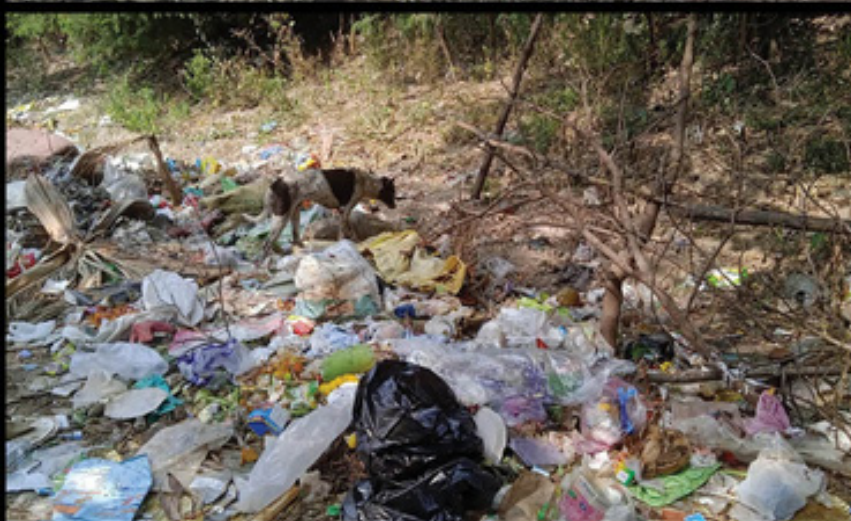# Epidemiology and Environmental Hygiene in Veterinary Public Health

Edited by **Tanmoy Rana**

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**Epidemiology and Environmental Hygiene
in Veterinary Public Health**

Epidemiology and Environmental Hygiene in Veterinary Public Health

Edited by

Tanmoy Rana, M.V.Sc & PhD
Assistant Professor, Department of Veterinary Clinical Complex
West Bengal University of Animal & Fishery Sciences
Kolkata, India

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Contents

List of Contributors

Javed Jameel A
Department of Veterinary Clinical Medicine, Ethics
and Jurisprudence, College of Veterinary and Animal
Sciences, Kerala Veterinary and Animal Sciences
University, Pookode, India

Oluwadamilola Olawumi Abiodun-Adewusi
Department of Health Sciences and Social Work
Western Illinois University, Macomb, IL, USA, 61455

Eshun A. Ama
Department of Food and Animal Science
Alabama A&M University, Normal, AL, USA

Njideka Adeniyi
Department of Food and Animal Science
Alabama A&M University, Normal, AL, USA

Vivek Agrawal
Department of Veterinary Parasitology, College of Veterinary
Sciences & Animal Husbandry, Nanaji Deshmukh
Veterinary Science University, Mhow, Indore, India

Nma Bida Alhaji
Department of Veterinary Public Health and
Preventive Medicine, University of Abuja, Abuja, FCT,
Nigeria, 900105

Pranav Anjaria
College of Veterinary Science and Animal Husbandry
Kamdhenu University, Anand, India

Varun Asediya
M. B. Veterinary College, Dungarpur, India

Akeem Adebola Bakare
Division of Epidemiology, Department of Environmental
and Public Health Sciences, University of Cincinnati
Cincinnati, OH, USA, 45221

Sanjay Bharti
College of Veterinary & Animal Sciences, DUVASU
Mathura, India

Dipanwita Bhattacharya
Faculty of Veterinary and Animal Sciences, Institute
of Agricultural Sciences, Banaras Hindu University
Mirzapur, India

Manubhai N. Brahmbhatt
College of Veterinary Science and Animal Husbandry
Kamdhenu University, Anand, India

Annada Das
Department of Livestock Products Technology
West Bengal University of Animal and Fishery Sciences
Kolkata, India

Baleshwari Dixit
Department of Veterinary Public Health &
Epidemiology College of Veterinary Science & Animal
Health, 486001, Rewa, NDVSU, Jabalpur, Madhya
Pradesh, India
and
Department of Livestock Products Technology
College of Veterinary Science and Animal Husbandry
Rewa, NDVSU, Jabalpur, Madhya Pradesh, India

Nourhan Eissa
Department of Animal Hygiene and Zoonoses, Faculty
of Veterinary Medicine, University of Sadat City, Sadat
City, Egypt

Negin Esfandiari
Department of Food Hygiene and Quality Control
Division of Epidemiology, Faculty of Veterinary Medicine
University of Tehran, Tehran, Iran

Samuel U. Felix
Faculty of Veterinary Medicine, National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria
Department of Food and Animal Science, Alabama A&M University, Normal, AL, USA

Meena Goswami
College of Veterinary & Animal Sciences, DUVASU Mathura, India

Poornima Gumasta
College of Veterinary and Animal Sciences, Bihar Animal Sciences University, Patna, Bihar, India

Abbas Rabiu Ishaq
Paws and Claws Specialist Veterinary Clinic, Riyadh, KSA

Udit Jain
College of Veterinary & Animal Sciences, DUVASU Mathura, India

J. Jyothi
Department of Veterinary Medicine, P.V. Narasimha Rao Telangana Veterinary University, Hyderabad, India

Athira K
Department of Veterinary Epidemiology and Preventive Medicine, College of Veterinary and Animal Sciences Kerala Veterinary and Animal Sciences University Pookode, India

Justin Davis K
Department of Veterinary Epidemiology and Preventive Medicine, College of Veterinary and Animal Sciences Kerala Veterinary and Animal Sciences University Pookode, India

Manav Kansal
ICAR-IVRI, Izatnagar, Bareilly, India

Manoj Kumar Karanam
Department of Veterinary Surgery and Radiology, College of Veterinary Science, Garividi, India

Jaysukh B. Kathiriya
Department of Veterinary Public Health & Epidemiology College of Veterinary Science & Animal Husbandry Kamdhenu University, Junagadh, India

Akhilesh Kumar
Division of Medicine, ICAR-IVRI, Izatnagar, Bareilly, India

Amit Kumar
Department of Veterinary Surgery and Radiology, Lala Lajpat Rai University of Veterinary and Animal Sciences Hisar, India

Anuj Kumar
College of Veterinary & Animal Sciences, DUVASU Mathura, India

Atul Kumar
Department of Veterinary Public Health and Epidemiology, CSK HP Agricultural University Palampur, India

Manesh Kumar
Department of Veterinary Public Health and Epidemiology, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, India

Narendra Kumar
College of Veterinary and Animal Sciences, Bihar Animal Sciences University, Patna, Bihar, India

Naveen Kumar
Department of Veterinary Public Health and Epidemiology, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, India

Sandeep Kumar
Cluster University of Jammu, Jammu and Kashmir, India

Neelam Kurmi
Department of Animal Husbandry and Dairying Sagar, India

Mahmuda Malik
College of Veterinary and Animal Sciences, Bihar Animal Sciences University, Patna, Bihar, India

Sivakumar Mani
Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute,Tamil Nadu Veterinary and Animal Sciences University, Theni, India

Samuel C. Maureen
JayCare Medical Centre, Crestwood Medica Center, Huntsville, AL, Kaduna, Nigeria

Abhinav Meena
Department of Veterinary Parasitology,
Apollo College of Veterinary Medicine, Jaipur, Rajasthan,
302031, India

Raghvendra Mishra
Department of Veterinary Public Health, M.B. Veterinary
College, Dungarpur, India

Dinesh Mittal
Department of Veterinary Public Health and
Epidemiology, Lala Lajpat Rai University of Veterinary
and Animal Sciences, Hisar, India

Simpson Monya
Department of Food and Animal Science, Alabama A&M
University, Normal, AL, USA

Faizan ul Haque Nagrami
College of Biotechnology, DUVASU, Mathura, India

Mohammadreza Najafi
Department of Pathobiology, Faculty of Veterinary
Medicine, Urmia University, Urmia, Iran

Mona Abdelghany Nasr
Department of Anatomy and Embryology, Faculty of
Veterinary Medicine, University of Sadat City, Sadat
City, Egypt

Jitendrakumar Nayak
College of Veterinary Science and Animal Husbandry
Kamdhenu University, Anand, India

Deepak Nelagonda
Department of Poultry Science, SNK AH Polytechnic
College, Anantapur, India

Ismail A. Odetokun
Department of Veterinary Public Health and Preventive
Medicine, University of Ilorin, Ilorin, Kwara State,
Nigeria, 240003

Santanu Pal
ICAR – Indian Veterinary Research Institute, Izatnagar
Bareilly, India

Ramadevi Pampana
Department of Veterinary Parasitology, College of
Veterinary Science, Garividi, India

Parul
College of Veterinary & Animal Sciences, DUVASU
Mathura, India

Ashish C. Patel
Veterinary College, Kamdhenu University, Anand, India

Abhishek Pathak
Department of Veterinary Parasitology, Apollo College of
Veterinary Medicine, Jaipur, Rajasthan, India

Anil Patyal
Department of Veterinary Public Health and
Epidemiology, Dau Shri Vasudev Chandrakar Kamdhenu
Vishwavidyalaya, Durg, India

Priyambada
College of Biotechnology, DUVASU, Mathura, India

Tanmoy Rana
Department of Veterinary Clinical Complex, West Bengal
University of Animal & Fishery Sciences, Kolkata, India

Shriya Rawat
College of Veterinary & Animal Sciences, SVPUAT
Meerut, India

Bhavanam Sudhakara Reddy
College of Veterinary Science, Sri Venkateswara
Veterinary University, Proddatur, Andhra Pradesh, India

Amitava Roy
Department of Livestock Farm Complex, West Bengal
University of Animal & Fishery Sciences, Kolkata, India

Diptimayee Sahoo
College of Veterinary and Animal Sciences, Bihar Animal
Sciences University, Patna, Bihar, India

Simant Kumar Sahoo
Veterinary Officer, Odisha State Government,
Gajapati, India

Gungi Saritha
Department of Veterinary Medicine, Sri Venkateswara
Veterinary University, Tirupati, India

Varun Kumar Sarkar
Division of Medicine, ICAR-IVRI, Izatnagar,
Bareilly, India

Souti Prasad Sarkhel
Faculty of Veterinary and Animal Sciences, Institute of Agricultural Sciences, Banaras Hindu University Mirzapur, India

Kaushik Satyaprakash
Faculty of Veterinary and Animal Sciences, Institute of Agricultural Sciences, Banaras Hindu University, Mirzapur, India

Harshit Saxena
Division of Medicine, ICAR-IVRI, Izatnagar, Bareilly, India

Sulochana Sen
Department of Animal Genetics and Breeding, College of Veterinary Science & Animal Health, Rewa, India

Barkha Sharma
College of Veterinary & Animal Sciences, DUVASU Mathura, India

Nishant Sharma
College of Veterinary & Animal Sciences, GBPUAT Pantnagar, India

Sabhyata Sharma
Department of Veterinary Parasitology, Apollo College of Veterinary Medicine, Jaipur, Rajasthan, India

Sapna Sharma
Department of Public Health & Epidemiology Post Graduate Institute of Veterinary Education and Research College, 302031, Jaipur, India

Shweta Sharma
College of Biotechnology, DUVASU, Mathura, India

Uma Sharma
College of Biotechnology, DUVASU, Mathura, India

Arkaprabha Shee
Subject Matter Specialist (Animal Sci.), Dhaanyaganga Krishi Vigyan Kendra, Sargachi, Murshidabad, India

Chandra Shekhar
Department of Veterinary Public Health & Epidemiology College of Veterinary Science & Animal Husbandry Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, India

Aminu Shittu
Division of Quantitative Epidemiology, Department of Theriogenology and Production, Usmanu Danfodiyo University, Sokoto, Sokoto State, Nigeria, 840004

Pratistha Shrivastava
Department of Veterinary Parasitology, Institute of Veterinary Sciences and Animal Health, SOADU Bhubaneswar, India

Goverdhan Singh
College of Veterinary and Animal Science Navania, Vallabhnagar, Udaipur, RAJUVAS, Bikaner, India

Maninder Singh
Department of Veterinary Public Health and Epidemiology, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Rampura Phul, India

Parul Singh
College of Veterinary & Animal Sciences, DUVASU, Mathura, India

Ranvijay Singh
Department of Veterinary Public Health and Epidemiology College of Veterinary Science and A.H. NDVSU 482001, Jabalpur, Madhya Pradesh, India

Renu Singh
College of Veterinary & Animal Sciences, DUVASU Mathura, India

Sirigireddy Sivajothi
College of Veterinary Science, Sri Venkateswara Veterinary University, Proddatur, Andhra Pradesh, India

Manasi Soni
College of Veterinary Science and Animal Husbandry Kamdhenu University, Anand, India

M. Bhavya Sree
P.V. Narasimha Rao Telangana Veterinary University Hyderabad, India

Kambala Swetha
College of Veterinary Science, Sri Venkateswara Veterinary University, Proddatur, Andhra Pradesh, India

Vipul Thakur
College of Veterinary & Animal Sciences, SVPUAT
Meerut, India

Serlene Tomar
Department of Livestock Products Technology,
College of Veterinary Science and Animal Husbandry,
Rewa, NDVSU, Jabalpur, Madhya Pradesh, India

Bhavesh J. Trangadia
Department of Veterinary Pathology, College of Veterinary
Science & Animal Husbandry, Kamdhenu University
Junagadh, India

Vijay Laxmi Tripathi
College of Biotechnology, DUVASU, Mathura, India

K.M. Venkatesh
Veterinary Practitioner, Tamil Nadu, India

Kartikey Verma
CoVSc & AH, SVPUAT, Mathura, India

Shikhar Karan Verma
College of Veterinary & Animal Sciences, DUVASU
Mathura, India

Yamini Verma
Department of Veterinary Pathology, College of Veterinary
Science & Animal Health, Jabalpur, India

Rajesh Kumar Vandre
Department of Animal Genetics and Breeding, College of
Veterinary Science & Animal Health, Rewa, India

Balram Yadav
College of Veterinary and Animal Science Navania,
Vallabhnagar, Udaipur, RAJUVAS, Bikaner, India

Jay P. Yadav
Department of Veterinary Public Health and
Epidemiology, College of Veterinary Science, Guru Angad
Dev Veterinary and Animal Sciences University, Rampura
Phul, India

Mariam Yakubu
Department of Food and Animal Science, Alabama A&M
University, Normal, AL, USA

Somu Yogeshpriya
Department of Veterinary Medicine, Veterinary College
and Research Institute, Tamil Nadu Veterinary and
Animal Sciences University, Orathanadu, India

Ashemi Yusuf
World Bank Regional Disease Surveillance System
Enhancement Project, Abuja, Nigeria

Preface

Veterinary epidemiology deals with a close association between adverse effects with a selected potential causative factor/ cause of interest, such as exposure to a chemical or a disease agent. The basic principle of veterinary epidemiology is that disease occurs seldom in a population, but it may be more likely to happen in certain groups of a population, at certain times, and also in specific locations with a specific pattern. Veterinary epidemiology can play a major role in emerging disease outbreaks, denoting the understanding of the etiological factors as a good prevention of infections with a zoonotic significance. On the other hand, environmental hygiene generally covers all the practical preventive and control strategies used for the improvement of the basic environmental conditions affecting animal health and is in relation to various diseases. Various environmental conditions including purity of water, the status of animal waste disposal as well as food from contamination are the most provoking indices for the occurrence of diseases with zoonotic concern. Various pollutants and waste materials are hazardous to animal health. The book provides a target-organ-oriented presentation of environmental hazards, with a detailed discussion of selected exposures of asbestos, radon, lead, and indoor and outdoor air pollutants. The book also designs observational studies, validity in epidemiological studies, systematic reviews, and statistical modeling, to deliver more advanced material for the students actively involved in the epidemiological study. The full scope of epidemiology, with chapters covering causality, disease occurrence, determinants, disease patterns, disease ecology, and much more are elaborately described in this book. The book features updated information regarding current resources on the subject of veterinary epidemiology, surveillance, and diagnostic test validation and performance. The book describes the logical progression in relation to epidemiological concepts and methods for the developments in research and teaching. This book also expands risk, statistical and economic analyses, and surveillance for various diseases. The contamination of diseases largely depends on environmental indices. pollutants and all of which interact to affect health. Transmission of germs, viruses, and vectors may increase due to inadequate routine cleaning of the environment. The book entitled "Epidemiology and Environmental Hygiene in Veterinary Public Health" 1e will provide a current resource on the subject of veterinary epidemiology and environmental hygiene. Both aspects are essential for the spreading of diseases. The book is a reference for veterinary general practitioners, government veterinarians, agricultural economists, and members of other disciplines interested in animal diseases. It is also very essential reading for epidemiology as well as veterinary public health students at both the undergraduate and postgraduate levels. The book chapters are systematically arranged for the epidemiological significance and environmental hygiene in veterinary public health. The book is designed to intensify the current thoughts and scientific modules for the betterment of understanding for the readers. The book will be designed interestingly by providing color figures, line figures, and tables. The book will also be helpful for students, researchers, academicians, industry sectors, milk producer's unions, veterinarians, and farm managers as a reference book. The book will be of primary importance for audience/readers involved in epidemiological as well as public health research. The management of environmental hygiene with epidemiological forecasts will be discussed elaborately by emphasizing the degree of severity of diseases. The book was structured on the thoughts and understanding of the readership globally in such a fashion that every epidemiology professional/Veterinary Medicine faculty/Territory Veterinary Professional will gather knowledge and will be expertise in Veterinary Epidemiology and Environmental hygiene all in one in the book. Moreover, the epidemiology and spreading/contamination of diseases largely depend on environmental indices. Environmental hygiene is the most important prevention to protect against contamination of any disease. The proposed book will relate the correlation between epidemiology and environmental hygiene nicely. In my opinion, the book is stronger, more powerful, and more relevant for the readership. The impact of environmental hygiene and its effect on animal health is elaborately described in a lucrative manner. This book provides useful information about the

man–environmental–health interrelationships with a strong basic background in the environmental health discipline. This book elaborately describes the nature of environmental hazards with the great relationship between the environment and the health of man. The final aspect of the book deals with the overall prospects for the planning and management of the environmental hygiene. This book is a valuable resource for individuals working in the environmental health sciences.

Dr. Tanmoy Rana
West Bengal University of Animal & Fishery Sciences
Kolkata, India

Acknowledgments

Section 1

Impacts of Epidemiology

1

Epidemiology: Principles, Aims and Scope, Methods, Components and Application

Ismail A. Odetokun[1], Aminu Shittu[2], Akeem Adebola Bakare[3], Oluwadamilola Olawumi Abiodun-Adewusi[4], and Nma Bida Alhaji[5]

[1] *Department of Veterinary Public Health and Preventive Medicine, University of Ilorin, Ilorin, Kwara State, Nigeria, 240003*
[2] *Division of Quantitative Epidemiology, Department of Theriogenology and Production, Usmanu Danfodiyo University, Sokoto, Sokoto State, Nigeria, 840004*
[3] *Division of Epidemiology, Department of Environmental and Public Health Sciences, University of Cincinnati, Cincinnati, OH, USA, 45221*
[4] *Department of Health Sciences and Social Work, Western Illinois University, Macomb, IL, USA, 61455*
[5] *Department of Veterinary Public Health and Preventive Medicine, University of Abuja, Abuja, FCT, Nigeria, 900105*

1.1 Introduction

1.1.1 Definition of Veterinary Epidemiology

Veterinary epidemiology is a dynamic scientific field focused on the in-depth analysis of disease patterns, their geographical distribution, and the multifaceted determinants of diseases and health-related events within animal populations (Toma et al. 1999; Doherr and Audigé 2001). Drawing heavily from the principles and methodologies of epidemiology, the field of veterinary epidemiology extends these concepts to the domain of animal health and well-being (Thrusfield et al. 2018). Veterinary epidemiologists wield a diverse array of investigative tools and techniques to rigorously monitor, analyze, and interpret data about a wide spectrum of animal diseases and health-related challenges (Martin et al. 1987). Veterinary epidemiology is fundamentally concerned with the systematic exploration of how diseases manifest and propagate within animal populations. This approach is crucial for effective disease control, prevention, and safeguarding of both animal and public health (Salman 2009a).

1.1.2 Importance of Veterinary Epidemiology in Safeguarding Animal and Public Health

Veterinary epidemiology is a discipline with profound significance in safeguarding both animal and public health. Its role encompasses a wide range of critical aspects, each contributing to the well-being of animals and humans. Let's explore its importance in greater detail:

1) **Preventing Zoonotic Diseases:** One of the paramount roles of veterinary epidemiology is to monitor and control animal diseases, which is essential in preventing zoonotic diseases. Zoonotic diseases are those that can be transmitted from animals to humans. By identifying and addressing diseases in animal populations, veterinary epidemiologists play a crucial part in reducing the risk of such diseases spilling over to humans. For instance, by controlling diseases in livestock, they minimize the risk of zoonotic pathogens entering the food supply and affecting human health (Heymann 2015; Thrusfield et al. 2018).

2) **Early Detection and Containment of Disease Outbreaks:** Veterinary epidemiology contributes significantly to the early detection and containment of disease outbreaks in animal populations. By implementing surveillance systems and conducting regular monitoring, it enables the rapid identification of diseases. Early detection is vital for implementing control measures that can help prevent the rapid spread of diseases within animal populations. This, in turn, helps to avert economic losses in the livestock industry (Salman 2009a).

3) **Economic Impact and Livestock Industry:** The economic implications of animal diseases are substantial. Disease outbreaks in livestock can result in significant financial losses for the livestock industry, which can affect food

production, trade, and livelihoods. Veterinary epidemiology plays a critical role in minimizing these economic losses by controlling and preventing diseases. This benefits both animal agriculture and the broader economy (Rushton 2008).

4) **Ensuring Food Safety:** The discipline of veterinary epidemiology contributes to food safety by ensuring the health of animals within the food production chain. Healthy animals are more likely to produce safe food products, whether it's meat, dairy, or other animal-derived products. Monitoring and controlling diseases in animals are integral to preventing the contamination of food products, which can lead to foodborne illnesses in humans. It helps in maintaining the integrity of the food supply and public trust in food safety (Doherr and Audigé 2001).

5) **Assessment of Veterinary Interventions:** Veterinary epidemiology aids in the assessment of the efficacy and safety of veterinary interventions, including vaccines and treatments. By conducting studies and analyzing data, veterinary epidemiologists help determine the effectiveness of various interventions in preventing or treating diseases in animals. This ensures that the products and practices used in animal health management are safe and efficient (Martin et al. 1987).

Veterinary epidemiology is vital for safeguarding animal and human health, from preventing zoonotic diseases to enabling early detection and control of animal disease outbreaks. The economic benefits, food safety, and the assessment of veterinary interventions underscore its significance in maintaining the health and well-being of both animal populations and the broader public.

1.2 Principles of Veterinary Epidemiology

1.2.1 Understanding Disease Patterns

1.2.1.1 Descriptive Epidemiology

Descriptive epidemiology is a foundational principle of veterinary epidemiology that serves as the initial step in understanding disease patterns in animal populations. This approach involves the systematic collection and analysis of data to characterize the patterns and distribution of diseases among animals (Dohoo et al. 2009). Descriptive epidemiology is crucial for identifying key factors such as time, place, and affected populations, providing a fundamental understanding of disease occurrence (Thrusfield et al. 2018). In this chapter, we'll explore the significance of descriptive epidemiology in veterinary medicine, provide examples, and suggest references for further reading.

Significance of Descriptive Epidemiology
Descriptive Epidemiology is Essential for a Multitude of Reasons, Including:

a) **Identifying Temporal Trends:** One of the primary objectives of descriptive epidemiology is to recognize temporal patterns in disease occurrence. By analyzing data over time, it helps determine when diseases are more likely to occur, whether they exhibit seasonality, and whether there are long-term trends (Martin et al. 1987; Magnet and Izquierdo 2023). For example, in a study of foot-and-mouth disease in cattle, descriptive epidemiology may reveal that outbreaks tend to peak during certain seasons, such as the rainy season.

b) **Mapping the Geographic Distribution:** Another critical aspect of descriptive epidemiology is mapping the geographical distribution of disease cases. It helps identify specific regions or areas where diseases are concentrated or where clusters of cases occur (Elliott et al. 2000; Pfeiffer et al. 2008). In the context of a brucellosis outbreak in a country, descriptive epidemiology can highlight areas with the highest prevalence of the disease and regions where control measures should be prioritized.

c) **Characterizing Affected Populations:** Descriptive epidemiology delves into the characteristics of the populations affected by the disease. This includes data on species, age, sex, and other relevant attributes of the animals involved. For instance, in the study of avian influenza in poultry, descriptive epidemiology may reveal whether the disease primarily affects certain species, such as ducks or chickens, or whether it impacts birds of a particular age group (Nguyen et al. 2014; Islam et al. 2023).

d) **Early Detection of Outbreaks:** By regularly monitoring and analyzing disease data, descriptive epidemiology enables the early detection of outbreaks (Al-Hemoud et al. 2021). This is particularly crucial for rapid response and the implementation of control measures. For example, in the context of African swine fever (ASF) outbreak, monitoring temporal and geographic patterns can help identify emerging outbreaks in specific pig populations (Kim et al. 2021).

Tools in Descriptive Epidemiology

Descriptive epidemiology employs a range of tools and techniques to explore the distribution and patterns of diseases within animal populations. Among these, two key tools are disease mapping and spatial analysis. These tools play a critical role in understanding the geographic dimensions of disease occurrence.

a) **Disease Mapping:** Disease mapping is a powerful tool that allows epidemiologists to visualize and analyze the geographic distribution of disease cases. It involves plotting the locations of disease cases on a map, creating a spatial representation of the outbreak (Cromley and McLafferty 2012). Disease mapping typically involves collecting data on the geographic coordinates (latitude and longitude) of disease cases. These coordinates are then used to place points on a map, with each point representing a reported case. The map can also incorporate various symbols, colours, or shading to differentiate between affected and unaffected areas. Disease mapping provides a clear, visual representation of disease distribution, making it easier to identify areas with higher disease incidence and clusters of cases (Elliott et al. 2000; Pfeiffer et al. 2008). This spatial visualization is crucial for decision-making, as it helps authorities and epidemiologists target control measures, allocate resources efficiently, and implement interventions in areas with the greatest need.

b) **Spatial Analysis:** Spatial analysis is a statistical examination of the spatial distribution of disease cases. It involves the application of various analytical techniques to explore the geographic patterns of disease incidence, assess clustering, and understand spatial relationships (Elliott et al. 2000; Pfeiffer et al. 2008). Spatial analysis employs statistical methods to evaluate the spatial arrangement of disease cases in their geographic locations. Techniques may include spatial autocorrelation (examining the degree of similarity between neighbouring locations), cluster analysis (identifying disease clusters), and point pattern analysis (assessing the arrangement of cases) (Pfeiffer et al. 2008). Spatial analysis is essential for determining whether disease cases are randomly distributed, clustered, or exhibit spatial patterns. This knowledge aids in identifying high-risk areas, understanding disease transmission dynamics, and tailoring interventions. For instance, spatial analysis might reveal that cases of bovine tuberculosis tend to cluster in specific counties or regions within a country, which can inform targeted surveillance and control strategies (Shittu et al. 2013; Tembo et al. 2020).

1.2.1.2 Analytical Epidemiology

Analytical epidemiology is a crucial branch of veterinary epidemiology that goes beyond describing disease patterns. It focuses on investigating the causes of diseases by exploring the relationships between potential risk factors or exposures and disease outcomes. The primary goal of analytical epidemiology is to establish a causal relationship between these exposures and disease occurrence. This is achieved through a range of research methods and statistical techniques. Let's delve into analytical epidemiology, its significance, and the common methods used.

Understanding Analytical Epidemiology

Analytical epidemiology is a pivotal branch of veterinary epidemiology that delves deep into understanding the causes of diseases in animal populations. It aims to answer the fundamental question: "Why does a disease occur in certain animals or populations?" This form of epidemiology investigates the role of various risk factors, exposures, or interventions in disease causation (Dohoo et al. 2009). By identifying causal relationships between these factors and disease occurrence, analytical epidemiology provides critical insights that are indispensable for disease prevention and control strategies.

Common Methods in Analytical Epidemiology

1) **Case-Control Studies:** Case-control studies are a fundamental method in analytical epidemiology (Filardo et al. 2011). These observational studies are designed to compare animals or groups with a specific disease (cases) to those without the disease (controls). The primary objective of case-control studies is to identify factors associated with the disease's occurrence. This method is widely used in veterinary epidemiology for investigating various diseases and risk factors (Dohoo et al. 2009; Thrusfield et al. 2018).

Analytical epidemiology holds significant importance in veterinary medicine for several reasons:

- **Evidence-Based Decision-Making:** It provides a scientific basis for understanding the causes of diseases. This, in turn, helps in making evidence-based decisions regarding disease prevention and control measures (Haimerl et al. 2013).
- **Disease Intervention:** It aids in pinpointing the factors contributing to disease occurrence and spread. This information is vital for developing targeted interventions, control measures, and management practices (Salman 2009b).

- **Evaluating Interventions:** It plays a key role in assessing the effectiveness of interventions such as vaccines, treatments, and management practices. By conducting analytical studies, veterinary epidemiologists can determine whether these interventions are achieving their desired outcomes (Nuvey et al. 2022).
- **Preventing Outbreaks:** It is valuable in identifying high-risk factors and populations. This knowledge can be instrumental in preventing disease outbreaks and ensuring the health and well-being of animal populations (Morse et al. 2012; Halasa et al. 2020; Todd 2020).

2) **Cohort Studies:** Cohort studies are a vital method in analytical epidemiology, particularly when researchers aim to study the long-term effects of exposures on disease outcomes (Bhopal 2016a). These studies involve following a group of animals with a common exposure over time to assess how that exposure affects their health.

3) **Statistical Modeling:** Statistical modelling is a powerful method in analytical epidemiology that involves the use of mathematical and statistical techniques to analyze data and assess the relationships between risk factors and disease outcomes (Grassly and Fraser 2008; Yadav and Akhter 2021). These models enable researchers to quantify the strength of associations and make predictions about disease occurrence. In the context of veterinary epidemiology, statistical modelling plays a crucial role in understanding and managing diseases. Here's an example:

1.2.2 Causation and Association

Causation in veterinary epidemiology involves establishing a cause-and-effect relationship between a particular factor (exposure) and a disease outcome. It implies that the factor is responsible for the occurrence of the disease (Thrusfield et al. 2018). Demonstrating causation is a complex process that requires thorough investigation and adherence to specific criteria.

Association, on the other hand, signifies a statistical relationship between a factor (exposure) and a disease outcome. An association does not necessarily imply causation. While an association suggests that there is a connection between the factor and the disease, it could be due to various factors, including confounding variables or chance (Koepsell and Weiss 2009; Thrusfield et al. 2018).

Veterinary epidemiologists employ various criteria to assess causation, helping distinguish true causation from mere association. Some of these criteria include:

1) **Temporality:** The exposure must precede the disease outcome in time. This criterion ensures that the exposure is a potential cause rather than a result of the disease. For example, if vaccination against a specific disease precedes a decrease in disease incidence, this suggests a temporal relationship (Dohoo et al. 2009).

2) **Strength of Association:** A strong association between the exposure and the disease outcome is more suggestive of causation. A weak association is less likely to be causal. The strength of association is often quantified using measures like the relative risk or odds ratio (Dohoo et al. 2009; Shimonovich et al. 2021).

3) **Dose-Response Relationship:** A dose-response relationship implies that as the level or intensity of exposure increases, the risk of the disease outcome also increases (Kilcoyne et al. 2013; Pettygrove 2016). For example, if higher levels of pesticide exposure are associated with a higher incidence of a specific health condition in domestic dogs and their owners (Wise et al. 2022), this suggests a dose-response relationship.

4) **Consistency:** Consistency means that the observed association is consistent across different studies and populations. If multiple studies in various settings consistently show an association between a factor (e.g., a specific toxin) and a disease (e.g., toxic-related symptoms), it adds strength to the argument for causation (Gad 2024).

1.2.3 Population Approach

The population approach in veterinary epidemiology is centred on the health and well-being of entire animal populations, rather than just individual cases (Bhopal 2016b). It recognizes that the health of a group of animals is influenced by a complex interplay of factors and that controlling diseases at the population level is often more effective in preventing and managing health issues (Dohoo et al. 2009). This approach emphasizes preventive measures and interventions that benefit the larger population.

Reasons for the Population Approach in Veterinary Epidemiology:
The population approach is crucial in veterinary epidemiology for several reasons:

1) **Disease Control:** The population approach is instrumental in controlling the spread of diseases within animal populations. By focusing on entire groups of animals, epidemiologists can implement strategies that reduce the risk of disease outbreaks and minimize the associated economic losses (Salman 2009b).

2) **Preventive Measures:** The population approach places a strong emphasis on preventive measures, including vaccination campaigns, biosecurity measures, and surveillance systems (Salman 2009a). These measures are vital for maintaining and improving the health of animal populations by reducing the risk of disease introduction and spread.
3) **Public Health:** Many diseases that affect animals are zoonotic, meaning they can be transmitted to humans. Controlling these diseases in animal populations is essential for safeguarding public health. Preventing zoonotic diseases at the population level reduces the risk of human infection (Rahman et al. 2020).

1.3 Aims and Scope of Veterinary Epidemiology

The main goal of Veterinary Epidemiology is to gain insights into how animal diseases spread and what factors contribute to their occurrence as well as how they evolve. This knowledge plays a role in devising measures for preventing, controlling, and eradicating diseases. Veterinary Epidemiology covers a range of areas including diseases, zoonoses (diseases that can be transmitted between animals and humans) population dynamics, and the impact of environmental factors on animal health. It also delves into the ramifications of diseases on both animal industries and society. Veterinary Epidemiology is a field for comprehending, averting, and managing animal diseases. Its extensive scope and interdisciplinary approach offer insights into disease patterns, transmission dynamics, and risk factors. Applying principles researchers and practitioners contribute towards enhancing animal health, public health, and the sustainability of animal industries (Noah 2023).

1.3.1 Surveillance of Animal Diseases

Monitoring animal diseases involves continuous tracking as well as gathering data about the occurrence, distribution, and characteristics of diseases within populations of animals. This comprehensive process serves as a tool for disease management and control by enabling the detection of outbreaks by analyzing disease trends promptly and developing well-informed strategies to mitigate the impact, on both animal welfare and human health (Drewe et al. 2011). Surveillance encompasses components such as gathering data, analyzing information, detecting early signs, assessing trends, and risks reporting findings, and facilitating communication (Drewe et al. 2011).

1.3.1.1 Types of Surveillance

- **Passive Surveillance**
  Passive surveillance relies on the reporting of disease cases by veterinarians, farmers, or diagnostic laboratories. It is a process that provides data without the need for specific data collection efforts.
- **Active Surveillance**
  Active surveillance involves efforts to collect data often focusing on target populations or regions. This method is particularly useful for monitoring diseases or populations at risk.
- **Syndromic Surveillance**
  Syndromic surveillance emphasizes monitoring signs or symptoms rather than confirmed disease diagnoses. It plays a role in the detection of emerging diseases and can be implemented in real-time surveillance systems.

1.3.1.2 Monitoring Disease Outbreaks

Monitoring and managing animal disease outbreaks is important in veterinary medicine. By monitoring and promptly responding to these outbreaks, we can effectively prevent the spread of diseases and safeguard both animal and human populations. To monitor animal disease outbreaks systematically and comprehensively, a multi-faceted approach is adopted involving surveillance to gather and analyze data on disease occurrences while also investigating suspected cases (Drewe et al. 2011). Various sources of information are used, including laboratory tests, clinical observations, and reporting systems. These tools help veterinarians and public health officials spot patterns and trends making it easier to detect diseases early and respond appropriately (Drewe et al. 2011).

Furthermore, advancements in technology have revolutionized disease monitoring. Geographical Information Systems (GIS) are employed to map the occurrence of diseases, helping identify high-risk areas. Additionally, modern techniques like Polymerase Chain Reaction (PCR) have improved capabilities, enabling accurate detection of pathogens. By monitoring and working together collaboratively we can protect the well-being of animals and human health while minimizing the impact of disease outbreaks on our society (Drewe et al. 2011).

1.3.1.3 Identifying Emerging Diseases

Emerging diseases are novel infectious diseases that have recently appeared or are increasing rapidly in frequency. Identifying and understanding these diseases is crucial for prevention, control, and management (Drewe et al. 2011). A comprehensive approach is needed to address these challenges. Firstly, surveillance systems play a role in detecting emerging diseases. Early identification allows for responses and containment measures. Effective surveillance involves monitoring disease patterns and analysing data thoroughly while promptly reporting any trends or outbreaks. Secondly, laboratory diagnostics are essential for identifying and characterizing emerging diseases (Drewe et al. 2011). Cutting-edge technologies and methodologies are utilized to identify pathogens or genetic material which greatly assists in the diagnosis of diseases and conducting investigations. However, scientists, healthcare professionals, and policymakers must collaborate and share information. International cooperation, research networks, and open data platforms play a role in facilitating the exchange of knowledge and expertise thus enabling a response to emerging diseases (Salman 2009a). Adopting an approach encompassing surveillance, diagnostics, and collaboration is essential for recognizing and comprehending emerging diseases (Salman 2009). By remaining vigilant and fostering cooperation among nations we can effectively combat these threats to global health.

1.3.2 Disease Control and Prevention

In the field of epidemiology, disease control, and prevention play a role. It is crucial to have strategies in place to manage outbreaks and ensure the well-being of animals and humans. Disease control and prevention are important for maintaining the health of animal populations with vaccination programs and quarantine measures being components (Perez 2015). These strategies not only help contain the spread of diseases but also prevent the emergence of ones.

1.3.2.1 Vaccination Programs

Vaccination is an aspect of disease control. Its purpose is to protect animals against diseases. Vaccination programs offer benefits from safeguarding animals to protecting entire populations. The basic idea behind vaccination is to stimulate an animal system so that it develops resistance against pathogens. This is achieved by introducing an inactive version (or sometimes just a part) of the pathogen into the animal's body. As a result, the immune system produces a targeted response, including creating memory cells that "remember" the pathogen. This enables a more efficient response if the animal encounters the pathogen, in the future (Robertson 2020).

Hence vaccination programs play a role, in controlling and preventing diseases. It is crucial to customize vaccination programs according to the needs of animal populations, known as targeted strategies. This involves considering factors such as disease prevalence, population density, and the vulnerability of species. The primary objective of any vaccination program is to cover the targeted population or achieve herd immunity (Robertson 2020). Herd immunity occurs when a sufficient proportion of the population becomes immune reducing the transmission of agents and safeguarding individuals. Understanding vaccination principles, including vaccine selection and administration protocols is vital for achieving success (Robertson 2020).

1.3.2.2 Quarantine Measures

On the other hand, quarantine measures are another aspect of disease control in veterinary epidemiology. They are typically implemented when there is suspicion or confirmation of a disease outbreak within a population (Drewe et al. 2011). During the quarantine period, infected animals are isolated from ones throughout the incubation phase (Robertson 2020). This also applies to animals before introducing them to an existing population. These measures aim to prevent disease spread and allow time for interventions to be implemented. These interventions may include testing, treatment options, and in cases where necessary, euthanasia (Drewe et al. 2011).

The successful implementation of quarantine measures depends on adherence, to protocols. These guidelines involve identifying animals at risk, providing isolation facilities, and closely monitoring for signs of illness. Since many infectious diseases are global, it is crucial to have cooperation for the implementation of quarantine measures. This includes sharing information between countries following protocols and enabling trade with risk of disease transmission (Drewe et al. 2011).

Controlling and preventing diseases requires a collaborative approach. This involves maintaining surveillance, implementing targeted vaccination programs, and enforcing quarantine measures (Robertson 2020). These combined efforts contribute to the health and well-being of animal populations. By adhering to these principles veterinary professionals can effectively address the challenges posed by agents thus safeguarding the health of both animals and humans (Robertson 2020).

1.3.3   Research and Investigation

In the field of epidemiology conducting research and thorough investigations are crucial for understanding diseases. This extensive exploration focuses on the methods used to study disease outbreaks and pinpoint risk factors. It sheds light on the role these activities play in controlling and preventing diseases well as studying health conditions that affect animal populations (Drewe et al. 2011).

The essence of research in this field lies in comprehending the patterns, causes, and impacts of health and disease conditions within groups of animals. It is essential for gaining insights into diseases and implementing control measures. Through research, we unravel the complexities of disease dynamics, identify factors that contribute to risks, and develop targeted interventions. This empirical approach enhances our ability to protect animal populations, preserve biodiversity, and mitigate threats that can be transmitted between animals and humans. In our pursuit of knowledge, veterinary epidemiological research serves as a cornerstone for ensuring the well-being of both animals and humans in an interconnected world.

On the other hand, investigation in Veterinary Epidemiology involves an examination of disease outbreaks, to control them effectively while preventing their recurrence. Employing investigation techniques can help determine the cause behind an outbreak, understand its mode of transmission, and identify steps to prevent future incidents.

1.3.3.1   Investigating Disease Outbreaks

Investigating outbreaks of diseases in the field of epidemiology is a process that plays a vital role in controlling diseases. Epidemiologists employ methodologies to trace the origin, transmission pathways, and factors contributing to outbreaks. This relies on a surveillance system that constantly monitors and gathers data on animal populations allowing for detection of abnormalities in disease patterns (Drewe et al. 2011). Advanced diagnostic tools help identify pathogens quickly aiding in intervention. Epidemiological studies, such as case-control analyses provide insights into the dynamics of outbreaks. These investigations are crucial for devising targeted interventions and preventive measures to ensure the health and resilience of animal populations when faced with challenges (Salman 2009).

1.3.3.2   Identifying Risk Factors

Identifying risk factors is a pursuit in epidemiology to understand disease dynamics better. Systematic assessments involve scrutinizing elements like animal demographics, environmental variables, and management practices to pinpoint sources of disease (Perez 2015). In-depth, case-control studies meticulously compare unaffected groups to determine the variables contributing to disease outbreaks and devise interventions (Robertson 2020). Spatial and temporal analyses reveal patterns and correlations that shed light on risk factors while enhancing our understanding of disease spread. Mapping the distribution of cases over space and time provides insights into dynamics aiding in identifying environmental or geographical risk factors (Thrusfield and Christley 2018).

In addition, it is crucial to highlight the significance of reservoirs and vector surveillance as their role extends beyond the primary host species. To effectively identify transmission pathways and implement measures that disrupt the disease cycle it becomes essential to conduct thorough surveillance of potential reservoirs and vectors (Thrusfield and Christley 2018). This meticulous investigation provides insights for professionals enabling them to develop targeted interventions that proactively mitigate risks and safeguard the health of animal populations (Robertson 2020).

1.4   Methods in Veterinary Epidemiology

1.4.1   Data Collection

Introduction: Data collection in veterinary epidemiology is defined as gathering, recording, and analyzing information about animal health and diseases. The data collection procedure is an integral part of animal population health studies; hence, it is critical for comprehending disease dynamics and developing effective health management strategies (Drewe et al. 2011).

Scope and Relevance: Traditional data collection activities include everything from documenting individual disease cases to conducting large-scale surveys. However, recent trends in data management and information technology have upscaled the process to include database management, big data analysis, machine learning, data simulation, and

mathematical modelling (Drewe et al. 2011). Ultimately, gathering and analyzing data in veterinary epidemiology is critical for identifying disease patterns, comprehending epidemiological trends, and making sound decisions in animal health management. Some of the importance of data collection include the following.

1) **Surveillance and Early Detection:** In veterinary epidemiology, data collection enables continuous surveillance of animal health; thereby, helping in identifying and tracking disease trends over time. Continuous monitoring is critical for the early detection of emerging or re-emerging diseases. Additionally, real-time data collection is crucial for understanding the spread and severity of the disease, especially in cases of an outbreak (Perez 2015). Information garnered can often guide the immediate response, including quarantine measures, vaccination campaigns, and other control strategies (Salman 2009).

2) **Understanding Disease Dynamics**: Data collection helps veterinary epidemiologists to understand the nitty-gritty of a disease outbreak, right from the first observable clinical sign to all prevention and control strategies deployed to contain the outbreak (Perez 2015). Furthermore, the collected data can also be deployed to predict and prevent future outbreaks.

3) **Research and Policy Development**: Data collected from a disease investigation can serve as a critical resource for epidemiological research and the development of public health policies while also helping to improve veterinary clinical practices (Salman 2009).

1.4.2 Methods of Data Collection

1.4.2.1 Case Reporting

Case Reporting: In the field of veterinary epidemiology, case reporting serves as a vital mechanism for understanding and managing animal health and disease outbreaks. It involves the systematic documentation of individual animal disease cases by veterinarians or animal health workers, as well as all treatment and control strategies deployed to handle the disease. Timely documentation of cases is essential for the early detection of disease outbreaks; hence, enabling quick and effective response measures to mitigate the spread (Drewe et al. 2011).

Furthermore, case reports offer invaluable insights into the progression and characteristics of diseases within individual animals and populations. Case reporting can be mandatory in cases of diseases with significant public health or economic implications, with specific reporting pattern platforms from national and international regulations while voluntary reporting albeit not legally required is critical for tracking emerging diseases or less common health issues. Consequently, mandatory reporting ensures the systematic tracking of major diseases, whereas voluntary reporting is critical for identifying emerging health threats (Drewe et al. 2011).

Often, case data is entered into specialized databases or disease registries with the use of electronic systems or epidemiological software. Subsequently, data access report data is analyzed to determine disease trends, patterns, and potential outbreak hotspots (Drewe et al. 2011). This information is critical for epidemiological research, disease control strategies, vaccination programs, and public health policies. accuracy and completeness are critical, necessitating regular data quality checks and validation procedures (Robertson 2020).

1.4.2.2 Sampling

Sampling: Sampling forms a crucial part of data collection in veterinary epidemiology, offering insights into disease prevalence, risk factors, and the overall health status of animal populations. It involves taking a sizable number of animals from the overall population; especially since it is difficult to conduct any reasonable study with the whole animal population (Thrusfield and Christley 2018).

Principles of Sampling Design: The first step in survey design is to clearly define the objectives. This includes determining what information is needed, such as disease prevalence, risk factors, or general health indicators. The strength of any survey is to represent the population of interest as much as possible, it is therefore critical to select the appropriate target population (Drewe et al. 2011). This decision affects the survey results' relevance and applicability to the general population. Various data collection methods, ranging from questionnaires and interviews to physical examinations and laboratory testing, can be used depending on the survey objectives. Additionally, effective execution necessitates meticulous planning, which includes logistics coordination, resource allocation, and personnel training (Robertson 2020).