitis, herpangia, and aphthous stomatitis.

5. FUNGAL ZOONOTIC DISEASES WITH ORAL MANIFESTATIONS

5.1. Histoplasmosis

It is a systemic fungal zoonotic infection caused by Histoplasma capsulatum, a dimorphic fungus caused by soil enriched with bird and bat droppings that is infected through inhalation of spores. Although, it is primarily a respiratory disease, it is considered as environmentally acquired zoonosis.

Oral lesions: Chronic, painful ulcers with indurated borders, nodular or granulomatous lesions mimicking carcinoma and are common on tongue, palate, buccal mucosa (Ng K H & Siar C H, 1996).

5.2. Cryptococcosis

It is an opportunistic fungal infection caused primarily by Cryptococcus neoformans and gattii, encapsulated yeasts found in soil contaminated with pigeon droppings and decaying wood. The disease predominantly affects immune-compromised individuals.

Oral manifestations: Ulcerative or nodular lesions on gingiva and palate, granulomatous lesions (Santiso G M, et al., 2021).

Dental Relevance: Frequently misdiagnosed as malignancy.

5.3. Blastomycosis

Blastomycosis is a systemic fungal infection caused by Blastomyces dermatitidis. It is acquired through inhalation of moist soil enriched with decaying vegetation and animal feces. It has a zoonotic relevance because dogs serve as sentinels of environmental exposure.

Oral features: Painful, irregular ulcers with induration and involvement of alveolar bone causing tooth mobility, verrucous lesions (Mutalik V S, et al., 2021).

5.4. Paracoccidioidomycosis

It is a chronic systemic fungal infection also known as South American blastomycosis. It primarily affects agricultural workers due to occupational exposure to contaminated soil.

Oral manifestations: Mucosal ulcerations, spontaneous gingival bleeding, periodontal destruction, nodal or ulcerative lesions on lip or palate and cervical lymphadenopathy (Costa M de C, et al., 2021).

Dental Relevance: Misdiagnosis as malignancy or other chronic ulcers is common leading to delay in treatment. Dental professionals, particularly in endemic regions play a vital role in early detection.

5.5. Sporotrichosis

It is a chronic subcutaneous mycosis caused by dimorphic fungi. It is associated with frequent traumatic inoculation of fungal spores from contaminated soil, plants or organic matter.

Oral manifestations: Ulcerative lesions, granulomatous lesions, papules mainly in the tongue, palate and buccal mucosa, bleeding gums, dysphagia, and halitosis (Abrahão A C, et al., 2023).

Dental Relevance: Dentists will be the first clinician to encounter the oral sporotrichosis due to its ulcerative presentations.

5.6. Aspergillosis

It is caused by species of genus Aspergillus, a ubiquitous saprophytic fungus commonly found in soil decaying vegetation, dust and indoor environments. It may affect both immune-competent and immune-compromised individuals with various oral manifestations.

Oral manifestations: Painful necrotic ulcer with gray or black pseudo membranes, palatal ulceration and necrosis, and black necrotic plaques on tongue, palate and buccal mucosa (Chermetz M, et al., 2016).

Dental Relevance: Dentists may encounter persistent necrotic oral ulcers or sinus-related complaints unresponsive to routine therapy.

5.7. Zygomycosis

It is more accurately termed as mucor mycosis and is rare but severe opportunistic fungal infection caused by fungi of the order mucorales. It is a rapidly progressive angio-invasive disease. Though uncommon, its oral manifestations are critical.

Oral manifestations: Black necrotic eschar on the palate, painful oral ulcerations, diffuse swelling with pus discharge, trismus and oro-facial pain, maxillary sequestration and oroantral fistula in advanced cases (Janjua O S, et al., 2021).

Dental Relevance: Oral necrosis and non-healing post-extraction sockets in diabetic or immune-compromised patients should raise suspicion of mucor mycosis by the dental professionals.

6. PARASITIC ZOONOTIC DISEASES WITH ORAL MANIFESTATIONS

6.1. Leishmaniasis

It is a neglected tropical zoonotic disease caused by protozoa of genus Leishmania. It can be transmitted to humans through the bite of infected female phlebotomine sandflies. The disease is endemic in various countries.

Oral involvement: Ulcerative, nodular, or granulomatous lesions on tongue, palate, gingiva and nasopharyngeal destruction in mucocutaneous forms (World Health Organization, 2023).

6.2.Toxoplasmosis

It is caused by a protozoan parasite Toxoplasma gondii. This infection can be caused by the ingestion of tissue cysts in undercooked meat, oocysts shed in feces or congenitally from mother to fetus and the cats are the definitive host.

Oral relevance: Rare oral ulcers, gingivitis and necrotizing lesions in immune-compromised hosts, submandibular lymphadenitis (Saxena S, et al., 2018).

6.3. Echinococcosis

It is also known as hydatid disease, a zoonotic parasitic infection caused by larval stages of tapeworms belonging to genus Echinococcus. Humans are accidental intermediate hosts infected through ingestion of parasite eggs shed in the feces of definitive host primarily dogs.

Oral findings: Cystic swellings in jawbones or oral soft tissues may resemble odontogenic cysts (Moro P & Schantz P M, 2009).

7. INFECTION CONTROL AND OCCUPATIONAL RISK IN DENTISTRY

Dentists face occupational risks through direct contact with saliva and blood, aerosol inhalation, and contaminated instruments.

Key measures:

- Universal precautions with Personal Protective Equipment.
- Rubber dam and high-volume suction to reduce aerosols.
- Pre-procedural antimicrobial rinses.
- Rigorous sterilization protocols.
- Avoidance of unverified animal-derived biomaterials.

8. DENTISTRY WITHIN THE ONE HEALTH FRAMEWORK

The One Health concept integrates human, animal, and environmental health. Dentistry plays a key role through:

Early detection: Dentists often first identify unusual oral lesions.

Surveillance: Reporting clusters of cases aids outbreak control.
Education: Counseling on zoonotic risks of pets, hygiene, and travel.
Research: Safe biomaterial development, oral diagnostic tools.
Collaboration: Interfacing with physicians, veterinarians, and public health experts.

9. CASE VIGNETTES

9.1. Case 1: Tuberculosis Misdiagnosed as Oral Cancer

Case Vignette 1 - Lingual Tuberculosis misdiagnosed on first biopsy as carcinoma

A middle-aged patient presented with an ulcerated mass of the tongue that was clinically suspicious for squamous cell carcinoma. The first biopsy was non-representative and did not yield a definitive diagnosis, reinforcing the suspicion for malignancy. Persistent clinical concern prompted repeat biopsy, which demonstrated epithelioid cell granulomas with central caseous necrosis; Ziehl–Neelsen stain identified Mycobacterium tuberculosis. Chest imaging and sputum testing were then performed to evaluate systemic disease. The patient received anti-tubercular therapy with subsequent healing of the oral lesion; unnecessary radical surgery was thereby avoided (Al-Rikabi A C & Arafah M A R, 2011).

Case Vignette 2 - Lingual Tuberculosis mistaken for an extensive malignant fissure

A 36-year-old woman presented with progressive trismus and a painful fissured lesion of the undersurface and lateral border of the tongue that clinically resembled an extensive malignant fissure. The lesion had been present for months and produced restricted mouth opening; there were no significant respiratory symptoms. Initial clinical impression was of a neoplastic process because of the chronic, indurated nature of the tongue lesion and functional impairment. Incisional biopsy revealed granulomatous inflammation with caseation and acid-fast bacilli on histology/staining, and subsequent evaluation excluded other causes of granulomas. The patient was started on standard anti-tubercular therapy, with marked clinical improvement and resolution of trismus and tongue lesion within weeks to months (Razem B, et al., 2021).

Case Vignette 3 - Buccal mucosa ulcer indistinguishable clinically from squamous cell carcinoma

A 55-year-old man presented with a painless, indurated ulcer at the angle of the mouth/buccal mucosa that had persisted for months despite topical and short-course antibiotic therapy. Clinically the lesion had rolled, indurated margins typical of oral cancer, and regional lymph nodes were palpable. Laboratory workup showed an elevated erythrocyte sedimentation rate. Histopathology of the lesion demonstrated granulomatous inflammation with Langhans giant cells consistent with tuberculosis; chest imaging revealed pulmonary changes consistent with coexisting pulmonary tuberculosis. Anti-tubercular therapy led to resolution of the oral lesion without oncologic surgery (Ram H, et al., 2012).

Key clinical learning points

- Oral tuberculosis is rare but important in the differential diagnosis of chronic, non-healing, indurated oral ulcers especially in tuberculosis-endemic areas or in patients with risk factors.
- Oral lesions may mimic squamous cell carcinoma clinically (rolled/indurated margins, persistent ulceration, regional lymphadenopathy).
- Non-representative or inadequate biopsy specimens can mislead clinicians; repeat, deep, or excisional biopsies may be necessary.
- Histopathology (granulomas with caseation) plus acid-fast staining, culture, or molecular tests confirm diagnosis; chest imaging and sputum testing are essential to detect pulmonary involvement.
- Correct diagnosis avoids unnecessary radical surgery and allows curative medical therapy with anti-tubercular drugs.

9.2. Case 2: Histoplasmosis in Immuno-compromised Host

Case vignette - HIV with multiple painful oral ulcers

A 61-year-old woman with advanced HIV infection presented with an 8-week history of multiple, painful, well-demarcated clean-based ulcers on the tongue and hard palate.

Biopsy of an oral lesion showed numerous histiocytes containing intracellular yeast forms consistent with Histoplasma capsulatum; fungal blood cultures subsequently grew H. capsulatum, confirming disseminated histoplasmosis. She was treated with intravenous amphotericin B for 2 weeks followed by prolonged oral itraconazole, with complete resolution of oral lesions and no recurrence on follow-up. This case highlights that persistent oral ulcers in patients with AIDS may be the presenting sign of disseminated histoplasmosis and that mucosal biopsy with fungal stains is diagnostic and guides lifesaving antifungal therapy (Hendren N, et al., 2017).

Key clinical learning points

- Oral lesions (ulcers, nodules, verrucous plaques) are common presentations of disseminated histoplasmosis in immunocompromised patients and may be the first or only visible clue.
- In advanced HIV, oral histoplasmosis can present as multiple painful ulcers; biopsy plus fungal stains/culture or antigen testing establish diagnosis; amphotericin B followed by itraconazole is the standard regimen (Hendren N, et al., 2017).

10. CHALLENGES AND FUTURE DIRECTIONS

- *Diagnostic Delays*: Many dentists are unfamiliar with zoonotic lesions. Hence, there would be diagnostic delays.
- *Resource Limitations*: Confirmatory laboratory testing is unavailable in some regions.
- *Emerging Threats*: Climate change and deforestation increase zoonotic spillover risk.
- *Educational Gaps*: Dental curricula often neglect zoonotic diseases.

Future directions: Include incorporating zoonoses into dental training, developing rapid chair-side diagnostics, and enhancing interdisciplinary collaborations.

CONCLUSION

Zoonotic diseases present a growing challenge for dentistry. Oral manifestations provide critical diagnostic cues, while dental professionals face occupational risks.

Dentists, by recognizing these conditions and adopting the One Health perspective, can significantly contribute to prevention, early detection, and management of zoonoses. A multidisciplinary approach integrating dentistry with medicine, veterinary sciences, and public health is essential to confront emerging zoonotic threats in the 21st century.

REFERENCES

Abrahão, A. C., Agostini, M., de Oliveira, T. R., Noce, C. W., Júnior, A. S., Cabral, M. G., ... & Mesquita, R. A. (2023). Oral manifestations of sporotrichosis: A neglected disease. *Journal of Clinical and Experimental Dentistry,* 15(1), e82–e88. https://doi.org/10.4317/jced.60513

Ajao, S. O., Damle, N., Zhao, M., Ferreira, G., Kaye, K. S., & Mills, J. P. (2024). Disseminated histoplasmosis with oral involvement and co-infection with Pneumocystis in a patient with HIV: A case report. *IDCases,* 39, e02119. https://doi.org/10.1016/j.idcr.2024.e02119

Al-Rikabi, A. C., & Arafah, M. A. R. (2011). Tuberculosis of the tongue clinically masquerading as a neoplasm: A case report and literature review. *Oman Medical Journal,* 26(4), 267–268. https://doi.org/10.5001/omj.2011.64

Benedict, K., Toda, M., & Jackson, B. R. (2021). Revising conventional wisdom about histoplasmosis in the United States. *Open Forum Infectious Diseases*, 8(7), ofab306. https://doi.org/10.1093/ofid/ofab306

Birek, C. (2000). Herpesvirus-induced diseases: Oral manifestations and current treatment options. *Journal of the California Dental Association*, 28(12), 911–920.

Chermetz, M., Gobbo, M., Rupel, K., Ottaviani, G., Tirelli, G., Bussani, R., ... & Di Lenarda, R. (2016). Combined orofacial aspergillosis and mucormycosis: Fatal complication of a recurrent paediatric glioma - Case report and review of literature. *Mycopathologia*, 181(9–10), 723–733. https://doi.org/10.1007/s11046-016-0020-9

Costa, M. de C., de Carvalho, M. M., Sperandio, F. F., Ribeiro Junior, N. V., Hanemann, J. A. C., Pigossi, S. C., ... & Migliari, D. A. (2021). Oral paracoccidioidomycosis affecting women: A systematic review. *Mycoses*, 64(2), 108–122. https://doi.org/10.1111/myc.13215

Fonseca-Silva, F., Inacio, J. D. F., Canto-Cavalheiro, M. M., Menna-Barreto, R. F. S., & Almeida-Amaral, E. E. (2016). Oral efficacy of apigenin against cutaneous leishmaniasis: Involvement of reactive oxygen species and autophagy as a mechanism of action. *PLoS Neglected Tropical*

Diseases, 10(2), e0004442. https://doi.org/10.1371/journal.pntd.0004442

Giuffra, V., Milanese, M., & Minozzi, S. (2020). Dental health in adults and subadults from the 16th-century plague cemetery of Alghero (Sardinia, Italy). *Archives of Oral Biology*, 120, 104928. https://doi.org/10.1016/j.archoralbio.2020.104928

Haake, D. A., & Levett, P. N. (2015). Leptospirosis in humans. In *Current Topics in Microbiology and Immunology*. 387, 65–97. Springer. https://doi.org/10.1007/978-3-662-45059-8_5

Hampson, K., Coudeville, L., Lembo, T., Sambo, M., Kieffer, A., Attlan, M., Barrat, J., Blanton, J. D., Briggs, D. J., Cleaveland, S., Costa, P., Freuling, C. M., Hiby, E., Knopf, L., Leanes, F., Meslin, F. X., Metlin, A., Miranda, M. E., Müller, T., … Dushoff, J. (2015). Estimating the global burden of endemic canine rabies. *PLoS Neglected Tropical Diseases*, 9(4), e0003709. https://doi.org/10.1371/journal.pntd.0003709

Hendren, N., Yek, C., Mull, J., & Cutrell, J. B. (2017). Disseminated histoplasmosis presenting as multiple oral ulcers. *BMJ Case Reports*, 2017, bcr-2017-220364. https://doi.org/10.1136/bcr-2017-220364

Iranmanesh, B., Khalili, M., Amiri, R., Zartab, H., & Aflatoonian, M. (2021). Oral manifestations of COVID-19 disease: A review article. *Dermatologic Therapy*, 34(1), e14578. https://doi.org/10.1111/dth.14578

Janjua, O. S., Shaikh, M. S., Fareed, M. A., Qureshi, S. M., Khan, M. I., Hashem, D., ... & Khurshid, Z. (2021). Dental and oral manifestations of COVID-19-related mucormycosis: Diagnoses, management strategies and outcomes. *Journal of Fungi*, 8(1), 44. https://doi.org/10.3390/jof8010044

Jones, K. E., Patel, N., Levy, M., Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. *Nature*, 451(7181), 990–994. https://doi.org/10.1038/nature06536

Joseph, B., & Anil, S. (2023). Oral lesions in human monkeypox disease and their management-A scoping review. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 135(4), 510–517. https://doi.org/10.1016/j.oooo.2022.12.009

Kapoor, S., Gandhi, S., Gandhi, N., & Singh, I. (2014). Oral manifestations of tuberculosis. *Chrismed Journal of Health and Research,* 1(1), 11–14. https://doi.org/10.4103/2348-3334.130865

Mignogna, M. D., Muzio, L. L., Favia, G., Ruoppo, E., Sammartino, G., Zarrelli, C., & Bucci, E. (2000). Oral tuberculosis: A clinical evaluation of 42 cases. *Oral Diseases,* 6(1), 25–30. https://doi.org/10.1111/j.1601-0825.2000.tb00102.x

Mittal, N., & Medhi, B. (2007). The bird flu: A new emerging pandemic threat and its pharmacological intervention. *International Journal of Health Sciences* (Qassim), 1(2), 277–283.

Moro, P., & Schantz, P. M. (2009). Echinococcosis: A review. *International Journal of Infectious Diseases,* 13(2), 125–133. https://doi.org/10.1016/j.ijid.2008.03.037

Mutalik, V. S., Bissonnette, C., Kalmar, J. R., & McNamara, K. K. (2021). Unique oral presentations of deep fungal infections: A report of four cases. *Head and Neck Pathology,* 15(2), 682–690. https://doi.org/10.1007/s12105-020-01243-8

Ng, K. H., & Siar, C. H. (1996). Review of oral histoplasmosis in Malaysians. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology,* 81(3), 303–307. https://doi.org/10.1016/S1079-2104(96)80461-2

Panicker, P., Kumar, P. M., Francis, F., & George, A. L. (2025). Cat scratch disease: The inconspicuous cause of cervical lymphadenopathy. *Journal of Pharmacy and Bioallied Sciences*, 17 (Suppl 2), S1991–S1993. https://doi.org/10.4103/jpbs.jpbs_1641_24

Ram, H., Kumar, S., Mehrotra, S., & Mohommad, S. (2012). Tubercular ulcer: Mimicking squamous cell carcinoma of buccal mucosa. *Journal of Maxillofacial and Oral Surgery,* 11(1), 105–108. https://doi.org/10.1007/s12663-011-0282-1

Razem, B., El Hamid, S., Salissou, I., Raiteb, M., & Slimani, F. (2021). Lingual primary tuberculosis mimicking malignancy. *Annals of Medicine and Surgery*, 67, 102525. https://doi.org/10.1016/j.amsu.2021.102525

Santiso, G. M., Messina, F., Gallo, A., Marín, E., Depardo, R., Arechavala, A., ... & Negroni, R. (2021). Tongue lesion due to Cryptococcus neoformans as the first finding in an HIV-positive patient. *Revista Iberoamericana de Micología*, 38(1), 19–22. https://doi.org/10.1016/j.riam.2020.04.005

Saxena, S., Kumar, S., & Kharbanda, J. (2018). Toxoplasmosis submandibular lymphadenitis: Report of an unusual case with a brief review. *Journal of Oral and Maxillofacial Pathology*, 22(1), 116–120. https://doi.org/10.4103/jomfp.JOMFP_208_17

White, R. J., & Razgour, O. (2020). Emerging zoonotic diseases originating in mammals: A systematic review of effects of anthropogenic land-use change. *Mammal Review*, 50(4), 336–352. https://doi.org/10.1111/mam.12201

Wilson, P. J., Rohde, R. E., Oertli, E. H., & Willoughby, R. E., Jr. (2019). Rabies: Clinical considerations and exposure evaluations [Google Books version]. *Elsevier Health Sciences*. Retrieved March 15, 2025, from https://books.google.com/books?id=vnWODwAAQBAJ

World Health Organization. (2023). *Leishmaniasis*. Retrieved March 15, 2025, from https://www.who.int/news-room/fact-sheets/detail/leishmaniasis

World Health Organization Regional Office for the Eastern Mediterranean. (n.d.). *Zoonotic diseases*. Retrieved March 15, 2025, from https://www.emro.who.int/about-who/rc61/zoonotic-diseases.html

Zhu, P., Ji, W., Li, D., Li, Z., Chen, Y., Dai, B., ... & Sun, Y. (2023). Current status of hand-foot-and-mouth disease. *Journal of Biomedical Science,* 30(1), 15. https://doi.org/10.1186/s12929-023-00887-w

CHAPTER 3

RABIES DISEASE SIGNIFICANCE AND TREATMENT

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INTRODUCTION

Viral encephalitis, which is caused by rabies, kills up to 70,000 people annually worldwide. Humans can contract viral encephalitis from the saliva of infected animals. With cases going back 4,000 years, rabies is among the oldest known diseases. A rabid animal bite was always fatal for the most of human history. After being bitten by a potentially rabid animal, many people used to kill themselves because they were so afraid of contracting rabies. Less developed nations are not as fortunate as the United States, where, during the past 20 years, there have only been roughly two rabies deaths annually because to strict prophylactic measures prompted by Pasteur's 1885 rabies vaccine.

Types of rabies disease

There are two main types of rabies they are furious rabies and paralytic rabies. Both types of rabies are fatal and cause inflammation of the brain and spinal cord. Furious rabies Symptoms include hyperactivity, hallucinations, fever, hydrophobia, and spasms. This form of rabies is similar to the "furious" rabies that affects animals .About two-thirds of people with rabies have furious rabies

Paralytic rabies symptoms include paralysis and coma. This form of rabies is similar to the "paralytic" or "dumb" rabies that affects animals About 20% of people with rabies have paralytic rabies This form of rabies is often misdiagnosed, leading to under-reporting of the disease Rabies is a viral disease that spreads to humans through the saliva of infected animals is a viral zoonotic disease. Once symptoms appear, rabies is almost always fatal. The rabies virus Is part of the Rhabdoviridae family and the Lyssavirus genus.

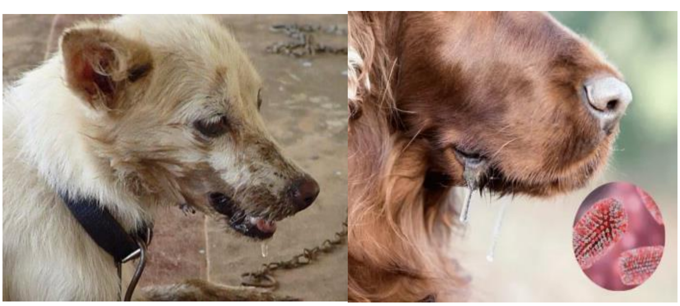

Figure 1: Furious rabies and Paralytic rabies

1. ETIOLOGY

Two components make up the bullet-shaped virus family Rhabdoviridae, which causes rabies. The viral envelope, which makes up the first component, is thought to be more structural, whereas the ribonucleocapsid core is found in the second, more functional part. The most typical way for the virus to spread is through the bite of an infected mammal, both domestic and wild, though saliva can also transmit through torn skin or mucous membranes. The virus can also be inhaled in aerosolised form, consumed, transferred from one area to another, and even acquired through organ transplantation.

1.1 Signs and Symptoms

The first symptoms of rabies may be very similar to those of the flu and may last for days.

Later signs and symptoms may include:

- Fever
- Headache
- Nausea
- Vomiting
- Agitation
- Anxiety
- Confusion
- Hyperactivity
- Difficulty swallowing
- Excessive salivation
- Fear brought on by attempts to drink fluids because of difficulty swallowing water
- Fear brought on by air blown on the face
- Hallucinations
- Insomnia
- Partial paralysis

Figure 1: Fever and vomiting

2. PATHOPHYSIOLOGY

After viral transmission, the rhabdovirus targets the central nerves and spreads across the peripheral nervous system, resulting in encephalomyelitis. In people, the initial signs and symptoms (headache, fever, and malaise) resemble those of any other nonspecific viral illness. Following these mild symptoms, agitation, anxiety, and finally outright delirium may develop. Tingling at the bite site within the first several days following a rabies bite is a relatively common symptom. It's interesting to note that the virus specifically affects highly innervated tissues (such the salivary glands) before returning to the peripheral nervous system (CNS) after spread. The virus finally damages the brainstem, which is typically the most badly affected part of the central nervous system. The inflammatory response causes the harmful effects, and it's unclear how these alterations affect function. Finally, it is thought that the virus influences neurotransmission, and apoptosis can happen via both virus-dependent and cell-dependent pathways. Upon exhibiting clinical symptoms, rabies is always lethal.

Excessive pharyngeal muscular spasms can occur with the sight, taste, or sound of water, and the "frothing," as depicted in the films Cujo and Old Yeller, is caused by hypersalivation. It's known as "hydrophobia." A rapid mortality results from the virus's eventual progression to total nervous system failure. Even while animals usually pass away within ten days, the incubation period after inoculation can range from two weeks to six years, on average. Among the variables that determine the onset time are the severity of the wound, the location of exposure, and the viral load.

3. TREATMENT

Individuals should promptly wash any bites or scratches from potentially rabies-infected animals for 15 minutes using soapy water, povidone iodine, or detergent if the animal licks an open wound. By doing this, the quantity of virus particles may be reduced. The next step is for them to get medical help right away. Treatment for possible rabies infections involves a series of injections after exposure but before symptoms appear. Assuming that the animal has rabies and starting the vaccination is safer because medical personnel typically don’t know if the animal has the disease. The only choice if symptoms have already started could be to make the patient comfortable and, if necessary, provide breathing support.

4. FUTURE RESEARCH

Future rabies research focuses on developing novel vaccines and treatments, understanding the virus-host interaction, and improving rabies control strategies, with a global goal of eliminating dog-mediated human rabies deaths by 2030. Here's a more detailed look at key areas of future rabies research. New Vaccines and Treatments are Novel Vaccine Technologies: Research is exploring new vaccine platforms, including recombinant rabies virus-vectored vaccines, recombinant poxvirus-vectored vaccines, recombinant adenovirus-vectored vaccines, DNA-based vaccines, and plant-derived oral vaccines. Improved Post-Exposure Prophylaxis (PEP): Efforts are underway to develop vaccines that require fewer injections and improve compliance with PEP protocols.Therapeutic Approaches: Research is exploring new therapeutic strategies, including the use of monoclonal antibodies (like the F11 antibody) and antiviral drugs, with the goal of developing a cure for rabies. Combination Therapies: Investigating the effectiveness of combining different therapies, such as antiviral drugs, hypothermia, and other agents, to improve treatment outcomes. Understanding Rabies Virus and Host Interaction are Virus Evolution and Epidemiology: Studying the evolution of the rabies virus in different regions and over time to better understand its spread and develop targeted control measures. Pathogenesis: Researching the mechanisms by which rabies virus infects and damages the nervous system to develop more effective treatments. Host Immune Response: Investigating the host's immune response to rabies infection to identify biomarkers for prognosis and therapeutic response. Improving Rabies Control Strategies. Dog Vaccination: Developing effective and accessible dog vaccination programs, including strategies for vaccinating dogs under three months of age, which are often missed in vaccination campaigns. Wildlife Rabies Control Using oral rabies vaccines to control rabies in wildlife populations, particularly in areas where wildlife are a source of human exposure. Public Health Education Raising public awareness about rabies prevention and treatment to improve compliance with PEP protocols and reduce human rabies cases. Strengthening Rabies Management Capabilities: Supporting developing countries in building their capacity to manage rabies outbreaks and implement effective control strategies. Global Initiatives Zero by 30, The Global Strategic Plan to Prevent Human Deaths from Dog-Mediated Rabies by 2030, which aims to eliminate human deaths from dog-mediated rabies by 2030, is a key driver for future research and action. National Rabies Control Programs: Strengthening national rabies control programs, such as the National Rabies Control Program (NRCP) in India, to improve surveillance, prevention, and treatment efforts.

CONCLUSION

Rabies is a fatal viral illness that impacts the central nervous system, but it can be prevented through vaccination and timely treatment of bites from potentially rabid animals. In conclusion, rabies is a critical public health concern globally. The effectiveness of rabies vaccinations is evident when administered before or after exposure to an infected animal’s bite. Proper care of bite wounds from animals suspected of having rabies is essential to control the disease’s transmission. Responsible pet ownership, adequate training, and consistent rabies vaccinations for dogs are key to ensuring the safety of pets and communities. Anyone who may have been exposed to the virus should seek medical attention promptly, without waiting for any symptoms to appear.

REFERENCES

Amparo ACB, Jayme SI, Roces MCR, Quizon MCL, Mercado MLL, Dela Cruz MPZ, Licuan DA, Villalon EES, Baquilod MS, Hernandez LM, Taylor LH, Nel LH. The evaluation of Animal Bite Treatment Centers in the Philippines from a patient perspective. PLoS One. 2018;13(7):e0200873.

Bedeković T, Lohman Janković I, Šimić I, Krešić N, Lojkić I, Sučec I, Robardet E, Cliquet F. Control and elimination of rabies in Croatia. PLoS One. 2018;13(9):e0204115.

Beyene TJ, Mourits MCM, Kidane AH, Hogeveen H. Estimating the burden of rabies in Ethiopia by tracing dog bite victims. PLoS One. 2018;13(2):e0192313.

Broban A, Tejiokem MC, Tiembré I, Druelles S, L'Azou M. Bolstering human rabies surveillance in Africa is crucial to eliminating canine-mediated rabies. PLoS Negl Trop Dis. 2018 Sep;12(9):e0006367.

De Silva AP, Harischandra PL, Beane A, Rathnayaka S, Pimburage R, Wijesiriwardana W, Gamage D, Jayasinghe D, Sigera C, Gunasekara A, Cadre M, Amunugama S, Athapattu PL, Jayasinghe KSA, Dondorp AM, Haniffa R. A data platform to improve rabies prevention, Sri Lanka. Bull World Health Organ. 2017 Sep 01;95(9):646-651.

Fisher CR, Streicker DG, Schnell MJ. The spread and evolution of rabies virus: conquering new frontiers. Nat Rev Microbiol. 2018 Apr;16(4):241-255.

Hennenfent AK, Iyengar P, Davies-Cole J. Assessing rabies knowledge gaps in human and animal healthcare professionals practicing in Washington, DC-A one health approach. Zoonoses Public Health. 2018 Dec;65(8):947-956.

Lampejo T, Bruce M, Teall A, Dall'Antonia M, Crawley-Boevey E, Grant P, Polhill S, Pillay D, Brown D, Brown M, Nastouli E. Caring for a patient with rabies: implications of the Milwaukee protocol for infection control and public health measures. J Hosp Infect. 2017 Aug;96(4):385-391.

Landford J, Nunn M. Good governance in 'one health' approaches. Rev Sci Tech. 2012 Aug;31(2):561-75.

Langedijk AC, De Pijper CA, Spijker R, Holman R, Grobusch MP, Stijnis C. Rabies Antibody Response After Booster Immunization: A Systematic

Review and Meta-analysis. Clin Infect Dis. 2018 Nov 28;67(12):1932-1947.

Lu XX, Zhu WY, Wu GZ. Rabies virus transmission via solid organs or tissue allotransplantation. Infect Dis Poverty. 2018 Aug 15;7(1):82.

Middleton D, Edwin JJ, Johnson KO, Warshawsky BF. A descriptive analysis of rabies post-exposure prophylaxis data: 2013, Ontario, Canada. Zoonoses Public Health. 2018 Feb;65(1):e66-e78.

Pedersen K, Schmit BS, DeLiberto TJ, Suckow JR, Davis AJ, Slate D, Chipman RB, Hale RL, Gilbert AT. Raccoon (*Procyon lotor*) biomarker and rabies antibody response to varying oral rabies vaccine bait densities in northwestern Pennsylvania. Heliyon. 2018 Sep;4(9):e00754.

Prevaldi C, Paolillo C, Locatelli C, Ricci G, Catena F, Ansaloni L, Cervellin G. Management of traumatic wounds in the Emergency Department: position paper from the Academy of Emergency Medicine and Care (AcEMC) and the World Society of Emergency Surgery (WSES). World J Emerg Surg. 2016;11:30.

Robardet E, Rieder J, Barrat J, Cliquet F. Reconsidering Oral Rabies Vaccine Bait Uptake Evaluation at Population Level: A Simple, Noninvasive, and Ethical Method by Fecal Survey Using a Physical Biomarker. J Wildl Dis. 2019 Jan;55(1):200-205.

Sambo M, Hampson K, Changalucha J, Cleaveland S, Lembo T, Lushasi K, Mbunda E, Mtema Z, Sikana L, Johnson PCD. Estimating the Size of Dog Populations in Tanzania to Inform Rabies Control. Vet Sci. 2018 Sep 07;5(3)

Ugolini G, Hemachudha T. Rabies: changing prophylaxis and new insights in pathophysiology. Curr Opin Infect Dis. 2018 Feb;31(1):93-101.

Yahiaoui F, Kardjadj M, Laidoudi Y, Medkour H, Ben-Mahdi MH. The epidemiology of dog rabies in Algeria: Retrospective national study of dog rabies cases, determination of vaccination coverage and immune response evaluation of three commercial used vaccines. Prev Vet Med. 2018 Oct 01;158:65-70.

Yang DK, Kim HH, Cho IS. Strategies to maintain Korea's animal rabies non-occurrence status. Clin Exp Vaccine Res. 2018 Jul;7(2):87-92.

CHAPTER 4

ZOONOTIC STUDIES – ZOONOTIC DISEASE TRANSMISSION HUMAN – ANIMAL INTERFACE

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INTRODUCTION

Zoonotic studies focuson the infectious diseases caused to human which were transmitted from animals, birds and etc., such kind of disease are termed as zoonoses. The zoonotic study aims in the health concern of the common people all around the world. Bacteria, virus, parasitic are some common zoonotic pathogens. These diseases spread through water, food or from the surroundings. They can even spread through direct contact with animals. At current we have more than 200 zoonotic diseases. Typically, a zoonoticstudies would cover the study of infectious diseases that can spread from animals to people, including their causes, modes of transmission, epidemiology, preventative measures, and the "One Health" approach that takes into account the interdependence of environmental, animal, and human health when researching and treating these conditions. The term “zoonoses” is derived from the Greek word “zoon”, which means animal and “noses”, which means illness.In accordance with World Health Organisation (WHO), among the total human pathogens over 61% were identified as zoonotic in nature. These zoonotic germs change their nature so that they can adapt themselves to make humans as natural host. Some examples of zoonotic diseases are Rabis, Ebola, SARS, COVID-19, leptospirosis, brucellosis, Lyme diseaseand so on.

In the past, zoonotic illnesses have greatly influenced human development, particularly in communities and cultures that tamed and bred animals for clothing and food. One of the most common and feared threats to humanity is zoonoses. Zoonoses are found all throughout the planet, extending beyond the bounds of nature. Their significant impact on the world economy and health is well recognized, and it ranges from limits on other international trade activities to prohibitions on the importation of all animal products and the international movement of animals and illnesses. Zoonoses are therefore no longer only a national issue. Worldwide surveillance is required for the efficient management of zoonoses.

1 HISTORY OF ZOONOTIC STUDIES

Zoonotic diseases which were also termed as zoonoses, are a kind of infection which are transmitted from animals to humans. these diseases evolved and becomes a revolutionary in human history by shaping pandemics and ignites medical advancement. In earlier stage rabies and tuberculosis, a kind of zoonotic diseases are observed. just taking rabies as an example - Louis Pasture studied about it and become first to found vaccine for such zoonotic diseases ages back. Not only pasture, Robert Koch in 1882 identified tuberculosis a kind of bacterial infection which was transferred from cattle to human by Mycobacterium Bovis strain. After these discoveries Alexandre Yersin in 1894 identified a bacteriumYersinia pestis that act as the causative agent of plague, it spread all over the Europe during middle age time. The plague spread through fleas that had bitten infected rodents, leading to some of the deadliest outbreaks in history. Over time, we've managed to tame some of these diseases with better sanitation, vaccinations, and medical treatments, but they still pose a real threat today. Conventionally, the zoonotic diseases have set a path way for many global pandemics. many outbreaks have caused due to zoonotic diseases which was originated from pigs or birds. The two main virologists Richard Shope and Johan Hultin were the persons who firstly identified the deadly Spanish Flu of 1918. In this modern world this was turned into the most eminent stain of the influenza virus is H1N1. Montagnier and Gallo identified that HIV was the first traced back to nonhuman primates in the year 1981. likewise, in 1976 Peter Piot and his team found Ebola virus which was transmitted from fruit bats.

2. CLASSIFICATION OF ZOONOTIC DISEASES

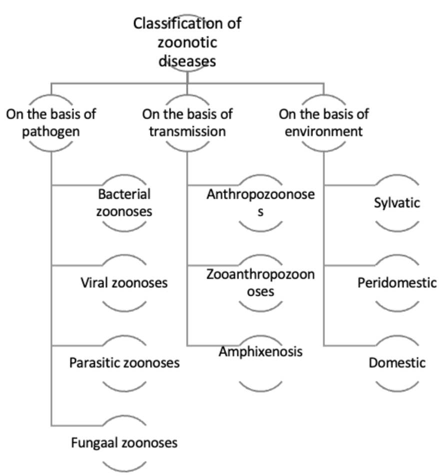

Figure 1: Classification of Zoonotic Diseases

On the basis of pathogen type zoonotic diseases are classified into various kinds:

- Bacterial zoonoses
- Viral zoonoses
- Parasitic zoonoses
- Fungal zoonoses

2.1 Bacterial Zoonoses

Bacterial zoonoses are affected from animals to human through the infectionscaused by bacteria. These bacterial infections can be affected through both direct contact and indirect contact. Bites, scratches or any kind of fluid material like saliva from animals comes under direct contact whereas infection by contaminated food, water or soil comes under indirect contact. Few examples of bacterial zoonoses infections (Table 1)

Table 1: Diseases and Their Associated Animal Reservoirs.

Diseases	Caused by	Animal reservoir
Salmonellosis	Salmonella bacteria	Reptiles, amphibians, poultry
Brucellosis	Brucella bacteria	Cattle, sheep, pigs
Cat scratch diseases	Bartonella henselae bacteria	Cats
Lyme disease	Borrelia burgdorferi bacteria	Mice, deer
Psittacosis	Chlamydophila psittaci bacteria	Birds
Anthrax	Bacillus anthracis bacteria	Grazing animals
Leptospirosis	Leptospira bacteria	Rats, mice, dogs
Q – fever	Coxiella burnetii bacteria	Cattle, sheep, goats
Tularemia	Francisella tularensis	Rabbit, hares, rodents

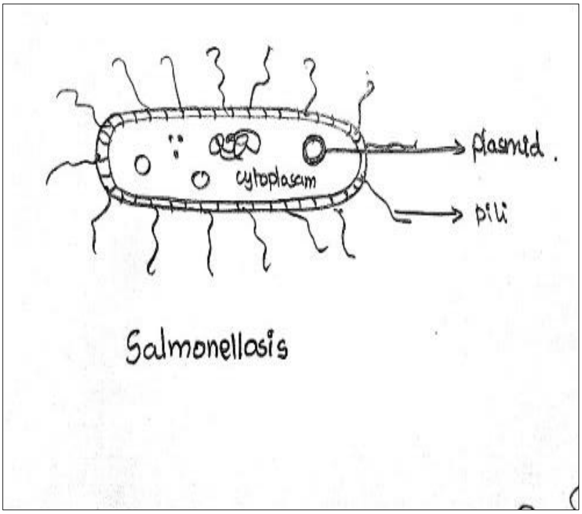

Figure 2: Represents the Schematic Image of Bacterial Species – salmonellosis

These bacterial zoonoses have more chance of affecting a person who has a job exposer mainly to animals like veterinarians, farmers or person who contact with animals.

2.2 Viral Zoonoses

Viral zoonoses are affected from animals to human through the infections caused by viruses. These viral infections can be affected through both direct contact and indirect contact. Bites, scratches or any kind of fluid material like saliva from animals comes under direct contact whereas infection by vectors like mosquito, contaminated food, water or soil comes under indirect contact. Few examples of viral zoonoses infections (Table 2).

Table 2: Variety of Viral Diseases with Animal Reservoirs and Vectors

Diseases	Caused by	Animal reservoir
Rabies	Lyssavirus, Rhabdoviridae	Dogs, bats, foxes
Ebola virus	Filoviridae	Fruit bats
Nipah virus	Paramyxoviridae	Bats
Hantaviruses	Bunyaviridae	Rodents

Coronaviruses	SARS-CoV, MERS-CoV, SARS-CoV-2	Bats , intermediate hosts- civets, camels, pangolins
Dengue	Flaviviridae, Togaviridae	Aedes mosquitoes
Zika		
Chikungunya		
West nile virus	Flavivirus, Flaviviridae	Birds
Japanese encephalitis virus	Flavivirus, Flaviviridae	Culex mosquitoes
Avian influenza	H5N1, H7N9	Wild birds
Swine influenza	H1N1, H3N2v	Pigs

To elaborate, many zoonotic viruses produce subclinical infections in reservoir species but serious disease in humans. Viruses like rabies and Japanese encephalitis are neurotropism, which means they infect the central nervous system. Haemorrhagic viruses like Ebola and CCHF damage blood vessels and result in internal bleeding. Coronaviruses — similar to hantaviruses — are a type of respiratory virus that may lead to pneumonia, ARDS, or respiratory failure.

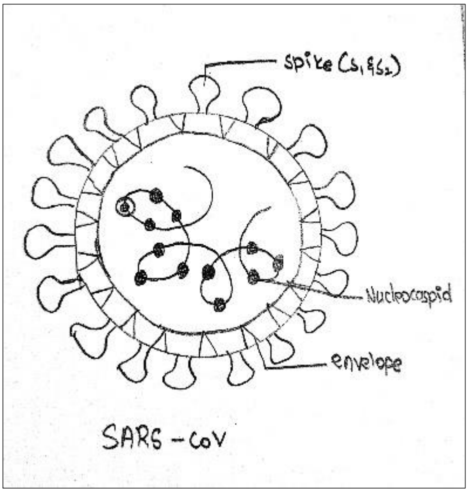

Figure 3: Represents the Schematic Image of Viral Species - SARS – CoV species

2.3 Parasitic Zoonoses

Parasitic zoonoses are affected from animals to human through the infections caused by viruses. These parasitic infections can be affected through both direct contact and indirect contact. They can transmit by direct contact by the exposure to contaminated water, insect vector or by the exposure to affect feces. Few examples of parasitic zoonoses infections (Table 3).

Table 3: Focusing on Parasitic and Vector-borne Diseases

Diseases	Caused by	Animal reservoir
Toxoplasmosis	Toxoplasma gondii	Cat feces
Trypanosomiasis	Trypanosoma spp.	Tsetse flies
Echinococcosis	Echinococcus spp.	Dog tapeworms
Schistosomiasis	Schistosoma spp.	Freshwater snails
Taeniasis/ cysticercosis	Taenia solium	Pork or beef tapeworms
Leishmaniasis	Leishmania spp.	Sandflies
Lyme diseases	Borrelia burgdorferi	Infected ticks

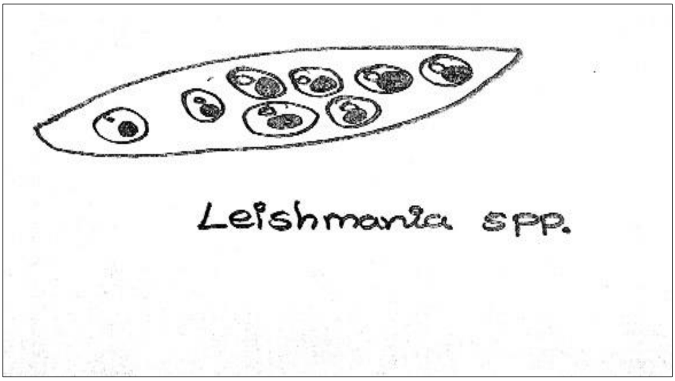

Figure 4: Represents the Schematic Image of Parasitic Species – Leishmania spp.

2.4 Fungal Zoonoses

Fungal zoonoses are affected from animals to human through the infections caused by fungai. These fungal infections can be affected through both direct contact and indirect contact. These zoonoses are not that much common like bacterial or parasitic zoonoses. Few examples of fungal zoonoses infections (Table 4).

Table 4: A Group of Fungal Infections that can be Transmitted from Animals to Humans

Disease	Caused by	Animal reservoir
Dermatophytosis (ringworm)	Microsporum spp.	Dogs, cats, cattle, horses
Sporotrichosis (rose gardener's disease)	Sporothrix schenckii	Cats, rodents, horses
Cryptococcosis	Cryptococcus neoformans	Birds(pigeons mainly), bats
Histoplasmosis	Histoplasma capsulatum	Birds, bats
Blastomycosis	Blastomyces dermatitidis	Dogs

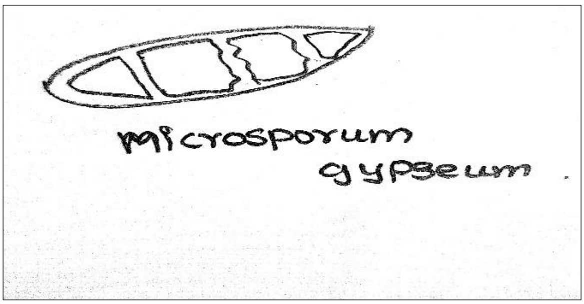

Figure 5: Represents the Schematic Image of Fungal Species - Microsporum spp.

On the basis of transmission zoonotic diseases are classified into various types:

- Anthropozoonoses
- Zooanthropozoonoses
- Amphixenosis

Anthropozoonoses: Infectious processes which can be transmitted from animals to humans are termed anthropozoonoses. Transmission (a.k.a. routes of transmission) is through: oral contact; ingestion (eating); inhalation (breathing); vectors (mosquito, rat, etc.); and environmental exposure. Severe, life-threatening diseases are caused by a plethora of bacterial pathogens (bacteria pathogens), viral pathogens, fungal pathogens, parasitic pathogens, and prion pathogens. The most famous examples are rabies, which can be transmitted through the razors of animals, vesicular brucellosis, which is caused by the compulsory former milk or meat contaminated, and plague, generated by the bite of an insect in an infected exposing. The intermediary host is an important component of the life cycle of some anthropozoonoses. There are also leptospirosis and histoplasmosis - while others are acquired from contaminated water or soil.Ticks and sandflies arthropods are the main causative agent in spreading vector-borne diseases. Indeed, these illnesses do represent a significant problem for the public health sector notably in rural and agricultural areas. Vaccination, control of vectors, making sure of uncontaminated food and water, having good and heathy health condition, and keeping awareness camps minimises human exposure which plays important role in reducing the risk of transmission of these zoonotic diseases.

Zooanthropozoonoses: Zooanthropozoonoses are primarily diseases that travel from humans to animals (reverse zoonoses), but in few cases they also tend cyclable back to humans. In contrast to normal zoonoses which usually flow from animals to humans, zooanthropozoonoses are caused by pathogens that have their roots in humans and then infect animals, they become as the outbreak to domestic animals, wildlife, and biodiversity. These diseases are carried out by viruses, bacteria, fungi, or parasites and are mostly transmitted through direct contact, aerosols, or food and water that has been infected.

Some suchas tuberculosis (Mycobacterium tuberculosis), which can come from humans to cattle, elephants, and primates, and the influenza viruses, for example, H1N1 and COVID-19 that have been as well transmitted to pigs, cats, and minks. Methicillin-resistant Staphylococcus aureus (MRSA) is one such example, in which MRSA spreads from humans to pets and causes serious skin infections. Sufferers of the infections fungal, as dermatophytosis (ringworm) are often transmitted from humans to animals as well. The problems of these infections are an increasing source of concern in veterinary and wildlife medicine, since they are capable of producing new reservoirs of disease, genetic mutations of the pathogens, and the threats to existing animal preservation efforts.

Amphixenosis: AmphixenosIs result from contact between humans and animals whereby both can get infected. This mode of pathogenic transmission can lead to virulent outbreaks thereby giving rise to new strains. The pandemic influenza viruses- H1N1, H5N1, and H7N9-spread in one life cycle from birds to pigs, and humans while past human transmission of COVID-19 from the SARS-CoV-2 virus has reached cats and minks. Other examples include the reciprocal transmission of tuberculosis Mycobacterium tuberculosis between humans, cattle, and elephants, on the one hand; and transmission of methicillin-resistant Staphylococcus aureus (MRSA) between pets, livestock, and owners, on the other hand. The presence of many hosts and vectors in such diseases as leishmaniasis makes them even harder to control. Amphixenoses involve the interface between human health, veterinary medicine, and conservation because of their role in pathogen evolution, antibiotic resistance, and new reservoirs of infection.

On the basis of environment zoonotic diseases are classified into various types:

- Sylvatic
- Peridomestic
- Domestic

Sylvatic: Sylvatic conditions are both wild and natural living conditions like forests or wild ecosystems that have a high-volume wildlife population thriving and interrelating. To clarify the meaning of these terms in the context of zoonoses, natural environments can be seen as a reservoir of all kinds of pathogens that can be domesticated, such as bacteria, fungi and viruses, and can be carried by animals to humans. Most of these zoonotic pathogens arise from animals that live in the wild, such as, bats, rodents and primates, and, therefore, the possibility of wildlife as the primary habitat of a disease is not a contradiction to the ecology of a disease. However, vectors such as tick, mosquito, and flea carrying infectious agents for the human body are required in addition to animal species for the transmission of the disease via them in sylvatic environments.

Spillover events result from disease transmission between wildlife and humans through several factors such as direct contact with animals, hunting, deforestation or climate change. This climate disturbance changes the pattern of interactions between the components of the ecosystems and may thus influence their resilience in relation to the survival of zoonotic agents and thereby the risk of human infection. For which reason, Research of the sylvatic cycle of pathogens becomes the most urgent task in global health in order to predict and prevent emerging infectious diseases like Ebola, Lyme disease, and Plague.

Peridomestic: Peridomestic zoonotic research targets the spread of zoonotic disease in settings where human residence coexists with animal populations, e.g., backyards, farms, and urban or suburban environments. In contrast to sylvatic settings, which include wildlife in their natural habitats, peridomestic settings include animals that reside near humans, such as domestic pets, livestock, and commensal wildlife such as rodents, raccoons, and stray animals. These environments provide avenues for the transmission of zoonotic pathogens by direct contact, soiled surfaces, or vectors such as fleas, ticks, and mosquitoes.Human practices like inadequate waste disposal, animal husbandry, and urbanization can facilitate the transmission of zoonotic disease in peridomestic situations. Examples of zoonotic diseases that occur in these settings are rabies, leptospirosis, toxoplasmosis, and zoonotic influenza.

***Domestic*:** Domestic zoonotic studies explore how zoonotic diseases spread among people living closely with domesticated animals, whether in our homes with pets or on farms with livestock. Unlike spaces where wild or stray animals might roam near our homes, these domestic settings mostly involve beloved companion animals like dogs and cats, and farm animals like cows, chickens, and pigs. These animals can act as carriers of zoonotic pathogens, passing these diseases on to humans through direct contact, bites, scratches, or contaminated food and water. They can also spread via pests like fleas and ticks.

Some common zoonotic diseases we might encounter in these domestic environments include rabies, ringworm, toxoplasmosis, brucellosis, and bovine tuberculosis. Issues like poor hygiene, lack of vaccinations, and improper handling of animals can raise the risk of spreading these diseases. To help keep everyone safe, it’s essential to take preventive measures. Regular vaccinations for pets, good sanitation practices, responsible pet ownership, and biosecurity measures in farming can all play critical roles in controlling zoonotic diseases in our homes and farms.

3. EFFECTS OF ZOONOTIC DISEASES ON HUMAN WELFARE

Zoonotic diseases have a big impact on our health, causing everything from mild sickness to severe, life-threatening conditions. These diseases, which are passed from animals to people, include well-known threats like rabies and Ebola, which can be deadly, and more common ones like COVID-19 and influenza that can lead to pandemics affecting millions around the world. The effects on our health can vary, with symptoms like fever, breathing problems, neurological issues, and even organ failure, depending on the illness. Some, like tuberculosis that comes from cattle, can stick around for a long time, causing ongoing suffering and sometimes disability. Plus, in places where healthcare resources are scarce, zoonotic diseases can leave people malnourished and with weakened immune systems.

But it’s not just our physical health that takes a hit—there’s also a heavy psychological toll. The anxiety that comes with outbreaks, the sadness of losing loved ones, and the loneliness of being in quarantine can lead to mental health challenges like anxiety and depression. On top of that, economic problems crop up too, with people losing income, facing higher medical bills, and putting a strain on healthcare systems. Take the COVID-19 pandemic as an example; it shook up the global economy and healthcare services, causing job losses and financial struggles. Healthcare workers also bear the brunt, facing increased workloads and risks. To tackle these diseases, we need strong public health measures, vaccination efforts, better sanitation, and a united global approach to cushion the devastating effects on health and society.

Prevention from zoonotic diseases:

- Primary prevention
- Secondary prevention
- Tertiary prevention

3.1 Primary Prevention

In general, the primary prevention of zoonotic disease transmission is achieved by the reduction of exposure to the infectious agents. The most important means of achieving this is through hygiene and sanitation, which involves washing hands with soap and water after handling animals, cleaning shelters and farms, and proper removal of animal waste.

Food safety practices are very important in the prevention of zoonotic infections. Human beings should also eat well-cooked meat, eggs, and dairy products; and wash fruits and vegetables well, especially after coming into contact with livestock. Maintaining animal health and biosecurity is also key, which includes vaccination of domestic and farm animals, veterinary checks, and parasite control. Biosecurity measures should also be employed by farmers and owners of pets to prevent the outbreak of diseases.

Another important aspect is vector control, which is concerned with the management of vectors like ticks, mosquitoes, and rodents that transmit zoonotic diseases. Vector control is thus achieved through methods such as the use of insect repellents, wearing protective clothing, and eliminating breeding sites. In addition, animals should be handled in a safe manner where people avoid direct contact with wild or unknown animals, wear personal protective equipment while handling sick or dead animals, and instruct children in safe ways to interact with pets.

Public health measures, including disease surveillance and early outbreak detection, become crucial at a higher level in preventing zoonotic diseases. Other control measures may come in the form of slaughtering or quarantining infected animals to break the transmission. Travel and occupational safety precautions must also be adhered to by personnel interacting with animals such as veterinarians and farmers, by wearing personal protective equipment (PPE) and avoiding high-risk activities, such as bushmeat consumption.

3.2 Secondary Prevention

Secondary prevention of zoonotic diseases is about catching and treating problems early to prevent them from spreading. Quick identification of infections is crucial, using medical exams and lab tests like PCR and ELISA. These tests are important for early diagnosis and regular monitoring. By improving disease monitoring programs, especially in high-risk places such as farms, live animal markets, and slaughterhouses, we can better detect and respond to outbreaks. Immediate medical treatment is essential once a disease is identified. Using the right treatments—whether antimicrobial, antiviral, antifungal, or anti parasitic—along with post-exposure prophylaxis (PEP) for diseases like rabies, can prevent serious health issues and save lives. If infections worsen, hospitalization and supportive care are necessary to manage symptoms effectively.

Public health measures are crucial in preventing outbreaks and minimizing transmission risks. Quarantining and isolating infected people or animals are key strategies. Contact tracing is also important, as it involves monitoring exposed individuals to ensure they get needed medical care. Infection control in healthcare and veterinary settings is vital. This includes using personal protective equipment (PPE) and following strict hygiene practices to help contain the disease. Vaccination and immunization play significant roles in secondary prevention. High-risk groups, like veterinarians, farmers, and slaughterhouse workers, benefit from targeted vaccination programs. Immunizing animals, such as vaccinating dogs against rabies and livestock for brucellosis, helps control disease reservoirs in animals and reduces the risk to humans.

3.3 Tertiary Prevention

Tertiary prevention of zoonotic diseases focuses on lessening the long-term effects of infections, avoiding complications, and improving life quality for those impacted. This stage is vital for managing ongoing issues from zoonotic infections, such as brain damage from rabies or organ failure from brucellosis. Rehabilitation programs, like physical therapy and mental support, aid recovery from severe infections. In some cases, advanced medical care, such as organ transplants, is needed to address severe damage caused by these diseases.

Long-term medical care is a key part of tertiary prevention. It ensures people with chronic zoonotic conditions receive the right medications and follow-up care. For instance, those with zoonotic tuberculosis must undergo long-term antibiotic treatment to prevent the disease from returning or worsening. Regular check-ups and lab tests help doctors monitor disease progression and adjust treatment as needed. Public health efforts at this stage work to minimize disabilities and assist affected individuals in rejoining society, offering them social and economic support.

This prevention stage also includes research and policy updates to improve disease management. Developing better treatment and rehabilitation plans through clinical studies can lead to improved outcomes for future patients. Strengthening healthcare systems, especially in areas prone to zoonotic diseases, ensures timely and effective treatment. Collaboration across fields, like medicine, veterinary science, and environmental science, is crucial under the One Health approach to fully address long-term disease impacts.

In essence, tertiary prevention aims to reduce suffering, prevent further health decline, and enhance the well-being of those already affected by zoonotic diseases. By emphasizing long-term care, rehabilitation, and ongoing medical advancements, tertiary prevention is essential in reducing the long-term burden of zoonotic infections on individuals and public health systems.

CONCLUSION

Zoonotic diseases, which are illnesses that can be passed from animals to humans, pose a major threat to public health worldwide. To tackle these diseases, we need a well-rounded plan. Studies on zoonotic diseases are crucial because they help us understand how these diseases spread, what makes them risky, and how to prevent them effectively. Research also leads to better vaccines, improved diagnostic tools, and more effective treatments, all of which help reduce the number of infections. Preventing zoonotic diseases requires several key steps. First, we can reduce exposure by practicing good hygiene, getting vaccinated, and taking care of animal health. Second, early diagnosis and quick treatment are essential, along with measures to contain the disease. Third, providing long-term medical care and rehabilitation is important for those affected. By implementing these measures, we can lower the number of cases, stop outbreaks, and improve recovery for patients.

Governments play a big role in fighting zoonotic diseases through policy-making, surveillance, and funding for research and healthcare. They enforce rules on food safety, wildlife trade, and livestock management to prevent the spread of diseases. National and international cooperation, like the One Health approach, improves coordination among human, animal, and environmental health sectors. Public awareness campaigns, vaccination programs, and early warning systems further enhance our efforts to prevent these diseases.

In summary, combating zoonotic diseases requires teamwork from researchers, healthcare professionals, government officials, and the public. Improving surveillance, strengthening healthcare systems, and fostering global cooperation are essential steps to reducing the impact of zoonotic diseases and ensuring public health safety.

REFERENCE

Allen T, Murray KA, Zambrana-Torrelio C, Morse SS, Rondinini C, Di Marco M, Breit N, Olival KJ, Daszak P. Global hotspots and correlates of emerging zoonotic diseases. Nat Commun. 2017;8(1):1124. doi: 10.1038/s41467-017-00923-8.

Authority EFS. Prevention ECfD, Control: the European Union One Health 2021 Zoonoses Report. EFSA J. 2022;20(12):e07666. doi: 10.2903/j.efsa.2022.7666.

Beaty B.J., Marquardt W.C. The Biology of Disease Vector. University Press of Colorado; Niwot, CO, USA: 1996.

Chomel B.B. Encyclopedia of Microbiology. 3rd ed. Elsevier Inc., University of California; Davis, CA, USA: 2009. Zoonoses; pp. 820–829.

Chomel BB. Control and prevention of emerging parasitic zoonoses. Int J Parasitol. 2008;38(11):1211–7. doi: 10.1016/j.ijpara.2008.05.001.

County of Los Angeles Public Health Overview of Zoonoses. [(accessed on 20 July 2020)]

Dahal R, Kahn L. Zoonotic diseases and one health approach. *Epidemiol.* 2014;4:e115.

Day MJ. Pet-Related Infections. Am Fam Physician. 2016 Nov 15;94(10):794-802.

Field H, Young P, Yob JM, Mills J, Hall L, Mackenzie J. The natural history of Hendra and Nipah viruses. Microbes Infect. 2001 Apr;3(4):307-14.

Goldstein EJ. Bite wounds and infection. Clin Infect Dis. 1992 Mar;14(3):633-8.

McNeill W.H. Plagues and People. Anchor Press; New York, NY, USA: 1976.

Meslin FX. Impact of zoonoses on human health. Vet Ital. 2006 Oct-Dec;42(4):369-79.

Messenger AM, Barnes AN, Gray GC. Reverse zoonotic disease transmission (zooanthroponosis): a systematic review of seldom-documented human biological threats to animals. PLoS ONE. 2014;9(2):e89055. doi: 10.1371/journal.pone.0089055.

Parish LC, Schwartzman RM. Zoonoses of dermatological interest. Semin Dermatol. 1993 Mar;12(1):57-64.

Rahman MT, Sobur MA, Islam MS, Ievy S, Hossain MJ, El Zowalaty ME, Rahman AT, Ashour HM. Zoonotic Diseases: Etiology, Impact, and Control. Microorganisms. 2020 Sep 12;8(9)

Slingenbergh J. World Livestock 2013: Changing Disease Landscapes. Food and Agriculture Organization of the United Nations (FAO); Rome, Italy: 2013.

Thompson A., Kutz S. Introduction to the Special Issue on 'Emerging Zoonoses and Wildlife'. Int. J. Parasitol. Parasites Wildl. 2019;9:322. doi: 10.1016/j.ijppaw.2019.07.002.

Torgerson P.R., Torgerson D.J. Public health and bovine tuberculosis: What's all the fuss about? Trends Microbiol. 2010;18:67–72. doi: 10.1016/j.tim.2009.11.002.

World Health Organization WHO Health Topic Page: Zoonoses. [(accessed on 20 July 2020)]

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