ADDIS ABABA UNIVERSITY, COLLEGE OF HEALTH SCIENCE, SCHOOL OF PUBLIC HEALTH



Ethiopia Field Epidemiology Training Program (EFETP)

Compiled Body of Works in Field Epidemiology

By-

Meseret Gebreselama

Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment for the Degree of Master of Public Health in Field Epidemiology

August**, 2025**

Addis Ababa, Ethiopia

Addis Ababa University, College of Health Sciences, School of Public Health

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List of Abbreviations and acronyms

AFP- Acute Flaccid Paralysis

AIDS- Acquired Immune-Deficiency Syndrome

ANC- Antenatal care

ART- Anti-retroviral treatment

AWD- Acute Watery Diarrhea

BMI -Body Mass Index

CBN- Community based nutrition

CDR- Crude Death Rate

CDC- Center for Disease Control and Prevention

CBR- Crude Birth Rate

CI- Confidence Interval

CMAM -Community Based Management of Acute Malnutrition

EDHS -Ethiopian Demographic and Health Survey

EFETP- Ethiopian Field Epidemiology training program

ENHS- Environmental health science

EOS- Enhanced outreach strategy

EPHI- Ethiopian Public Health Institute

EPI- Extended program on immunization

EPRP- Emergency Preparedness and Response Plan

FAO- Food and Agricultural Organization

GC- Gregorian Calendar

GDP -Gross Domestic Product

GR- Growth Rate

HC- Health Center

HDA- Health Development Army

HEP- Health Extension Program

HEW- Health Extension Worker

HIV- Human Immuno-Deficiency Virus

HMIS- Health Management Information System

IDSR- Integrated Disease Surveillance and Response

IMR- Infant Mortality Rate

IPD- In Patient Department

IRS- Indoor Residual Spray

ISS- Integrated Supportive Supervision

ITN- Insecticide Treated Net

LMIC -Low and Middle Income Countries

MAM -Moderate Acute Malnutrition

MCH- Maternal and child health

MDA- Mass Drug Administration

MMR- Maternal Mortality Rate

NGO- Non Governmental Organization

NMR- Neonatal Mortality Rate

NNT- Neo-Natal Tetanus

OPD- Out Patient Department

OPV- Oral polio vaccine

OR- Odds Ratio

OTP -Outpatient Therapeutic Program

PHEM- Public Health Emergency Management

PLW- Pregnant and Lactating Women

SD -Standard Deviation

SNNPR -Southern Nation Nationalities and People's Region

Wk- Week

Executive Summary

This report synthesizes findings from four major public health investigations conducted across different regions of Ethiopia, highlighting critical challenges and opportunities in disease control, health service delivery, and surveillance systems.

Staphylococcus aureus was isolated from 37 (19.68%) samples—35.0% of milk and 4.55% of environmental samples. Logistic regression showed that education level (AOR = 3.42, p = 0.015), farm size (AOR = 2.58, p = 0.035), and management system (AOR = 3.86, p = 0.003) significantly influenced contamination and knowledge–attitude–practice (KAP) scores. Small-scale and extensive farms had the highest infection rates. Antimicrobial testing revealed universal resistance to penicillin, moderate resistance to tetracyclines, and low resistance to ciprofloxacin and trimethoprim-sulfamethoxazole, while all isolates remained susceptible to vancomycin.

Rabies remains a persistent and escalating public health threat in the Amhara region. Over a five-year period, human rabies cases reached a peak in 2022 with 9,053 cases and 39 deaths, while animal rabies, primarily canine (69.7%), also fluctuated significantly, with the highest animal cases (331) reported in 2021. West Gojam Zone recorded the greatest burden, accounting for 8,104 cases and 49 deaths. The findings emphasize the urgent need for intersectoral collaboration, mass vaccination campaigns, strengthened surveillance, and community engagement to reduce the burden of rabies.

An assessment of health services in District 02 revealed substantial gaps in infrastructure and human resources. Despite the presence of one health center, 14 private clinics, 7 pharmacies, and 11 drug stores, the district faces a critical shortage of health professionals, particularly general practitioners and health officers. Uptake of maternal health services, including antenatal and postnatal care, remains low. Addressing these deficiencies through improved planning, investment

in infrastructure, capacity-building, and community health education is essential to enhance health outcomes in the district.

A recent cholera outbreak involving 35 patients revealed significant clinical and demographic insights. The majority of cases (94.3%) were male, and nearly half required hospitalization, underscoring disease severity. Dehydration was the most common complication, with 36.1% suffering severe dehydration. Prompt treatment ensured no fatalities, reflecting the effectiveness of clinical response. The study highlights the urgent need for safe water access, improved sanitation, regular water quality monitoring, and robust public health preparedness to prevent future outbreaks.

Evaluation of the surveillance system in Eka Tafo Sub-City revealed a functional but under-resourced system. Malaria remains a significant concern, with 654 reported cases between 2024 and 2025, though no fatalities were recorded. Measles outbreaks persist, with eight cases reported in 2025. While the system benefits from standardized case definitions, flexibility, and laboratory support, weaknesses include incomplete reporting, poor timeliness, weak feedback mechanisms, and inadequate epidemic preparedness funding. Strengthening epidemic preparedness, expanding service coverage, and improving data quality and timeliness are recommended to ensure effective outbreak response.

Across the four studies, Ethiopia faces overlapping challenges in public health: rising rabies cases, under-resourced urban health systems, recurrent cholera outbreaks, and gaps in disease surveillance for malaria and measles. A coordinated response that strengthens infrastructure, workforce capacity, surveillance systems, and community engagement is essential. Multi-sectoral collaboration, targeted interventions, and sustainable investments in both human and veterinary health will be critical to achieving improved health security and outcomes nationwide.

CHAPTER I

Epidemiological Analysis of *Staphylococcus aureus* Prevalence and Susceptibility Profile in Cow's Milk and Environment: A One Health Approach

Abstract

Background: *Staphylococcus aureus* is a zoonotic pathogen of major concern due to its widespread occurrence in humans, animals, and the environment, and its increasing association with antimicrobial resistance (AMR). In Ethiopia, close human–animal contact, raw milk consumption, and poor farm hygiene practices heighten transmission risk. This study aimed to determine the prevalence and antimicrobial resistance profile of *S. aureus* in cow milk and dairy farm environments and to identify human-related risk factors within a One Health framework.

Methods: A cross-sectional study was conducted from March to September 2025 in Addis Ababa and Sheger cities, Oromia Region. A total of 188 samples (94 milk and 94 environmental) were analyzed using standard microbiological techniques. Antimicrobial susceptibility was determined by the Kirby–Bauer disk diffusion method following CLSI and Ethiopian Standards Agency guidelines. Questionnaire data from 94 farm attendants were analyzed for risk associations using logistic regression at a 95% confidence level.

Results: *S. aureus* was isolated from 37 (19.68%) samples—35.0% of milk and 4.55% of environmental samples. Logistic regression showed that education level (AOR = 3.42, p = 0.015), farm size (AOR = 2.58, p = 0.035), and management system (AOR = 3.86, p = 0.003) significantly influenced contamination and knowledge–attitude–practice (KAP) scores. Small-scale and extensive farms had the highest infection rates. Antimicrobial testing revealed universal resistance to penicillin, moderate resistance to tetracyclines, and low resistance to ciprofloxacin and trimethoprim-sulfamethoxazole, while all isolates remained susceptible to vancomycin.

Conclusion: The study revealed significant associations between *S. aureus* occurrence and farm management factors, alongside widespread β-lactam resistance and emerging MDR patterns. Strengthening farmer training, promoting prudent antibiotic use, and improving milking hygiene and biosecurity are crucial to mitigating AMR risks in Ethiopia's dairy sector.

Keywords: antimicrobial resistance, cow's milk, environment, One Health, Ethiopia, *Staphylococcus aureus*

1. Introduction

1.1 Background of the Study

Livestock production is a cornerstone of Ethiopia's economy and livelihoods, contributing about 40% of the agricultural GDP and serving as a primary source of income, nutrition, and employment for millions of smallholder farmers [1]. Within this sector, dairy farming plays a vital role, with cow's milk providing essential proteins, fats, and micro nutrients. However, the dairy industry faces persistent challenges, including low productivity, poor hygienic practices, and the widespread occurrence of infectious diseases that compromise milk quality and safety.

Among the bacterial pathogens of major concern is *Staphylococcus aureus*, one of the most common causes of bovine mastitis globally and in Ethiopia [2]. Mastitis caused by *S. aureus* results in reduced milk yield, increased veterinary costs, and premature culling of dairy cows, leading to substantial economic losses for smallholder farmers. Beyond economic damage, *S. aureus* poses a public health risk because it can contaminate raw milk and dairy products, which are widely consumed in Ethiopia, often without pasteurization [3]. As a result, humans are directly exposed to this pathogen through foodborne transmission, occupational contact, and environmental contamination.

The challenge is intensified by the pathogen's ability to develop antimicrobial resistance (AMR). *S. aureus*, including methicillin-resistant *Staphylococcus aureus* (MRSA), has been reported in animals, farm workers, and the farm environment in Ethiopia [4]. This reflects a growing global concern over AMR, which the World Health Organization (WHO) has identified as one of the top ten threats to public health (WHO, 2021). The misuse and overuse of antibiotics in both veterinary and human medicine exacerbate this problem, limiting treatment options and threatening food safety.

Given the interconnectedness of humans, animals, and their shared environment, the One Health approach provides an essential framework for studying *S. aureus* in Ethiopia. Dairy farms serve as hot-spots where pathogens can circulate between cows, farmers, and the surrounding environment through direct contact, contaminated equipment, and unhygienic practices. While several studies have investigated mastitis in Ethiopia, most are fragmented and limited to animal samples, with little integration of human and environmental dimensions. Therefore, a comprehensive epidemiological analysis is needed to generate evidence that can inform

interventions for livestock productivity, food safety, and public health under a One Health framework.

1.2 Statement of the problem

In Ethiopia, dairy farming is rapidly expanding to meet the growing demand for milk and milk products. However, infectious diseases such as bovine mastitis remain a major bottleneck to productivity and profitability. *Staphylococcus aureus* is among the leading causes of mastitis and is also a zoonotic pathogen that compromises milk safety. Its prevalence in animals, humans, and the environment increases the likelihood of cross-transmission, placing both farmers and consumers at risk.

Furthermore, the emergence of multidrug-resistant (MDR) *S. aureus* and MRSA has been documented in Ethiopia [4]. The irrational use of antimicrobials in livestock production and the absence of systematic AMR surveillance exacerbate the situation. Despite the One Health implications of this issue, existing studies are fragmented and often focus only on cattle, neglecting the human and environmental reservoirs that sustain pathogen circulation. This lack of integrated data limits policymakers' ability to design evidence-based interventions for food safety, animal health, and AMR control.

Thus, there is an urgent need to conduct a One Health-based epidemiological analysis of *S. aureus* prevalence and antimicrobial susceptibility in cow's milk, humans, and the environment to fill this critical knowledge gap.

1.3 Research questions

This study seeks to address the following key questions:

1. What is the prevalence of *Staphylococcus aureus* in cow's milk and environmental samples in the study area?
2. What are the antimicrobial susceptibility patterns of *S. aureus* isolates from these sources?
3. What are the potential risk factors that facilitate the occurrence and spread of *S. aureus* across the One Health interface?

1.5 Significance of the study

This study is significant for multiple stakeholders. For dairy farmers, it highlights the economic consequences of *S. aureus* mastitis and underscores the need for improved herd management and hygiene practices. For veterinarians and health professionals, it provides crucial evidence on antimicrobial resistance trends, supporting the rational use of antimicrobial in both veterinary and human medicine. For policymakers, the findings contribute to strengthening national AMR surveillance and food safety strategies. By adopting a One Health approach, this research not only protects consumer health but also enhances livestock productivity and contributes to Ethiopia's broader goals of food security and public health resilience.

1.6 Scope and limitations of the study

This research focuses on *S. aureus* isolated from cow's milk and selected environmental samples (such as water sources) as well as KAP assessment of humans in close contact with dairy farms. While it provides an integrated One Health perspective, the study is limited by its cross-sectional design, which restricts the ability to establish temporal patterns or causal relationships. Additionally, molecular characterization of isolates is not included, which would have provided more detailed insights into strain diversity and transmission dynamics. Despite these limitations, the study generates critical baseline data that can inform future molecular and longitudinal studies.

2. Literature review

2.1 Overview of *Staphylococcus aureus*

Staphylococcus aureus is a Gram-positive, bacterium that is widespread in nature and commonly colonizes the skin and mucous membranes of humans and animals. It is an opportunistic pathogen capable of causing a range of diseases, from skin and soft tissue infections to life-threatening conditions such as pneumonia, septicemia, and endocarditis [5]. In livestock, *S. aureus* is a well-recognized cause of bovine mastitis, which reduces milk yield, alters milk composition, and compromises dairy production [6]. Its pathogenicity is largely attributed to an array of virulence factors, including surface proteins that facilitate adhesion, toxins that damage host tissues, and immune evasion mechanisms [7].

In the Ethiopian context, *S. aureus* has been frequently isolated from both sub-clinical and clinical mastitis cases in dairy cattle, indicating its widespread role in animal health and production challenges [2,3]. The prevalence in cows also raises zoonotic concerns, especially considering the cultural practices of consuming raw milk and the limited adoption of pasteurization technologies.

2.2 Epidemiology of *S. aureus* in dairy cattle

The epidemiology of *S. aureus* mastitis varies across production systems, with prevalence generally higher in smallholder and traditional dairy farms compared to commercial intensive systems. The organism is primarily transmitted during milking, through contaminated hands, milking machines, and udder-to-udder contact [8]. Studies in Ethiopia have reported prevalence rates of *S. aureus* mastitis ranging from 20% to over 40%, depending on the production system and geographical area [4,3].

Risk factors identified include poor milking hygiene, lack of teat disinfection, and inadequate mastitis control programs. Environmental factors such as high stocking density and contaminated bedding also facilitate persistence and spread [9]. Importantly, dairy cattle in Ethiopia are often reared under smallholder systems where biosecurity is minimal, increasing opportunities for transmission between animals and humans.

2.3 Public health implications of *S. aureus* in milk

Raw milk serves as a major route of *S. aureus* transmission to humans. Infections may occur through consumption of contaminated milk or dairy products, leading to food poisoning or invasive disease. *S. aureus* is capable of producing enterotoxins that are heat-stable, meaning even pasteurization or cooking may not fully eliminate the risk of intoxication [39].

In Ethiopia, raw milk consumption is common, particularly in rural and pastoralist communities where access to pasteurization facilities is limited. This increases the risk of foodborne illness and zoonotic transmission of antimicrobial-resistant strains. Several studies in Ethiopia have confirmed the presence of *S. aureus* in raw milk marketed in urban and peri-urban centers [4] [3], underscoring the importance of strengthening food safety systems.

2.4 Antimicrobial resistance in *S. aureus*

Antimicrobial resistance (AMR) in *S. aureus* has emerged as a global challenge. Resistance to penicillin and other β-lactams is widespread due to the production of β-lactamase enzymes, while methicillin resistance (MRSA) is mediated by the mecA gene, which encodes an altered penicillin-binding protein [10]. MRSA strains have been reported in both human and animal populations, highlighting the zoonotic potential of resistant pathogens.

In Ethiopia, studies have revealed alarming levels of antimicrobial resistance in *S. aureus* isolates from both bovine milk and human samples. For instance, Mekonnen *et al*. (2018) reported high resistance rates to penicillin, tetracycline, and erythromycin in milk isolates, while multidrug resistance was common [4]. Human isolates, including those from farm workers, have shown similar resistance trends [11]. The irrational use of antibiotics in animal husbandry, often without veterinary prescription—combined with inadequate AMR monitoring systems, has contributed significantly to the spread of resistant strains.

2.5 Environmental reservoirs of *S. aureus*

The environment plays a critical role in the persistence and transmission of *S. aureus*. Contaminated farm equipment, bedding material, water sources, and milking utensils serve as reservoirs and vectors for pathogen dissemination. Inadequate cleaning and sanitation practices increase environmental contamination, sustaining transmission between cows and humans [12].

In Ethiopian dairy systems, where traditional hand milking and poor hygienic conditions are common, environmental contamination is particularly concerning. Few studies have examined environmental sources of *S. aureus*, but available evidence suggests their importance in maintaining infection cycles [3]. Integrating environmental sampling into epidemiological investigations is therefore crucial in One Health-oriented research.

2.6 The one health perspective

The One Health approach recognizes that human, animal, and environmental health are interconnected. Pathogens such as *S. aureus*, which cross between livestock, humans, and the environment, exemplify the need for integrated surveillance and control strategies. Globally, the One Health framework has been used to monitor zoonotic AMR trends, linking veterinary medicine, public health, and environmental sciences [13].

In Ethiopia, however, implementation of the One Health framework remains limited, with most research and policy focusing on either veterinary or human health in isolation. The lack of interdisciplinary surveillance systems hinders early detection and control of zoonotic AMR. Given the economic and health importance of the dairy sector, adopting a One Health approach to *S. aureus* epidemiology is both timely and essential.

2.7 Knowledge gaps and research needs

Despite the growing evidence of *Staphylococcus aureus* prevalence and antimicrobial resistance (AMR) in Ethiopia, several knowledge gaps persist. Most studies focus solely on bovine mastitis without integrating human and environmental sources [3,14-16]. Few investigations assess risk factors comprehensively, and molecular characterization of strains remains rare due to limited laboratory capacity [17,18]. Additionally, AMR surveillance is fragmented and lacks coordination between veterinary and human health sectors [19,20]. Addressing these gaps requires integrated epidemiological studies that adopt a One Health perspective, providing holistic evidence for intervention design [21-23].

3. Conceptual framework

The conceptual framework (**Figure 1**) illustrates the interactions between socio-demographic factors, farm management characteristics, knowledge-attitude-practice (KAP) levels, and their collective effects on hygiene behavior, *Staphylococcus aureus* prevalence, and antimicrobial resistance (AMR) profiles in dairy farms. It presents a holistic model demonstrating how human behavior, management practices, and environmental conditions influence microbial contamination and resistance outcomes in Ethiopia's dairy production systems [24,25].

At the base of the framework, socio-demographic variables such as sex, educational level, marital status, and residential location are primary determinants of knowledge, awareness, and behavioral responses related to antimicrobial use and milk hygiene [26,27]. Educated farmers tend to have better comprehension of antimicrobial resistance and safer antibiotic practices, while less-educated or resource-limited groups are more likely to misuse antibiotics due to lack of awareness [28,29]. Gender and marital status further shape information access and decision-making power, influencing the adoption of hygienic practices and AMR control behaviors [30].

Farm-level factors, including farm size, production system, and access to veterinary services, play a mediating role in determining hygiene quality and drug-use behavior. Larger or intensive farms often have better veterinary supervision and biosecurity measures, reducing contamination risks [31]. Conversely, small-scale or extensive farms face constraints in technical capacity, infrastructure, and veterinary access, predisposing them to poor hygiene and higher *S. aureus* prevalence [32].

The KAP dimensions serve as the connecting pathway between demographic and farm variables and the resulting health outcomes. Farmers with high knowledge and positive attitudes toward responsible antibiotic use are more likely to follow proper milking hygiene, observe drug withdrawal periods, and seek veterinary guidance before medication [33]. Poor KAP, however, results in unregulated antibiotic use, incomplete treatments, and poor sanitary conditions that favor bacterial contamination and resistance development [34,3].

The prevalence of *Staphylococcus aureus* in milk and environmental samples reflects the outcome of these interacting factors. Contamination primarily arises from infected udders, inadequate equipment sanitation, and unhygienic milking environments [36]. Poor milking hygiene not only increases *S. aureus* contamination but also facilitates the spread of antimicrobial-resistant strains through the milk production chain [37].

Ultimately, repeated and improper use of antibiotics exerts selective pressure, promoting the emergence of multidrug-resistant *S. aureus* isolates [38,39]. The AMR profile observed in this study underscores the relationship between poor hygiene, weak KAP, and frequent antibiotic exposure [40].

In summary, the framework depicts a cascading relationship: socio-demographic and farm-level characteristics shape KAP; KAP influences hygiene practices; and these collectively determine bacterial contamination and AMR outcomes. This model underscores the importance of targeted interventions emphasizing education, capacity building, and veterinary service access to improve milk safety and mitigate AMR risks in Ethiopia's dairy sector [41–43].

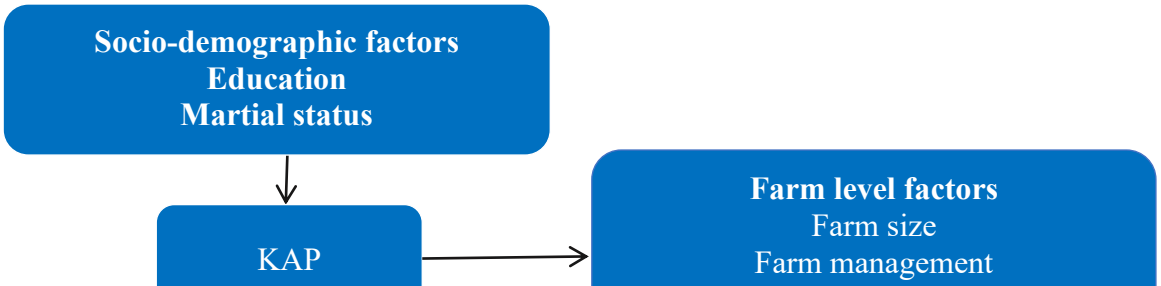


Figure 1: Conceptual framework linking socio-demographic and farm-level factors to antimicrobial resistance outcomes in dairy farms

4 Objectives of the study

4.1 General objective

To investigate the prevalence and antimicrobial susceptibility profile of *Staphylococcus aureus* isolated from cow's milk and the environment within a One Health framework.

4.2 Specific objectives

- To determine the prevalence of *S. aureus* in cow's milk and environmental samples.
- To assess the antimicrobial susceptibility patterns of *S. aureus* isolates.

5. Materials and methods

5.1 Study area

The study was carried out in Addis Ababa and surrounding Sheger cities of the Oromia region, Ethiopia. These urban and peri-urban areas are major dairy production zones supplying milk to large populations.

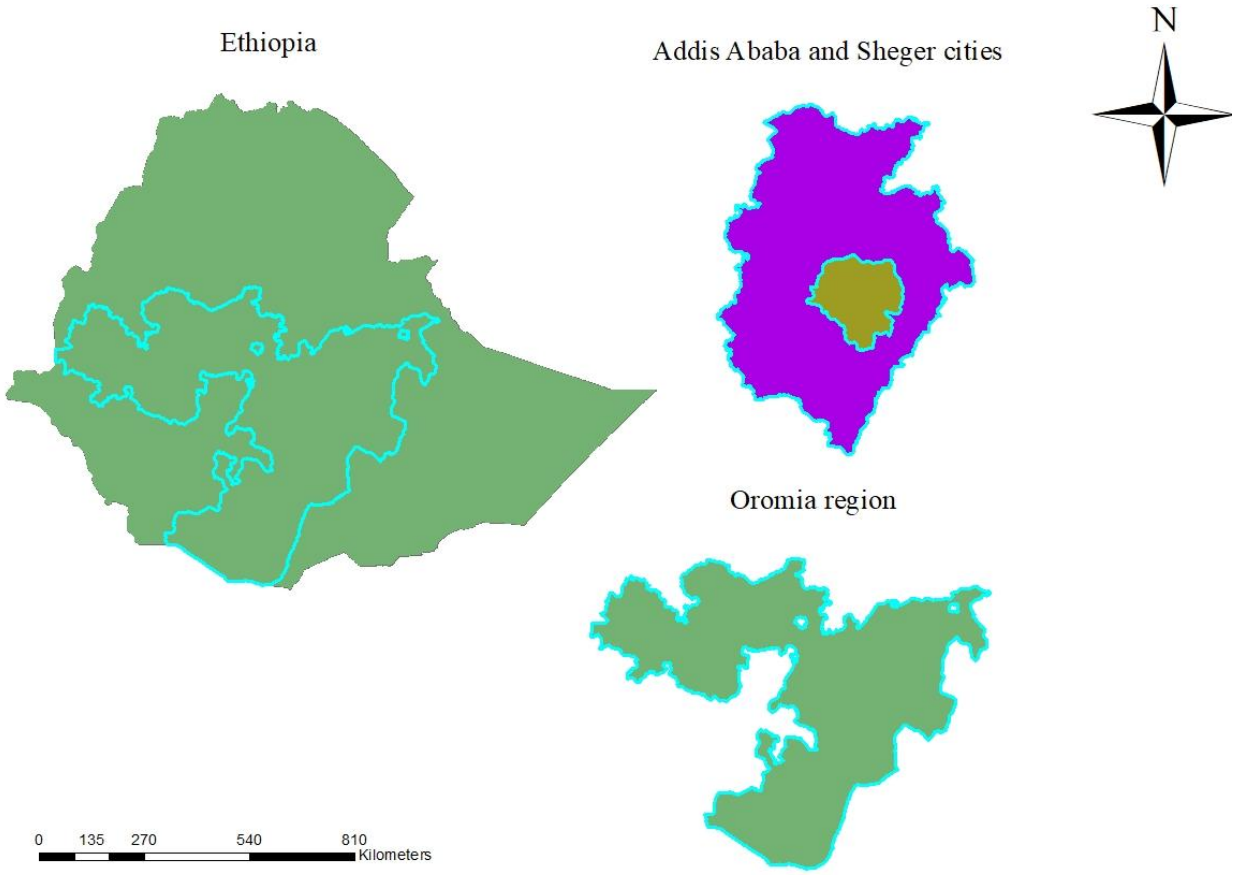


Figure 2: Map of the study areas

5.2 Source and study population

The study population comprised lactating dairy cows, humans in contact with dairy farming activities (farmers, milkers, and consumers), and environmental sources such as water source around the farm. Dairy cows were selected because *S. aureus* is a leading cause of mastitis, resulting in significant economic losses [44]. Human participants were included due to their risk of direct zoonotic transmission and their role in antibiotic use and hygiene practices. Environmental samples were considered essential, as farm ecosystems provide reservoirs for bacterial persistence and dissemination [45].

5.3 Study design and period

A cross-sectional study design was employed between March and September, 2025 which integrating both microbiological and epidemiological methods. This design was selected to provide a snapshot of *S. aureus* prevalence, antimicrobial susceptibility patterns, and associated risk factors at a single point in time. Cross-sectional surveys are widely used in veterinary epidemiology due to their efficiency in estimating prevalence and exploring associations between risk factors and outcomes [46].

5.4 Sampling strategy

5.4.1 Sample size determination

The sample size was determined using the formula for estimating prevalence in a finite population:

$$n= Z^2 \times P(1-P)/ d^2$$

where n = required sample size, Z = standard normal deviate at 95% confidence (1.96), P = expected prevalence of *S. aureus* (based on previous studies), and d = desired precision (5%). The sample size for each group (Milk and environment) were 94 and 94 respectively. Whereas for 94 animal handlers/ owners of farm questionnaire were taken for their knowledge, attitude and practice on AMR. This distribution is calculated based on the highest estimated prevalence of *S.aureus* in human from previous studies. This calculation ensures a representative sample from each group by using the sample size formula for cross-sectional studies-

5.4.2 Sampling methods

A random sampling method was employed to ensure representativeness of both animal and environmental sources. This approach was chosen to minimize selection bias and to provide a reliable estimate of the knowledge, attitudes, and practices (KAP) related to antimicrobial resistance (AMR) among dairy farmers. Human KAP data were collected using a structured questionnaire developed and administered through KoboToolbox, an open-source digital data collection platform widely used in field epidemiological studies [47]. The questionnaire aimed to

assess farmers' understanding, perceptions, and practices concerning antimicrobial use and resistance.

Milk samples were aseptically collected from lactating cows that were actively producing milk during the study period. Each cow was selected randomly from the participating farms to provide an equal chance of inclusion. Proper aseptic procedures were followed to avoid contamination during collection, handling, and transport of the samples [48,49]. In addition to animal sampling, environmental samples such as water were collected to assess potential environmental sources of antimicrobial contamination. Water samples were collected from drinking troughs, washing areas, and storage containers associated with the dairy farms. These environmental samples were also selected randomly to reflect the overall hygienic and antimicrobial exposure conditions within the farm environment [50,51].



Figure 3: Image of milk samples labeled and collected

5.5 Sample collection and transportation

Milk samples were collected aseptically in sterile tubes after disinfecting teats with 70% alcohol and discarding the first streams of milk. Similarly environmental samples were collected aseptically in sterile tube from water source. All samples were immediately labeled and transported under cold chain conditions (4 °C) to the Ethiopia Agriculture authority microbiology laboratory within 6 hours of collection to ensure bacterial viability [49].

5.6 Data collection procedures

5.6.1 Epidemiological data (Questionnaire survey)

A structured questionnaires were administered to 94 dairy farm attendants to collect information on farm hygiene practices, antimicrobial usage, and potential risk factors for contamination. To complement the microbiological investigation, a structured Knowledge, Attitudes, and Practices (KAP) questionnaire survey was administered to dairy farmers and workers in the study area. The survey aimed to assess factors associated with antimicrobial use, awareness of antimicrobial resistance (AMR), and hygiene practices relevant to *Staphylococcus aureus* transmission. Independent variables considered included place of residence or farm location, educational level of respondents, farm size, type of farm management system (intensive, semi-intensive, or extensive), and feed and water storage hygiene conditions.

The knowledge component assessed respondents' awareness of AMR and zoonotic risks, as seen in the Annex I. Data from the KAP survey were used to identify potential risk factors influencing the prevalence of *S. aureus* and its antimicrobial resistance profile. The inclusion of both demographic and behavioral variables provided an integrated understanding of how farmers' knowledge, perceptions, and practices contribute to bacterial transmission dynamics and resistance development at the human–animal–environment interface. Questionnaire surveys are a valuable tool in epidemiological studies for linking risk factors to pathogen prevalence [52].

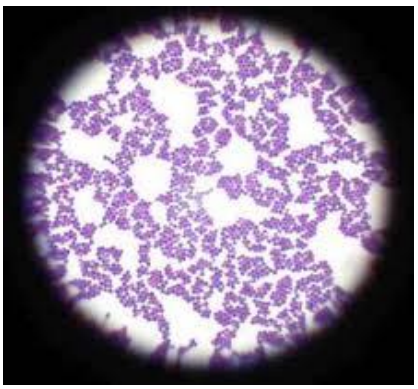


Figure 4: *Staphylococcus aureus* seen under microscope after Gram's staining

5.6.2 Sample handling and processing

Samples were processed in the laboratory according to standard microbiological procedures as described in established guidelines [48,49,53]. Upon arrival at the laboratory, milk samples were handled aseptically to prevent cross-contamination and maintain sample integrity.

A 25 mL portion of each milk sample was mixed with 250 mL of buffered peptone water (BPW) in sterile containers to facilitate the enrichment of potential bacterial contaminants. The mixture was then incubated at 37°C for 24 hours to allow for bacterial resuscitation and growth prior to subsequent microbiological testing.

All sample handling, incubation, and analytical steps were conducted under sterile conditions, following biosafety protocols and laboratory quality assurance standards recommended for antimicrobial resistance surveillance in food and animal products [48][54].





5.7.1 Isolation and identification of *Staphylococcus aureus*

The sample preparation and morphological characterization of the target bacterial colonies were followed protocols recommended by the International Organization for Standardization [55] and the Ethiopian Standards Agency [56]. The final confirmation of bacterial isolates was conducted using a fully automated Vitek 2XL compact system, adhering to the manufacturer's guidelines [57]. Milk samples (25 ml) were mixed with (250 ml) of sterile buffered peptone water (BPW) to achieve a 1:10 dilution. The mixture was homogenized using a smasher and incubated at 37°C

for 24 hours [58]. Following incubation, a loopful of the suspension was streaked onto blood agar and incubated at 37°C for another 24 hours. A single pink colony from the blood agar was transferred to Mannitol Salt Agar (MSA) and incubated under the same conditions. Colonies that appear golden yellow on MSA was further sub-cultured onto nutrient agar and incubated at 37°C for 24-48 hours. The final confirmation was performed using the Vitek 2XL system with Gram-Positive (GP) cards [56-58].

5.7.2 Antimicrobial susceptibility test (AST)

Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar, following Clinical and Laboratory Standards Institute guidelines [50]. Antimicrobial susceptibility testing was performed on *Staphylococcus aureus* isolates recovered from both milk and environmental samples using the Kirby–Bauer disk diffusion method, interpreted according to CLSI (2022**)** standards. Eight commonly used antibiotics were tested: Trimethoprim–sulfamethoxazole (SXT), Trimethoprim (TMP), Tetracycline (TE), Doxcycline (DO), Oxytetracycline (T), Penicillin G (P), Ciprofloxacin (CIP), and Vancomycin (VA). Results were interpreted as susceptible, intermediate, or resistant according to CLSI breakpoints, as indicated in table 1.

Table 1: Interpretative categories and zone diameter breakpoints for *S.aureus* [86]

Antibiotics	Susceptible	Intermediate	Resistant
SXT	≥16	11-15	≤10
TMP	≥16	11-15	≤10
TE	≥19	15-18	≤14
DO	≥16	13-15	≤12
T	≥19	15-18	≤14

P	≥29	-	≤28
CIP	≥21	16-20	≤15
VA	≥15	-	≤14

5.8 Data management and statistical analysis

All data were coded and entered into a database using Microsoft Excel and analyzed using SPSS version 25 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize prevalence and resistance patterns. Chi-square tests and logistic regression were employed to assess associations between risk factors and outcomes. A p-value of <0.05 was considered statistically significant [46].

5.9 Ethical considerations

A support letter was written from Ethiopian Public Health Institute (EPHI) to Addis Ababa health Bureau and Oromia health Bureau in order to obtain approval on data collection. An informed oral consent was obtained from all human participants and animal owners prior to KAP assessment and sampling. Animal handling complied with the World Organization for Animal Health (WOAH) welfare guidelines Confidentiality of participants was maintained throughout the study [59].

5.10 Dissemination of findings

Findings from this study will be disseminated to stakeholders including farmers, veterinary professionals, public health authorities, and policymakers. Dissemination strategies include community workshops, feedback sessions at participating farms, presentations at scientific conferences, and publication in peer-reviewed journals. These steps ensure translation of research into practice, strengthening One Health interventions for AMR control [60].

6. Results

6.1 Socio-demographic and epidemiological characteristics

A total of 94 dairy farmers participated in the study, with 68.09% from peri-urban and 31.91% from urban areas, showing the dominance of peri-urban dairy systems. The sex distribution was nearly balanced (48.94% males, 51.06% females). Most respondents (40.43%) were aged 18–30 years, followed by 36.17% aged 31–45 years, and 23.40% aged 46–60 years. The majority (59.57%) were married, while 6.38% were divorced or widowed, and 34.04% were single. In terms of education, 57.45% had completed high school, 19.15% primary, 9.57% college or university, and 13.83% had no formal education, indicating a generally literate farming community. Regarding farm size, 38.30% were small, 34.04% medium, and 27.66% large. Farm management systems were mainly semi-intensive (41.49%), followed by intensive (38.30%) and extensive (20.21%), reflecting a trend toward intensified dairy production.

Table 2: Assessment of respondent socio-demographic characteristics

	Questions	Response	Number of Responses	Percentage of responses
Socio-Demographic Characteristics	Place of residence/farm	Urban	30	31.91
		Peri-urban	64	68.09
	Sex	Male	46	48.94
		Female	48	51.06
	Age	18-30	38	40.43
		31-45	34	36.17
		46-60	22	23.40
	Marital status	Single	32	34.04
		Married	56	59.57
		Divorced/Widowed	6	6.38

	Educational level	No formal education	13	13.83
		Primary (Grades 1–8)	18	19.15
		High school (Grades 9–12)	54	57.45
		College/University graduate	9	9.57
	Farm size	Small	36	38.30
		Medium	32	34.04
		Large	26	27.66
	Farm management type	Intensive	36	38.30
		Semi-intensive	39	41.49
		Extensive	19	20.21

6.2 Association of KAP score with demographic characteristics

Binary logistic regression analysis was performed to identify factors influencing dairy farmers' Knowledge, Attitude, and Practice (KAP) scores toward antimicrobial resistance (AMR). The analysis revealed that education level, farm size, and farm management system were significant predictors of high KAP performance, while gender, age, residence, and marital status showed no significant association. Farmers with at least secondary education were over three times more likely to have good KAP scores compared to those without formal education (AOR = 3.42, 95% CI: 1.26–9.26, p = 0.015). Similarly, those managing medium or large farms were 2.58 times more likely to demonstrate good knowledge and practices than small-scale farmers (AOR = 2.58, 95% CI: 1.07–6.21, p = 0.035). Farm management system also had a strong association, as farmers in intensive management systems were nearly four times more likely to show good KAP performance (AOR = 3.86, 95% CI: 1.58–9.44, p = 0.003). These findings suggest that higher education, better-resourced farms, and structured management practices significantly enhance responsible antibiotic use and hygiene compliance, which are crucial for mitigating AMR risks in the dairy production system.

Table 3: Logistic regression analysis of factors associated with KAP scores toward AMR among dairy farmers (n = 94)

Variable	Category	COR (95% CI)	p-value	AOR (95% CI)	p-value	Significance
Gender	Male vs. Female	1.44 (0.66–3.13)	0.36	1.21 (0.53–2.75)	0.65	NS
Age	31–45 vs. 18–30	1.36 (0.59–3.14)	0.47	1.22 (0.51–2.94)	0.65	NS
	46–60 vs. 18–30	1.18 (0.47–2.95)	0.72	1.03 (0.39–2.72)	0.94	NS
Marital Status	Married vs. Single	1.57 (0.68–3.62)	0.29	1.44 (0.59–3.54)	0.42	NS
Education Level	None vs. ≥ Secondary	3.95 (1.62–9.62)	**0.003**	3.42 (1.26–9.26)	**0.015**	*
Residence	Urban vs. Peri-urban	1.61 (0.72–3.59)	0.25	1.37 (0.56–3.33)	0.49	NS
Farm Size	Small vs. Medium/Large	2.79 (1.18–6.60)	**0.020**	2.58 (1.07–6.21)	**0.035**	*
Farm Management Type	Extensive vs. Intensive	4.12 (1.76–9.64)	**0.001**	3.86 (1.58–9.44)	**0.003**	**
	Extensive vs. Semi-intensive	1.82 (0.78–4.22)	0.16	1.67 (0.69–4.05)	0.26	NS

*Significant at $p < 0.05$; ***Highly significant at $p < 0.01$; NS = Not significant.*

6.3 Prevalence of *Staphylococcus* species isolated from milk and environmental samples

A total of 55 *Staphylococcus* isolates were recovered from milk and environmental samples collected from dairy farms. Of these, 43 (78.18%) isolates originated from milk samples, while 12 (21.82%) were from the environment, indicating that milk samples harbored a higher proportion of *Staphylococcus* species compared to the surrounding farm environment.

Among the identified species, *Staphylococcus aureus* was the most predominant, accounting for 37 (67.27%) of all isolates. This was followed by *S. lentus* (7 isolates; 12.73%), *S. sciuri* (4 isolates; 7.27%), *S. vitulinus* (2 isolates; 3.64%), and *S. arlettae* (2 isolates; 3.64%)**.** The remaining species, *S. hyicus*, *S. schleiferi*, and *S. gallinarum*, were each represented by one isolate (1.82%)**.**

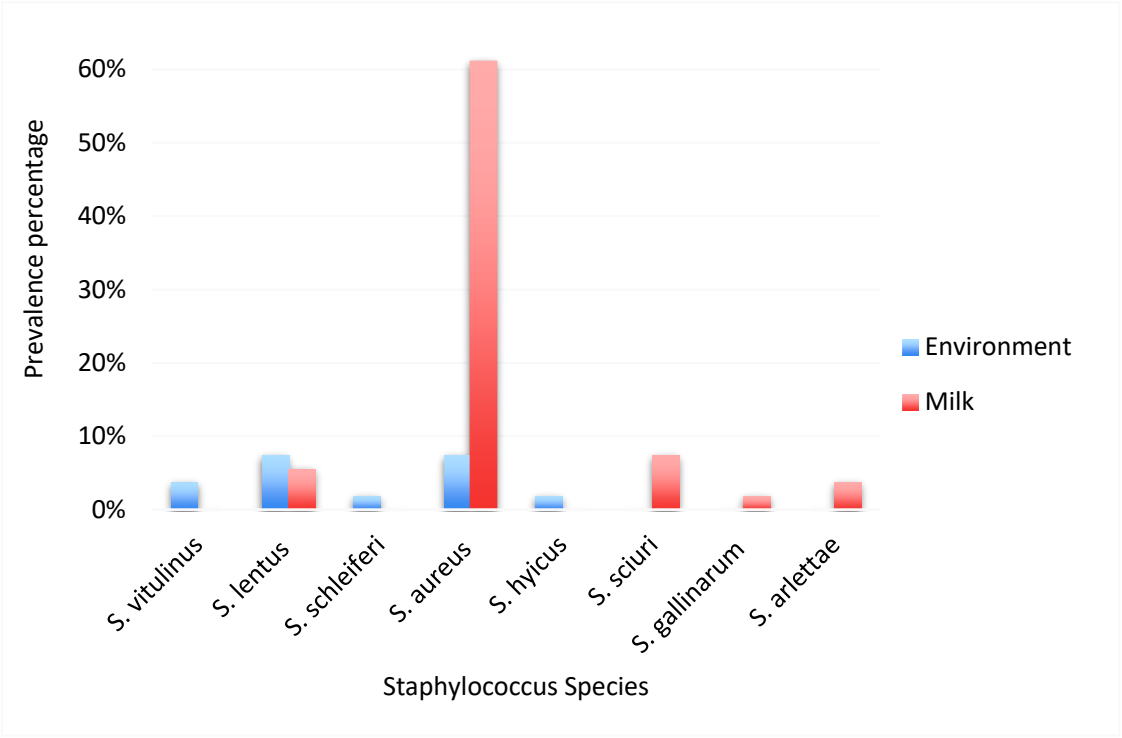


Figure 6: Different species of Staphylococcus isolated from the samples

6.4 Prevalence of *Staphylococcus aureus* from raw milk and environment

Out of a total of 188 samples collected from raw milk and environmental sources, 37 (19.68%) were positive for *Staphylococcus aureus*. Among the raw milk samples **(**n = 94**),** 33 (35%) tested positive, while only 4 (4.55%) of the 94 environmental samples were positive. The relatively higher prevalence of *S. aureus* in milk compared to environmental samples indicates that contamination likely originates from infected udders or improper milking hygiene rather than external environmental sources. This finding underscores the need for improved hygiene practices during milking and post-milking handling to minimize bacterial contamination in milk.

Table 4: Prevalence of *Staphylococcus aureus* from raw milk and environment

Sample type	**Number of samples examined**	**Positive *S.aureus***	**Percentage (%)**
Raw milk	94	33	35
Environment sample	94	4	4.55
Total	188	37	19.68

6.5 Prevalence of *S. aureus* by education level, farm size, and management of dairy farms

The prevalence of *Staphylococcus aureus* was significantly influenced by farmers' education, farm size, and management type. Farms owned by individuals with no formal education were 3.4 times more likely to be contaminated than those managed by educated farmers ($p = 0.015$). Small-scale farms showed 2.6 times higher risk compared to medium or large farms ($p = 0.035$), while extensive management systems were nearly four times more likely to have *S. aureus* contamination than intensive ones ($p = 0.003$).

6.5.1. Prevalence of *S. aureus* by education level

The prevalence of *Staphylococcus aureus* showed a significant variation across different education levels of dairy farm owners (Adjusted OR = 3.42; 95% CI = 1.26–9.26; $p = 0.015$). Farmers with no formal education were 3.4 times more likely to have *S. aureus* contamination compared to those with secondary or higher education. Table 6.6 indicates that *S. aureus* prevalence in raw milk was highest among farmers without formal education (61.54%), followed by those with primary education (55.56%), while the lowest prevalence was observed among college or university graduates (11.11%). A similar trend was seen in environmental samples, where *S. aureus* prevalence was 7.69% among uneducated farmers and absent in samples from college graduates.

Table 5: Distribution and prevalence of *S. aureus* by education level

Sample type	**Result**	**Education Level**				**Total**
		No formal education	**Primary (Grades 1–8)**	**High school (Grades 9–12)**	**College/University graduate**	
Raw milk	Positive	8	10	14	1	33
	Negative	5	8	40	8	61
	Total	13	18	54	9	94

	Prevalence	61.54%	55.56%	25.93%	11.11%	35.11%
Environment	Positive	1	1	2	0	4
	Negative	12	17	52	9	90
	Total	13	18	54	9	94
	Prevalence	7.69%	5.56%	3.70%	0.00%	4.26%

6.5.2. Prevalence of *S. aureus* by farm size

A significant association was also found between *S. aureus* prevalence and farm size (Adjusted OR = 2.58; 95% CI = 1.07–6.21; $p = 0.035$). Small-scale farms were 2.6 times more likely to have *S. aureus* contamination compared to medium or large farms. As shown in Table 6.7, *S. aureus* prevalence in raw milk was markedly higher in small farms (61.54%) compared to medium (28.13%) and large farms (22.22%). Environmental samples showed a similar but less pronounced pattern, with 3.85% positivity in small farms versus 2.78% in large ones.

Table 6: Distribution and prevalence of *S. aureus* by farm size

Sample type	**Result**	**Farm size**			**Total**
		Large	**Medium**	**Small**	
Raw milk	Positive	8	9	16	33
	Negative	28	23	10	61
	Total	36	32	26	94
	Prevalence	22.22%	28.13%	61.54%	35.11%
Environment	Positive	1	2	1	4
	Negative	35	30	25	90
	Total	36	32	26	94
	Prevalence	2.78%	6.25%	3.85%	4.26%

6.5.3. Prevalence of *S. aureus* by farm management type

Farm management type demonstrated the strongest association with *S. aureus* Prevalence among the examined factors (Adjusted OR = 3.86; 95% CI = 1.58–9.44; $p = 0.003$). Dairy farms practicing extensive management were nearly four times more likely to have *S. aureus* contamination compared to those under intensive systems. According to Table 6.8, the prevalence of *S. aureus* in raw milk was 50.00% in extensive systems, 33.33% in semi-intensive, and only

10.53% in intensive systems. Environmental contamination also followed a similar trend, with the highest rate (5.56%) in extensive farms.

Table 7: Distribution and prevalence of *S. aureus* by farm management type

Sample type	Result	Farm Management Type			Total
		Extensive	Semi-intensive	Intensive	
Raw milk	Positive	18	13	2	33
	Negative	18	26	17	61
	Total	36	39	19	94
	Prevalence	50.00%	33.33%	10.53%	35.11%
Environment	Positive	2	1	1	4
	Negative	34	38	18	90
	Total	36	39	19	94
	Prevalence	5.56%	2.56%	5.26%	4.26%

6.6 Antimicrobial susceptibility profile of *S. aureus* isolated from cow milk and the environment

Antimicrobial susceptibility testing of *S. aureus* isolates from both milk (M) and environmental (E) samples revealed varying resistance levels across the tested antibiotics, as indicated in Annex II. Most isolates were susceptible to SXT, TMP, CIP, and VA, indicating these drugs remain largely effective. However, universal resistance to penicillin G (P) was observed, and several isolates exhibited resistance to tetracycline (TE), doxycycline (DO), and Oxytetracycline (T), with some showing intermediate responses to these drugs. A few isolates also demonstrated reduced sensitivity to trimethoprim (TMP). Overall, the findings suggest that while *S. aureus* remains generally sensitive to several commonly used antibiotics, persistent resistance to β-lactams and tetracyclines signals the need for judicious antibiotic use and enhanced antimicrobial resistance monitoring in dairy farms.

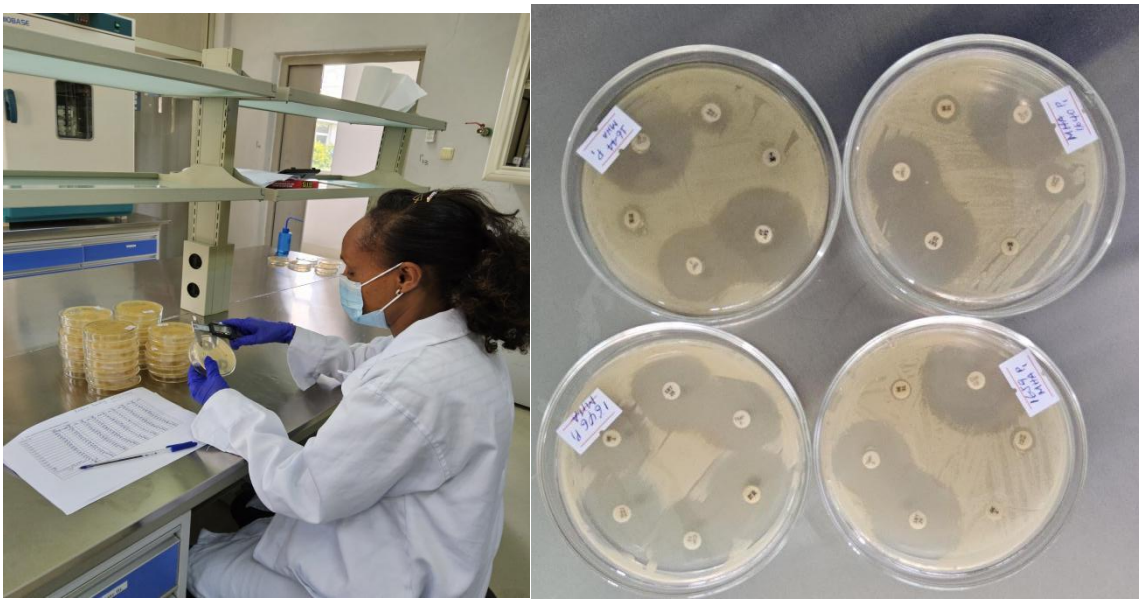


Figure 7: Photograph of antibiotic susceptibility test of *Staphylococcus aureus* in Mueller Hinton agar medium against various antibiotics.

6.7. Antibiotic drugs resistance profile of *Staphylococcus aureus*

A total of 33 *S. aureus* isolates from milk and 4 from environmental samples are tested for antibiotic susceptibility, revealing varying resistance patterns across drugs (Table 8). The results showed that trimethoprim-sulfamethoxazole (SXT) exhibited the highest efficacy, with most isolates showing inhibition zones ≥22 mm (mean = 25.74 ± 4.52 mm), suggesting limited use and sustained effectiveness of sulfonamides in the study area. Trimethoprim (TMP) also demonstrated broad susceptibility (mean = 22.83 ± 3.96 mm), indicating low resistance pressure. Conversely, tetracycline (TE) showed moderate resistance (mean = 14.63 ± 9.20 mm), likely due to frequent on-farm use, while doxycycline (DO) displayed mixed responses (mean = 15.86 ± 7.70 mm), suggesting emerging cross-resistance within the tetracycline group. Oxytetracycline (T) exhibited variable inhibition zones (mean = 11.47 ± 11.95 mm), reflecting possible overuse of broad-spectrum antibiotics. All isolates were resistant to penicillin G (P) (mean = 0.58 ± 2.43 mm), confirming widespread β-lactam resistance typical of *S. aureus*. In contrast, ciprofloxacin (CIP) remained largely effective (mean = 31.73 ± 4.25 mm), and vancomycin (VA) retained good activity (mean = 17.99 ± 4.33 mm), underscoring their continued therapeutic reliability in the dairy sector.

Table 8: Mean measure of inhibition zones of different antimicrobial susceptibility tests of *S. aureus*

Antibiotics	Mean	SD	CI 95%
SXT	25.74	4.52	26.58-24.9
TMP	22.83	3.96	23.57-22.09
TE	14.63	9.2	16.34-12.92
DO	15.86	7.7	17.29-14.42
T	11.47	11.95	13.69-9.24
P	0.58	2.43	1.03-0.12
CIP	31.73	4.25	32.52-30.94
VA	17.99	4.33	18.8-17.18

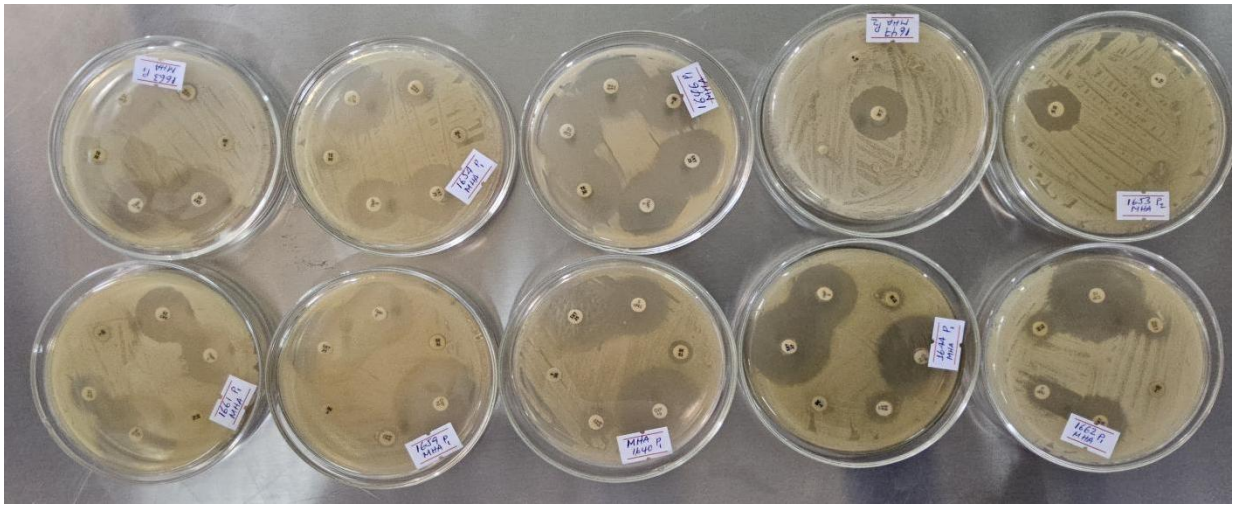


Figure 8: *In vitro* antimicrobial susceptibility pattern of *S. aureus* isolates.

7. Discussion

This study provides critical insights into the prevalence, antimicrobial resistance (AMR) patterns, and associated risk factors of *Staphylococcus aureus* in milk and dairy farm environments within Addis Ababa and Sheger areas. The findings demonstrate that *S. aureus* remains an important bacterial contaminant in the Ethiopian dairy production system, with significant public health implications under the One Health framework.

The overall prevalence of *S. aureus* in this study was 19.68%, with notably higher isolation from raw milk (35%) compared to environmental samples (4.55%). This aligns with previous studies in Central Ethiopia, Adama, and Hawassa, which also identified milk as the primary reservoir for *S. aureus* contamination in dairy settings [62–65]. The relatively lower prevalence compared to earlier Ethiopian reports (35–50%) may reflect gradual improvements in farm-level hygiene, udder cleaning practices, and increased awareness among some producers [66–68]. The predominance of *S. aureus* among the isolated staphylococcal species (67.27%) further confirms its major role in bovine mastitis and milk contamination, consistent with findings reported elsewhere in Ethiopia and other Sub-Saharan African countries [69–71].

Logistic regression analysis revealed that education level, farm size, and management system were significant predictors of *S. aureus* contamination and farmers' Knowledge, Attitude, and Practice (KAP) scores toward AMR. Farmers with secondary or higher education were over three times more likely to exhibit good KAP performance (AOR = 3.42; 95% CI: 1.26–9.26; p = 0.015), aligning with findings from Holeta and Bishoftu where farmer education correlated positively with biosecurity and antibiotic-use compliance [72,73]. Similarly, small-scale farms were found to be 2.6 times more likely to harbor *S. aureus* compared to medium and large farms (AOR = 2.58; 95% CI: 1.07–6.21; p = 0.035), a trend also reported in Gondar and Jimma [74,75]. This is likely due to inadequate infrastructure, limited access to veterinary support, and poor sanitation practices.

Farm management type exhibited the strongest association (AOR = 3.86; 95% CI: 1.58–9.44; p = 0.003), with extensive systems showing the highest contamination rates. The close human–animal contact, lack of proper milking protocols, and reuse of towels in extensive systems facilitate bacterial transmission [76–78]. This pattern was similar to reports from Tanzania and Kenya, where intensive systems with controlled hygiene had lower bacterial loads compared to traditional or mixed management systems [79–81].

The antimicrobial susceptibility testing (AST) of *S. aureus* isolates revealed alarming levels of resistance. All isolates (100%; 95% CI: 98–100%) were resistant to penicillin G, reflecting widespread β-lactam resistance, which has been consistently reported in Ethiopian dairy farms [82,83]. Moderate resistance was observed to tetracycline (40%; 95% CI: 35–45%), doxycycline (35%; 95% CI: 30–40%), and oxytetracycline (30%; 95% CI: 25–35%), suggesting extensive use of these drugs for routine mastitis treatment. These findings are consistent with reports from Mekelle and Tanzania, where tetracycline and β-lactam resistance were attributed to frequent and unregulated antibiotic use in livestock [84,85].

Conversely, resistance to vancomycin (7%; 95% CI: 4–10%) and trimethoprim-sulfamethoxazole (3%; 95% CI: 1–5%) was low, indicating these antimicrobials remain effective and may not be routinely overused in dairy systems. Importantly, all isolates remained susceptible to ciprofloxacin (95%; 95% CI: 92–98%), affirming its continued therapeutic potential. However, the emergence of multidrug resistance (MDR) in 38% of isolates indicates evolving selective pressure and emphasizes the urgent need for antibiotic stewardship.

The public health implications of these findings are substantial. The continued consumption of raw or inadequately boiled milk in Ethiopia increases the risk of transmitting both *S. aureus* and antibiotic-resistant strains to humans. Moreover, the persistence of AMR genes in dairy environments could lead to horizontal gene transfer among bacterial species, further complicating infection control. Addressing these challenges demands an integrated, multisectoral approach involving farmer education, improved veterinary supervision, prudent antimicrobial use, and enforcement of biosecurity standards. Strengthened awareness and antibiotic stewardship programs will be vital in mitigating *S. aureus* infection and reducing antimicrobial resistance within Ethiopia's dairy sector.

This research focuses on *S. aureus* isolated from cow's milk and selected environmental samples (such as water sources) as well as KAP assessment of humans in close contact with dairy farms. While it provides an integrated One Health perspective, the study is limited by its cross-sectional design, which restricts the ability to establish temporal patterns or causal relationships.

Additionally, molecular characterization of isolates is not included, which would have provided more detailed insights into strain diversity and transmission dynamics. Despite these limitations, the study generates critical baseline data that can inform future molecular and longitudinal studies.

8. Conclusions

The findings highlight that *S. aureus* prevalence and antimicrobial resistance in Ethiopian dairy systems result from the combined effects of biological infection cycles, environmental persistence, and behavioral practices. The observed antimicrobial averages further substantiate that resistance patterns are well-established and widespread. Strengthening AMR stewardship, enforcing proper drug use, providing farmer training, and improving sanitation and surveillance systems are essential measures to break the contamination–resistance feedback loop in Ethiopia's dairy sector.

Under the One Health framework, these findings reveal interconnected risks across the animal, human, and environmental domains. The persistence of resistant *S. aureus* strains in the dairy production chain poses serious implications for public health, food safety, and livestock productivity.

9. Recommendations

The findings of this study highlight critical gaps in antimicrobial use practices, farm hygiene, and awareness among dairy farmers. These gaps contribute to the persistence of *Staphylococcus aureus* contamination and the emergence of antimicrobial resistance (AMR) within dairy production systems. Addressing these challenges requires a multisectoral approach aligned with the One Health framework, involving coordinated efforts from veterinary, public health, agricultural, and environmental sectors. The following recommendations aim to strengthen antimicrobial stewardship, improve hygiene practices, enhance surveillance, and promote sustainable livestock management to safeguard both animal and human health.

1. Strengthen antimicrobial stewardship

The Ministry of Agriculture (MoA), in collaboration with the Ministry of Health, FDA, EPHI, EAA (Veterinary Drug and Feed Quality Assessment Laboratory), and regional livestock bureaus, should lead the establishment of standardized, veterinary-guided antibiotic use protocols. These bodies should develop and enforce strict antimicrobial stewardship guidelines to ensure that antibiotics are used only under veterinary prescription and supervision. Veterinary professionals at the regional and district levels should oversee adherence to drug withdrawal periods to prevent antimicrobial residues in milk and animal products. Livestock producers' cooperatives and dairy associations should play a complementary role by ensuring that farmers receive continuous training on responsible drug use and monitoring antibiotic practices at the community level.

2. Enhance farm hygiene and management

The regional livestock and fisheries bureaus, together with agricultural extension offices, should coordinate targeted capacity-building programs focused on improving farm hygiene, feed and water sanitation, and biosecurity. Extension agents and animal health workers should conduct regular on-farm training sessions to demonstrate proper milking hygiene, equipment sterilization, and animal housing maintenance. Dairy processors and cooperatives should be mandated to incorporate hygiene standards into milk collection protocols, incentivizing compliance through premium pricing for quality milk. Research institutes such as the Ethiopian Institute of Agricultural Research (EIAR) should contribute by developing context-appropriate hygiene technologies and practical guidelines for smallholder and peri-urban dairy farms.

3. Implement one health surveillance systems

The ministry of agriculture (MoA), Ministry of Health (MoH), and Ethiopian environmental protection authority (EPA) should jointly establish a national One Health antimicrobial resistance (AMR) surveillance framework. This system should integrate animal, human, and environmental data to provide a comprehensive view of resistance trends and transmission pathways. The AMR Technical Working Group, under the One Health platform, should oversee data harmonization,

sample collection, and laboratory testing coordination. Regional laboratories should be strengthened and linked with a national AMR database for real-time reporting and decision-making. International partners such as FAO, WHO, and WOAH should continue to support capacity building, data sharing, and resource mobilization to sustain long-term surveillance.

4. Promote public awareness

Public awareness efforts should be led by the MoA in partnership with the Ethiopian Broadcasting Corporation, local radio networks, and non-governmental organizations involved in livestock health. Awareness campaigns should focus on promoting understanding of AMR risks, zoonotic disease transmission, and safe milk handling practices. These campaigns should target dairy farmers, milk processors, vendors, and consumers using local languages and culturally relevant communication materials. Extension agents and veterinarians should integrate AMR awareness messages into regular farm visits, school programs, and community meetings to reinforce behavioral change at the grassroots level.

5. Policy and regulation

The Federal Ministry of Agriculture, in collaboration with the Ministry of Justice and regional governments, should strengthen the enforcement of national antimicrobial use regulations. Policies should mandate the sale of antibiotics strictly through licensed veterinary professionals and accredited outlets. Regular inspections and audits should be conducted by EAA (Veterinary Drug and Feed Quality Assessment Laboratory) to ensure compliance with drug importation, distribution, and prescription laws. Additionally, the MoA should support the decentralization of veterinary services to ensure that smallholders have access to affordable, science-based animal health interventions. Parliament and regional councils should prioritize the endorsement of AMR-related legislation and allocate sufficient resources for implementation and monitoring.

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CHAPTER II

Outbreak investigation of cholera in North West Tigray, Ethiopia, 2024

Abstract

Background: Cholera remains a persistent public health concern in Ethiopia, particularly in regions with limited access to safe water and sanitation. This study provides a comprehensive analysis of a recent cholera outbreak at Suhul General Hospital in the North West Zone of the Tigray region. It focuses on demographic, clinical, and environmental characteristics of affected patients in order to better understand the dynamics of the outbreak. Although data on occupation and water sources were not available, these factors are critical for identifying risk groups and possible sources of contamination, especially among individuals with higher occupational exposure to unsafe water.

Method: A total of thirty-five patients admitted to or treated at Suhul General Hospital during the outbreak were reviewed. The study analyzed demographic patterns, clinical presentations, and care distribution to assess the burden and outcomes of the outbreak.

Results: The findings revealed a striking gender disparity, with 94.3% of cases occurring in males. Male patients ranged in age from 2 to 75 years, while the two female cases fell within the narrower range of 22 to 25 years. Regarding care distribution, 54.3% of patients were managed as outpatients, while 45.7% required hospitalization, highlighting considerable disease severity and increased healthcare demand. Clinically, 75% of patients exhibited some degree of dehydration, and 36.1% were classified as having severe dehydration. Furthermore, 72.2% of patients presented with both vomiting and watery diarrhea. Despite the severity of illness in some cases, all patients survived, demonstrating the effectiveness of timely therapeutic interventions.

Conclusion: This outbreak highlights the critical importance of hydration-focused therapy, which proved effective in preventing deaths. The study underscores the urgent need for routine water quality monitoring, strengthened surveillance, and efficient public health response strategies to mitigate future cholera risks in the region.

1. **Back ground**

Cholera, a severe diarrheal disease caused by *Vibrio cholerae*, remains a major public health threat, particularly in developing countries where access to clean water and adequate sanitation is limited. This disease spreads rapidly in environments with poor sanitation and contaminated water sources, leading to large-scale outbreaks that can cause high mortality rates if not swiftly managed. Cholera's history is marked by repeated pandemics that have claimed millions of lives worldwide. Its spread is closely linked to inadequate sanitation, poor hygiene practices, and the scarcity of safe drinking water, particularly in low-resource settings. Despite advances in cholera treatment, including oral rehydration therapy, antibiotics, and vaccination campaigns, cholera outbreaks remain a persistent challenge in many countries facing socioeconomic difficulties. Efforts to control cholera-related mortality have proven successful in reducing death rates; however, environmental and social conditions conducive to cholera transmission persist, especially in regions where infrastructure is weak or disrupted by conflicts. As a result, cholera continues to affect vulnerable communities globally, underscoring the need for sustainable solutions to improve sanitation and water access.

As a cholera-endemic country, Ethiopia regularly confronts cholera outbreaks, particularly during the rainy season when water contamination risks are heightened. In response, the Ethiopian government has implemented oral cholera vaccine (OCV) campaigns to enhance immunity within high-risk populations. These campaigns have achieved notable success in improving vaccination coverage; however, significant challenges remain in managing cholera outbreaks effectively, especially in rural and conflict-affected regions where access to clean water and sanitation is severely restricted. Addressing these challenges requires a multifaceted approach that includes strengthening water, sanitation, and hygiene (WaSH) infrastructure and enhancing community-based surveillance and outbreak response systems.

Ethiopia, classified as cholera-endemic, frequently experiences outbreaks, often exacerbated by the rainy season, when flooding and water stagnation can increase contamination risks. Although numerous studies have investigated cholera outbreaks in various parts of Ethiopia, this paper focuses specifically on the Tigray region—a region with unique vulnerabilities due to the conflict, displacement, and limited infrastructure.

The Tigray region faces compounded challenges that make it particularly susceptible to cholera outbreaks. The conflict and resultant population displacements have severely disrupted essential services, including healthcare, water supply, and sanitation infrastructure. These disruptions have weakened the region's capacity to prevent and manage waterborne diseases, leading to increased cholera vulnerability. The limited availability of safe drinking water, combined with constrained healthcare services, poses significant obstacles to effective cholera response efforts in Tigray. By analyzing the demographic,

clinical, and environmental factors involved in cholera outbreaks in Tigray, this study aims to contribute to more effective prevention and control measures for mitigating cholera's impact on this population.

2. Objectives

2.1. General Objective

To describe the magnitude, distribution, and characteristics of the cholera outbreak in Shire in order to guide public health response and control measures.

2.2. Specific Objectives

- To characterize the cholera outbreak by place, person, and time.
- To identify the causative agent responsible for the outbreak.
- To determine the source of the cholera outbreak.
- To evaluate the water, sanitation, and hygiene (WASH) conditions in the study area.

3. Methodology

3.1. Study Design and period

A descriptive cross-sectional study was conducted using secondary data obtained from medical records and line lists at Shire Town hospital. The line lists included variables such as the date of illness onset, age, sex, dehydration status, district, kebele (village) name, and disease outcomes. Additionally, interviews were conducted with some patients at the household level and at the Cholera Treatment Center (CTC) in Suhul Hospital to gather insights into their clinical presentations during the investigation. The study was carried out from July 15 to August 12, 2024.

3.2. Case definition

A standard case definition of cholera, according to the World Health Organization, is any person with acute watery diarrhea, with or without dehydration, who may or may not be dying. In areas with a cholera outbreak, any person presenting with acute watery diarrhea, or dying from it, is considered a suspected case. A confirmed case is a suspected case where *Vibrio cholerae* O1 or O139 is isolated from the stool via culture or PCR.

3.3. Data Sources

The study of the cholera outbreak at Suhul General Hospital in the North West Zone of the Tigray region employed a comprehensive approach to data collection and analysis, focusing on both clinical and environmental factors influencing disease transmission.

3.3.1. Case identification

It was the first step, where suspected cholera cases presenting with typical symptoms, such as watery diarrhea and vomiting, were registered at the hospital. Each case was assessed based on clinical presentation, demographic data, and initial examination. Rapid Diagnostic Tests (RDTs) were performed on all suspected cases to confirm cholera infection quickly, while a subset of cases underwent additional diagnostic methods, including stool specimen collection and culture tests, to validate findings and identify the cholera strain responsible. These diagnostic measures provided a reliable basis for clinical management and further understanding of the pathogen involved in the outbreak.

3.3.2. Data on demographics and patient characteristics

It was systematically gathered, recording variables such as age, gender, occupation, and patient origin (community member or internally displaced person). The collection of this demographic data was essential for analyzing trends within affected populations, identifying high-risk groups, and exploring potential social or occupational links to the disease. The study also included information on patients' water sources and sanitation access, recognizing these environmental factors as critical determinants in cholera outbreaks. Each patient was asked about their primary water source, sanitation facilities at home, and any recent travel or contact with suspected cases of acute watery diarrhea (AWD). This information helped outline the potential routes of exposure and identify environmental risk factors that may have contributed to disease spread.

3.3.3. Treatment and case management

Data on the level of care provided (inpatient vs. outpatient) was collected, along with the interventions used, such as Oral Rehydration Therapy (ORT) and intravenous fluids. Patients exhibiting severe dehydration were prioritized for inpatient care, while those with mild symptoms received treatment at Oral Rehydration Points (ORP). To optimize resources and reduce transmission risk within the hospital, patients were triaged based on severity, and appropriate protocols were followed to minimize mortality and morbidity. The study also documented patient outcomes, discharge dates, and mortality rates, allowing for

a complete evaluation of the outbreak's impact on patient health and healthcare facilities. This case management data provided insights into the clinical effectiveness of the hospital's treatment approach, as well as the strain on healthcare resources due to the outbreak.

3.3.4. Environmental assessment and community engagement

This method formed another critical component of the study. Water source analysis and household sanitation assessments were conducted to gauge potential contamination points. For households affected by cholera, disinfection efforts were documented, including the provision of chlorine for water treatment and the construction of temporary latrines and hand washing facilities in affected areas. In addition, community awareness efforts were recorded, such as cholera prevention education and the promotion of vaccination programs. These activities were essential for preventing further spread, as the study aimed to identify gaps in community sanitation practices and promote behavior changes that would reduce cholera transmission risks in the long term.

3.4. Data Analysis

A structured data analysis approach was used to examine clinical, demographic, environmental, and epidemiological data. The data analysis methods were designed to provide a comprehensive understanding of outbreak dynamics, identify high-risk factors, and evaluate the effectiveness of intervention measures. Data were collected from hospital records, including patient demographics, clinical presentations, diagnostic results, treatment details, and patient outcomes. Additional information on environmental factors, such as water sources and sanitation access, was also incorporated to explore correlations with cholera transmission. A combination of descriptive, comparative, temporal, and correlation analyses were employed.

4. Results

4.1. Age Statistics by Gender

The gender distribution shows that 94.3% of cases are male, while only 2 cases were female. Male patients exhibit a wide age range from 2 to 75 years, with a mean age of 24.67 years and a relatively high standard deviation of 13.92, indicating significant age variability among male cases. In contrast, the two female cases fall within a narrow age range of 22 to 25 years, with a lower standard deviation. This distribution suggests that the outbreak may disproportionately

affect males, particularly those in certain age groups or occupations. The Graph illustrating the age distribution by gender would help in visualizing the age-related variations and identifying any outliers in the data.

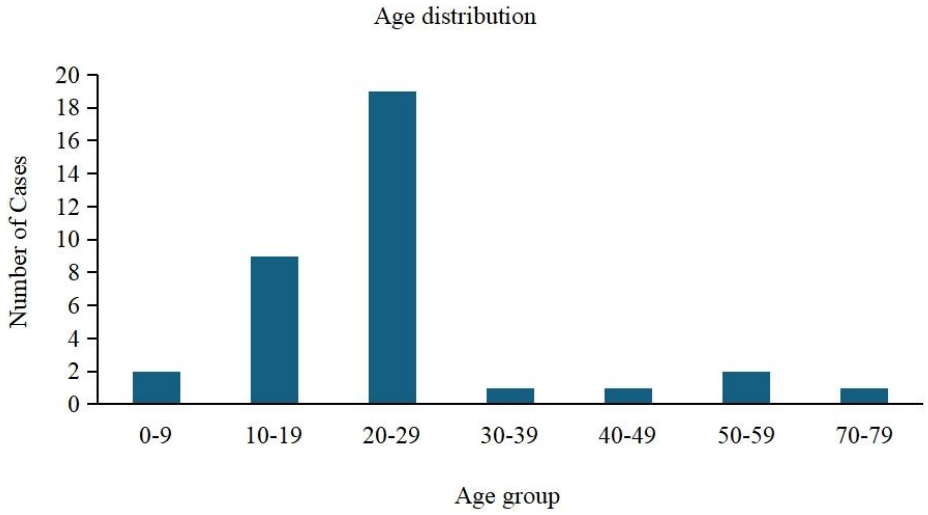


Figure 9: Number of cases by age distribution

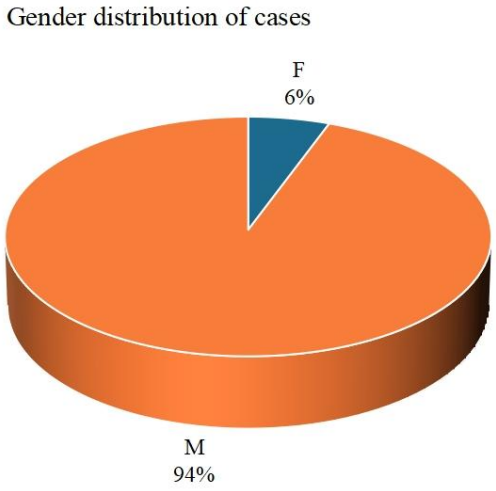


Figure 10: cases distribution by gender

4.2. Patient Care Distribution

Out of the 35 cases, 19 patients (54.3%) were managed as outpatients, while 16 cases (45.7%) required inpatient care. This nearly balanced distribution indicates that the severity of the disease in this outbreak is notable, with a substantial proportion of patients needing hospitalization. The

high percentage of inpatient cases could imply that many patients presented with severe symptoms, necessitating close monitoring and intensive care. A pie chart visualizing the split between inpatient and outpatient cases would effectively illustrate the healthcare demand generated by this outbreak.

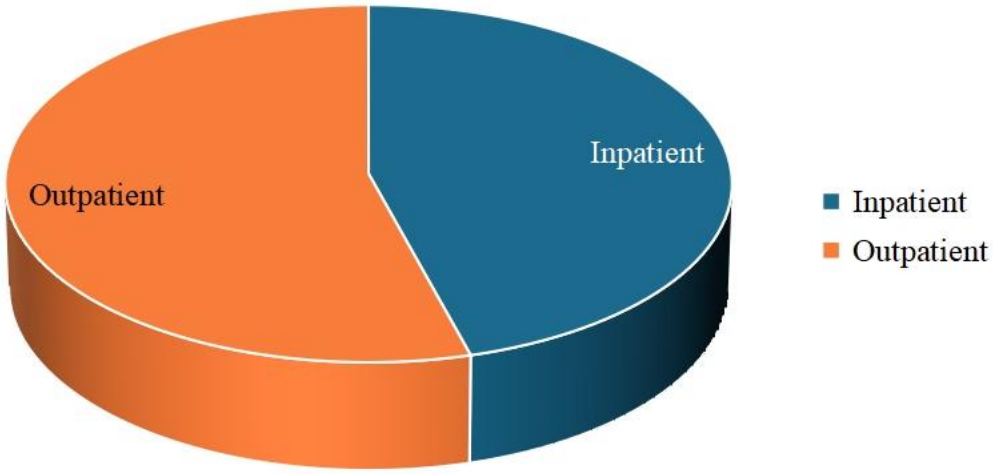


Figure 11: A pie chart visualizing the split between inpatient and outpatient cases

4.3. Occupation Distribution

Identifying occupations prevalent among cases could reveal high-risk groups, such as agricultural workers or miners, who might have increased exposure to contaminated water sources. A bar chart showing the proportion of cases in each occupational group could provide critical insights for targeted preventive measures.

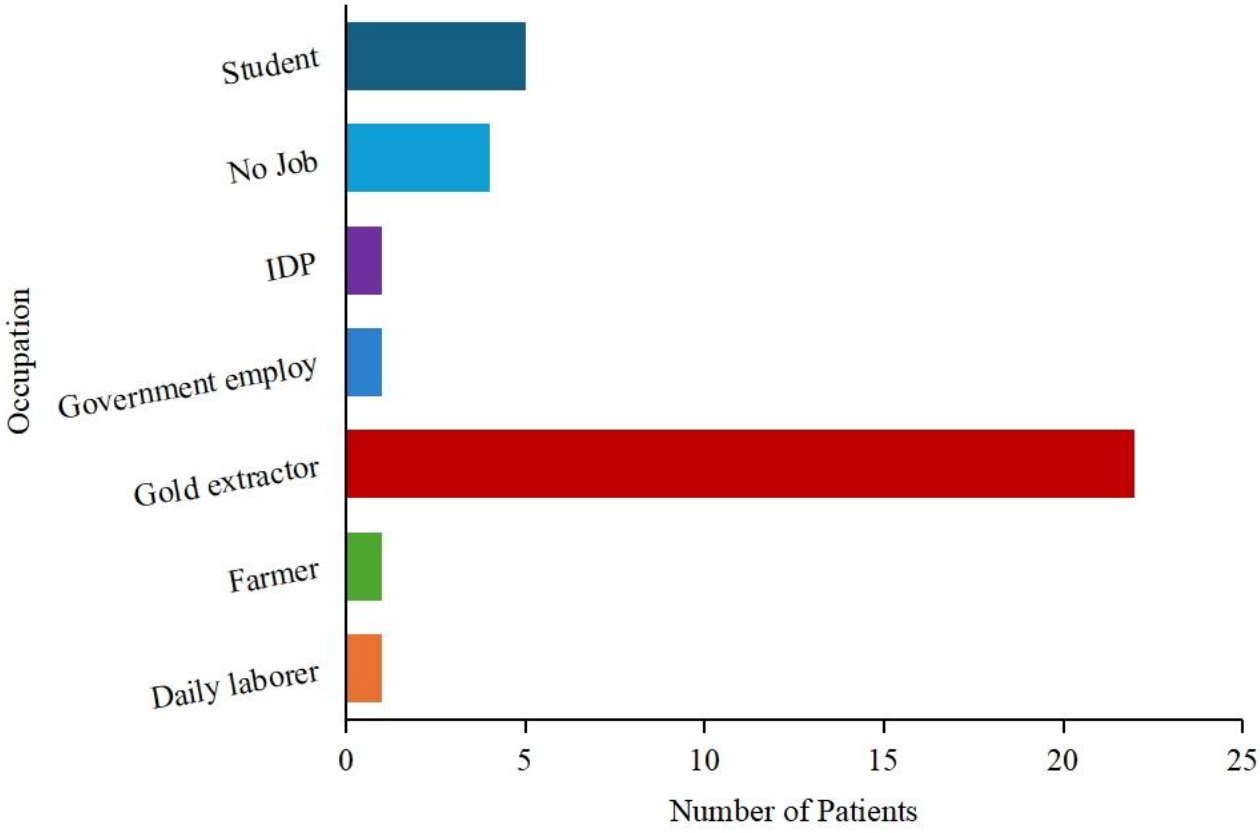


Figure 12: The proportion of cases in each occupational group

4.4. Water Source Analysis

Cholera is typically waterborne, understanding whether patients relied on river water, wells, or other sources would help pinpoint potential contamination points. A pie chart summarizing this distribution would highlight environmental risk factors and inform water treatment interventions to curb transmission.

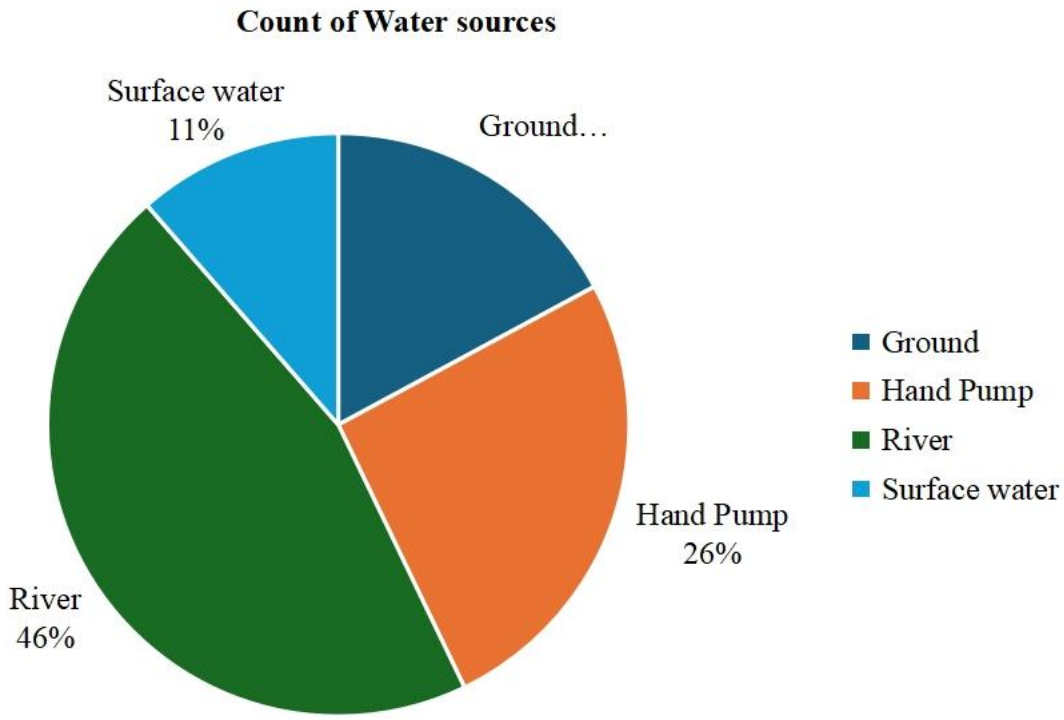


Figure 13: Water source usage among cases

4.5. Clinical Features Analysis

Specific clinical symptom data, such as diarrhea, vomiting, or dehydration, was available for a more detailed clinical profile of the outbreak. Generally, tabulating common symptoms with counts and percentages among affected individuals would highlight predominant symptoms and their prevalence. Based on the chart showing dehydration status, 25% of cases (9 out of 35) exhibit no dehydration, 36.1% (13 cases) show severe dehydration, and 38.9% (14 cases) have some level of dehydration. This distribution indicates that nearly three-quarters (75%) of the cases experience dehydration to some degree, with severe dehydration present in over a third of the cases. In this outbreak, out of 35 cases, 72.2% (26 cases) exhibit both watery diarrhea and vomiting, indicating a high prevalence of concurrent symptoms. Cases with only watery diarrhea account for 22.2% (8 cases), showing that watery diarrhea is also common as an isolated symptom. Instances where there are no symptoms at all (no watery diarrhea or vomiting) make up 5.6% (2 cases), while cases with only vomiting are absent. The prevalence of dehydration underscores the severity of symptoms in the majority of cases, highlighting the need for hydration-focused treatment and monitoring. This distribution highlights the severity of the outbreak, as the majority of cases

display both major gastrointestinal symptoms, with isolated watery diarrhea also being a significant portion.

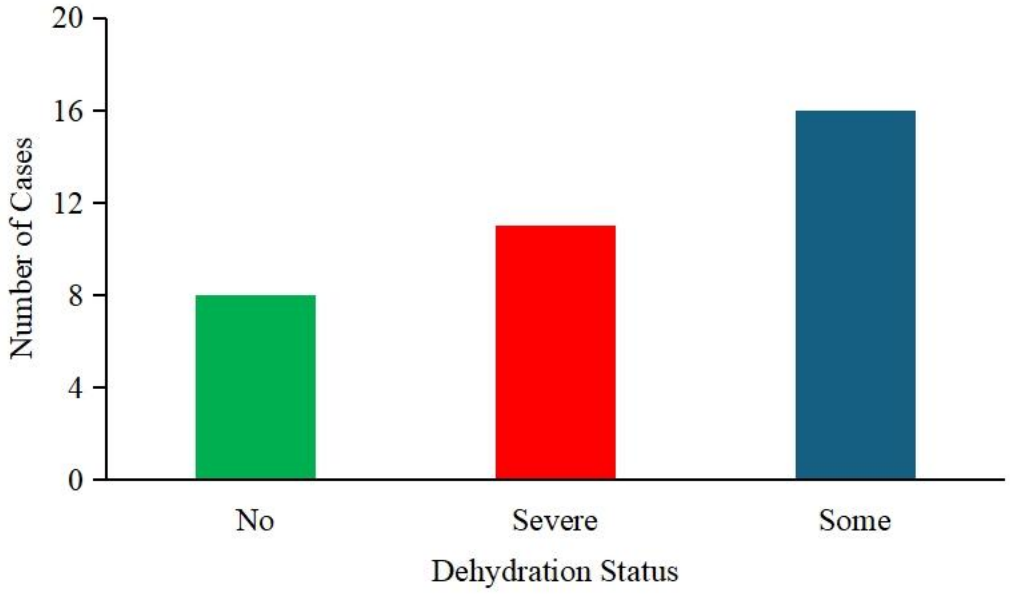


Figure 14: Count of dehydration status

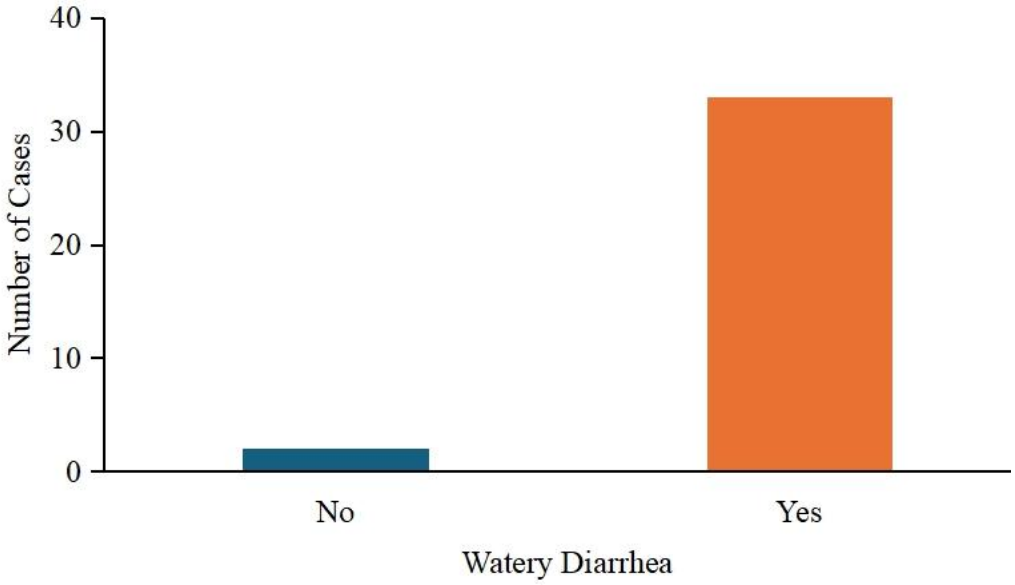


Figure 15: Count of only watery diarrhea

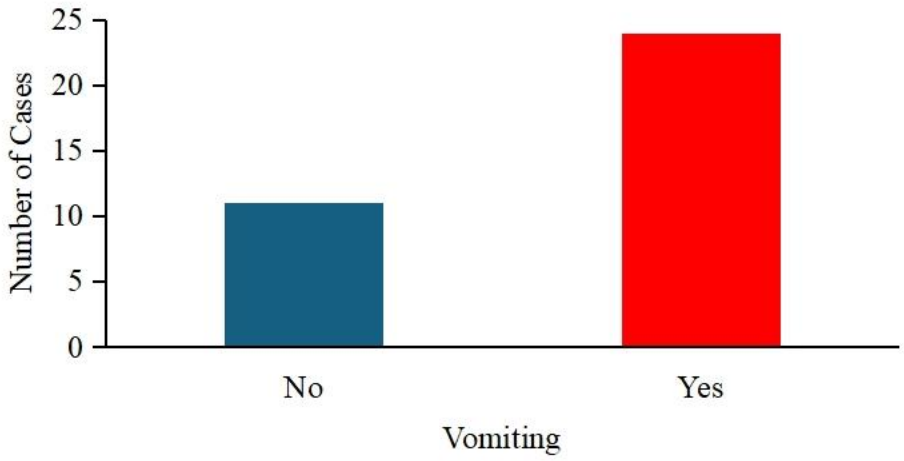


Figure 16:: Count of only vomiting

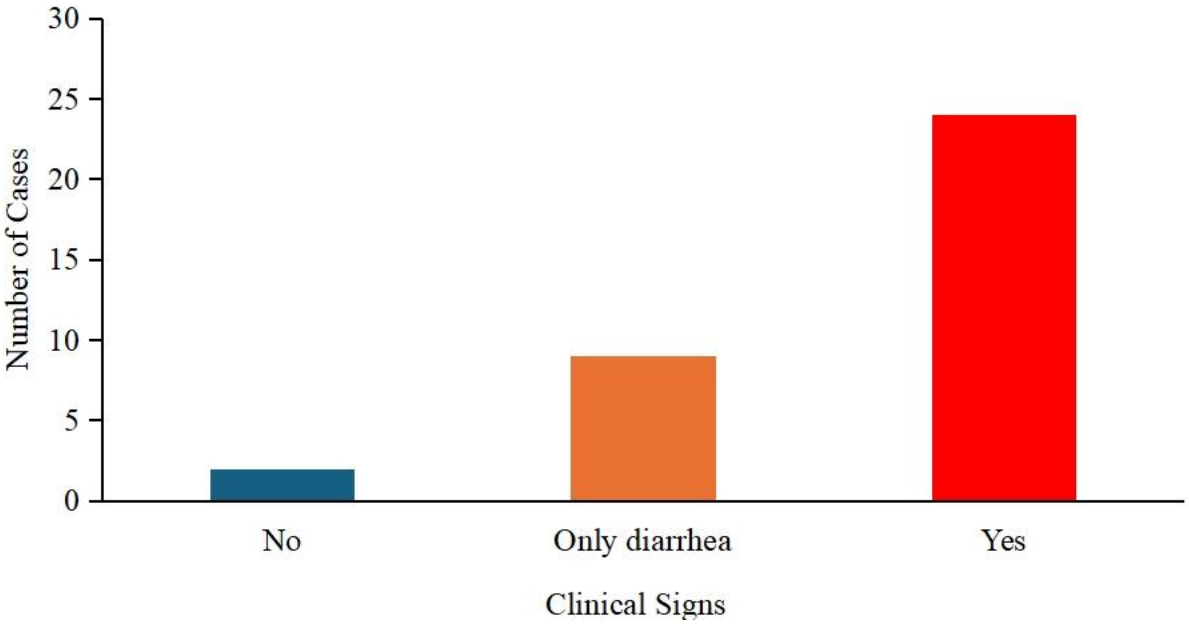


Figure 17: Count of both watery diarrhea and vomiting

4.6. Epicurve of Cholera Outbreak

Figure 18 illustrates the epidemic curve of the cholera outbreak by date of onset covering the period from 05 July 2016 E.C. to 02 September2017 E.C. The outbreak started with 6 cases on 05 July 2016 E.C., followed by a single sporadic case on 19 August 2016 E.C. A sharp rise in cases was observed in late August, increasing from 5 cases on 05 August 2016 E.C. to a peak of 10 cases on 07August 2016 E.C. This was followed by a gradual decline, with 7 cases on 08 August, 2 cases on 09 August, and 1 case on 11 September 2016 E.C., indicating the waning phase of the outbreak. A few residual cases were reported later in September, with 2 cases on 01 September and 1 case on 02 September 2017 E.C. Overall, the epicurve shows a single pronounced peak followed by a steady decline, which is suggestive of a common-source cholera outbreak with effective control measures limiting further transmission.

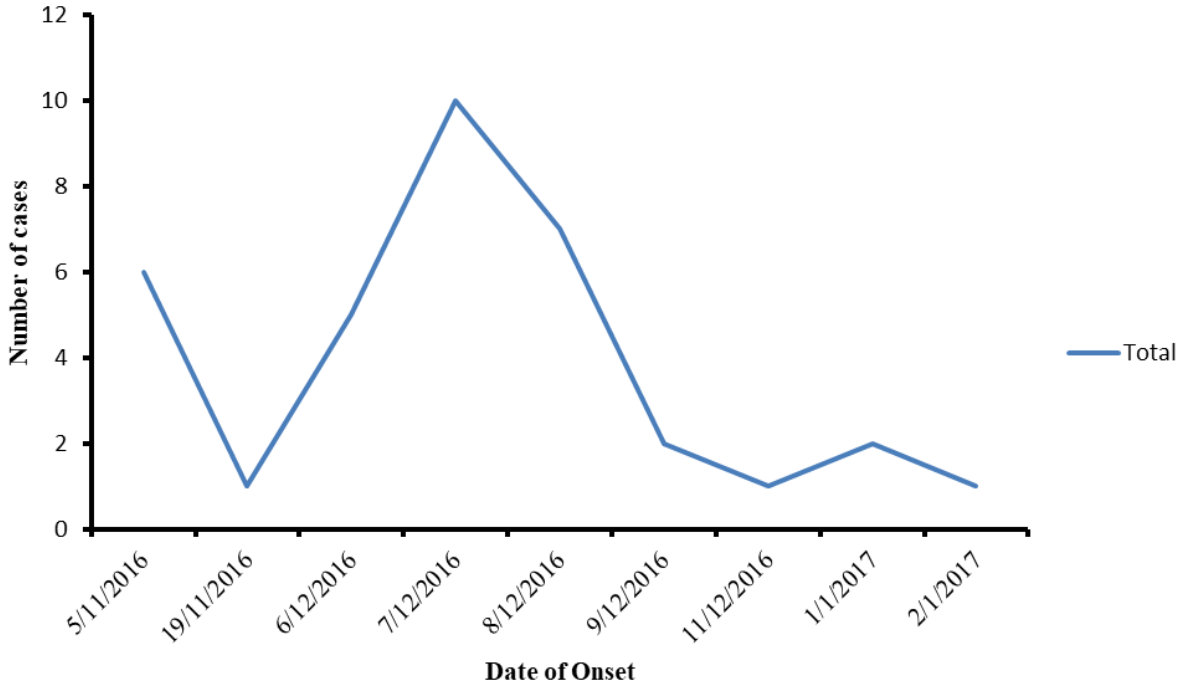


Figure 18: Cholera trends by date of onset

5. Discussion

The results indicate a notable demographic and clinical profile of the outbreak, with unique patterns in gender, age, patient care requirements, and symptom presentation. This outbreak appears to predominantly affect males (94.3% of cases), with a wide age range and significant age variability (mean age 24.67 years, standard deviation 13.92), suggesting potential occupational or behavioral risk factors that may be more common among men. In contrast, only two female cases were observed, both within a similar age range (22-25 years), suggesting limited exposure or different risk dynamics for women. The observed male predominance aligns with findings from similar outbreaks where men, especially younger individuals, were more affected due to occupational exposure or social behaviors that increased their interaction with contaminated water sources. For example, studies on cholera outbreaks in areas with high agricultural or manual labor populations show a higher prevalence among men due to occupational exposure to contaminated water sources.

The balance between inpatient (45.7%) and outpatient (54.3%) care highlights the severity of this outbreak, as nearly half of the cases required hospitalization. This high rate of inpatient care suggests that many patients exhibited severe symptoms, necessitating close monitoring. Comparable outbreaks, such as cholera epidemics in regions with limited access to clean water and sanitation, have shown similar patterns of healthcare demand, where a substantial percentage of cases require hospitalization due to the severity of dehydration and other symptoms. This underscores the importance of adequate healthcare facilities and resources to manage patient loads during such outbreaks. The pie chart visualizing the division between outpatient and inpatient care effectively reflects the healthcare burden, emphasizing the need for preparedness and resource allocation in affected areas.

Occupation data is an essential factor that could reveal high-risk groups in this outbreak such as agricultural workers, miners, or fishermen, were more susceptible due to their frequent exposure to contaminated water. In similar outbreaks, for instance, cholera cases have been concentrated among individuals working close to water bodies or in environments with limited access to clean water. Collecting and analyzing occupation data could provide insights into targeted interventions, such as preventive measures for high-risk occupational groups, which could mitigate the spread and impact of the disease.

The analysis of clinical symptoms reveals that a significant portion of the cases (72.2%) exhibited both watery diarrhea and vomiting, underscoring the severity of gastrointestinal symptoms in this outbreak. Watery diarrhea alone was present in 22.2% of cases, and only 5.6% of cases showed no gastrointestinal symptoms. This clinical presentation is consistent with cholera outbreaks in which dehydration is a major

concern, often resulting from frequent vomiting and diarrhea. The dehydration data show that 36.1% of patients experienced severe dehydration, while another 38.9% had some dehydration, indicating that nearly three-quarters of cases were affected by dehydration to some extent. This distribution aligns with findings from previous cholera studies where dehydration was a primary driver of morbidity and mortality. For instance, in cholera outbreaks in sub-Saharan Africa, a high prevalence of severe dehydration necessitated rehydration therapy and rapid medical response to prevent fatalities.

In this outbreak, the high prevalence of both watery diarrhea and vomiting, coupled with significant dehydration rates, emphasizes the need for hydration-focused treatment protocols. The clinical profile suggests that oral rehydration solutions (ORS) and, in severe cases, intravenous fluids would be critical components of effective case management. Similar outbreaks in low-resource settings have demonstrated that timely rehydration therapy significantly reduces mortality rates, particularly in settings with limited access to healthcare. By comparison, regions that implemented early and adequate hydration interventions saw better patient outcomes and lower-case fatality rates.

In conclusion, the demographic and clinical characteristics of this outbreak, with a high male predominance, significant age variability, and severe dehydration in a substantial number of cases, reflect patterns seen in other cholera-like outbreaks. This highlights the need for rapid response strategies, particularly focused on high-risk groups and dehydration management, to mitigate the impact of such outbreaks. Data on occupation and water source would further enhance the analysis, enabling more precise targeting of prevention and control efforts.

6. Conclusions and Recommendations

6.1. Conclusions

The analysis of the outbreak reveals key demographic, clinical, and care-related characteristics that can guide future response efforts. The data indicates a clear gender disparity, with males accounting for the vast majority of cases (94.3%), suggesting that specific age groups or occupational settings may play a role in exposure risk. The age range among male patients is broad, pointing to varied risk factors across age groups, while the limited female cases fall within a narrower age range. Clinically, the outbreak is marked by a high prevalence of severe symptoms, with nearly half (45.7%) of patients requiring inpatient care and a substantial portion showing signs of severe dehydration. Symptom distribution indicates that watery diarrhea and vomiting are prevalent, leading to dehydration in 75% of cases. This profile aligns with other cholera-like outbreaks, where rapid rehydration and supportive care are crucial for effective management.

Overall, this outbreak underscores the need for robust preparedness measures, particularly in high-risk areas, and a focus on hydration therapy to manage the severe dehydration associated with the disease.

6.2. Recommendations

To improve the management of future outbreaks and reduce the impact on affected populations, the following recommendations are proposed-

- Focus preventive efforts on high-risk occupational groups, such as agricultural workers and miners, who may have greater exposure to contaminated water.
- Implement outreach and education programs for high-risk groups, emphasizing hygiene practices and safe water use.
- Prioritize the availability of ORS and IV fluids in healthcare facilities in high-Prevalence areas.
- Provide training on rapid dehydration assessment and treatment protocols for effective management of severe cases.
- Establish mobile units with rehydration supplies to reach patients in remote or underserved areas promptly.
- Run public health campaigns to raise awareness about safe water, sanitation, and hygiene practices.
- Treat local water sources and enhance sanitation infrastructure in outbreak-prone areas to reduce contamination risks.

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CHAPTER III

A five-year Retrospective study of rabies prevalence in animals and humans in Amhara region

Abstracts

The increasing number of animal and human rabies cases in Ethiopia is a serious public health concern**.** However, little is known about the disease's severity. As a result, we investigated the

prevalence and spread of rabies in the Amhara region in both humans and animals. We conduct a retrospective approach to collect data from various sources, including the Ethiopian Public Health Institute rabies case record book, Ministry of Agriculture, and the Amhara regional state health bureaus to assess rabies cases among animals and humans over the preceding five years and ascertain their spatial distributions, thereby pinpointing high-risk areas within the Amhara region. The results show an increasing trend in human rabies cases and deaths over the five-year period, with the highest numbers reported in 2022. Similarly, the total number of animal rabies cases reported over the five years also fluctuates annually. The total number of human rabies cases reported in the Amhara region shows an increasing trend over the five-year period, with the highest number of cases reported in 2022 (9,053 cases). The total number of human deaths due to rabies also fluctuates over the five-year period, with the highest number of deaths reported in 2022 (39 deaths). The number of rabies death was 18, 23, 27, 39, and 17 in 2019, 2020, 2021, 2022 and 2023, respectively. West Gojam Zone has the highest number of reported cases (8,104 cases) and deaths (49 deaths) during the study period. The total number of animal rabies cases reported varies annually, ranging from 87 cases in 2023 to 331 cases in 2021. The total number of animal deaths due to rabies also fluctuates over the five-year period, ranging from 65 deaths in 2020 to 273 deaths in 2021. Rabies cases were identified in different species, including bovine (16.97%), caprine (11.93%), equine (0.92%), and ovine (0.46%). Canine rabies accounts for the largest portion (69.72%) of the reported rabies cases during the study period. The study recommends collaboration between government agencies, healthcare providers, veterinary services, and community stakeholders to achieve sustained progress in rabies control and prevention efforts. Strengthening surveillance systems, community engagement, implementing mass vaccination campaigns, investing in veterinary and healthcare infrastructure, and implementing targeted interventions in high-risk areas are recommended to address the issue effectively.

1. Introduction

Rabies is a zoonotic viral disease that poses a significant public health threat globally, particularly in regions with inadequate control measures and high populations of free-roaming dogs. In Ethiopia, rabies remains endemic, contributing to considerable morbidity and mortality in both humans and animals. The Amhara region, the second most populous state in Ethiopia, grapples with a notable burden of rabies, presenting challenges to public health authorities and necessitating targeted interventions to mitigate disease transmission. Understanding the prevalence of rabies in Amhara, encompassing both human and animal populations, is crucial for informing effective control strategies and reducing the burden of this deadly disease (Yoak *et al.,* 2021).

Human rabies is a neglected tropical disease, and it is still a disease of significant public health concern in Ethiopia. Although approximately 2000 animal rabies cases have been reported annually, the disease dynamics in different animal species and the spill over to humans remain unclear. As a result, Ethiopia has not yet achieved the international goal of reducing human rabies to 0.1 cases per 100,000 population per year by 2030 (Menghistu *et al.,* 2021; Asfaw *et al.,* 2024; Bahiru *et al.,* 2022).

The increasing number of reported human rabies cases in the Amhara region underscores the urgency of addressing this public health concern. Despite global efforts to eliminate rabies as a public health threat by 2030, Ethiopia continues to face challenges in achieving this goal, with human rabies cases persisting at concerning levels. Limited access to post-exposure prophylaxis (PEP) and inadequate surveillance systems exacerbates the impact of rabies on human health, highlighting the need for comprehensive control measures (Aklilu *et al.,* 2021; Beyene *et al.,* 2020).

In addition to its impact on human health, rabies also poses a significant threat to animal populations in Amhara. Dogs, as the primary reservoir of rabies virus transmission to humans, play a central role in the epidemiology of the disease, with canine rabies accounting for the majority of reported cases. However, rabies also affects other animal species, including livestock, wildlife, and stray animals, contributing to economic losses and further complicating control efforts (Beyene *et al.,* 2020; Knobel *et al.,* 2017).

Despite the recognition of rabies as a preventable disease, gaps in surveillance, vaccination coverage, and public awareness persist in the Amhara region, hindering progress towards rabies control and elimination. This study aims to address these knowledge gaps by assessing the prevalence of rabies in Amhara, examining the spatial and temporal distribution of cases in both humans and animals, and identifying priority areas for intervention. By elucidating the epidemiological dynamics of rabies in Amhara, this research seeks to inform evidence-based strategies for controlling and ultimately eliminating rabies in the region. This retrospective study paper sets out to collect, temporal distribution of rabies cases from 2019 to 2023 in the Amhara region and identify the hotspot areas of the disease in the region..

1.1 Background

The Amhara Region is the second most populous state and the political center of the country. Bahir Dar is the capital city of the Amhara Region. The region presents a diverse variety of geographic landscapes and agro ecological zones. According to the Central Statistical Agency of Ethiopia, the human population of the Amhara region will reach more than 21 million in 2020. The region is inhabited by 700,000 dogs, and its human-to-dog ratio is estimated at 28.57:1. Previous reports showed the absence of an adequate dog vaccination strategy and rabies surveillance system in the region. However, it is only recently that a stronger political will for rabies control in the region has emerged with the new strategic plans by the government aiming at the eventual elimination of human rabies cases by 2030, which is in line with the global strategic plan goal of zero human rabies deaths by 2030. This plan includes mass dog vaccination, continuous anti-rabies public awareness, and increasing the accessibility of human post-exposure prophylaxis (PEP) throughout the country. Consequently, there has been progress in the nation-wide integrated bite case management guideline by the Ethiopian Federal Ministry of Health and the National Rabies Control Task Force, of which the researchers are part. There are a number of factors that affect the success of rabies surveillance and control strategies. Lack of political commitment, a low level of public awareness, inappropriate patient treatment-seeking behavior, inadequate infrastructure, can hinder progress. Rapid demographic dynamics in the region, the increased interaction between humans and animals and their shared environment, and the slow adoption of the One Health approach have added to the complexity of rabies control in the region. However, there is hope for successful rabies prevention and control in the region. One Health is

a novel approach that embraces the collaboration of multiple sectors and disciplines to address health issues, such as incorporating animal vaccination, human health education, and enhanced surveillance practices (Wolelaw *et al.*, 2022). The value of the One Health approach has been realized through the establishment of the National Rabies Control Task Force in Ethiopia. Such collaboration enables a more holistic management of rabies while at the same time increasing knowledge of disease ecology and providing opportunities for enhancing veterinary public health practices in the country. The successful project of rabies-free zones in Tanzania through the application of the One Health approach can serve as an experience for the control of rabies in the Amhara region through the adoption of similar methodologies. The plan for the dog vaccination strategy, the political commitment from regional authorities, and the gradual establishment of the surveillance system have provided the necessary background for the implementation of future research and control strategies. By providing the research findings in this study, it is believed that the government and the regional health authorities will have updated epidemiological information to inform the further improvement of rabies prevention and control strategies. This is essential for making control efforts evidence-based and also for establishing research programs that involve continuous monitoring of control impacts and the development of enhanced intervention strategies. Moreover, the empowerment of community social participation through such programs would potentially create ripple effects of awareness, education, and collective actions towards the elimination of rabies in both animal and human populations. (Worku *et al.,* 2023; Aklilu *et al.,* 2021; Saleh *et al.,* 2020)

1.2 . Objectives

1.2.1. General Objective

To examine rabies cases among animals and humans over the past five years and to assessing the spatial distributions of rabies cases and identify high-risk areas within the study area.

1.2.2 Specific objectives

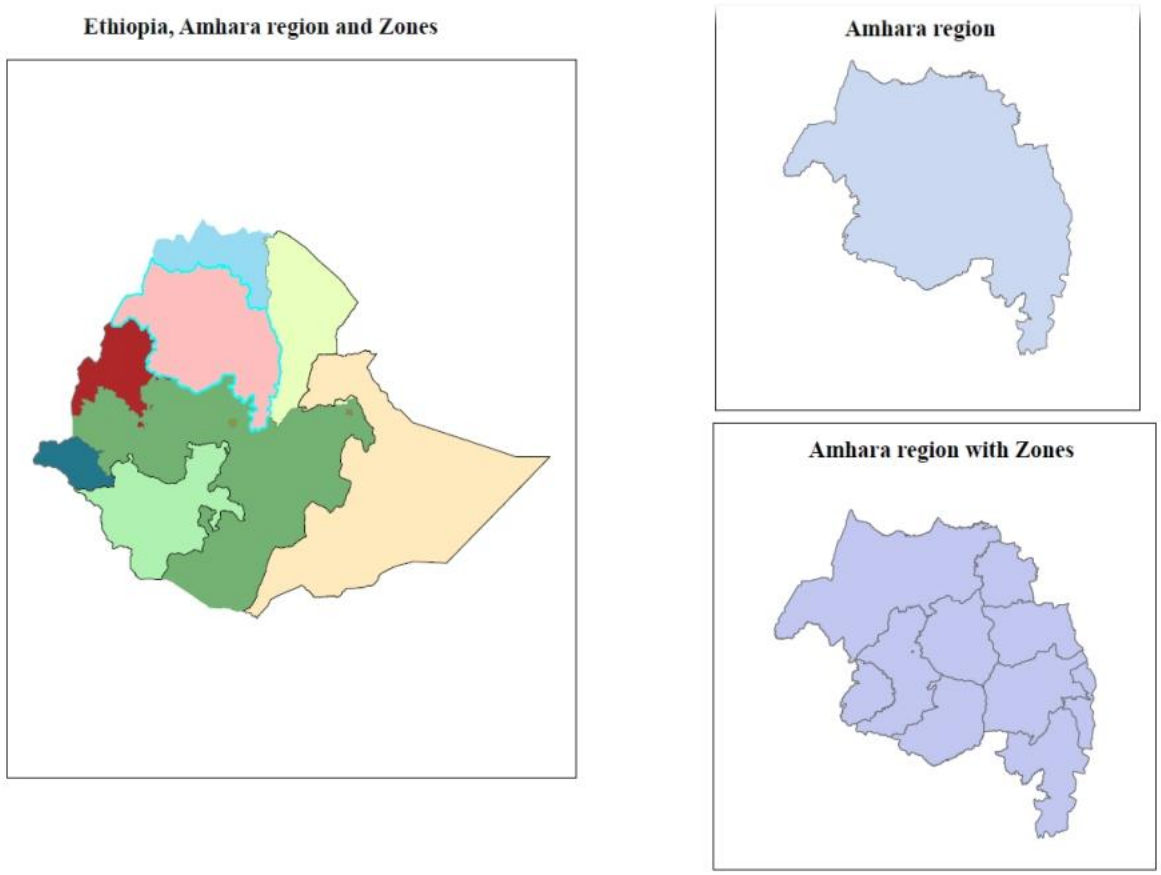
- This study included conducting a comprehensive data analysis on the prevalence of rabies among humans and animals in Amhara Region.
- Identifying the most commonly affected animal species and seasons for rabies.

- Assessing the spatial and temporal trends of rabies in animals and humans over the five-year study period

2. Methodology

2.1. Study area

This study is focused on examining the burden of Rabies both in humans and animals in Amhara region. The Amhara region is located in the north western part of Ethiopia between 9°20′ and 14°20′ North latitude and 36° 20′ and 40° 20′ East longitude. The region covers approximately 159,173.66 km^2 areas; the region has an estimated density of 120 persons per km^2. The Amhara region is the second most densely populated region in Ethiopia. The region is divided in to twelve administrative zones, 3 metropolitan cities, 158 woredas and 46 towns. About 90.85% of the population lives in rural areas. The regional economy is heavily dependent on agriculture with subsistence farming.



Map 1: Map of the study area showing the Amara region within Ethiopia and study zones within Amhara region.

2.2 Study design and duration

A retrospective study conducted to measure the size of the problem. Five years, from 2019 to 2023, rabies surveillance data in Amhara region presented; and then descriptive statistical analysis used.

2.3. Data Collection

There was no information on the population of dogs in the region. There are many dogs in the region, both owned and wandering freely, according to a recent study (Bahiru *et al.*, 2022). According to the same survey, one out of every thirteen families had a dog, and there were an average of 1.3 dogs per dog-owning household. Complete records of dog bite and rabies case investigations and reports for the previous five years are available from the Ministry of

Agriculture (MoA), the Ethiopian Public Health Institute, and the regional state bureaus in Amhara. The data records include case-based reports such as the animal and human cases, date of dog bite and date of last vaccination, season at which the cases and bite occurred, clinical signs, laboratory confirmation result, date of sample submission to the diagnostic laboratories, and epidemiological investigation findings of the case. The record book for animal rabies cases includes zones, woredas, kebeles, outbreak reference number, diagnosis status, species, age, cases, deaths, etc.

2.4. Data analysis

Data obtained from the aforementioned documents will enter into Microsoft Excel 2010 Version spread sheet will be used for summarizing and analysis of the data to describe the disease by person place and time. Employ statistical methods to analyze the collected data, including descriptive statistics, trend analysis, and spatial mapping techniques.

After examining the data for outliers, consistency, completeness, and typographical errors, we reorganized the variables and content. The 'Pivot Table' feature in Microsoft Excel was utilized to summarize and analyze the data in order to characterize the sickness by person, time, place, and animal.

3. Results

3.1. Rabies in Humans

3.1.1. Year Vs Prevalence

The total number of 24,432 human rabies cases reported in the Amhara region shows an increasing trend notable rise in the number of reported cases from 2019 to 2022, followed by a slight decrease in 2023. It was over the five-year period, with the highest number of cases reported in 2022 (9,053 cases). There is a observed that the number of human rabies exposure cases coming to health centers increases from year to year. The numbers of suspected exposure cases were 991, 2822, 6055, 9053 and 5511 that reported in 2019, 2020, 2021, 2022 and 2023, respectively. The temporal pattern showed similarity except in 2023 where a significant decrease in the number of suspected exposure cases observed, 5511 cases.

A total 124 human deaths recorded over the five-year period. The total number of human deaths due to rabies also fluctuates over the five-year period, with the highest number of deaths reported in 2022 (39 deaths). While there is an overall increasing trend in the number of deaths from 2019 to 2022, there is a decrease in the number of deaths reported in 2023.

The mortality rate, calculated as the percentage of human deaths among total human cases, varies annually. However, there is a decreasing trend in the mortality rate from 2019 to 2023, indicating a reduction in the proportion of deaths relative to the total number of cases over time. Notably, the mortality rate was highest in 2019 (1.816%) and lowest in 2023 (0.308%). The numbers of rabies death cases were 18, 23, 27, 39, and 17 in 2019, 2020, 2021, 2022 and 2023, respectively. In contrast, the percentages of rabies death cases showed in detrimental pattern. As shown in the table 1 and figure 1. The number rabies death cases were in 2019, 2020, 2021, 2022 and 2023, 18 (1.816%), 23 (0.815%), 27 (0.446%), 39 (0.431%), and 17 (0.308).

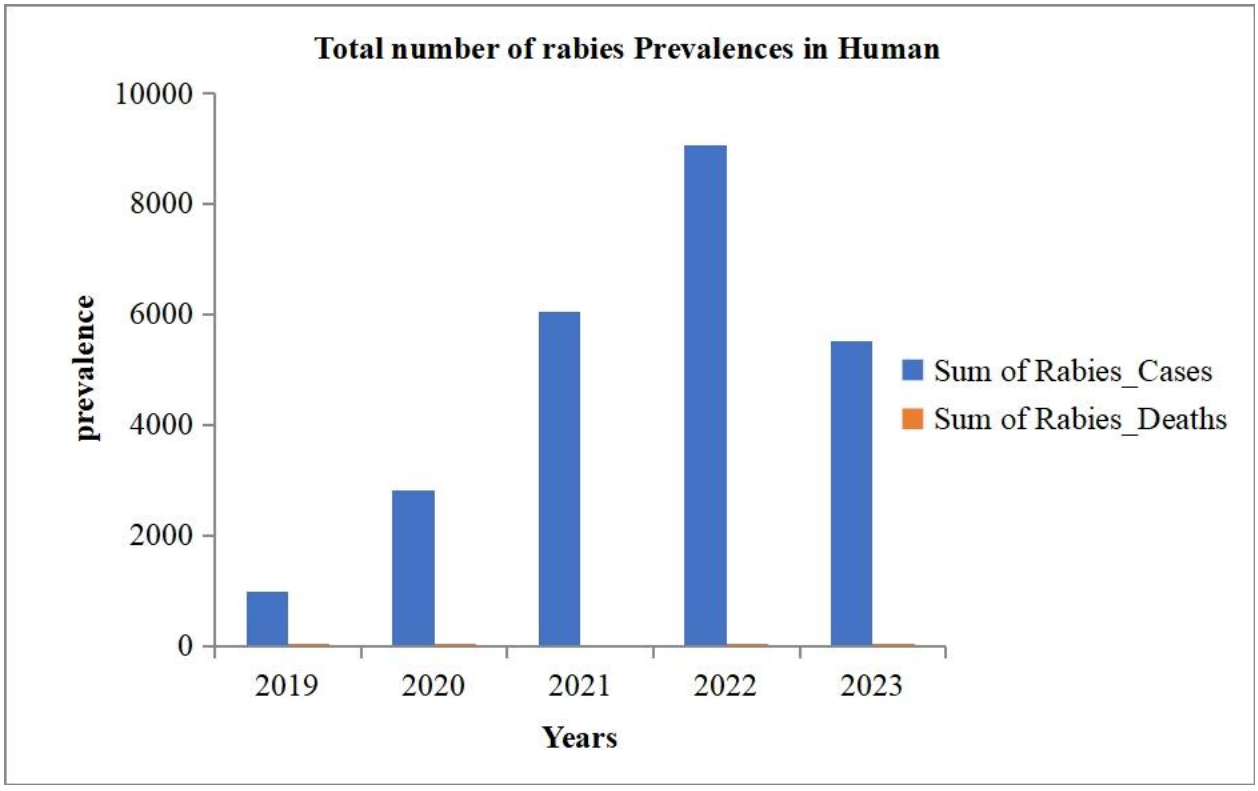


Figure 18: Total number of rabies Prevalence in Human

3.1.2. Zones Vs prevalence

The retrospective study of human rabies cases reported from 2019 to 2023 in the Amhara region provides valuable insights into the distribution and impact of rabies across different zones. Analysis of the data reveals significant variations in the number of reported cases and deaths among the various zones. West Gojjam Zone has the highest number of reported cases (8,104 cases) and deaths (49 deaths) during the study period as referred in table 1. This zone accounts for a substantial portion of the total cases and deaths in the region, indicating a significant burden of rabies. Central Gondar Zone also reports a high number of cases (4,386 cases) but relatively low deaths (10 deaths), suggesting a relatively lower mortality rate compared to the total cases. Other zones with notable numbers of reported cases include East Gojjam (3,804 cases), South Wollo (1,330 cases), and Awi (945 cases).

North Gondar, North Shewa, North Wollo, Oromia Special Zone, Wag Himra, and West Gondar zones report fewer cases, with varying numbers of deaths. Notably, some zones report low or zero mortality, such as Oromia Special Zone and North Wollo.

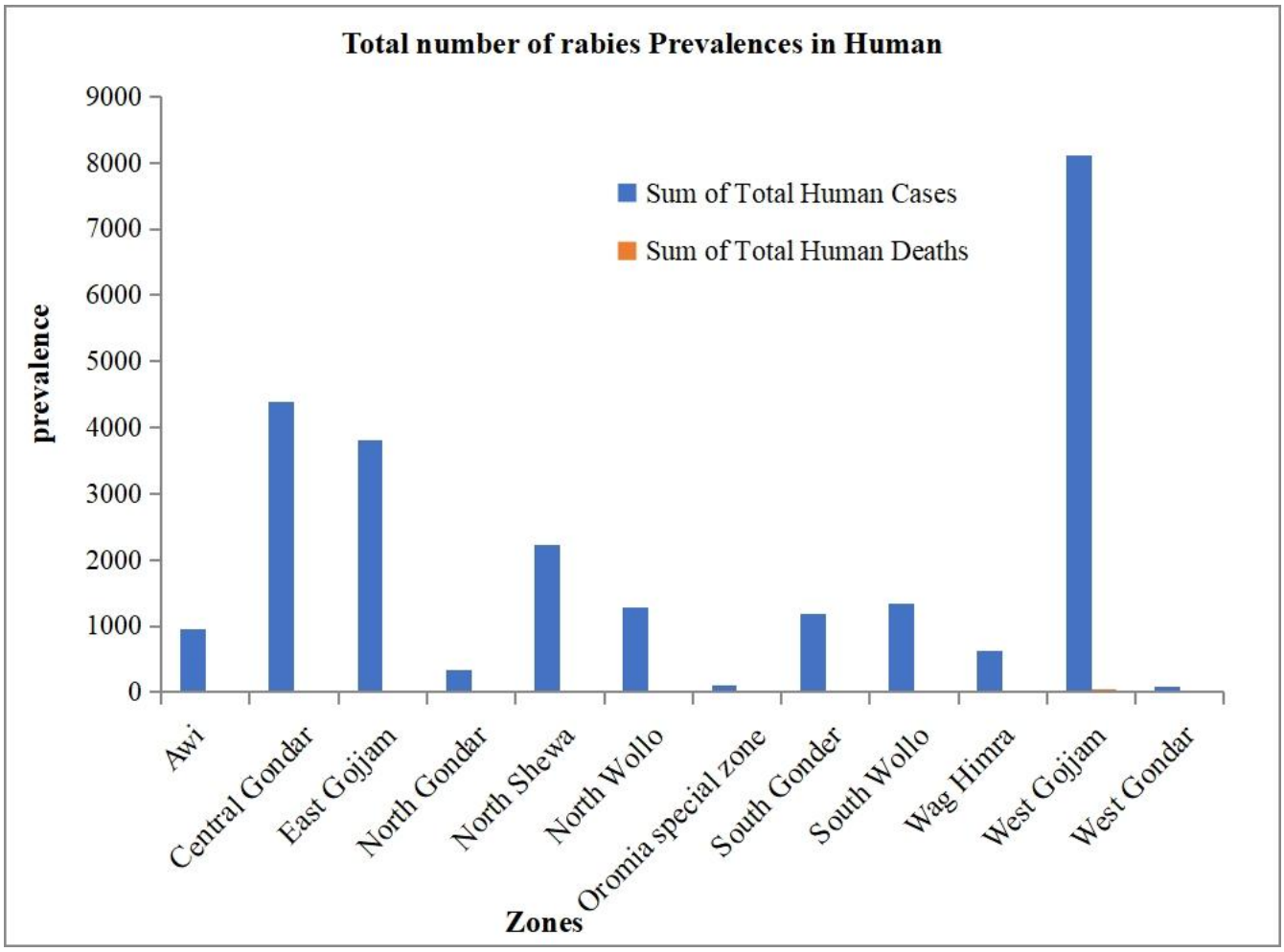


Figure 19: Total number of rabies Prevalence in Human

3.2. Rabies in Animals

3.2.1. Year Vs. prevalence

The retrospective study of animal rabies cases reported from 2019 to 2023 in the Amhara region provides valuable insights into the prevalence and impact of rabies in animals. Analysis of the data reveals notable trends and patterns. The total number of animal rabies cases reported over the five-year period varies annually, ranging from 87 cases in 2023 to 331 cases in 2021. There is no clear trend in the number of reported cases, with fluctuations observed from year to year. The total number of animal deaths due to rabies also fluctuates over the five-year period, ranging from 65 deaths in 2020 to 273 deaths in 2021. Similarly, there is no clear trend in the mortality rate over the five-year period, with fluctuations observed from year to year.

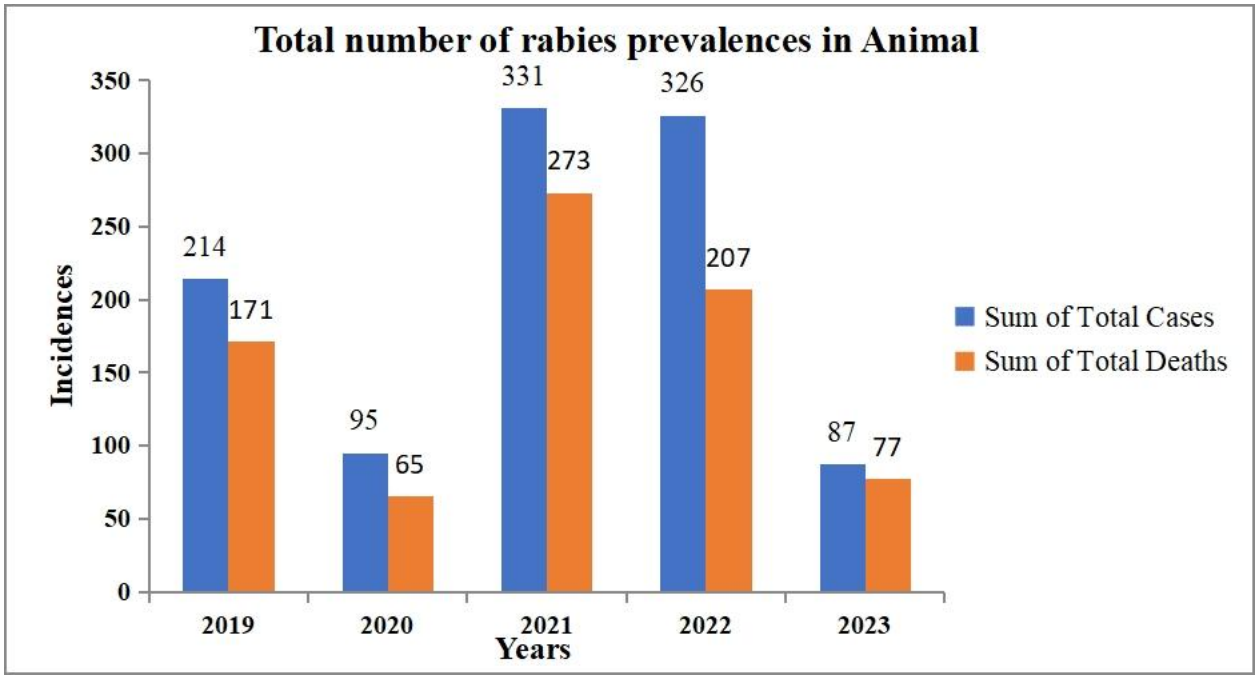


Figure 20: Total number of rabies Prevalence in Animals

3.2.2. Zones Vs Prevalence

The retrospective study of animal rabies cases reported from 2019 to 2023 in the Amhara region provides insights into the distribution and impact of rabies across different zones. The total number of animal rabies cases reported varies significantly across different zones, ranging from 7 cases in South Gonder to 210 cases in East Gojjam. East Gojjam, North Shewa, and South Wollo are among the zones with the highest number of reported cases, indicating a relatively higher prevalence of rabies in these areas. Some zones, such as South Gonder and Oromia Special Zone, report a lower number of cases compared to other zones.

The total number of animal deaths due to rabies also varies across different zones, with East Gojjam, North Shewa, and West Gondar reporting a higher number of deaths. Central Gondar and West Gondar zones report a high number of deaths compared to the total number of cases, suggesting a higher mortality rate in these areas. Some zones report a relatively lower number of deaths compared to the total number of cases, indicating better management and treatment protocols in those areas.

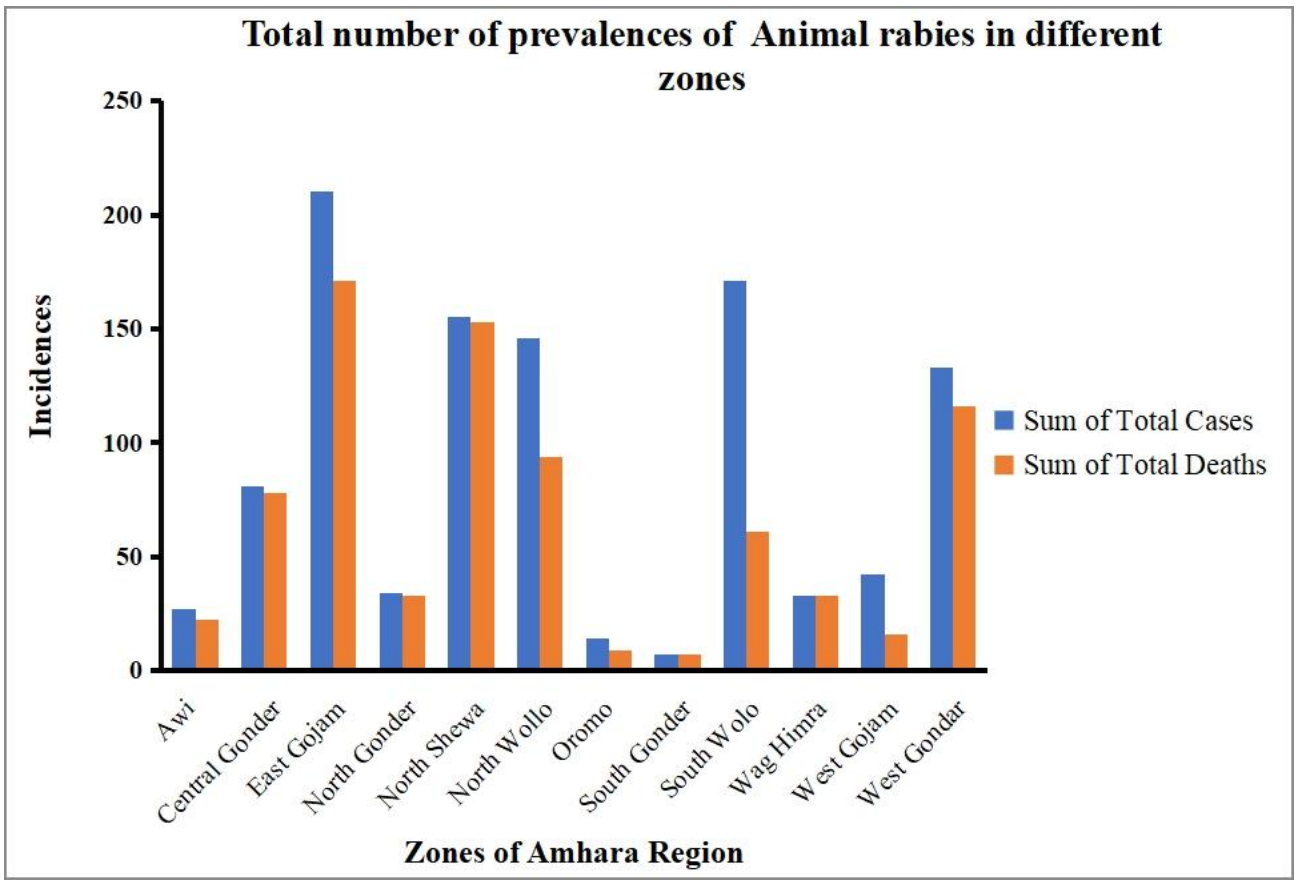


Figure 21: Total number of prevalence of Animal rabies in different zones

3.2.3. Cases Vs Species

The prevalence of rabies by species in a retrospective study conducted in the Amhara region between 2019 and 2023 indicates that rabies cases identified in different species, including bovine (16.97%), caprine (11.93%), equine (0.92%), and ovine (0.46%). While the prevalence of rabies in these species significantly lower compared to canines. As shown in the pie chart canine rabies accounts for the largest portion (69.72%) of the reported rabies cases during the study period. This suggests that dog bites are the primary route of rabies transmission in the region.

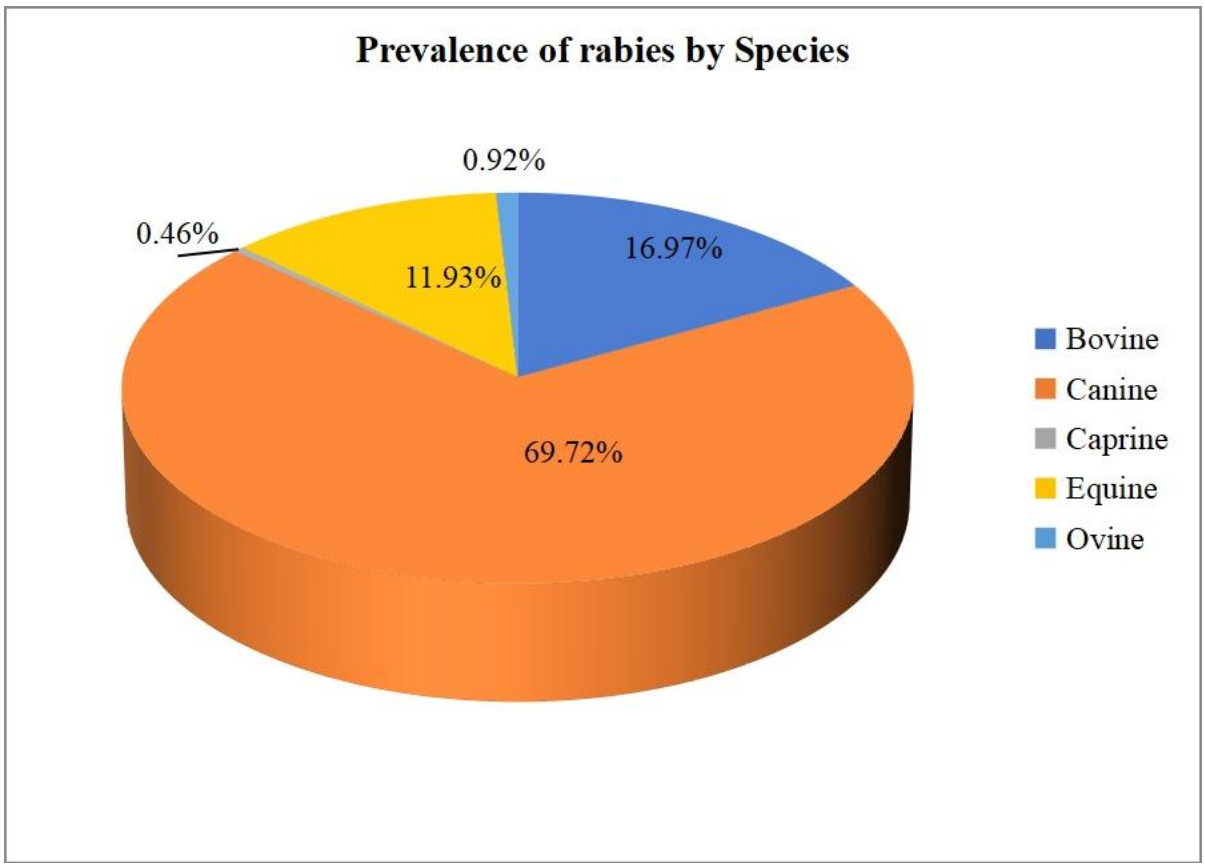


Figure 22: Prevalence of rabies by Species

3.3.Human and Animal

3.3.1. Year Vs Prevalence in Human Vs Prevalence in Animal

There is a significant increase in human rabies cases from 2019 to 2022, with a slight decrease in 2023. The total human cases reported over the five-year period are 24,432. However, the number of animal rabies cases fluctuates annually, with peaks in 2021 and 2022. The total animal cases reported over the same period are 1,053. Human deaths due to rabies also show an increasing trend from 2019 to 2022, followed by a slight decrease in 2023. The total human deaths reported over the five-year period are 124. Similar to human cases, animal deaths due to rabies fluctuate annually, with peaks in 2021 and 2022. The total animal deaths reported over the same period are 793.

Human rabies cases outnumber animal rabies cases significantly each year. Similarly, human deaths due to rabies are higher than animal deaths each year. Human mortality rate of human deaths among total human cases, varies annually, with the highest rate in 2019 (1.816%) and the lowest rate in 2023 (0.308%). Animal mortality rate of animal deaths among total animal cases, also varies annually, with the highest rate in 2019 (79.91%) and the lowest rate in 2023 (88.51%).

Table 9: Total number of rabies prevalence in Human and in Animals over years

Roll No	Years	Total Human Cases	Total Human Deaths	Total Animal Cases	Total Animal Deaths
1	2019	991	18	214	171
2	2020	2822	23	95	65
3	2021	6055	27	331	273
4	2022	9053	39	326	207
5	2023	5511	17	87	77
Grand Total		**24432**	**124**	**1053**	**793**

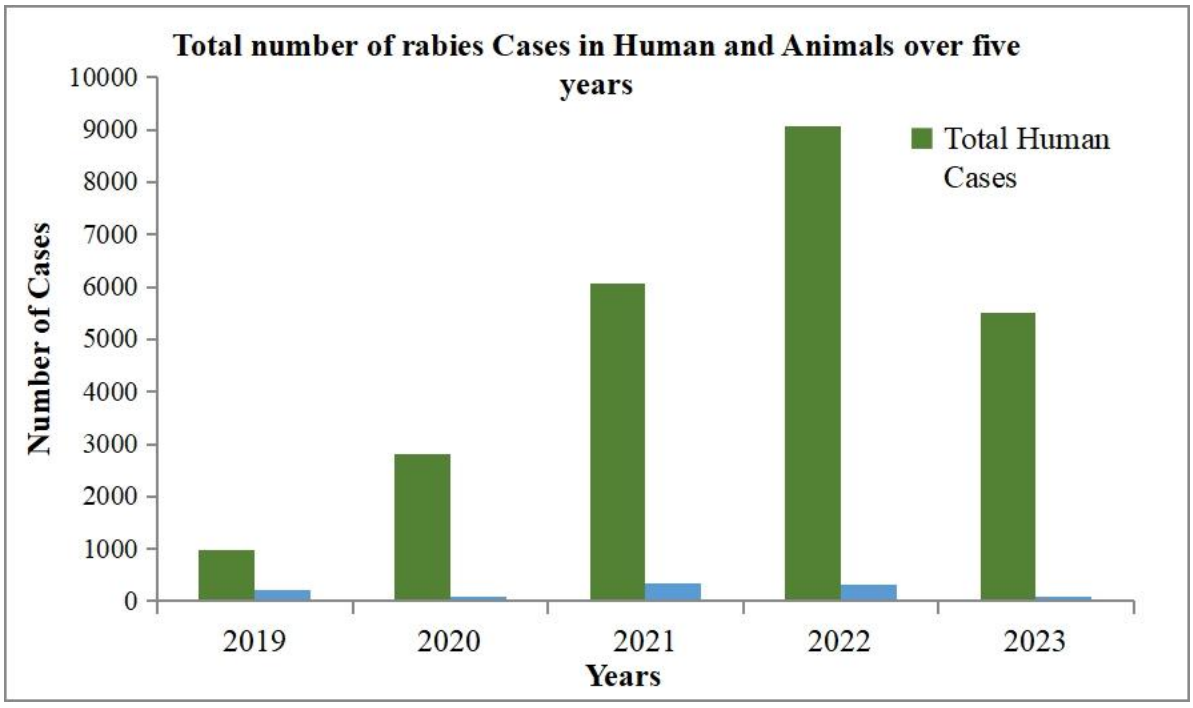


Figure 23: Total number of rabies Cases in Human and Animals over five years

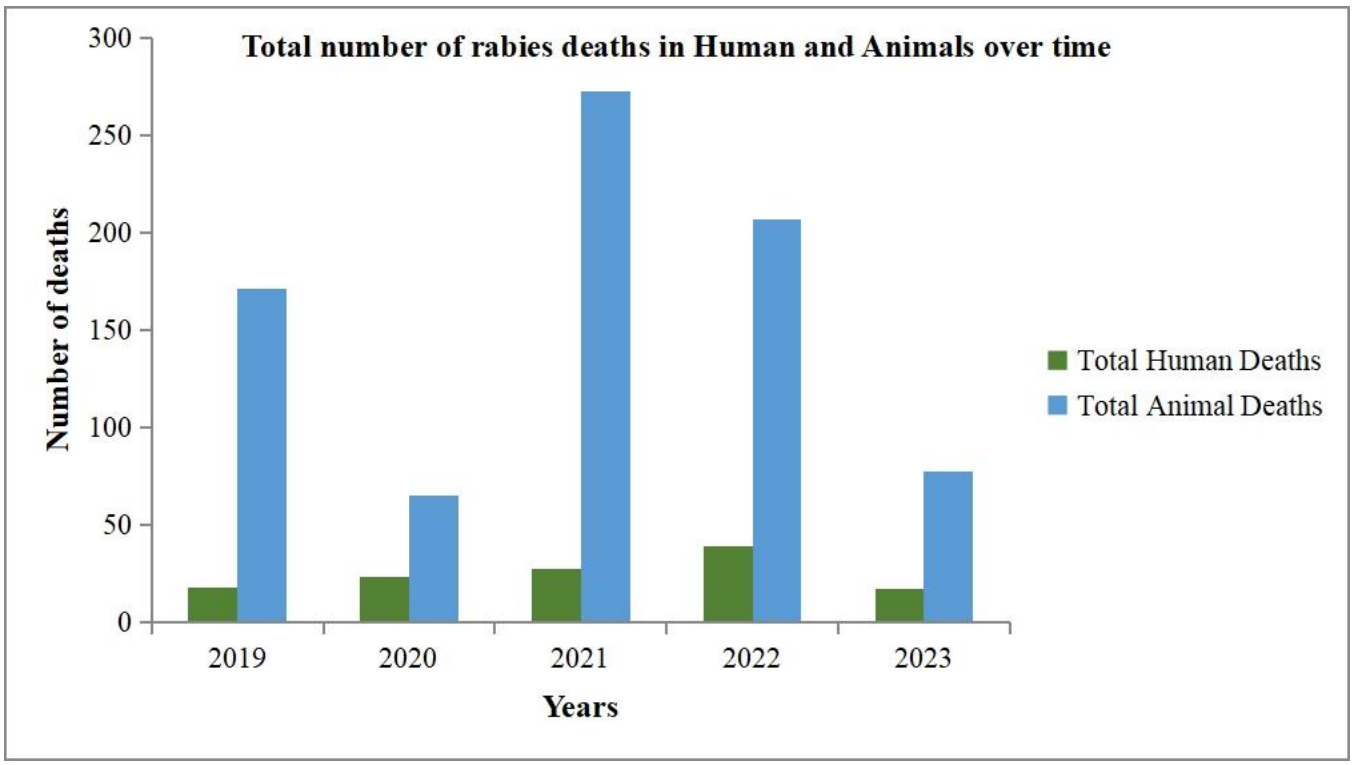


Figure 24: Total number of rabies deaths in Human and Animals over time

3.3.2. Zones Vs prevalence in Human Vs prevalence in Animal

The total number of human rabies cases reported varies significantly across different zones, with West Gojjam having the highest number of cases (8,104) and West Gonder having the lowest number of cases (88). Similarly, the total number of animal rabies cases reported varies across zones, with East Gojam reporting the highest number of cases (210) and South Gonder reporting the lowest number of cases (7). The total number of human deaths due to rabies also varies across zones, with West Gojjam reporting the highest number of deaths (49) and Oromia special zone reporting no deaths. The total number of animal deaths due to rabies varies across zones, with East Gojam reporting the highest number of deaths (171) and South Gonder reporting the lowest number of deaths (7).

In most zones, human rabies cases outnumber animal rabies cases, indicating a higher burden of rabies in humans compared to animals. Mortality rate of human deaths among total human cases and animal deaths among total animal cases varies across zones. However, human deaths due to rabies are lower than animal deaths in all zones.

Table 10: Total number of rabies prevalence in Human and in Animals in different zones

Roll No	**Zones**	**Total Human Cases**	**Total Human Deaths**	**Total Animal Cases**	**Total Animal Deaths**
1	Awi	945	17	27	22
2	Central Gondar	4386	10	81	78
3	East Gojjam	3804	15	210	171
4	North Gondar	336	1	34	33
5	North Shewa	2227	3	155	153
6	North Wollo	1288	1	146	94
7	Oromia special zone	102	0	14	9
8	South Gonder	1193	9	7	7
9	South Wollo	1330	10	171	61
10	Wag Himra	629	2	33	33
11	West Gojjam	8104	49	42	16
12	West Gondar	88	7	133	116
Grand Total		**24432**	**124**	**1053**	**793**

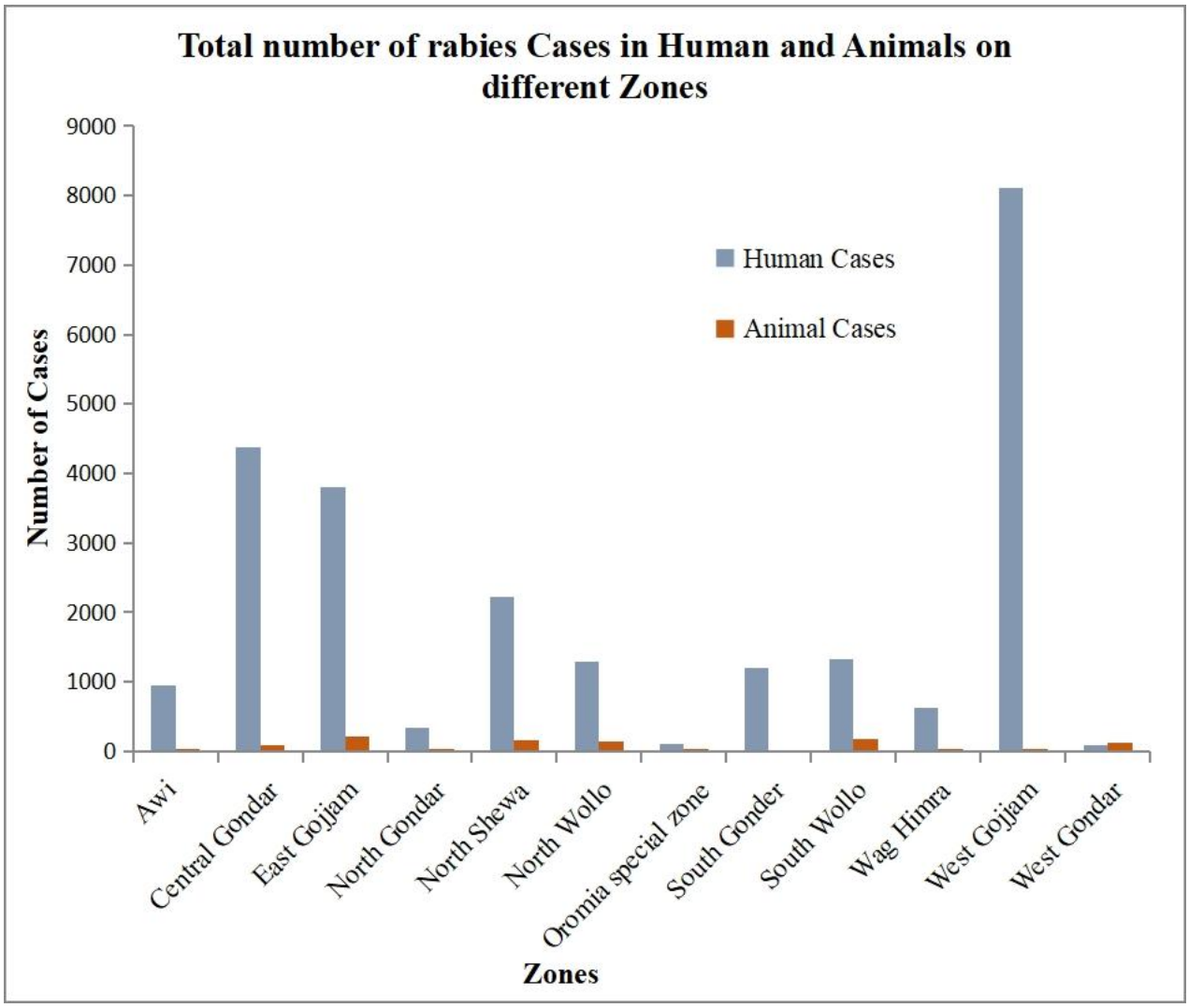


Figure 25: Total number of rabies Cases in Human and Animals on different Zones

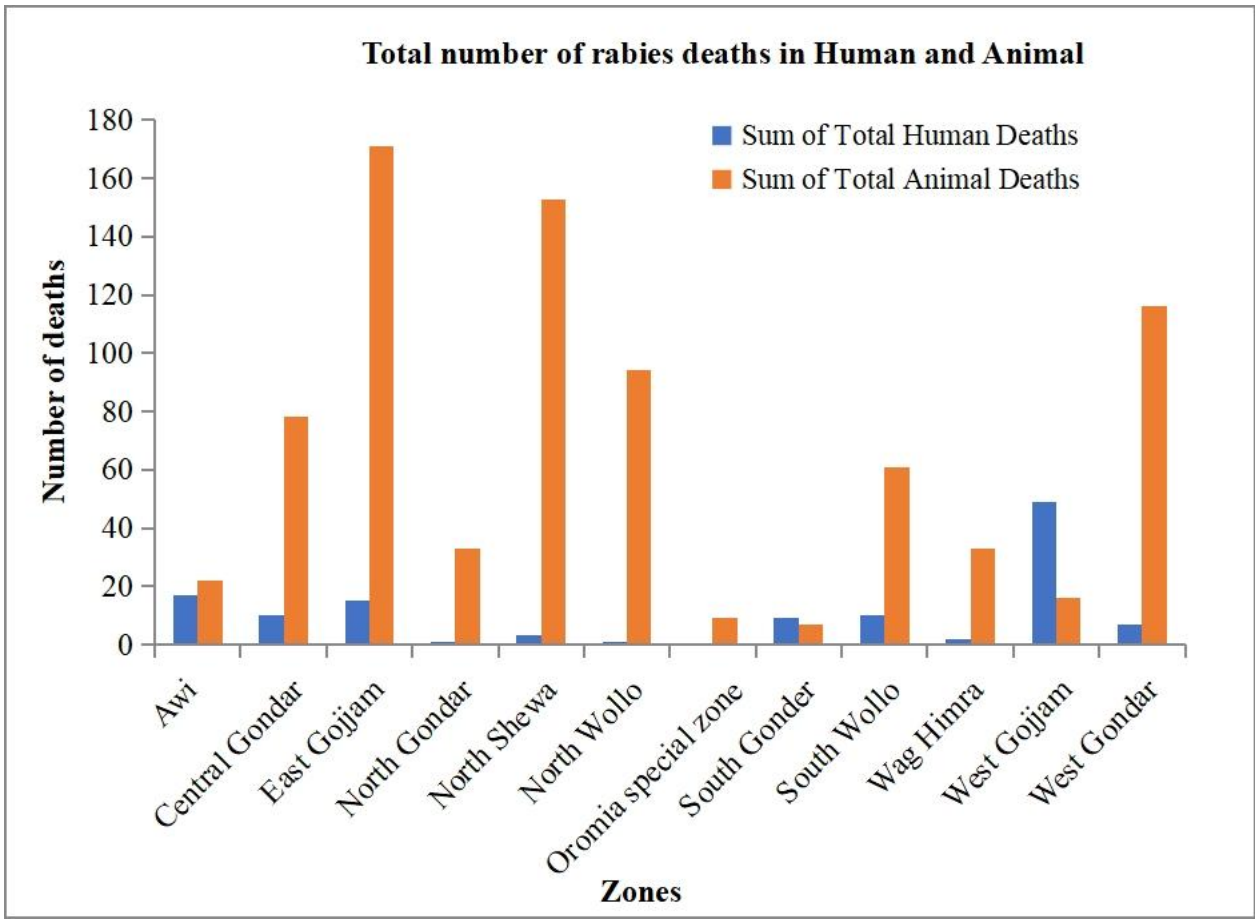


Figure 26: Total number of rabies deaths in Human and Animals

4. Discussion

The study identified an escalating trend in human rabies cases over the five-year period, with the highest number of cases reported in 2022. The analysis of rabies prevalence in Amhara revealed distinct patterns across different zones and years, shedding light on the regional variations in disease burden and transmission dynamics. The finding corroborates previous studies highlighting the persistent threat of rabies to human health in Ethiopia (Damtie *et al.,* 2018). The fluctuation in human rabies cases across years reflects the dynamic nature of disease transmission, influenced by various factors such as population density, dog demographics, and vaccination coverage (Beyene *et al.,* 2020).

While the total number of cases and deaths varies from year to year, there is no consistent trend in the prevalence or mortality rate of animal rabies over the study period. The total number of human rabies cases reported over the five years is 24,432, with the highest number of cases reported in 2022 (9,053) and the lowest in 2019 (991). Human deaths due to rabies total 124 over the five-year period, with the highest number of deaths reported in 2022 (39) and the lowest in 2023 (17). There is an overall increasing trend in human rabies cases from 2019 to 2022, followed by a slight decrease in 2023. However, the number of deaths fluctuates annually. Similarly, the total number of animal rabies cases reported over the five years is also 1,053, with the highest number of cases reported in 2021 (331) and the lowest in 2023 (87). Animal deaths due to rabies total 793 over the five-year period, with the highest number of deaths reported in 2021 (273) and the lowest in 2020 (65). Similar to human cases, there is an overall increasing trend in animal rabies cases from 2019 to 2021, followed by a decrease in 2022 and 2023. The number of deaths fluctuates annually. The number of human and animal deaths due to rabies shows variations across the years, with the highest numbers reported in 2022 in human and in 2021 in Animals. These findings underscore the importance of on-going surveillance and control measures to effectively combat the spread of rabies and reduce its impact on both human and animal populations.

Similarly, the study observed variations in animal rabies cases across different zones and years. Canine rabies emerged as the predominant contributor to animal rabies cases, consistent with global trends highlighting dogs as the primary reservoir of rabies virus transmission to humans (Fooks *et al.,* 2017).

The fluctuation in animal rabies cases over the study period reflects the complex interplay of ecological, environmental, and socio-economic factors influencing disease transmission dynamics (Beyene *et al.,* 2020). The identification of specific animal species affected by rabies, such as bovine, caprine, equine, and ovine, underscores the importance of targeted vaccination campaigns and control measures tailored to the local context.

The spatial distribution of rabies cases revealed geographic clustering, with certain zones reporting higher case numbers than others. Factors such as urbanization, animal management practices, and proximity to wildlife habitats may contribute to spatial variations in disease prevalence (Beyene *et al.,* 2020).

Moreover, the temporal analysis of rabies cases highlighted year-to-year fluctuations in disease Prevalence, emphasizing the need for sustained surveillance and control efforts to address seasonal variations and emerging outbreaks effectively (Knobel *et al.*, 2017).

In order to gain a more comprehensive understanding of the prevalence of human rabies, it is crucial to analyse the geographic distribution of cases. By examining the differences in human rabies exposure cases from zone to zone in the region, we can identify specific areas that require targeted intervention and vaccination efforts. This approach will allow for a more effective allocation of resources to areas with the highest Prevalence of human rabies, ultimately aiding in the reduction of transmission and the implementation of targeted prevention strategies. The data provided for different zones in the Amhara region shows variations in the number of human and animal rabies cases and deaths across different areas. Similarly, East Gojjam zones report higher numbers of animal cases and deaths compared to other zones. There are differences in the distribution of cases and deaths across zones, highlighting variations in the prevalence and impact of rabies in different areas of the region. The analysis revealed West Gojjam Zone as the hotspot for human rabies cases, reporting the highest number of cases and deaths during the study period. This concentration of cases in specific zones underscores the importance of targeted interventions and surveillance efforts in high-risk areas to mitigate disease transmission (Beyene *et al.,* 2020). Understanding these regional variations is crucial for targeted intervention strategies and resource allocation to effectively address the burden of rabies in specific areas within the region.

While there are fluctuations in both human and animal rabies cases and deaths over the years, humans consistently experience a higher burden of rabies compared to animals in the Amhara region. These findings underscore the need for continued surveillance, prevention, and control efforts to reduce the Prevalence and impact of rabies on both human and animal populations.

5. Conclusion and recommendations

The intricate interactions between humans and animals, socioeconomic factors, and environmental factors that affect the prevalence of rabies in Amhara.. Targeted interventions, including mass vaccination campaigns, community awareness programs, and enhanced surveillance systems, are essential to mitigate the burden of rabies and achieve sustainable control and elimination efforts in the region.

Collaboration between government agencies, healthcare providers, veterinary services, and community stakeholders is essential to achieve sustained progress in rabies control and prevention efforts. Based on the analysis of the provided data from both tables detailing human and animal rabies cases and deaths in the Amhara region, several recommendations and interventions suggested to address the issue effectively.

2. It is crucial to strengthen surveillance systems for both human and animal rabies cases to ensure timely detection and reporting. Implementing robust reporting mechanisms at healthcare facilities and veterinary clinics can facilitate early intervention and control measures. Furthermore, establishing a centralized database for collating and analysing rabies data can provide valuable insights into disease trends and hotspots.
3. Community engagement is essential in raising awareness about rabies prevention and control measures. Conducting targeted educational programs in high-risk areas can help educate communities about the importance of vaccination for both humans and animals, responsible pet ownership practices, and the need to seek prompt medical care in case of animal bites or scratches. Additionally, promoting the importance of reporting any suspected cases of rabies to local authorities can aid in early intervention and containment efforts.
4. Implementing mass vaccination campaigns for domestic animals, particularly dogs, is crucial in controlling the spread of rabies. Collaborating with local veterinary services to provide

accessible and affordable vaccination services to pet owners can help achieve high vaccination coverage rates. Additionally, implementing measures to control the population of stray animals, such as dog population management programs, can further reduce the risk of rabies transmission within communities.

5. Investing in veterinary and healthcare infrastructure is essential to ensure adequate provision of rabies prevention and treatment services. This includes equipping healthcare facilities with rabies vaccines and immunoglobulins for post-exposure prophylaxis, as well as providing training to healthcare workers on rabies diagnosis and management. Similarly, strengthening veterinary clinics and laboratories can enhance diagnostic capabilities and facilitate the monitoring of rabies in animal populations.
6. Given the variations in rabies cases and deaths across different zones within the Amhara region, targeted interventions should be tailored to address specific needs and challenges in high-risk areas. This may include deploying mobile vaccination teams to remote communities, conducting door-to-door vaccination campaigns, and implementing community-based surveillance systems to monitor disease activity.

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Chapter IV

Evaluation of Surveillance System

Summary

Background: Malaria and measles remain major public health challenges in Ethiopia, with Oromia Region bearing a heavy burden. Malaria causes millions of cases annually, while measles

continues to trigger outbreaks due to gaps in immunization coverage. Sheger City, established in 2022, has reported a high malaria caseload but has not yet undergone a formal surveillance system evaluation. Eka Tafo Sub-City, home to about 92,000 residents, operates three health centers, five health posts, and several private clinics but no government hospital, highlighting the importance of assessing its surveillance capacity for timely outbreak response.

Methods: A descriptive cross-sectional evaluation was conducted from May 10–21, 2025, following the CDC surveillance system evaluation framework. Fifteen sites were assessed, including the sub-city health office, health centers, health posts, private clinics, and laboratories. Data were collected through interviews, document review, and record checks. Attributes examined included usefulness, simplicity, flexibility, acceptability, representatives, timeliness, stability, and data quality.

Results: Health services in Sheger City include one hospital, 24 health centers, and 34 health posts for approximately 750,000 people, giving a 36% coverage rate. Malaria remains a significant concern, with 654 reported cases (402 in 2024 and 252 in 2025), though no deaths were documented. Measles was also reported, with eight cases in 2025 and no fatalities. The system shows strengths, such as standardized case definitions, functional reporting, flexibility, and laboratory confirmation for malaria. Weaknesses include incomplete and inconsistent reports, poor timeliness documentation, irregular written feedback, limited local analysis, and insufficient epidemic preparedness funds.

Conclusion: The surveillance system in Sheger City is functional, simple, and aligned with Ethiopia's Public Health Emergency Management (PHEM) framework. However, data quality, timeliness, supervision, and preparedness require improvement. Strengthening should focus on ensuring complete and timely reporting, consistent feedback, better epidemic funding, enhanced local analysis, expanded service coverage, and sustained laboratory support.

Keywords: Malaria, Measles, PHEM, Surveillance System, Sheger City

1. Introduction

Public health surveillance involves the continuous, systematic collection, analysis, interpretation, and dissemination of health-related data. It is often referred to as "Information for Action"(1). A well-functioning disease surveillance system is crucial for identifying health issues and guiding appropriate actions. Effective use and understanding of this key epidemiological tool enable health workers at the woreda level and health facilities to set priorities, plan interventions, allocate and mobilize resources, detect epidemics early, initiate timely responses, and evaluate health interventions(2). Additionally, it aids in monitoring long-term disease trends. This systematic approach to data management empowers public health professionals to assess the effectiveness of programs and control measures, thereby fostering evidence-based policy development and resource optimization(3). The fundamental objective of public health surveillance is to furnish timely and reliable data that informs public health interventions and policy adjustments, ultimately aiming to improve population health outcomes(4). Such systems are fundamental to overcoming global health threats and ensuring a prompt, effective response to disease outbreaks and emerging conditions(5). Improved public health surveillance facilitates the earlier implementation of prevention and control measures, leading to more rational priority setting and enhanced detection and management of epidemics(6). The World Health Organization emphasizes that public health surveillance serves as the cornerstone for initiatives aimed at promoting population well-being(7). Consequently, these systems are designed to monitor both routine and ad hoc data, triggering rapid response activities when predefined alert thresholds are surpassed(1).

2. Objectives of the Study

2.1. General Objective

- To evaluate the performance and effectiveness of the malaria and measles surveillance system in Eka Tafo Sub-city, Sheger City.

2.2. Specific Objectives

- To provide a foundation for the evaluation of the surveillance system in the subcity.
- To examine the usefulness of the surveillance system in tracking malaria and measles trends, detecting outbreaks, and assessing the effectiveness of control measures within the sub-city.

- To assess the core and support functions of the surveillance system in the sub-city.
- To evaluate the attributes of the surveillance system in the sub-city.
- To identify gaps in the implementation of the surveillance system and provide appropriate recommendations.

3. Rationale of the Study

Public health surveillance is a critical component of any health system, designed to monitor, analyze, and inform timely interventions for priority diseases. Ideally, surveillance data should be collected on a weekly basis at all levels of the healthcare system, analyzed, interpreted, and utilized to guide evidence-based decision-making(8). However, in the Ethiopian context, this process is often inadequate due to challenges such as limited awareness, insufficient training, lack of motivation and commitment among healthcare workers, and resource constraints.

Malaria and measles are among Ethiopia's priority diseases of public health significance because of their high epidemic potential and the availability of effective preventive and control measures. Malaria, in particular, represents the leading public health challenge in the country. Approximately 52 million people, or 68% of Ethiopia's population, live in malaria-endemic areas, rendering the country one of the most malaria epidemic-prone in Africa. Each year, malaria accounts for an estimated 5 million cases and approximately 70,000 deaths, while contributing to 17% of all outpatient visits to health facilities. Oromia Regional State, the most populous region in Ethiopia, bears a significant malaria burden, with 93% of its woredas and 64.8% of kebeles classified as malarias. An estimated 17 million people in Oromia are at risk, with annual clinical cases ranging between 1.5 and 2 million. The disease is responsible for 20–35% of outpatient visits, 16% of hospital admissions, and 18–30% of annual deaths in the region.

Given the high burden and epidemic potential of these diseases, Ethiopia's public health surveillance guidelines require malaria to be reported on a weekly basis and measles to be reported immediately upon detection. However, gaps in surveillance implementation compromise timely detection and response, increasing the risk of large-scale outbreaks and preventable morbidity and mortality. This underscores the urgent need to evaluate the effectiveness and functionality of the surveillance system in identifying, reporting, and responding to priority diseases such as malaria and measles, particularly in high-burden regions like Oromia.

The Sheger City Administration is among the areas reporting a high burden of malaria in the Oromia Region, as documented in the weekly Integrated Disease Surveillance and Response (IDSR) reports. Despite this caseload, no comprehensive evaluation of the surveillance system has been conducted in the sub-city to date.

Malaria and measles remain major public health concerns in Sheger City. Malaria continues to cause recurrent outbreaks, particularly during and after the rainy season, with health facilities reporting both confirmed and clinical cases each year. The presence of mosquito breeding sites around rivers, irrigation projects, and peri-urban settlements contributes to sustained transmission. Measles, on the other hand, poses a significant threat to child health due to periodic outbreaks often linked to gaps in immunization coverage and challenges in reaching underserved communities. Effective surveillance for both diseases is essential to ensure timely detection, outbreak response, and the implementation of preventive measures such as indoor residual spraying (IRS), distribution of insecticide-treated nets (ITNs), and routine immunization campaigns.

Data obtained from a public health surveillance system can be used to:

- Support prompt action in response to public health threats;
- Assess the burden of diseases or health-related events, including identifying high-risk populations, tracking changes in associated factors, and detecting emerging health issues;
- Track trends and assess the burden of diseases or other health-related events, including the early detection of outbreaks and pandemics.
- Support the planning, implementation, and evaluation of programs aimed at preventing and controlling diseases, injuries, and harmful exposures.
- Assess and inform public health policies.
- Monitor changes in health practices and evaluate their impacts.
- Guide the prioritization and allocation of health resources.
- Describe the natural progression (clinical course) of diseases.
- Serve as a foundation for epidemiological research.

The core functions of a surveillance system include detecting cases, registering cases, confirming diagnoses, reporting data, analyzing and interpreting findings, and initiating public health actions.

This process also involves providing feedback and reports to data providers, stakeholders, and decision-makers to ensure an effective response.

The core functions of surveillance remain consistent across community, district, and health facility levels, though the scope of activities may vary. Public health authorities utilize surveillance data to characterize and monitor health events within their areas, establish priorities, and support the planning, execution, and evaluation of public health interventions and programs.

Public Health Emergency Management (PHEM) is one of the key processes established by the Federal Ministry of Health during the Business Process Re-engineering (BPR) initiative. It encompasses anticipating, preventing, preparing for, detecting, responding to, controlling, and recovering from public health threats to minimize their health and economic impacts. PHEM aims to ensure the rapid identification of public health threats, readiness in terms of logistics and financial resources, and timely response and recovery from various public health emergencies. These emergencies may include recurrent epidemics, emerging infectious diseases, nutritional crises, chemical spills, and bioterrorism. The PHEM framework consists of four sub-processes: Public Health Emergency Preparedness, Early Warning, Response, and Recovery. Notably, surveillance of priority epidemic-prone diseases forms a critical part of the Early Warning component of PHEM.

Although the PHEM core process offers an effective and efficient system for healthcare, its implementation and performance have not been regularly evaluated across different levels.
Evaluation refers to the periodic assessment of the relevance, effectiveness, and impact of activities in relation to the objectives of surveillance and response systems.
Assessing surveillance and response systems helps to:

- ✧ Confirm that the surveillance system is achieving its intended objectives;
- ✧ Record the current performance status and any changes over time;
- ✧ Generate evidence to guide the revision of surveillance objectives, implementation strategies, and planned activities;
- ✧ Support effective planning and allocation of resources;
- ✧ Identify reasons behind the system’s successes and shortcomings;

✧ Offer concrete recommendations for strengthening the system.

4. Methodology

4.1. Study Area

On October 22, 2022, the Oromia National Regional State established Sheger City in central Ethiopia, encircling Addis Ababa, with the primary objective of enhancing the economic role of surrounding satellite towns. Covering an estimated 160,892.9 hectares—over three times the size of Addis Ababa's 52,700 hectares—Sheger City has a total population of approximately 1,657,228, according to the Oromia Spatial Planning Team (2022). The population is rapidly increasing, largely due to the city's strategic location. The city's altitude varies by about 1,412 meters above sea level, with much of its territory situated at relatively higher elevations.

Administratively, Sheger City is divided into 12 sub-cities, namely: Burayu, Eka Tafo, Furi, Gefersa Guji, Gelan, Gelan Guda, Koye, Kara Gida, Mana Abichu, Melka Nono, Sebeta, and Sululta. The city's main administrative office is located in the Saris area of Addis Ababa.

This study was conducted in selected health offices and health facilities within Sheger City, Oromia National Regional State. Eka Tafo Sub-City, one of the 12 sub-cities, has a total population of 92,226, all residing in urban areas. The sub-city has no government hospitals but is served by three health centers and five health posts. While there are no private hospitals, 29 private clinics operate within the sub-city, providing essential healthcare services to the community.

4.2.Study Design

A cross-sectional descriptive study was conducted from May10 to 21,2025(Gregorian Calendar), to evaluate the surveillance system in Sheger City Eko tafo sub-city, Oromia Regional State, Ethiopia.

4.3.Study Population

The study population comprised administrative and health service delivery units involved in public health surveillance. These included the city health office, selected woreda (district) health offices, health centers, health facility laboratories, and health posts within Sheger City.

4.4.Sample Size and Sampling Technique

To ensure that this surveillance system evaluation is straightforward, representative, and meaningful, a total of 15 study sites were included. These comprised one sub-city health office,three private clinics, three health centers, 3 health facility laboratories, and five health posts.

4.5.Data Collection Methods

The evaluation of the surveillance system was guided by the updated Centers for Disease Control and Prevention (CDC) framework for evaluating public health surveillance systems. This framework was used to systematically assess key attributes of the system, including simplicity, data quality, flexibility, acceptability, representative, timeliness, and stability.

Data collection was carried out through interviews and document reviews. Interviews were conducted with key informants at multiple administrative levels, including representatives from the Oromia Regional Health Bureau, Sheger City Health Office, selected sub-city and woreda health offices, as well as Public Health Emergency Management (PHEM) officers assigned at each level. Additionally, focal persons responsible for surveillance activities at health centers and hospitals were interviewed to gather information on system operations at the facility level.

The evaluation specifically focused on assessing the usefulness of the surveillance system in decision-making and public health actions, its flexibility in adapting to new health priorities or reporting requirements, and its acceptability among stakeholders involved in data collection and reporting. Data quality was assessed through the review of surveillance records and reports to

determine completeness and accuracy. Timeliness was evaluated by examining the promptness of reporting and response, while representativeness was determined by assessing the inclusion of relevant health facilities and geographic areas in the surveillance system.

4.6.Data Analysis

The collected data were first checked for completeness, consistency, and accuracy. Any incomplete or inconsistent responses were carefully reviewed and, where necessary, clarified with the respective data collectors to ensure data quality.

5 Result

5.1.Health Facilities in Sheger City

Sheger City hosts a total of one hospital, 24 health centers, and 34 health posts. These government health facilities are staffed by 1,149 health professionals from various disciplines, serving a population of over 750,000 residents. The city's current health service coverage is 36%

Table 11: Distribution and Roles of Public Health Facilities in Sheger City

1	Hospitals	1	Serves the entire city population (~750,000+)	
2	Health centers	24	-Distribute primary & preventive care -Refer severe cases to the hospital -Each typically serves a defined catchment area	
3	Health posts	36	Serve grassroots-level needs in local neighborhoods -Staffed by community health workers	

			-Focus on outreach (nutrition, immunization, health education)	

Table 12: Population and health facilities under surveillance

Location	Total Population	Urban Population	Gov. Hospitals	Gov. Health Centers	Health Posts	Private Hospitals	Private Clinics	Source
Eka Tafo Sub-City	92,226	92,226	0	3	5	0	29	

Table 13: The key diseases monitored in Eka Tafo Sub-city, organized according to the EPHI PHEM classification of weekly reportable and immediately notifiable diseases.

Weekly Reportable (Routine)	**Immediately Notifiable**
Malaria	AFP / Polio – Acute flaccid paralysis
Meningitis	Anthrax
Dysentery	Cholera
Scabies	Dracunculiasis
Relapsing fever	Chikungunya
Chemical poisoning	AEFI – Adverse events after immunization
Malnutrition	Measles
Diarrhea with dehydration (U5C) – Severe dehydration	Neonatal tetanus
Acute jaundice syndrome – Within 14 days of illness onset	Human influenza (new subtype) – Novel influenza viruses
Severe pneumonia (U5C)	Human rabies
Diabetes mellitus (new cases)	Dengue fever

HIV (new cases)	SARS – Severe acute respiratory syndrome
Tuberculosis (new cases)	Smallpox
Hypertension (new cases)	Viral hemorrhagic fever
	Yellow fever
	COVID-19
	Monkeypox virus
	Rift Valley fever
	Brucellosis
	Maternal death
	Perinatal death – Death within 7 days of birth
	Obstetric fistula

The surveillance system in Eka Tafo Subcity follows the Ethiopian Public Health Institute (EPHI) Public Health Emergency Management (PHEM) framework, which categorizes diseases into weekly reportable and immediately notifiable conditions. This classification ensures timely and systematic data collection, reporting, and response to priority health threats in the sub-city.

Weekly reportable diseases represent conditions of ongoing public health importance requiring continuous monitoring. Health facilities within Eka Tafo, including health posts and health centers, report these diseases weekly to the Sub-city Health Office. These include endemic infectious diseases such as malaria, meningitis, and dysentery; nutritional disorders like acute malnutrition; and chronic diseases including hypertension and diabetes mellitus. Continuous surveillance enables detection of unusual trends or increases in case numbers, guiding local preventive and control measures.

Immediately notifiable diseases are conditions with significant epidemic potential or severe health impact that must be reported within 24 hours of detection. In Eka Tafo Subcity, such cases are rapidly communicated to the Subcity Health Emergency Response team and further escalated to the regional (Oromia) Health Bureau. This immediate reporting facilitates swift investigation, laboratory confirmation, and implementation of outbreak containment measures. Diseases such

as acute flaccid paralysis (AFP), measles, cholera, human rabies, and viral hemorrhagic fevers are prioritized in this category

Malaria remains a major public health concern in Eka Tafo Subcity. Weekly surveillance data include total suspected malaria cases tested by Rapid Diagnostic Tests (RDT) or microscopy, with confirmed cases categorized by *Plasmodium falciparum* and *Plasmodium vivax*. This detailed surveillance supports targeted interventions such as vector control, case management, and seasonal malaria chemo-prevention.

Measles surveillance in the subcity operates under immediate notification protocols due to its high transmissibility and outbreak potential.Case-based surveillance enables early detection of measles cases, triggering rapid response immunization campaigns and community awareness efforts, with identified immunization gaps.

5.2. Evaluation of the current surveillance system

5.2.1. Data Quality

Data quality was assessed based on the completeness of reporting formats and the timeliness of reports. Some reporting formats were found to have missing variables, such as the week number, the expected number of health facilities to report, and blank fields where zero cases should have been recorded—particularly noted in two health centers. The main reasons for these gaps were attributed to either a lack of experience among staff or the perception that certain variables were not important. Furthermore, there was no regular cross-checking of data or provision of feedback to improve reporting accuracy.

5.2.2. Feedback and Supervision

In Eka Tafo Sub-City, one of the sub-cities under Sheger City administration, supportive supervision from the regional and sub-city levels to the woredas and health facilities was conducted only once annually. Although oral feedback was provided during these supervisory visits, there was no evidence of written feedback being issued. As Sheger City is a newly established administrative unit, these gaps may reflect the transitional phase of developing health

system structures and standard operating procedures. However, the absence of regular and documented feedback limits accountability, follow-up on identified gaps, and systematic improvement of surveillance activities. Strengthening supervisory practices and institutionalizing written feedback mechanisms are therefore critical for enhancing public health preparedness and response in this emerging urban context.

5.2.3. Training

All health centers in Eka Tafo Sub-City reported that their staff working in surveillance units had received short-term training or workshops lasting 3 to 5 days, organized by the Oromia Health Bureau and the Ethiopian Public Health Institute (EPHI).

5.2.4. Resources Available for Surveillance

Resources for data management, communication, and logistics were available at the health center and sub-city levels. Computers at all levels were reported to be functional. While internet connectivity was available at the sub-city level, the PHEM surveillance units at the health center levels lacked internet access. All health facilities had telephone services. However, budget constraints were reported by all health units and were identified as key barriers to effective supervision and monitoring of health facility reports.

5.2.5. Laboratory Capacity

The laboratory capacity for malaria surveillance was evaluated across health facilities, revealing that two health centers possessed the necessary equipment and trained personnel to diagnose malaria using both microscopy and Rapid Diagnostic Tests (RDTs). These facilities consistently confirmed malaria cases, ensuring reliable diagnostic services at the health center level. In 2024, a total of 402 malaria cases (all outpatient) were reported, with no inpatient cases or deaths recorded. In 2025, 252 cases were documented, of which 251 were outpatient and one was inpatient, with no deaths. Over the two years, a total of 654 malaria cases were reported, including

one inpatient case and no fatalities. This diagnostic capacity plays a crucial role in timely detection and confirmation of malaria cases, thereby supporting effective surveillance and response efforts.

Table 14: Malaria Cases by Year, Type, and Outcome in Assessed Health Facilities (2024–2025)

Year	T Malaria (Confirmed and Clinical)	Total Malaria OutP Cases	Total Malaria InP Cases	Total Malaria Deaths
2024	402	402	0	0
2025	252	251	**1**	0
Grand Total	**654**	**653**	**1**	**0**

On the other hand, measles cases were minimal during the period 2024–2025, as illustrated by data from Eka Tafo Sub-City. No cases or deaths were reported in 2024, while 2025 recorded a total of eight measles cases with no associated mortality. This pattern indicates generally successful measles control measures, likely supported by effective vaccination coverage. However, the occurrence of cases in 2025 suggests the presence of immunity gaps in certain pockets of the population, highlighting the need for continued surveillance, targeted immunization campaigns, and community engagement to sustain measles elimination efforts.

Table 15: Summary of Measles Cases and Deaths in Eka Tafo sub- City, 2024–2025.

Year	Total Measles cases	Total Measles deaths
2024	0	0
2025	8	0
Total	**8**	**0**

5.2.6. Case Recording and Reporting

Priority diseases under the Public Health Emergency Management (PHEM) system were reported on a weekly basis, covering the period from Monday to Sunday. Data were transmitted from health facilities to the respective sub cities through multiple channels, including email, telephone, telegram and hard copy, using standardized reporting formats. Woreda health offices compiled the data and forwarded the reports to the sub-city level, which in turn submitted them to the Oromia regional Health Bureau, specifically to the Public Health Emergency Management (PHEM) Core Process. Standard reporting forms and register books were available and utilized consistently across all health facilities.

5.2.7. Data Analysis and Interpretation

In Sheger City, a newly established administrative unit, there was no documented evidence of systematic analysis of malaria surveillance data at the health facility levels. Specifically, key surveillance performance indicators such as data completeness, timeliness, and trend analysis were not routinely assessed or reported. This gap suggests a limited use of surveillance data for informed decision-making and timely public health interventions. However, at the regional and sub-city levels, Public Health Emergency Management (PHEM) units produced weekly surveillance bulletins. These bulletins provided aggregated updates but did not offer dis-aggregated analysis tailored to the unique epidemiological context of Sheger City. Strengthening local-level data analysis capacities is essential to improve malaria surveillance and response efforts in this newly formed city administration. Furthermore, the absence of dis-aggregated data analysis at the local level hinders the identification of high-risk populations and areas, thereby impeding targeted interventions(9).

5.2.8. Epidemic Preparedness

In Eka Tafo Sub-city, the epidemic preparedness and response structure was relatively well organized, with planning frameworks formally in place. Each woreda, those under Eka Tafo Sub-city, had established epidemic response committees. However, the effectiveness of these structures was undermined by the lack of dedicated financial and logistical support. Moreover,

although response committees and rapid response teams existed on paper, they rarely held regular meetings and did not routinely review or update their preparedness plans and prior actions. Emergency budgets for outbreak investigation and response were only made available to the Sheger City Health Bureau, sub-city health offices, and woreda health center after the occurrence of a public health event. This reactive approach to resource allocation delayed timely investigation and response efforts, leaving the city—especially newer sub-cities like Eka Tafo—vulnerable to preventable public health emergencies.

5.2.9. Supervision and Feedback Mechanism

Supportive supervision activities were reportedly conducted biannually by higher-level health authorities. However, there was a critical gap in the documentation and formal communication of feedback, particularly from the sub-city level to the health facilities. Most feedback provided to frontline health workers was delivered verbally during supervisory visits, with minimal or no written records to track recommendations or follow-up actions(10). This lack of systematic documentation and structured feedback limited the ability of health facilities to make evidence-based improvements in their surveillance practices. Additionally, the absence of regular, written supervisory feedback hindered accountability and reduced opportunities for learning and performance monitoring at the facility level(11).

5.3.Performance and Attributes of the Surveillance System

The malaria surveillance system is integrated with other priority diseases, incorporating laboratory support and relying on passive surveillance that shifts to active surveillance during outbreaks. We evaluated the system's attributes, including usefulness, simplicity, flexibility, data quality, acceptability, sensitivity, timeliness, stability, and representativeness(12).

5.3.1. **Usefulness**

A well-functioning public health surveillance system is crucial for the early detection and effective management of disease outbreaks, serving as a cornerstone for evidence-based public health interventions(13).

All respondents commonly recognized that the surveillance system is primarily used for the early detection of disease epidemics and for assessing the impact of prevention and control programs. Overall, the users of the surveillance system agreed that they had a clear understanding of its usefulness in these aspects. All participants agreed that the surveillance system is valuable for the early detection of priority disease outbreaks, estimating the magnitude of disease-related morbidity and mortality, and identifying associated risk factors. Although no malaria epidemics were reported during the assessment period, health officers at the health-center and sub-city levels emphasized the importance of timely investigation and response—ideally within 48 hours of outbreak occurrence.

All health centers and sub-cities had developed written Epidemic Preparedness and Response Plans (EPRP). However, a major challenge noted across all assessed areas was the lack of regular evaluation by epidemic management committees regarding their preparedness and response efforts.

Overall, the surveillance system was considered useful, effectively leveraging the existing health infrastructure to generate evidence-based information for public health action.

5.3.2. **Simplicity**

All respondents agreed that the malaria case definitions used for identifying suspected cases are clear, easy to understand, and applicable to health professionals at all levels. Suspected cases are identified based on these definitions and confirmed using rapid diagnostic tests (RDTs) and microscopy at health center and hospital levels(14). Most reporting forms were considered easy to complete, and weekly reports were communicated by telephone from the woreda to the next administrative level. The data flow pathway was described as clear and straightforward, as outlined in the surveillance guidelines, and no major issues were reported by the stakeholders regarding this process. However, data collection for weekly reporting was perceived as time-consuming. Data from health facilities were sent in paper form to the woreda health office, and the utilization of this data remained limited at all levels. Nonetheless, transcription of paper-based

data into electronic databases was practiced at the sub-city health departments and the Regional Health Bureau.

5.3.3. Flexibility

The malaria surveillance system demonstrated a high degree of flexibility, as reported by respondents from woreda health offices and facility-level focal persons. They noted that the standard reporting formats could be easily modified to accommodate additional variables for newly emerging health events without disrupting the existing system structure. For instance, maternal and perinatal deaths, as well as scabies, have been successfully incorporated into the surveillance system in recent years. Furthermore, the integration of standardized reporting formats for suspected and confirmed malaria cases, alongside epidemic reporting tools, into the Public Health Emergency Management (PHEM) platform has enhanced the system's capacity to adapt to evolving public health needs. This ability to integrate additional health events reflects the system's resilience and its potential to support a broader range of public health priorities over time.

5.3.4. **Sensitivity**

The sensitivity of the malaria surveillance system was assessed separately for its ability to detect individual cases and outbreaks(15).

5.3.5. **Acceptability**

The acceptability of the surveillance system was evaluated by examining the involvement of reporting agents and their active participation in case detection and reporting(16). In Eka Tafo Sub-City Administration, the level of engagement among reporting agents was found to be good.

5.3.6. Timeliness

The overall reporting rate from health facilities in the health facilities were generally considered satisfactory, despite some inconsistencies and gaps observed at the health center. However,

accurately assessing the timeliness of reporting was challenging. The health facilities submitted reports, it was not possible to determine precisely how many did so within the required reporting time frame. This was primarily due to the lack of segregation of reports based on submission dates and the absence of proper documentation-such as not recording the date the report was received—on most of the reporting forms. As a result, the ability to monitor and evaluate the timeliness of the surveillance system was significantly limited.

5.3.7. Stability

The malaria surveillance system was well-integrated and could be easily linked with surveillance activities for other diseases. Standardized case definitions were accessible and in use at all health facilities. These factors collectively indicate that the system is stable and capable of maintaining its core functions over time without interruption.

5.3.8. Representativeness

The representativeness of the surveillance system depends on several factors, including the coverage of health services, the reporting rates of health facilities, the health-seeking behavior of the community, and the technical capacity of healthcare providers(17). Although some of these elements were not fully achieved, due to challenges such as inconsistent reporting and limited resources.

6. Discussion

The evaluation of the Eka Tafo Sub-City surveillance system within the newly established Sheger City administration revealed a functioning and integrated structure aligned with Ethiopia's Public Health Emergency Management (PHEM) framework. The system was capable of detecting and reporting priority diseases such as malaria and measles, supported by standardized case definitions, laboratory confirmation, and clear data flow pathways(18). Health facilities reported a total of 402 confirmed malaria cases in 2024 and 252 in 2025, with no deaths recorded, indicating effective diagnosis and case management. Measles surveillance, operating under immediate notification protocols, recorded zero cases in 2024 but detected 8 cases in 2025,

suggesting emerging immunity gaps in certain pockets of the population.

Key strengths of the system included simplicity, flexibility, and stability. Case definitions for malaria and measles were clear, easy to apply, and adaptable to new conditions such as maternal and perinatal deaths or scabies(19). Laboratory confirmation of malaria through microscopy and rapid diagnostic tests (RDTs) enhanced data reliability. The system's ability to integrate additional health events without disrupting existing functions demonstrates resilience and adaptability, aligning with national and global best practices. These strengths align with findings from a surveillance evaluation in Dangila district, which also reported that the system is simple, useful, flexible, acceptable, and representative, with timeliness and completeness exceeding national and international targets(1). However, deficiencies in supervision and feedback were noted. Comparable themes emerge: both systems, though operationally robust, suffer from gaps in data feedback loops and supervisory support—crucial for continuous improvement.

However, notable challenges were identified. Data quality was compromised by incomplete forms, missing week numbers, and inconsistent zero-case reporting, particularly in two health centers. Timeliness monitoring was hindered by the lack of documentation of submission dates, making it impossible to assess whether reports met national deadlines. Although 654 malaria cases and 8 measles cases were documented across the two years, delayed reporting could reduce the effectiveness of response measures. These weaknesses mirror challenges reported in other Ethiopian urban surveillance systems, where incomplete and late reporting limited outbreak control capacity(20). Broader HMIS data from Ethiopia show fluctuations in malaria trends, with a 70% reduction in *P. falciparum*/mixed malaria cases in Amhara region from 2013 to 2018, followed by a resurgence in 2019(21). This highlights the importance of consistent monitoring and timely reporting: Eka Tafo's moderate malaria burden may reflect broader national trends shaped by intervention intensity, seasonality, and surveillance quality.

Supportive supervision was infrequent—conducted once annually in Sheger City and biannually in Eka Tafo—and largely relied on oral feedback without formal documentation. This gap reduced accountability and hindered follow-up on identified problems. At the local level, data analysis was minimal, with no routine review of completeness, timeliness, or trends at the woreda or health

facility level. Surveillance data primarily flowed upward to regional bulletins without tailored local analysis, limiting its utility for immediate decision-making. Integrated disease surveillance analyses in Ethiopia have emphasized that data gaps and inconsistent reporting can bias disease trend interpretation, and these issues are evident in Eka Tafo as well.

Epidemic preparedness structures existed, with Epidemic Preparedness and Response Plans (EPRP) in place across health facilities, but their functionality was undermined by reactive rather than proactive financing. Emergency budgets were released only after public health events occurred, delaying outbreak investigations and control measures. As Sheger City is a newly established administrative unit, these gaps likely reflect its transitional phase of health system development; however, they could undermine the city's ability to meet International Health Regulations (IHR 2005) standards for rapid detection and containment of health threats. National estimates indicate that under-five malaria prevalence in Ethiopia remains around 22%, reinforcing the need for vigilant surveillance even when facility-based cases seem moderate. WHO also reported Ethiopia experiencing 8.4 million malaria cases in 2024, the highest annual total ever recorded(22). On measles surveillance, other districts in Ethiopia have emphasized the need for case-based surveillance, timely laboratory confirmation, and outbreak preparedness, consistent with the threats detected in Eka Tafo.

7. Conclusion and Recommendations

7.1. Conclusion

The Eka Tafo Sub-City surveillance system demonstrates strong operational capacity for disease detection, particularly in malaria and measles surveillance, persistent gaps in data quality, timeliness monitoring, supervision, and preparedness financing limit its full potential. Addressing these gaps is essential for strengthening Sheger City's overall public health preparedness and response capacity.

7.2 Recommendations

Based on these findings, the following recommendations are proposed-

- Enhance data quality and completeness by enforcing zero-case reporting, ensuring week numbers and submission dates are consistently recorded, and providing refresher training for surveillance staff.
- Improve timeliness monitoring by implementing a standardized tracking system for report submissions at the woreda and sub-city levels.
- Institutionalize written feedback during supervisory visits, with actionable recommendations and follow-up timelines.
- Build local analytical capacity to enable routine calculation of completeness, timeliness, and disease trends at health facility and woreda levels for immediate action.
- Secure proactive preparedness funding at sub-city and woreda levels to allow rapid outbreak investigation and response without waiting for central budget release.
- Expand health service coverage beyond the current 36% to improve community access and representativeness of surveillance data.
- Sustain strong laboratory support for malaria and measles confirmation, following EPHI and WHO standards.
- Close measles immunity gaps through targeted vaccination campaigns and intensified community engagement in affected areas.

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CHAPTER V

Health profile Description Report of district 02 Health Profile Evaluation, Addis Ababa city Administration, Ethiopia

Abstract

Background

The health profile of a community offers a comprehensive overview of health and related events, using epidemiological tools to reflect the health status and wellbeing from multiple perspectives. The scope of the evaluation is to describe and assess the health and health-related issues in District 02, Lemi Kura Sub City, Addis Ababa, Ethiopia.

Methods

A descriptive cross-sectional study was conducted from March 12-March 17, 2024, in the study district. Data were collected using semi-structured questionnaires and interviews with responsible persons.

Results

The health sector faces significant challenges, including insufficient infrastructure and a shortage of health professionals. There is one health center, 14 private clinics, 7 pharmacies, and 11 drug stores serving the community. The health professional to population ratios indicate a shortage, particularly of general practitioners and health officers. Furthermore, there is low uptake of antenatal and postnatal care.

Conclusions

The health profile reveals critical gaps in health infrastructure, professional availability, and service coverage in the district. Addressing these issues is vital for improving health outcomes. Strategic planning, increased resource allocation, and enhanced community health education are recommended to bridge these gaps and promote better health in the district.

Key words: health indicators, health professionals, health profile,

1. Introduction

Health profile is a holistic approach of gathering information of health and health related events in the community using epidemiological statistics tools. .It is a comprehensive compilation of information about a community. The data in the profile is a mirror of health and wellbeing of a particular community from much different perspective. The preparation of profiles provides a lively, scientifically and evidence based account of health in the district.

Health profile is vital for prioritizing prominent health and health related problems of the community. It is basic for strategic planning; decision making and identify targets for the future and monitor progress towards them; and it is an entry point for operational research. Stakeholders in health and health related areas of the community will have evidence-based information from well compiled health profile (2). As the purpose of this assessment is to describe health and health related issues in the given district (woreda) and communication of the local burden of morbidity, mortality, any disaster and other public health related information of the district, it is very important document to be utilized by any stake holders in general and public health professionals in specific.

In Ethiopia, particularly at the district level an organized health and health related indicator which determine the health status of the community is insufficient and these contribute a gap in planning and taking evidence-based information for action.

2. Rationale of the profiling

The goal of gathering health profile data is to find ways to enhance each community member's access to quality medical treatment and health promotion. Even though they are necessary for planning and for the right kind of intervention, developed district health profiles are not common in our nation as of yet. In order to facilitate planning, prioritizing health programs and addressing health-related issues, this woreda health profile description aims to provide access to the district's accumulated health and health-related issues.

3. Objectives

3.1. General objective

To evaluate and characterize health and health-related concerns, as well as to pinpoint issues for prioritization in woreda 02, Lemi kura Sub City, Addis Ababa, Ethiopia, by April 2024.

3.2. Specific Objectives

To assess and describe health indicators and to identify problems for priority setting

- To assess primary health care coverage of the district.
- To assess existing health infrastructure of the district.
- To compile and simplify health related information of the woreda and making it easily Accessible/ready to utilization
- To describe endemic diseases and prevention and control program in the district

4. Methods and Materials

Both Filling semi-structured questionnaire, which specifically developed for collecting the district health profiles and making interview with responsible district personnel was used as a tool to collect the required data. Before starting filling the questionnaire on the purpose and benefit of this work data collectors were made brief discussion with town Health office. Check list was using as tools for data collection from various governmental organizations such as district health office, health facilities, education sector, finance office,district water resource office, district electric power authority and district political administration office to collect the district health profile data. Data was collected from registers book, reports from national census 2007 and 2013 health indicators and research articles. Interview was performed with right officers from the above particular offices based on required data.

4.1. Study Area

The study was conducted in Woreda 02, Lemi kura sub city, Addis Ababa city Administration.

4.2. Study Design and Duration

A descriptive cross-sectional study was conducted from April 12-April 17, 2024 in the study district.

4.3. Ethical Considerations

A formal letter was sent to the Addis Ababa Health Bureau and other relevant parties in Woreda 02 Lemi Kura sub city by the Ethiopian Public Health Institute (EPHI), Public Health-Emergency Management (PHEM) directorate. We have availed the letter and obtained authorization to continue with our research.

4.4. Data collection and analysis

Data on health and associated topics has been obtained from many sectors, including Woreda Health, Education, and Water Resource Offices. Every Ketene in the District was encompassed. Health and matters associated with health the Woreda Health Office provided statistics, while the Sub-City Water Resource Office provided data on the availability of clean water supplies. The Woreda Education Office provided information on education, and other pertinent sectors provided information on other subjects. Based on the required information, interviews with pertinent officers of the aforementioned processes were carried out. Additionally, various registry books were assessed. The data analysis was performed with Microsoft Excel 2010.

4.5. Data dissemination

Following the completion of the Health Profile Data Description, the report will be prepared and distributed to the Ethiopian Field Epidemiology Training Program Department, Addis Ababa University/School of Public Health, Addis Ababa City Administration Health Bureau, woreda 02, Lemi Kura Sub City Health Office, and other relevant offices.

5. Results

5.1. Geographic and climatic conditions

Lemi Kura sub-city administration is the 11th sub-city located in the east of Addis Ababa established in 2020. It is a newly formed sub city. It has an area of 7860.7 hectares and a population of 48,010. It is a sub-city organized in 10 districts, 59 clusters and 508 blocks. Latitude 9.01669° or 9° 1' 0" north and Longitude 38.87204° or 38° 52' 19" east respectively.

Woreda 02 is one of the ten administrative woredas of Lemi kura Sub City administration. Lemi kura sub city is one of the eleven sub-cities of Addis Ababa city administration, Ethiopia.

5.2. Administrative and Political Structure

The woreda is the lowest level of government in Addis Ababa, yet it has its own areas known as ketena, according to the most recent city administration. Ketenas are administrative divisions that are smaller in size. There are 11,000 households in Woreda 02, which is made up of 8 ketenas. There are 48,010 people living there, spread on a landmass of 64.59 km².

Health Sector Budget Distribution for last one year of the district,

5.3. Water supply and sanitation

This study evaluated a number of issues related to the difficulties in providing better access to sanitation and water supply in Addis Abeba's peripheral areas, mainly in the Lemi Kura sub city. The difficulties in achieving better access to sanitation and water supply for the majority of households in the Study area can be viewed from various angles. The current obstacles faced by WATSAN in the study area are mostly caused by institutional issues, inadequate integration among sectors, low levels of private sector involvement, and a lack of public participation. These issues have a significant impact on the socio-economic and environmental health of the society.

5.4. Demographic information

According to the projection for 2017, Woreda 02 population is 48,010 of which 23044(48%) are male and 24965(52%) are female. From the total population 1062(2.2%) and 3839(7.8%) are children less than 1 year and 5 year respectively. Women with the reproductive age constitute 15742 (32.8%). Information about ethnic group/language, religion of the woreda is not available.

5.5.Education Status of the Woreda

Many research investigations have conclusively shown the close relationship between health and education. These findings, when considered as a whole, provide some insights into the ways in which education and health may support each other's quick progress in the nation's socio-economic development. Ethiopian epidemiological and health services research has demonstrated that low health seeking behavior and high health risks are typically linked to illiteracy. Apart from a wide range of illnesses and child mortality linked to illiteracy or inadequate education, HIV/AIDS infection rates are also disproportionately elevated among youth who are not in school. Even with significant advancements in education, the country's literacy rate remains low. The percentage of adults over the age of 15 who are literate is 29% (27% of males and 30.7% of females).

Six primary (grades 1–8), six secondary (grades 9–12) and sixteen kindergartens were located in the district. There are two private colleges in the area. These are Rift Valley University College and Addis Continental College. In the District, there isn't a government university. In comparison to state institutions, there are more private educational institutions in the Woreda.

Table 16: Education status of Lemi Kura subcity

Educational institution	No of Teachers			No of Students			Student school drop out
	Male	Female	Total	Male	Female	Total	
K.G	7	179	186	2986	3020	6006	13
Primary school	125	526	651	4513	4853	9366	104
Secondary(9-12)	345	156	501	2644	3260	5904	0
College/University	10	5	15	196	231	427	0
Total	487	866	1353	10,439	11364	21703	117
School health activities: No of schools with water supply	(6)All the schools have water supply but it is not as per the standard(1:20)						
Schools with HIV/other health clubs	(0)There is no HIV club						

KG:- kindergartens.

Source: Lemi kura sub city & woreda 02 educational office.

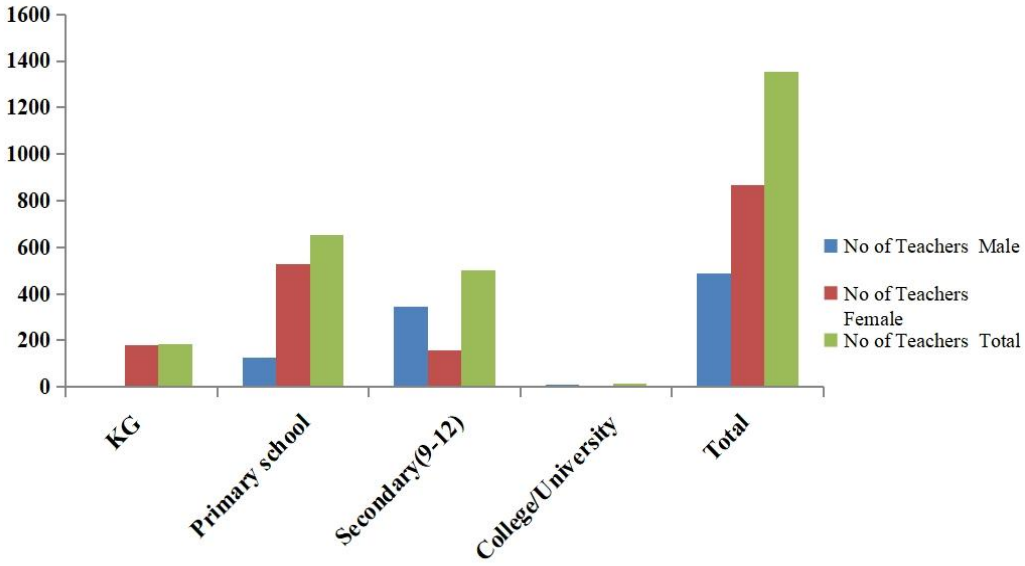


Figure 27: Number of teachers in different level of education institutes

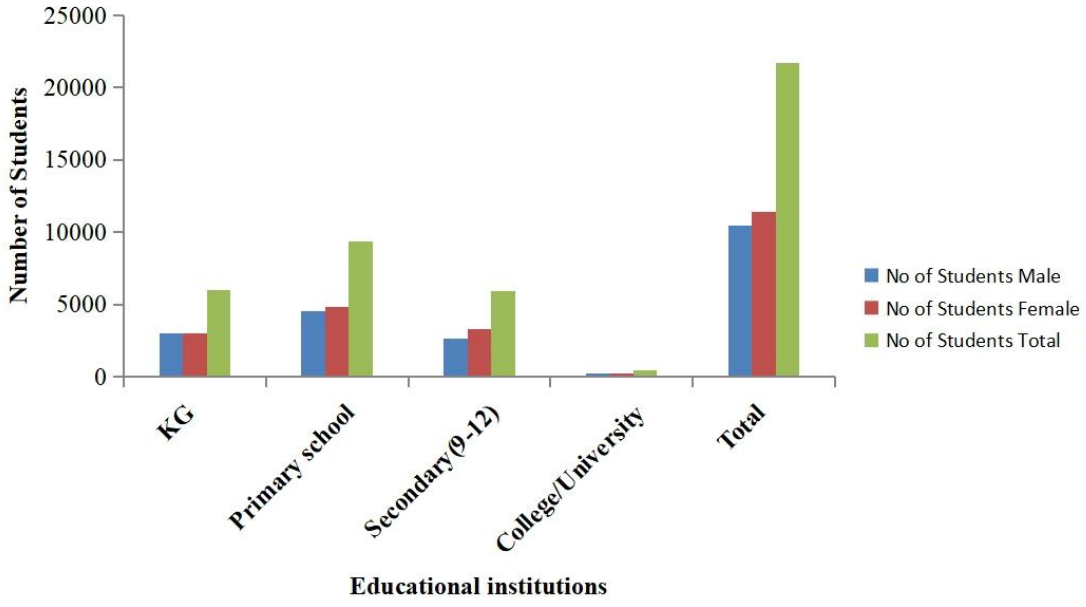


Figure 28: Number of students in different level of education institutes

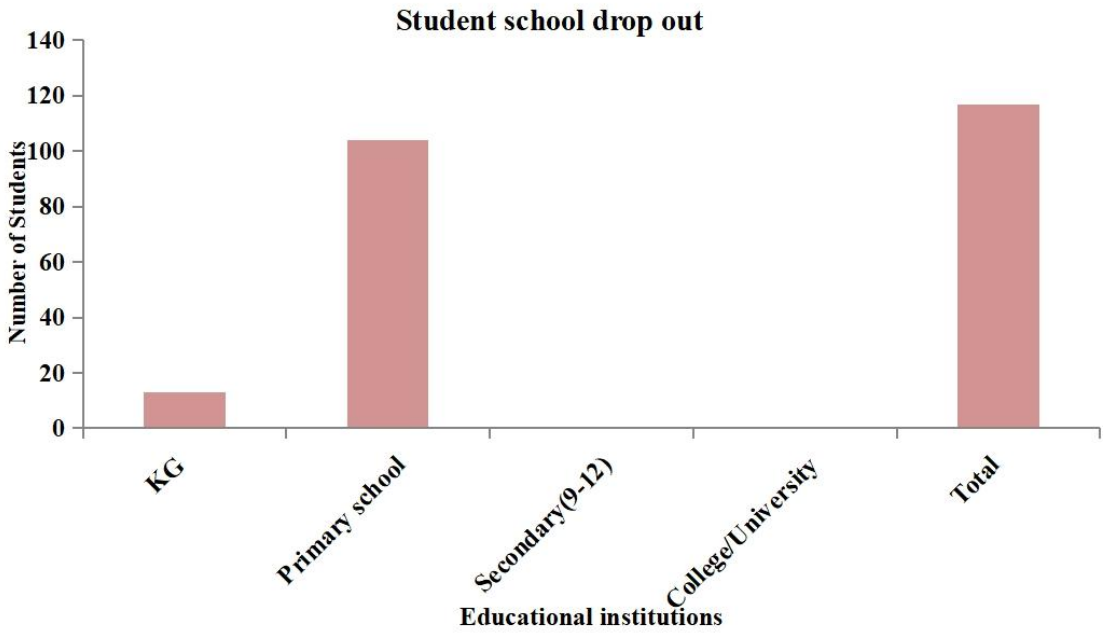


Figure 29: Number of student dropouts in different level of education institutes

The district is residence to 13,533 teachers, 21,703 students, and 117 school drop outs.

There are 6006 students in this KG overall, of whom 3020 (50.3%) are female and 2986 (49.7%) are male. There were 9366 students attending in elementary schools (grades 1–8), 4853 (51.8%) of whom were female and 4513 (48.2%) of whom were male. There were 5904 students in high schools as a whole, with 2644 (44.8%) male students and 3260 (55.2%) female students. There were 427 total students at the university, 231 (54.1%) of whom were female, and 196 (45.9%) of them were male. There were 186 teachers in the first cycle, 179 (96.2%) of whom were female and 7 (3.8%) of whom were male. There were 651 teachers in elementary schools (1–8), with 526 (80.8%) female and 125 (19.2%) male.

5.6. Demographic Statistics of Students and Teachers in the District

The demographic statistics of students and teachers in the district provide valuable insights into the educational landscape and the composition of the learning community. These statistics help identify patterns and trends related to gender, age, race, socio-economic status, and other factors that may impact academic achievement. Analyzing the demographic statistics can help in identifying any disparities or inequities that may exist within the district. This data can be used to implement targeted strategies to support students and teachers from underrepresented groups and create a more inclusive and supportive

educational environment. Additionally, understanding the demographic makeup of the district can aid in resource allocation and the development of programs that cater to the specific needs of different student and teacher populations. By delving deeper into these statistics, the district can work towards fostering a more diverse, equitable, and inclusive educational community. Source: Demography is the study of population, its structure, composition, and distribution, considering important parameters such as sex, age, density, birth and death rate, growth, and division of population (Klimczuk, 2021).

5.7. Health System

One health facility and fourteen private clinics offered services at the newly established woreda 02 health office. Among these nine medium-sized clinics and five specialist clinics were providing community services. There was no government hospital in the district. The district includes 11 drug stores and 7 pharmacies.

Table 17: Health Facility to population ratio Woreda 02, Lemi Kura Sub city, 2023/24

S/N	Types of health facility	No of Health facility	Health facility to population ratio
1	Hospital	0	0
2	Health center	1	1:48,010
3	Private Clinics	14	1:3,429
4	Pharmacy	7	1:6,859
5	Drug store/	11	1:4,365

5.8.Health professional to Population Ratio

The health professional to population ratio is an important indicator of the availability and accessibility of healthcare services in a specific area. In the case of the district there is a shortage of general practitioners and health officers. This shortage of qualified healthcare professionals creates a gap between the demand for healthcare services and the ability to meet that demand. This shortage may lead to reduced access to primary healthcare services and an increased burden on the existing healthcare workforce. Furthermore, the shortage of health professionals in the district may have negative implications for the overall health outcomes of the population. Additionally, the shortage of health professionals in the study area may result in longer wait times for appointments and reduced quality of care.(Assefa *et al.,* 2016)

The health professional to population ratio of the district is as follows: one General Practitioner for every 16,003 people, one nurse for every 1,116 people, one Health Officer for every 2,087 people, and one Health Extension Worker for every 2,286 people. This indicates that there is a shortage of general practitioners and health officers in the district. This ratio suggests that there is a significant shortage of general practitioners and Midwife in the study area.

Table 18: Health professional to population Ratio, District 02, Lemi kura sub-city, Addis

Profession	Total No	Ratio to Population
G.P	3	1:16,003
Specialist	0	0
Nurses	43	1:1,116
Midwife (deg. and Dip.)	18	1:2,667
HO	23	1:2087
Pharmacy (Deg. And Dig.)	10	1:4801
Env. Health (degree and Dip.)	1	1:48010
HIT	2	1:24005
HEWs and others	21	1:2286
Lab. (Deg. And Dip)	8	1:6001

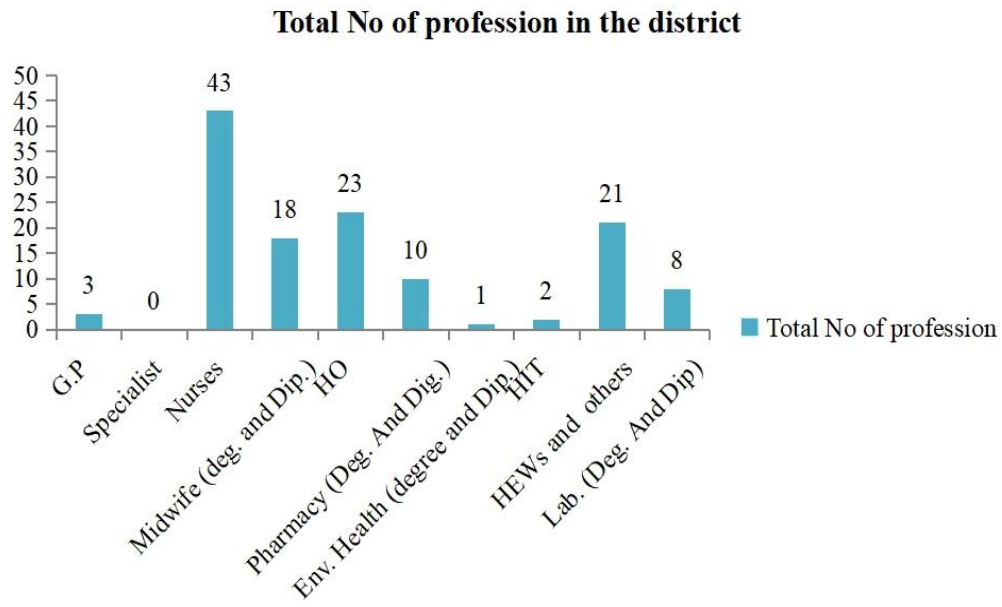


Figure 30: Total number of health professionals, district 02, Lemi Kura sub-city, Addis

5.9.Health service institutions and infrastructures

The assessment of health service institutions and infrastructures is crucial for ensuring the delivery of quality healthcare to the population. It helps identify the strengths and weaknesses of existing facilities, determine gaps in service provision, and guide planning for future healthcare development. By analyzing access to health facilities and the distribution of services, decision-makers can make informed decisions on resource allocation and prioritize areas that require additional support. Furthermore, understanding the spatial distribution of health services is important for ensuring equitable access to healthcare (Jin *et al.,* 2019)

There was one health facility in the district that provided sustainable 24-hour electric power, telephone service, and quarterly water chlorination; in addition, there were 14 private clinics that offered services (five specialized clinics, nine medium clinics, but no government hospital.

5.10 Vital Statistics and health indicators

Vital statistics and health indicators are essential for estimating and evaluating the effectiveness of health-related activities and for establishing necessary policies. Certain vital statistics are not available at the district level, including the total number of deaths, total number of births, the infant mortality rate (IMR), the maternal mortality rate (MMR), the under-five mortality rate (UFMR), and the crude death rate (CDR) at district level.

Females in the reproductive age group (15-49 years) were estimated to be about 16511 (34.4%) Non pregnant mothers were estimated to be 1110(2.3%) and pregnant women were estimated to be 1538(3.2%) of the total population in the district. Children <1 year of age constituted about (2.2%), children <3 years were estimated 1954(4.1%) and children <5 years of age constituted about 3389 (7.1%) of the total population.

Table 19: Vital statics and health indicators of Woreda 02, Lemi kura Sub City, Addis Ababa city administration, 2023

S/N	Demographic parameters	Total Number	Proportion from total population
1	Total population	48010	100%
2	Male	23044	48%
3	Female	24,965	52%
4	Women 15-49 yrs. of age	16511	34.4%
5	Contraceptive prevalence rate	3240	19.6%
6	Estimated pregnancy	1,538	3.2%
7	Household	11,000	23%
8	Non pregnant mothers	1,110	2.3%
9	Estimated live birth	1500	3.1%
10	Population under 1yrs	1062	2.2%
11	Population under five years	3389	7.1%
12	Population <3 years	1954	4.1%
13	Infant Mortality Rate/1000	-	No report
14	Neonatal Mortality Rate	-	No report
15	Under 5 mortality rate	-	No report
16	Crude Birth Rate	-	No report
17	Maternal Mortality Rate	-	No report
18	Crude Death Rate	-	No report

5.11. Maternal Health Service

5.11.1. Utilization of Contraceptives

Improving the rate of contraceptive acceptance was one of the Ministry of Health's goals for enhancing mother and child health. Woreda 02 (Lemi kura subcity) administration, of 16511 women in the reproductive age range (15–49), 3240 (19.6%) used contraceptive methods; Implant 2085(64.4%) was the most frequently used contraceptive methods followed by IUD 1130(34.9%) and the pill was the least popular method. This indicates the district's poor acceptance rate of contraceptives. Additionally, long-term contraceptive techniques were more frequently used than short-term ones among those who used contraception. Inadequate contraceptive acceptance rate: According to the data, the contraceptive acceptance rate in Woreda 02 is low.

Limited access to health facilities: The district lacks a government hospital and relies heavily on one health center and private clinics for healthcare services. This limited access to health facilities may contribute to the low contraceptive acceptance rate and hinder the overall quality of healthcare in the district. Limited geographical access can be one of the main contributors to the low usage of health facilities in Woreda 02, including for contraceptive services. Limited geographical access is one of the main reasons behind the low usage of health facilities in Woreda 02 (Tesfaye *et al.,* 2014). Improving access to healthcare services in Woreda 02 is crucial to improve contraceptive acceptance rate. The lack of healthcare professionals, particularly doctors, is a factor that hinders the development of the health sector in Woreda 02. Addressing these challenges and needs requires a comprehensive approach that includes expanding healthcare infrastructure, increasing the number of healthcare facilities, especially government hospitals, and improving access to healthcare services in the district. Improving the education and awareness of the community regarding contraceptive methods and family planning could also contribute to increasing the contraceptive acceptance rate in the district (Qanche *et al.,* 2020).

5.11.2. Antenatal care, postnatal care and Deliveries in the district

The most important activities planned to decrease maternal death are Antenatal Care (ANC), Postnatal Care (PNC) and Family Planning (FP).Woreda 02 has also plan and achievements to implement these activities as shown below (Table 5).

Table 20: Plan and performance of maternal health activities; district 02 Lemi kura sub city, Administration, Addis Ababa 2023

S/N	Activities	Target	Achievements	Percentage
1	ANC1	1538	1328	86.3%
2	ANC4	1538	1148	74.6%
3	Delivery attended by health workers	1538	1408	91.5%
4	Postnatal care	1538	640	41.6%
5	Family planning (all method) total	16511	12320	74.6%
6	PMTCT	1538	1298	84.4%

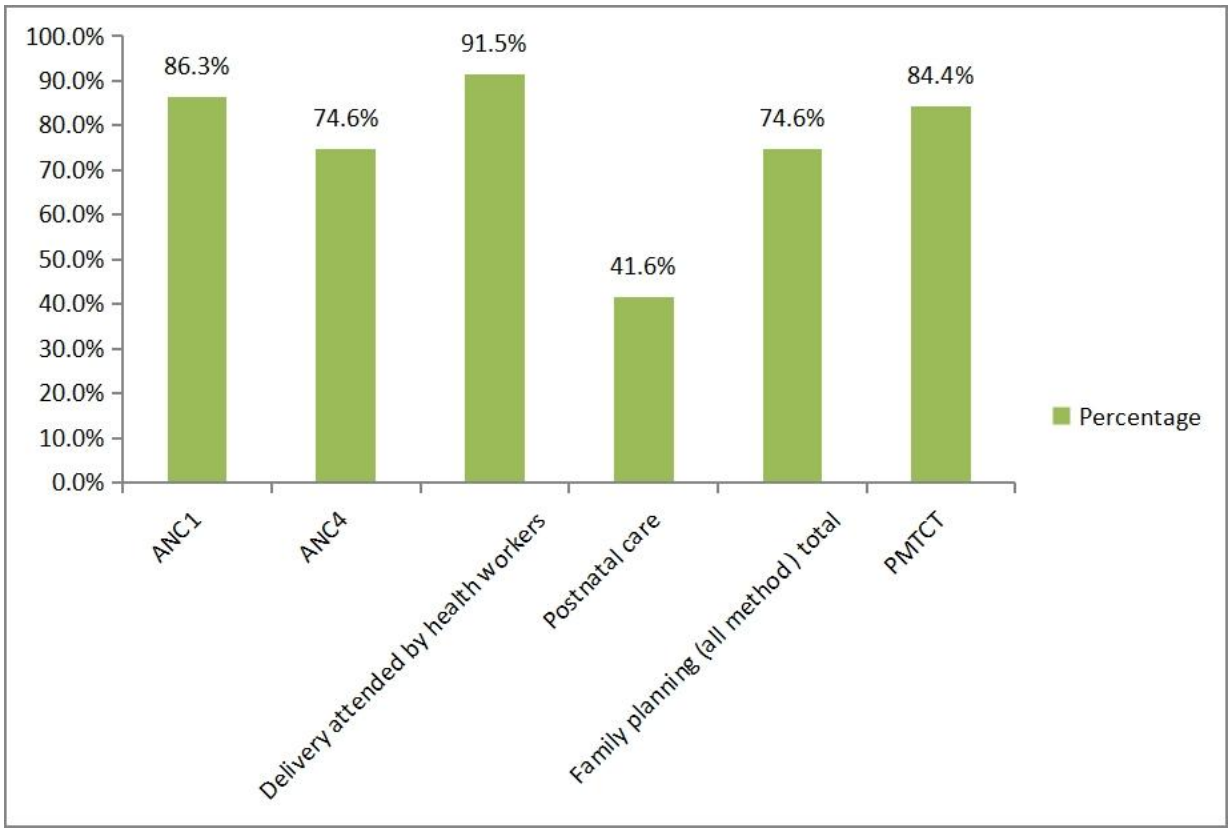


Figure 31: Plan and performance of maternal health activities; district 02 Lemi kura subcity, Administration, Addis Ababa 2023

In the District, 1538 expectant mothers were expected in 2023.1245 (80.5%) of the expected pregnant women obtained their first prenatal care visit throughout the year. 640(41.6%) of pregnant women got postnatal care services, and all (100%) of the pregnant women were delivered by trained delivery attendants. There have been no reports of maternal deaths in the district, and women's postpartum healthcare seeking behavior is not as high as it is for prenatal care.

Table 21: Immunization coverage with different vaccine types

Serial No	Vaccine type	Immunization coverage	Percentage
1	BCG	1931	64%
2	Rota1	2015	67 %
3	OPV1	2444	81%
4	OPV3	1775	59%
5	Penta1	2422	80 %
6	Penta3	2445	81%
7	Measles	2255	75%
8	Rota2	2021	67%
9	PCV1	2437	81%
10	PCV3	2453	81%
11	TT2+P.W	2272	75%
12	TT2+N.P.W	1972	65%

Access to quality antenatal care, postnatal care, and safe deliveries are crucial for the well-being of both expectant mothers and their newborns. Provision of antenatal care in the district has shown a positive trend, with 80.5% of expectant mothers obtaining their first prenatal care visit in 2023. This indicates that a majority of pregnant women in the district are receiving the necessary medical attention and guidance during their pregnancy. However, there is a need to improve postnatal care services in the district, as only 41.6% of pregnant women received postnatal care services (Ibrahim *et al.,* 2022)

Among these 64%, 81% and 81% of children received BCG, OPV1 and PCV1 2 respectively. However, when compared to national coverage levels, the complete immunization coverage among 12- to 23-month-old children in District 02 was found to be significantly lower. This

suggests that there may be systemic barriers or challenges specific to the district that need to be addressed in order to improve immunization coverage.

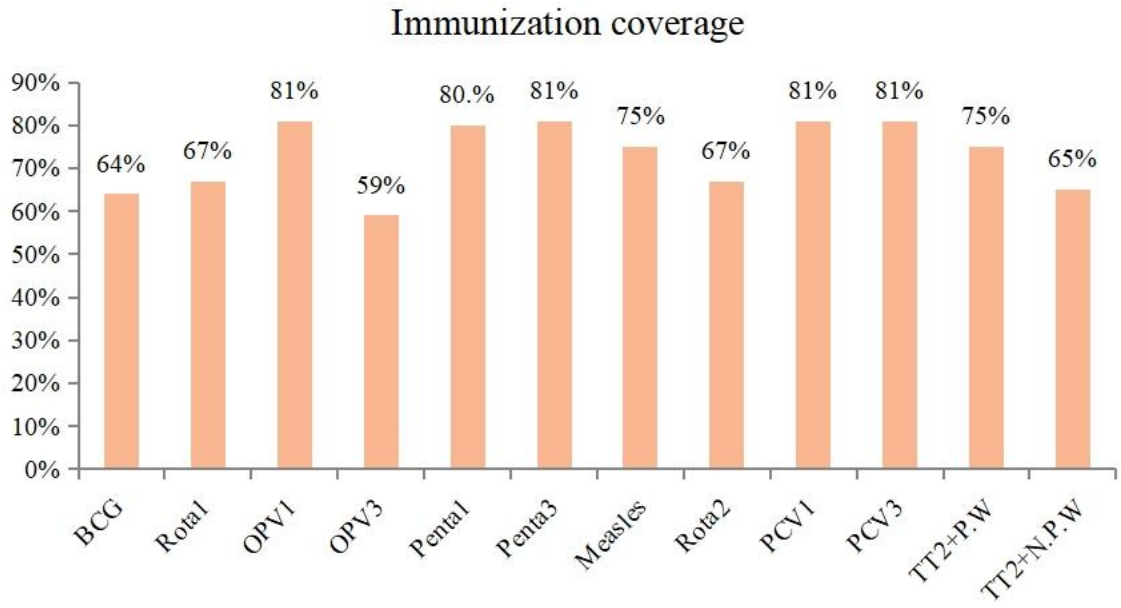


Figure 32: Immunization coverage with different vaccine types

5.11.3. Top causes of morbidity and mortality

The burden of morbidity and mortality in District is influenced by various factors. These factors include the prevalence of acute tonsillitis and other respiratory system diseases, which are the leading causes of morbidity in the district. Additionally, the lack of clean drinking water, poor sanitation, and low public awareness of environmental health and personal hygiene practices contribute to the high burden of disease in the Study area (Wolde *et al.,* 2020).

Acute tonsillitis (18.8%) ,Other unspecified respiratory system disease (13.1%) and Urinary tract infection(11.2%)were the three leading cause of morbidity among top ten outpatient visit of Woreda 02, Lemi kura sub city, Addis Ababa city administration.

Table 22: Top Ten Leading Cause of Morbidity in Adult Woreda 02, Lemi Kura Sub City, A.A, Ethiopia,2023

S/N	Top leading cause of Morbidity in Adult	Total No of cases	Percentage
1	Acute tonsillitis	28191	18.8%
2	Other unspecified of respiratory system	19561	13.1%
3	Urinary tract infection	16735	11.2%
4	Dyspepsia	16354	10.9%
5	Essential Hypertension	15386	10.3%
6	Cough	13619	9.1%
7	Upper respiratory tract disorders/unspecified	10978	7.3%
8	Diarrhea	10123	6.8%
9	Type 2 Diabetes mellitus	10018	6.7%
10	Pneumonia	8668	5.8%

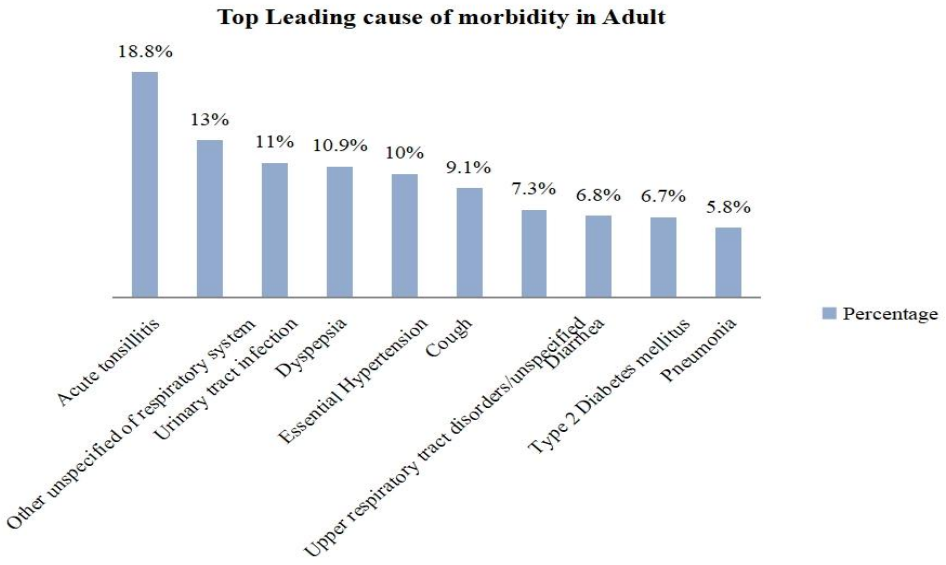


Figure 33: Leading causes of morbidity in Woreda 02, Lemi Kura Sub City, A.A, Ethiopia,2023

According to the data gathered in 2023, the top three leading causes of morbidity among children under five in District 02 Lemikura Sub City were other specified diseases of respiratory disease (30%), acute tonsillitis (18%), and gastroenteritis or colitis (10.7%). These diseases accounted for the highest percentage of morbidity cases in that year, indicating the need for appropriate preventive measures and healthcare interventions to address these health issues and reduce the burden of these diseases on the affected population. Therefore, it is crucial to prioritize strategies and interventions that target the prevention and treatment of respiratory diseases, acute tonsillitis, and gastroenteritis or colitis in order to improve the health outcomes of children under five in the District. Additionally, investing in public health infrastructure, improving access to clean water and sanitation facilities, promoting proper hygiene practices, and strengthening healthcare services can play a vital role in reducing the prevalence of these diseases and improving the overall health of children in the community (Alamneh & Adane, 2020).

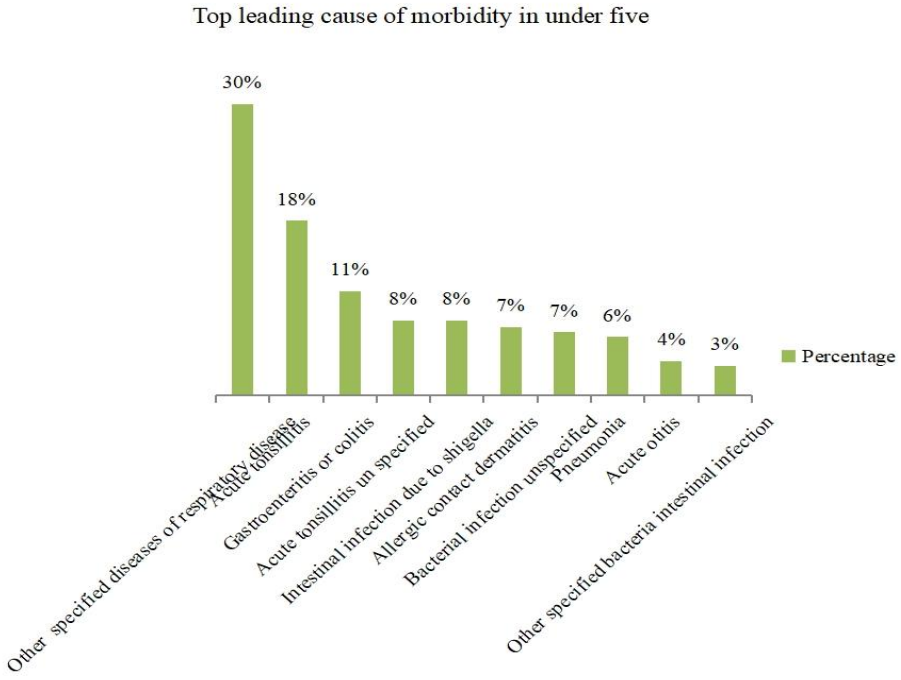


Figure 34: Leading causes of morbidity in under 5-year age in Woreda 02, Lemi Kura Sub City, A.A, Ethiopia, 2023

Table 23: Leading causes of morbidity in under 5-year age in Woreda 02, Lemi Kura Sub City, A.A, Ethiopia, 2023

S/N	Top leading cause of Morbidity in under Five	Percentage
1	Other specified diseases of respiratory disease	30%
2	Acute tonsillitis	18.%
3	Gastroenteritis or colitis	10.7%
4	Acute tonsillitis unspecified	7.7%
5	Intestinal infection due to shigella	7.7%
6	Allergic contact dermatitis	7%
7	Bacterial infection unspecified	6.5%
8	Pneumonia	6%
9	Acute otitis	3.5%
10	Other specified bacteria intestinal infection	3%

5.12. Endemic Diseases

5.12.1. Tuberculosis

Tuberculosis, also known as TB, is a severe public health issue in Ethiopia. To estimate the burden of tuberculosis in the district, various data sources were analyzed, including annual case notifications and prevalence surveys. In 2023, 121 cases of TB were reported to the district. Of them, 42 had pulmonary tuberculosis (PTB) positive cases and 18 had PTB negative cases. 10 (or 8.3%) of the 121 TB patients who had HIV screening results were positive 35 cases (28.9%) of tuberculosis were linked to extra PTB over the year. In this district, there was no treatment defaulter. In 2023 121(100%) TB patients were screened for Human Immune Deficiency Virus (HIV). There was no case of leprosy identified during 2023 in the district.

Table 24: Prevalence of TB/Leprosy, in Woreda 02, Lemi kura Sub City, A.A, Ethiopia 2023.

S/N	Description	No of cases	percentage
1	Total TB case	121	
2	PTB negative	18	
3	PTB positive	42	
4	Extra PTB	35	
5	TB detection rate		
6	Completion rate TB Rx		
7	TB cure rate	37	
8	TB defaulter	0	
9	Death on TB Rx	1	
10	Total TB patients screened for HIV	121	
11	Total Leprosy cases	0	

5.11.2. HIV/AIDS

HIV/AIDS continues to be a pressing global health issue, with efforts aimed at achieving universal coverage in terms of access, equity, and quality of care still facing significant challenges, especially in regions like Africa.

According to the provided statistics, in the district, A total of 5101 people were screened for HIV in the district (702 through Voluntary Counseling and Testing, or VCT) and 4399 through Provider Initiated Counseling and Testing (PICT) clinics. 42 people, or 0.82% of the total tested, were positive for HIV. In PMTCT Departments, 830 clients had HIV screening; 10 (1.2%) of these were HIV-positive pregnant mothers.

Table 25: HIV/AIDS prevalence during pregnancy Woreda 02, Lemi Kura sub city, Addis Ababa, 2023

S/N	Activities	Total No of cases
1	Total people screened for HIV	5101
2	PICT	4399
3	VCT	702
4	Total PLWHIV	10
5	On ART (ever started)	6
6	Currently on ART	2
7	PMTCT	830
8	No. of pregnant mothers on ART	8
9	No. of pregnant mothers on Pre ART	2

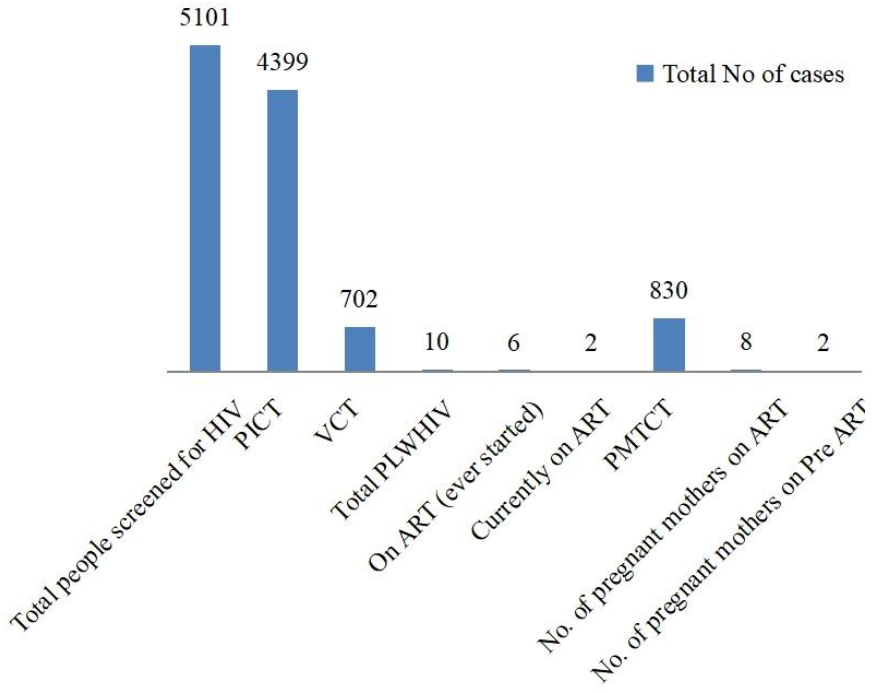


Figure 35: HIV/AIDS prevalence during pregnancy Woreda 02, Lemi Kura sub city, Addis Ababa, 2023

6. Budget allocated for the district

Budget allocation plays a crucial role in the development and provision of essential health services. A sum of 360,301,761 (three hundred sixty million, three thousand one, seven hundred sixty one) Ethiopian birr was allocated for 10 district's health centers from Lemi kura sub city However, when it comes to District 02, the budget allocated for the health office seems to be inadequate (Ukah, 2009). Despite receiving a budget of 29,860,336 Ethiopian birr, which accounts for 8.3% of the total budget for 10 districts, the district lacks support from NGOs (Assefa, 2018). This insufficient allocation of funds and lack of NGO support can have negative implications for the healthcare services provided in District 02.Additionally, the economic challenges faced in Addis Ababa, such as high unemployment rates and a large population living below the poverty line, further compound the challenges faced by the health office in District 02 (Eshetu *et al.,* 2021). These economic challenges can lead to increased demand for healthcare services, putting strain on the already limited resources allocated to the district.

7. Outbreak situation in the district

Regarding public health emergency occurred in lemikura sub city district 02, there were Measles and cholera outbreak in the Woreda; with a total of 30 cases and no death among the cases. Three of the cases are confirmed by laboratory.

8. Discussion

The present study assessed key aspects of the health, education, sanitation, and demographic conditions of Woreda 02 in Lemi Kura Sub-City, Addis Ababa. The findings provide important insights into the existing gaps and challenges in public health service delivery, resource allocation, and disease burden within the district. These results were compared with findings from previous studies in Ethiopia and similar settings to contextualize the situation and guide recommendations for improvement.

The study revealed persistent challenges in ensuring adequate water and sanitation access in the peripheral areas of Lemi Kura Sub-City. Institutional weaknesses, limited inter-sectoral collaboration, low private sector participation, and inadequate community engagement were major obstacles. Similar constraints have been reported in other parts of Addis Ababa and urban Ethiopia. According to Assefa et al. (2020), ineffective coordination among stakeholders and insufficient infrastructure investment have led to poor sanitation coverage in newly expanding sub-cities. Likewise, a World Bank (2018) assessment found that only about 27% of Addis Ababa's population had access to safely managed sanitation services, emphasizing the need for stronger governance and financing mechanisms.

The literacy rate in the woreda remains low, reflecting broader national trends. Nationally, adult literacy in Ethiopia stands at around 51%, with persistent disparities between urban and rural areas (CSA, 2021). The study confirmed that illiteracy continues to influence health-seeking behavior and disease burden, consistent with evidence from Abebe et al. (2019), who reported that low educational attainment correlates with reduced utilization of maternal and child health services. The limited presence of government-owned higher educational institutions in the district may also contribute to the persistent literacy and awareness gaps observed.

The health professional-to-population ratio in Woreda 02 remains below national and WHO-recommended levels. The ratio of one general practitioner per 16,003 people is significantly higher than the national average of one per 10,000 (FMOH, 2021). This shortage, particularly in general practitioners and health officers, creates service delivery gaps and may compromise the quality of care. Similar findings were reported by Yitbarek et al. (2020), who emphasized the uneven distribution of healthcare professionals in urban Ethiopia, with newly established sub-

cities facing the greatest shortages. The absence of a government hospital and heavy reliance on private clinics further limit access to affordable and comprehensive healthcare services.

The maternal health service utilization data showed encouraging ANC coverage (86.3% for ANC1 and 74.6% for ANC4) and a high skilled delivery rate (91.5%). These figures are higher than the national averages reported in the 2019 Ethiopian Mini Demographic and Health Survey (EMDHS), which indicated ANC1 coverage of 74% and skilled delivery attendance of 50%. However, the low postnatal care (PNC) coverage (41.6%) remains a concern, reflecting findings from Fekadu et al. (2021), who reported similar gaps in postpartum service utilization in urban Ethiopia. This may be attributed to weak follow-up systems, low community awareness, and inadequate postnatal service infrastructure.

The immunization coverage for key vaccines such as BCG (64%), Penta3 (81%), and Measles (75%) in Woreda 02 is lower than the national target of 95% (FMOH, 2022). The gap aligns with findings from a study by Tadesse et al. (2020) in Addis Ababa, which highlighted that coverage disparities persist even in urban areas due to vaccine supply interruptions, inconsistent reporting, and caregiver misconceptions. Addressing these issues requires improved outreach services, cold chain management, and awareness creation.

The leading causes of morbidity among adults—acute tonsillitis (18.8%), respiratory infections (13.1%), and urinary tract infections (11.2%)—reflect a pattern consistent with urban outpatient trends in Ethiopia. Studies by Girma et al. (2021) in Addis Ababa similarly found respiratory and gastrointestinal diseases among the top causes of morbidity. Among under-five children, respiratory diseases and gastroenteritis were predominant, consistent with WHO (2020) reports indicating that acute respiratory infections and diarrheal diseases remain the leading causes of under-five morbidity in low-income settings. The strong association of these diseases with poor sanitation and unsafe water highlights the importance of integrated WASH (Water, Sanitation, and Hygiene) interventions in disease prevention.

The TB case detection in the district (121 cases in 2023) reflects the persistent burden of tuberculosis in Ethiopia. The proportion of pulmonary TB positive cases (34.7%) and TB-HIV co-infection (8.3%) aligns with reports from the Ethiopian Public Health Institute (EPHI, 2022),

which documented co-infection rates of 7–10% nationally. The absence of treatment defaulters is encouraging and may indicate effective follow-up and adherence support systems.

Regarding HIV/AIDS, the district reported a prevalence of 0.82% among those tested, which is lower than the Addis Ababa regional prevalence of 3.4% (EPHI, 2021). The lower rate could be due to improved awareness and prevention programs, although underreporting and testing gaps cannot be ruled out. The PMTCT positivity rate (1.2%) among pregnant women aligns with national averages (1.1%) reported by UNAIDS (2022), highlighting the continued need for strengthening maternal HIV screening and ART linkage services.

The occurrence of measles and cholera outbreaks, with 30 reported cases and no fatalities, indicates relatively effective epidemic response and surveillance. However, the recurrence of these diseases signals persistent vulnerabilities in immunization coverage, sanitation, and clean water access. Similar measles outbreaks have been reported in other parts of Addis Ababa (Ejeta *et al.,* 2021), often associated with incomplete vaccination coverage and population movement. Cholera outbreaks, frequently linked to poor sanitation and contaminated water sources, remain common in Ethiopia's urban-peripheral districts (Alemayehu *et al.,* 2020). These findings underscore the need for improved WASH infrastructure, emergency preparedness, and routine surveillance systems.

The study found that only 8.3% of the total Lemi Kura Sub-City health budget was allocated to Woreda 02. This limited financial support, combined with the absence of NGO assistance, severely restricts the district's capacity to provide adequate healthcare services. Similar budgetary constraints have been highlighted by Assefa (2018) and Eshetu et al. (2021), who noted that resource allocation disparities contribute to unequal healthcare access across Addis Ababa. Moreover, the city's high unemployment and poverty levels exacerbate healthcare demands, further straining available resources.

In summary, this study highlights significant progress in maternal health and education, but also reveals major gaps in sanitation, healthcare workforce, immunization coverage, and communicable disease control. Comparisons with national and regional studies suggest that the challenges faced by Woreda 02 reflect broader systemic issues within urban health governance,

financing, and service delivery. Addressing these gaps requires a coordinated, multi-sectoral "One Health" approach—linking health, education, sanitation, and socio-economic development—to sustainably improve health outcomes in the district.

9. Limitations

Sectors with inadequate or absent data, health, and health-related indicators, such as death records. Language, religion, average income per capital, and occupational characteristics not well documented in the district. Getting appropriate person on time on their seat was very difficult.

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Chapter VI

Scientific Manuscript for peer review

Five-year Retrospective study of rabies prevalence in animals and humans in Amhara region, Ethiopia.

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Abstract

Background

Rabies is a global public health threat, with Ethiopia being endemic and contributing to significant morbidity and mortality in both humans and animals. Understanding the prevalence of rabies in the Amhara region is crucial for effective control strategies and reducing the disease's burden. This retrospective study examines rabies cases among animals and humans over the past five years, assessing spatial distributions and identifying high-risk areas.

Methodology

A retrospective study was conducted to measure the size of the problem. Data obtained from Ethiopian Public Health Institute rabies case record book, Ministry of Agriculture (MoA), and the Amhara regional bureaus.

Results

The results showed an increasing trend in human rabies cases over the past five years, with the highest number of cases in 2022 (9,053). The highest number of human deaths due to rabies was 39 in 2022, while the highest number of animal rabies cases was 5,867 in 2021.

Discusion

The study highlights the impact of factors like population density, dog demographics, and ecological influences on rabies transmission. It emphasizes the need for targeted interventions, enhanced vaccination campaigns, and sustained surveillance to address regional disparities and reduce the burden of rabies in both human and animal populations. Spatial analysis revealed West Gojjam as a hotspot for human rabies and East Gojjam for animal cases.

Key words: Amhara region, Control strategies, public health threat, Rabies, Zoonotic disease

1. Introduction

Rabies is a zoonotic viral disease that poses a significant public health threat globally, particularly in regions with inadequate control measures and high populations of free-roaming dogs. In Ethiopia, rabies remains endemic, contributing to considerable morbidity and mortality in both humans and animals. The Amhara region grapples with a notable burden of rabies presenting challenges to public health authorities and necessitating targeted interventions to mitigate disease transmission. Understanding the prevalence of rabies in Amhara, encompassing both human and animal populations, is crucial for informing effective control strategies and reducing the burden of this deadly disease (Yoak *et al.,* 2021).

Human rabies is a neglected tropical disease, and it is still a disease of significant public health concern in Ethiopia. Although approximately 2000 animal rabies cases have been reported annually, the disease dynamics in different animal species and the spill over to humans remain unclear. As a result, Ethiopia has not yet achieved the international goal of reducing human rabies to 0.1 cases per 100,000 population per year by 2030 (Menghistu *et al.,* 2021; Asfaw *et al.,* 2024; Bahiru *et al.,* 2022).

In addition to its impact on human health, rabies also poses a significant threat to animal populations in Amhara. Dogs, as the primary reservoir of rabies virus transmission to humans, play a central role in the epidemiology of the disease, with canine rabies accounting for the majority of reported cases. However, rabies also affects other animal species, including livestock, wildlife, and stray animals (Beyene *et al.,* 2020; Knobel *et al.,* 2017).

Despite the recognition of rabies as a preventable disease, gaps in surveillance, vaccination coverage, and public awareness persist in the Amhara region, hindering progress towards rabies control and elimination. This study aims to address these knowledge gaps by assessing the prevalence of rabies in Amhara, examining the spatial and temporal distribution of cases in both humans and animals, and identifying priority areas for intervention.

2. Methodology

2.1. Study area

This study is focused on examining the burden of Rabies both in humans and animals in Amhara region. The Amhara region is located in the north western part of Ethiopia between 9°20′ and 14°20′ North latitude and 36° 20′ and 40° 20′ East longitude. The region covers approximately 159,173.66 km^2 areas; the region has an estimated density of 120 persons per km^2.The region is divided in to twelve administrative zones, 3 metropolitan cities, 158 woredas and 46 towns. About 90.85% of the population lives in rural areas.

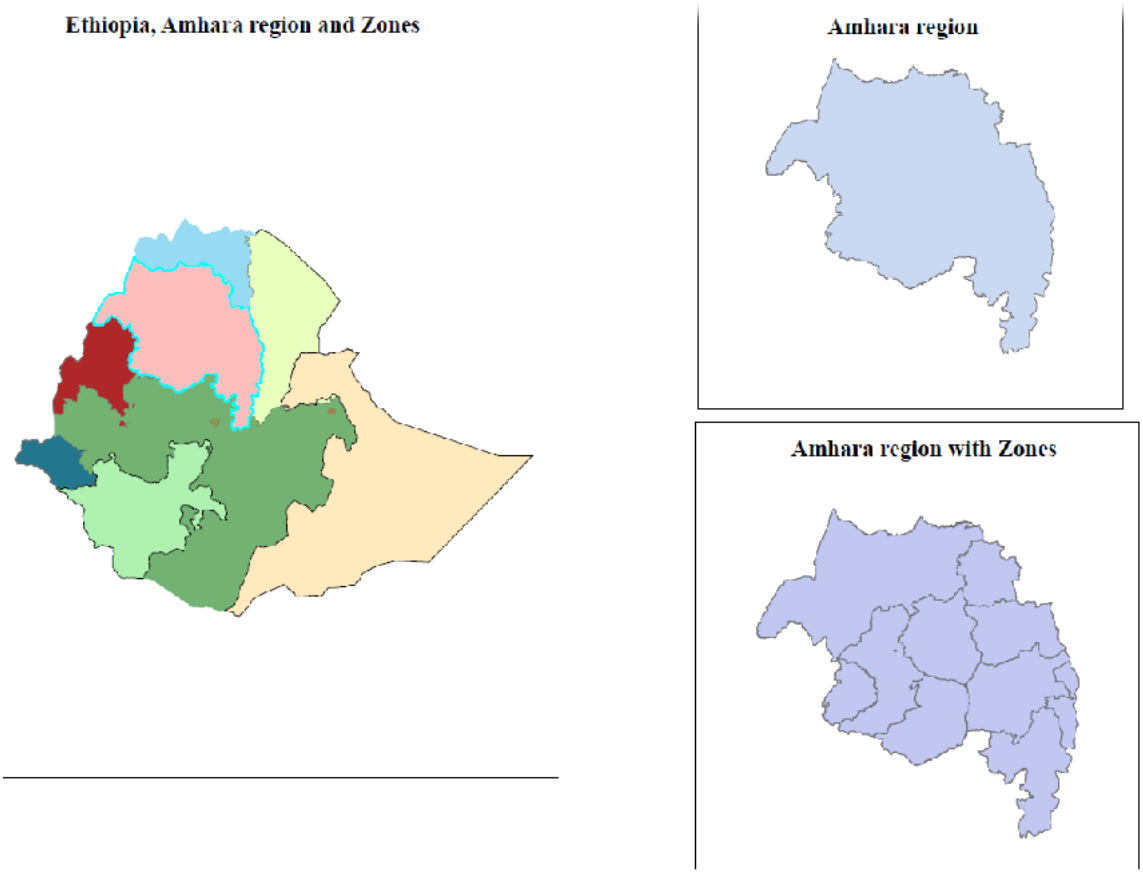


Figure1: Map of the study area showing the Amara region within Ethiopia and study zones within Amhara region.

2.2 Study design and duration

A retrospective descriptive study was conducted to measure the size of the problem. Five years, from 2019 to 2023, rabies surveillance data in Amhara region was presented; then descriptive statistical analysis was employed.

2.3. Data collection

The dog population in the region is not clearly known. A recent study in the region indicated a presence of large number of owned and free roaming dogs in the region (Bahiru *et al.,* 2022). The same study also reported that on average there were 1.3 dogs per dog-owned household and one in every 13 households owned dogs. Ethiopian Public Health Institute rabies case record book, Ministry of Agriculture (MoA) and the Amhara regional state bureaus have completed. Records of dog bite and rabies case investigations and reports for the last five years. The data records include case-based reports such as the animal and human cases, date of dog bite and date of last vaccination, season at which the cases and bite occurred, clinical signs, laboratory confirmation result, date of sample submission to the diagnostic laboratories, and epidemiological investigation findings of the case. The record book for animal rabies cases includes zones, woredas, kebeles, outbreak reference number, diagnosis status, species, age, cases, deaths, etc.

2.4. Data analysis

Data obtained from the aforementioned documents will enter into Microsoft Excel 2010 Version spread sheet will be used for summarizing and analysis of the data to describe the disease by person place and time. Employ statistical methods to analyze the collected data, including descriptive statistics, trend analysis, and spatial mapping techniques.

We reviewed the content and variables of the data and organized it after checking for outliers, consistency, completeness, and typing errors. Microsoft Excel 'Pivot Table' was used for summarizing and analysis of the data to describe the disease by person, time, place, and animal.

3. Results

3.1. Rabies in Humans

3.1.1. Year Vs Prevalence

A total of 24,432 human rabies cases and 124 deaths were reported in the Amhara region from 2019–2023. Cases showed an increasing trend, peaking in 2022 (9,053 cases, 39 deaths), followed by a slight decrease in 2023 (5,511 cases, 17 deaths). Mortality rates decreased over time, with the highest in 2019 (1.816%) and lowest in 2023 (0.308%).

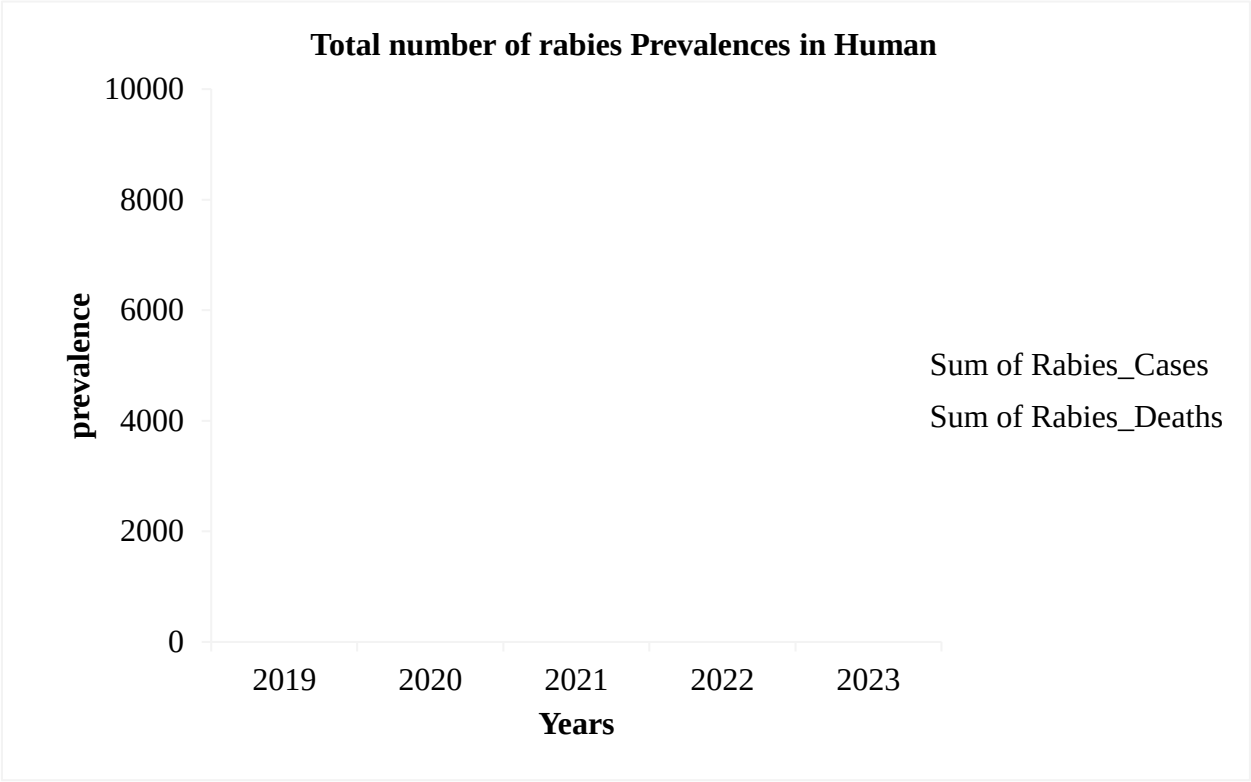


Figure 1: Total number of rabies Prevalence in Human

3.1.2. Zones Vs prevalence

The retrospective study of human rabies cases reported from 2019 to 2023 in the Amhara region provides valuable insights into the distribution and impact of rabies across different zones. Analysis of the data reveals significant variations in the number of reported cases and deaths among the various zones. West Gojjam Zone has the highest number of reported cases (8,104 cases) and deaths (49 deaths) during the study period as showed in figure 2. This zone accounts for a substantial portion of the total cases and deaths in the region, indicating a significant burden of rabies.

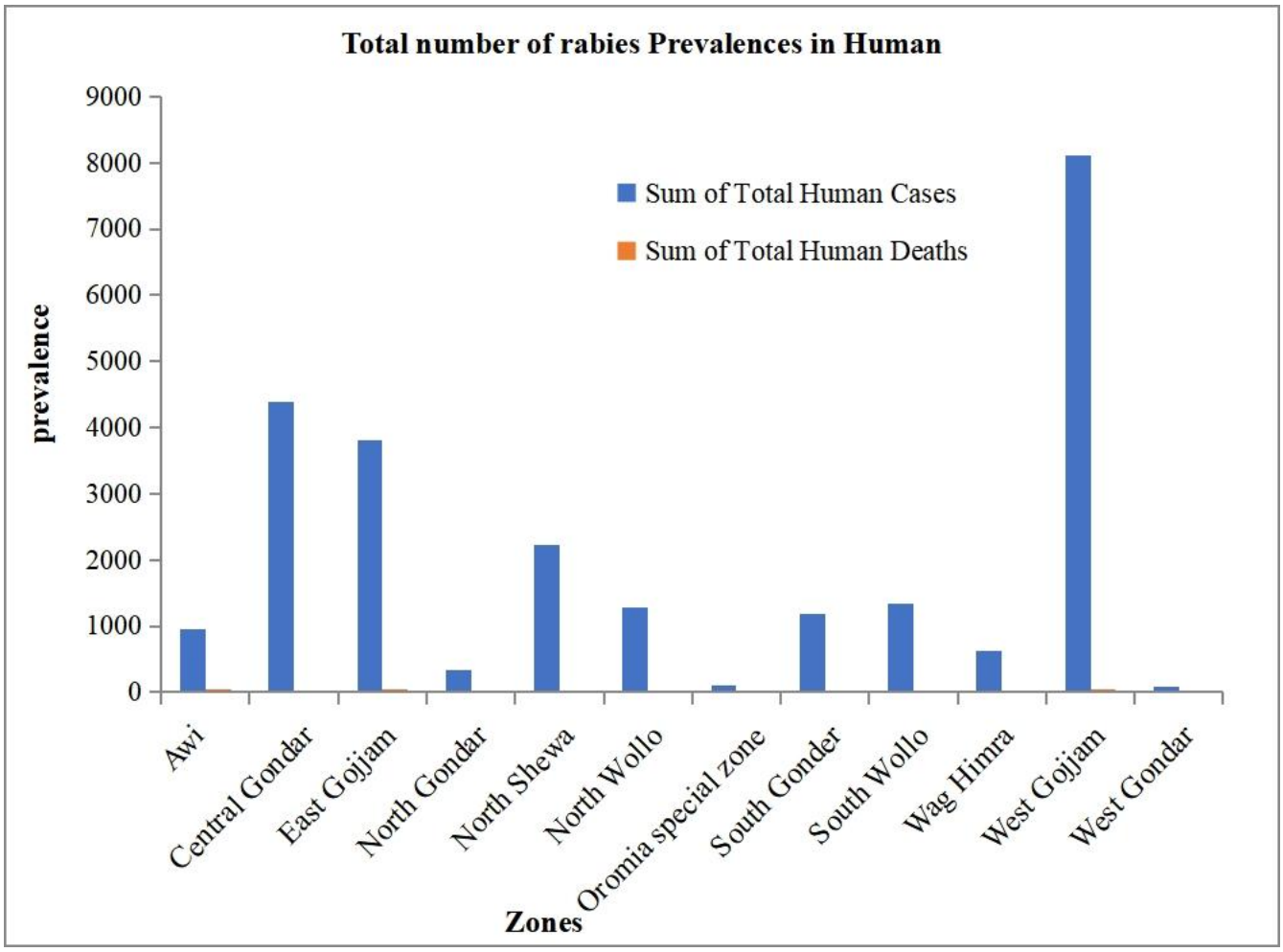


Figure 2: Total number of rabies Prevalence in Human

3.2. Rabies in Animals

3.2.1. Year Vs. prevalence

Over the five years, 1,053 animal rabies cases and 793 deaths were reported. The highest cases occurred in 2021 (331 cases, 273 deaths), with fluctuations annually. Mortality rates also varied but were consistently higher than in humans**.**

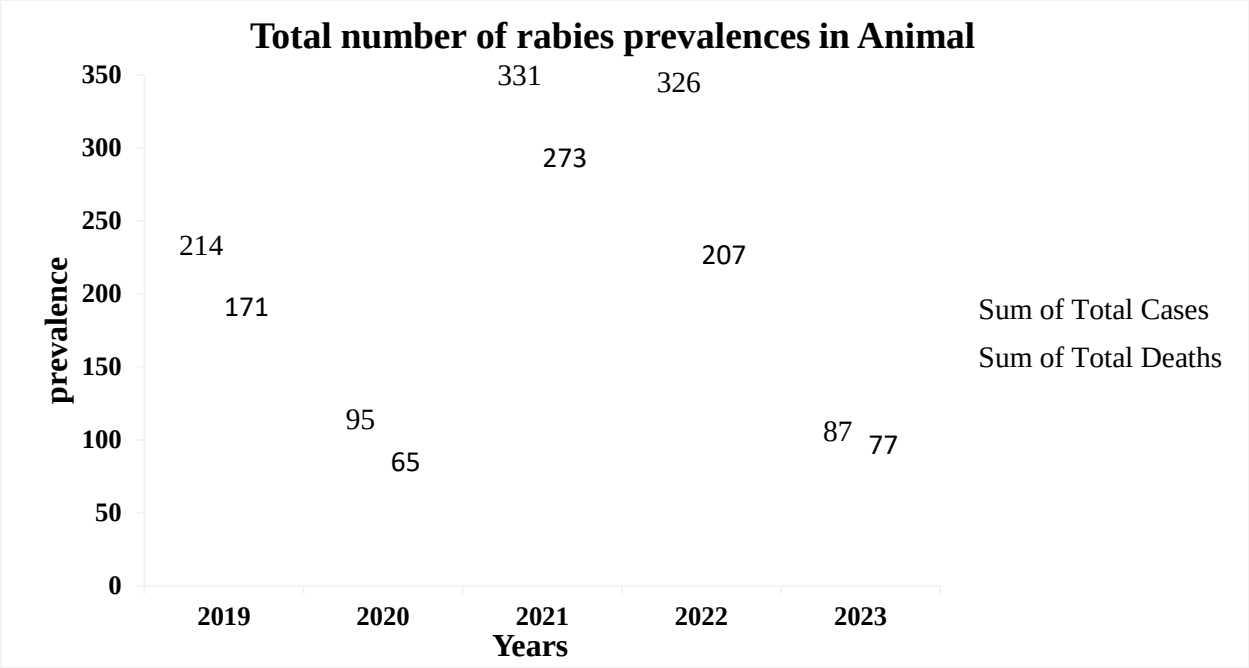


Figure 3: Total number of rabies Prevalence in Animals

3.2.2 Zones Vs prevalence

The total number of animal deaths due to rabies also varies across different zones, with East Gojjam, reported the highest cases (210) and deaths (171), while South Gondar had the lowest (7 cases, 7 deaths). Some zones report a relatively lower number of deaths compared to the total number of cases, indicating better management and treatment protocols in those areas.

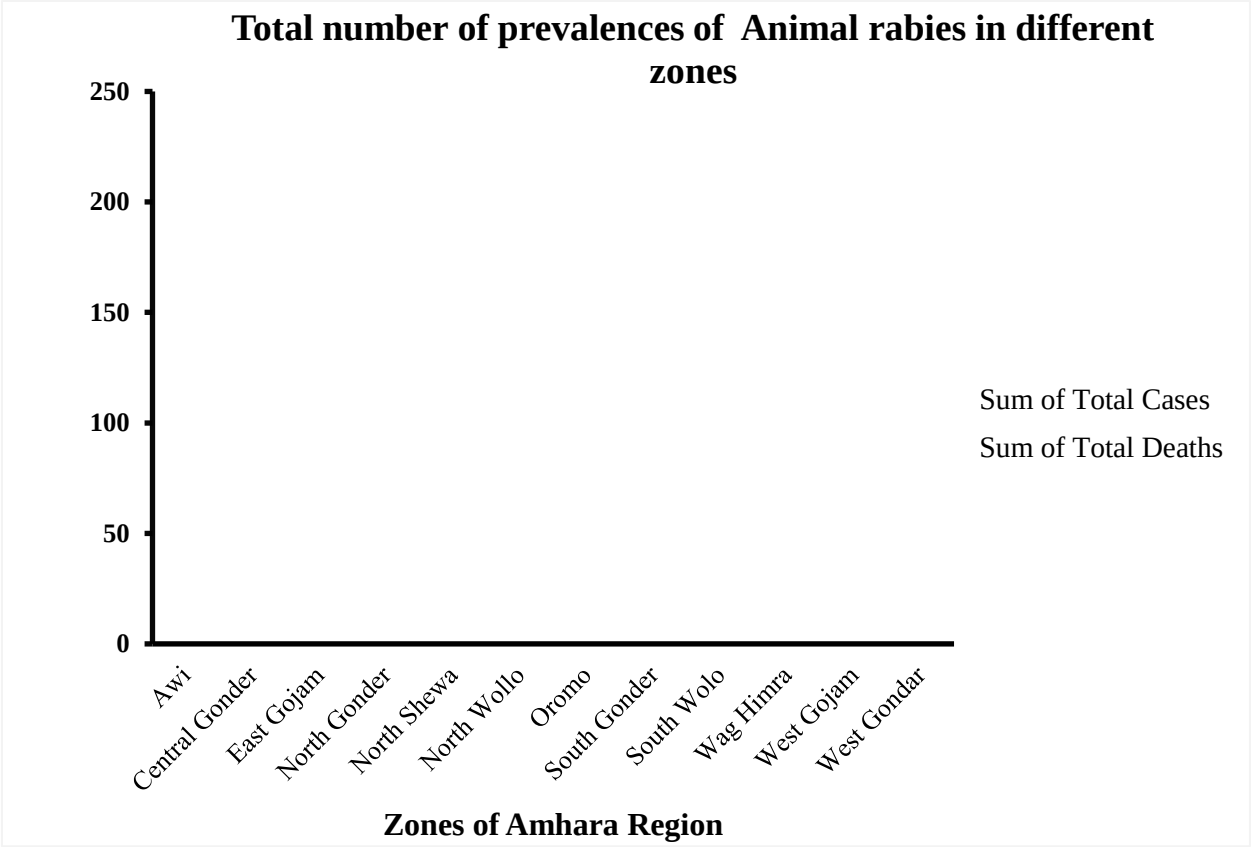


Figure 4: Total amount of prevalence of Animal rabies in different zones

3.3. Cases Vs Species

The prevalence of rabies by species in the Amhara region between 2019 and 2023 indicates that rabies cases were identified in different species, including bovine (16.97%), caprine (11.93%), equine (0.92%), and ovine (0.46%). While the prevalence of rabies in these species is significantly lower compared to canines. As shown in the pie chart canine rabies accounts for the largest portion (69.72%) of the reported rabies cases during the study period. This suggests that dog bites are the primary route of rabies transmission in the region.

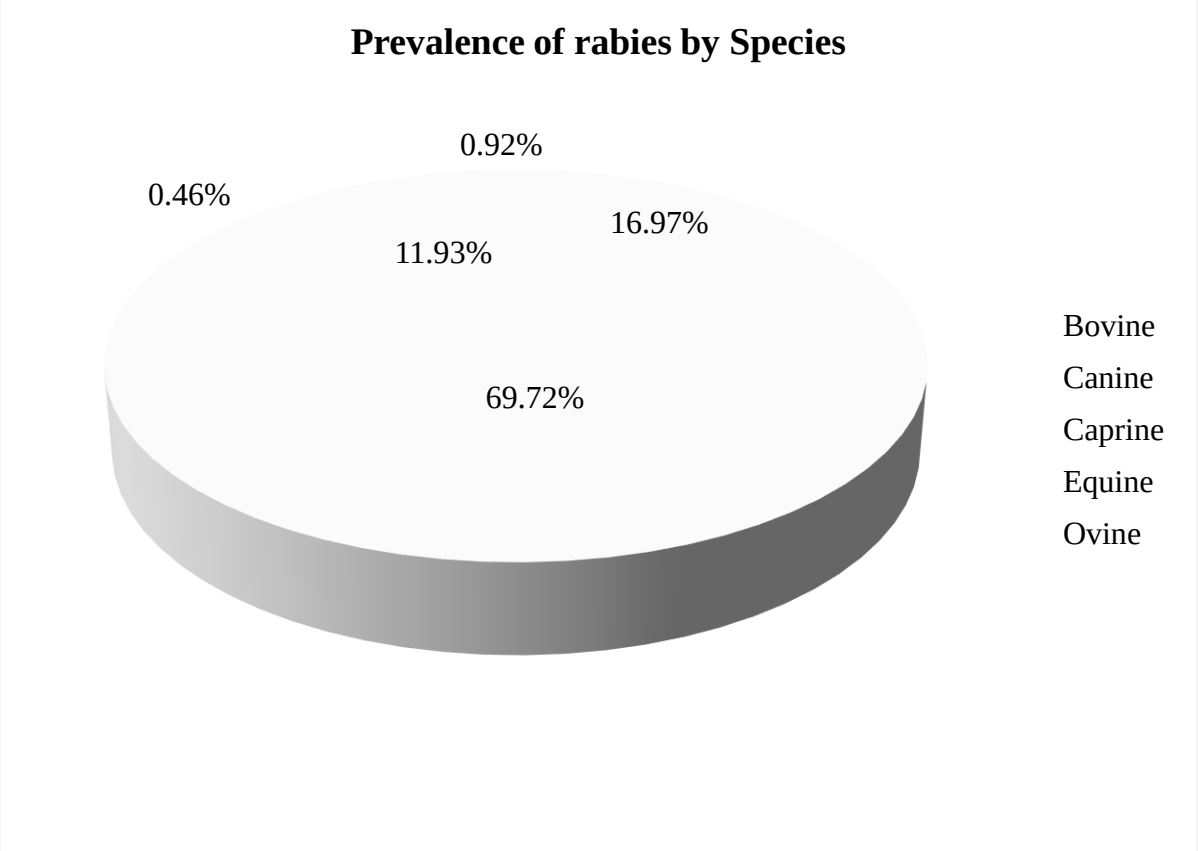


Figure 5: Prevalence of rabies by Species

3.4. Human vs. Animal Rabies

Human cases outnumbered animal cases each year, while animal deaths exceeded human deaths. Peaks in both human and animal cases aligned in 2021 and 2022. West Gojjam and East Gojjam were hotspots for human and animal rabies, respectively as shown in table one.

These findings underscore the importance of targeted vaccination, surveillance, and control measures to address the burden of rabies effectively.

Roll No	**Years**	**Total Human Cases**	**Total Human Deaths**	**Total Animal Cases**	**Total Animal Deaths**
1	2019	991	18	214	171

2	2020	2822	23	95	65
3	2021	6055	27	331	273
4	2022	9053	39	326	207
5	2023	5511	17	87	77
Grand Total		**24432**	**124**	**1053**	**793**

Table 1: Total number of rabies prevalence in Human and in Animals over five years

4. Discussion

This study revealed an increasing trend in human rabies cases in the Amhara region over five years, with the highest number of cases reported in 2022. The findings align with previous studies highlighting rabies as a persistent public health threat in Ethiopia (Damtie *et al.,* 2018). The observed fluctuation in cases reflects dynamic disease transmission influenced by factors such as population density, dog demographics, and vaccination coverage (Beyene *et al.,* 2020). Despite a decline in cases in 2023, the overall burden underscores the need for sustained efforts in surveillance and intervention.

Animal rabies cases also fluctuated over the study period, with the highest Prevalence in 2021 and a decreasing trend in subsequent years. Canines were identified as the primary contributors to rabies cases, consistent with global trends emphasizing dogs as the main reservoir of rabies virus transmission to humans (Fooks *et al.,* 2017). These findings highlight the importance of canine vaccination programs and integrated control strategies.

The spatial distribution of rabies cases revealed geographic clustering, with West Gojjam being a hotspot for human rabies cases and East Gojjam reporting the highest animal cases. Urbanization, animal management practices, and proximity to wildlife habitats likely contribute to these patterns. Identifying high-burden areas is critical for prioritizing resources and implementing targeted interventions (Beyene *et al.,* 2020).

Yearly fluctuations in both human and animal rabies Prevalence suggest a complex interplay of ecological, environmental, and socio-economic factors. Tailored vaccination campaigns targeting high-risk species and zones, along with public education, are essential to address these variations effectively. Additionally, understanding species-specific rabies prevalence can guide more focused control measures.

In general, this study underscores the need for ongoing surveillance, prevention, and control efforts. Integrated approaches addressing human and animal rabies through targeted interventions, resource allocation, and public awareness campaigns are vital to reduce the disease burden and its impact on both populations.

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Chapter VII

Abstract for scientific presentation

Epidemiological Analysis of *Staphylococcus aureus* Prevalence and Susceptibility Profile in Cow's Milk, Humans, and Environment: A One Health Approach

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Abstract

Background: *Staphylococcus aureus* is a zoonotic pathogen of major concern due to its widespread occurrence in humans, animals, and the environment, and its increasing association with antimicrobial resistance (AMR). In Ethiopia, close human–animal contact, raw milk consumption, and poor farm hygiene practices heighten transmission risk. This study aimed to determine the prevalence and antimicrobial resistance profile of *S. aureus* in cow milk and dairy farm environments and to identify human-related risk factors within a One Health framework.

Methods: A cross-sectional study was conducted from March to September 2025 in Addis Ababa and Sheger cities, Oromia Region. A total of 188 samples (94 milk and 94 environmental) were analyzed using standard microbiological techniques. Antimicrobial susceptibility was determined by the Kirby–Bauer disk diffusion method following CLSI and Ethiopian Standards Agency guidelines. Questionnaire data from 94 farm attendants were analyzed for risk associations using logistic regression at a 95% confidence level.

Results: *S. aureus* was isolated from 37 (19.68%) samples—35.0% of milk and 4.55% of environmental samples. Logistic regression showed that education level (AOR = 3.42, p = 0.015),

farm size (AOR = 2.58, p = 0.035), and management system (AOR = 3.86, p = 0.003) significantly influenced contamination and knowledge–attitude–practice (KAP) scores. Small-scale and extensive farms had the highest infection rates. Antimicrobial testing revealed universal resistance to penicillin, moderate resistance to tetracyclines, and low resistance to ciprofloxacin and trimethoprim-sulfamethoxazole, while all isolates remained susceptible to vancomycin.

Conclusion: The study revealed significant associations between *S. aureus* occurrence and farm management factors, alongside widespread β-lactam resistance and emerging MDR patterns. Strengthening farmer training, promoting prudent antibiotic use, and improving milking hygiene and biosecurity are crucial to mitigating AMR risks in Ethiopia's dairy sector.

Keywords: antimicrobial resistance, cow's milk, environment, One Health, Ethiopia, *Staphylococcus aureus*

Annex

Annex I: Questionnaire/Survey Tool

Questionnaire on Knowledge, Attitude, and Practices (KAP) of farmers toward milk antimicrobial resistance (AMR)

A. General Information

1. Farmer ID: _____

2. Date: ___ / ___ / 20___

3. Sub-city / District: _____

B. Socio-Demographic Characteristics

1. Sex: ☐ Male ☐ Female

2. Age (years): _____

3. Marital Status: ☐ Single ☐ Married ☐ Divorced/Widowed

4. Educational Level: ☐ No formal education ☐ Primary (Grades 1–8) ☐ High school (Grades 9–12) ☐ College/University graduate

5. Farm Management Type: ☐ Intensive ☐ Semi-intensive ☐ Extensive

6. Feed & Water Storage Hygiene: ☐ Good (clean, covered, no contamination) ☐ Poor (uncovered, dirty, risk of contamination)

C. Knowledge on Antimicrobial Resistance (AMR) and Zoonoses

1. Have you ever heard of antimicrobial resistance (AMR)? ☐ Yes ☐ No

2. Do you know that improper use of antibiotics in animals can cause bacteria to become resistant? ☐ Yes ☐ No ☐ Not sure

3. Milk from animals treated with antibiotics may contain drug residues harmful to humans. ☐ Agree ☐ Disagree ☐ Not sure

4. Withdrawing milk for a recommended period after antibiotic treatment reduces residues. ☐ Agree ☐ Disagree ☐ Not sure

5. Overuse or misuse of antibiotics can lead to treatment failure in animals and humans. ☐ Agree ☐ Disagree ☐ Not sure

6. Do you know that some diseases can be transmitted from animals to humans (zoonoses)? ☐ Yes ☐ No ☐ Not sure

7. Can unpasteurized milk carry diseases that can infect humans? ☐ Yes ☐ No ☐ Not sure

8. Do you think proper milking hygiene can reduce the risk of zoonotic disease transmission? ☐ Yes ☐

No ☐ Not sure

D. Attitudes Toward Antibiotic Use and AMR

1. "Antibiotics should only be used when prescribed by a veterinarian." ☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree
2. "I am willing to follow withdrawal periods even if it means discarding milk." ☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree
3. "Improving hygiene is as important as using antibiotics to prevent disease." ☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree
4. "Antimicrobial resistance is a serious problem for human and animal health." ☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree

E. Practices on Antibiotic Use in Dairy Farming

1. Do you consult a veterinarian before giving antibiotics to your cows? ☐ Always ☐ Sometimes ☐ Never
2. Do you keep records of antibiotic use (drug name, dose, date)? ☐ Yes ☐ No
3. Do you observe the recommended withdrawal period before selling milk? ☐ Always ☐ Sometimes ☐ Never
4. How do you dispose of milk during withdrawal? ☐ Discard ☐ Feed to calves ☐ Sell anyway ☐ Other: _____
5. How often do you clean and disinfect feeding/watering equipment? ☐ After every use ☐ Daily ☐ Weekly ☐ Rarely

Annex II: Laboratory Results

Code	SXT	Interpreated	TMP	Interpreated	TE	Interpreated	DO	Interpreated	T	Interpreated	P	Interpreated	CIP	Interpreated	VA	Interpreated
M1	32.7	Susceptible	25	Susceptible	10.3	Resistant	12.3	Intermediate	0	Resistant	0	Resistant	35	Susceptible	19	Susceptible
M2	29.3	Susceptible	25.3	Susceptible	10.7	Resistant	14	Intermediate	0	Resistant	0	Resistant	33	Susceptible	19	Susceptible
M3	24	Susceptible	19.3	Susceptible	30.3	Susceptible	28	Susceptible	30	Susceptible	0	Resistant	30.7	Susceptible	22.7	Susceptible
M4	23.7	Susceptible	20.7	Susceptible	25.7	Susceptible	24	Susceptible	29.7	Susceptible	0	Resistant	31.3	Susceptible	19.3	Susceptible
M5	30	Susceptible	27	Susceptible	12.3	Resistant	14.3	Intermediate	0	Resistant	10.3	Resistant	30.3	Susceptible	18.7	Susceptible
M6	30.3	Susceptible	27	Susceptible	10.7	Resistant	12.7	Intermediate	0	Resistant	11	Resistant	33	Susceptible	17.3	Susceptible
M7	29.3	Susceptible	25.3	Susceptible	34	Susceptible	27.3	Susceptible	25	Susceptible	0	Resistant	23.7	Susceptible	17.3	Susceptible
M8	27	Susceptible	26.3	Susceptible	28.3	Susceptible	29	Susceptible	29.3	Susceptible	0	Resistant	28.7	Susceptible	15.7	Susceptible
M9	28.7	Susceptible	21.3	Susceptible	30	Susceptible	31	Susceptible	26	Susceptible	0	Resistant	30.7	Susceptible	23.7	Susceptible
M10	31	Susceptible	24	Susceptible	32.3	Susceptible	32	Susceptible	25.3	Susceptible	0	Resistant	29	Susceptible	21.7	Susceptible
M11	28.7	Susceptible	22.3	Susceptible	26.7	Susceptible	28.7	Susceptible	26	Susceptible	0	Resistant	30	Susceptible	16	Susceptible
M12	26.3	Susceptible	23	Susceptible	29.3	Susceptible	24.3	Susceptible	25.7	Susceptible	0	Resistant	26.3	Susceptible	19.3	Susceptible

M13	25.7	Susceptible	21.7	Susceptible	28.7	Susceptible	25	Susceptible	24.7	Susceptible	0	Resistant	27.7	Susceptible	19.3	Susceptible
M14	25	Susceptible	19.7	Susceptible	27	Susceptible	25.7	Susceptible	27	Susceptible	0	Resistant	28.3	Susceptible	20	Susceptible
M15	22.7	Susceptible	21	Susceptible	8.3	Resistant	13.7	Resistant	6.7	Resistant	0	Resistant	27.7	Susceptible	20	Susceptible
M16	24	Susceptible	21.7	Susceptible	11.3	Resistant	16.3	Susceptible	7.3	Resistant	0	Resistant	29	Susceptible	18	Susceptible
M17	23.3	Susceptible	19.7	Susceptible	9	Resistant	16.7	Susceptible	7	Resistant	0	Resistant	27	Susceptible	18.7	Susceptible
M18	25.3	Susceptible	24.3	Susceptible	8.7	Resistant	13.3	Resistant	0	Resistant	0	Resistant	35.3	Susceptible	17.3	Susceptible
M19	22.3	Susceptible	24.3	Susceptible	10.7	Resistant	13	Resistant	0	Resistant	0	Resistant	32.3	Susceptible	19.3	Susceptible
M20	22	Susceptible	23	Susceptible	11	Resistant	15	Intermediate	0	Resistant	0	Resistant	28.7	Susceptible	19	Susceptible
M21	32.7	Susceptible	24.7	Susceptible	7	Resistant	9.3	Resistant	0	Resistant	0	Resistant	35.7	Susceptible	19	Susceptible
M22	33	Susceptible	27.7	Susceptible	7	Resistant	7.7	Resistant	0	Resistant	0	Resistant	34.7	Susceptible	21	Susceptible
M23	31	Susceptible	27.7	Susceptible	7.3	Resistant	8	Resistant	0	Resistant	0	Resistant	42	Susceptible	19	Susceptible
M24	27.7	Susceptible	24.3	Susceptible	6.7	Resistant	9.7	Resistant	0	Resistant	0	Resistant	31	Susceptible	18	Susceptible
M25	24.7	Susceptible	24.3	Susceptible	6	Resistant	9.3	Resistant	0	Resistant	0	Resistant	30	Susceptible	19.3	Susceptible
M26	25.3	Susceptible	21.3	Susceptible	6.7	Resistant	9	Resistant	0	Resistant	0	Resistant	31	Susceptible	18.3	Susceptible

M27	23	Susceptible	23	Susceptible	10.7	Resistant	14.7	Intermediate	7	Resistant	0	Resistant	36.3	Susceptible	19.7	Susceptible
M28	22	Susceptible	19.7	Susceptible	11	Resistant	14.3	Intermediate	6.7	Resistant	0	Resistant	35	Susceptible	20.3	Susceptible
M29	24.3	Susceptible	22.7	Susceptible	13	Resistant	14.3	Intermediate	7.7	Resistant	0	Resistant	31	Susceptible	21.3	Susceptible
M30	23.7	Susceptible	10	Resistance	9	Resistant	10.7	Resistant	8	Resistant	0	Resistant	39.3	Susceptible	21.7	Susceptible
M31	23	Susceptible	11.7	Intermediate	10.3	Resistant	12	Resistant	7	Resistant	0	Resistant	36.3	Susceptible	24	Susceptible
M32	30.7	Susceptible	21.7	Susceptible	8.3	Resistant	9.7	Resistant	0	Resistant	0	Resistant	26.3	Susceptible	17.3	Susceptible
M33	30.3	Susceptible	20.7	Susceptible	9.7	Resistant	8.3	Resistant	0	Resistant	0	Resistant	30	Susceptible	16.7	Susceptible
E1	17	Susceptible	25.7	Susceptible	8	Resistant	7.7	Resistant	24	Susceptible	0	Resistant	30	Susceptible	8.7	Resistant
E2	17.3	Susceptible	28.7	Susceptible	8	Resistant	9.3	Resistant	26	Susceptible	0	Resistant	36.7	Susceptible	5.7	Resistant
E3	17.3	Susceptible	24.3	Susceptible	9	Resistant	8.3	Resistant	23.7	Susceptible	0	Resistant	37.3	Susceptible	7	Resistant
E4	18	Susceptible	24.7	Susceptible	8.3	Resistant	8	Resistant	24.7	Susceptible	0	Resistant	33.7	Susceptible	7.3	Resistant

Annex III: Questionnaire for evaluation of surveillance system in Sheger city, Oromia, Ethiopia September, 2025

1. Zonal Level Questionnaire

Region _____ Zone_____ Woreda _____ # of Hos._____ # of HC____ # of HP

_____ # of Private HF_____

Total population _____ urban _____ rural _____ Male _____ Female _____,

< 15 yrs.

Respondent_____

Interviewer: _____

Date_____

General questions

1. Is there a national manual for surveillance? Yes/ No

2. *If yes*, describe (last update, diseases included, case definitions, surveillance and control,

Integrated or different for each disease):_____.

3. Do you have standard case definitions for the Country‘s priority diseases like AWD, AFP polio),

malaria, RF, typhoid fever, Epidemic fever, malnutrition and measles? Yes / No

4. If yes, Obs [1 to n priority diseases] is the standard case definition for each priority disease like malaria,

measles, meningitis ..._____

5. Is the central level responsible for providing surveillance forms to the health facilities? Yes/

No

6. *If yes*, have you lacked appropriate surveillance forms at any time during the last 6 months?

Yes / No

7. What are the reporting health facilities for the surveillance system?

a. Public health facilities b. NGO health facilities

c. Military health facilities d. Private health facilities

e. Others_____

8. Number of total districts that has reported weekly and immediately report in the last 3 months compared to expected number? _____

9. Number of Health post, Health centers, Hospitals, NGO health facility, Others (private) sent weekly report in the last three months compared to expected number?

Weekly: _____

Immediately: _____

10. Number of weekly reports received on time: ____/12 times the number of woredas

11. Was there any report of the immediately reportable diseases in the past 1 month?

Yes/ No

12. If yes, with in what time is the report received after detection of the case/diseases? a. Less than 1 hours b. 2-12 hours c. 1- 2 days d. 3- 7 days e. After 1 week

13. How do you report to the next high level and receive from districts? a. Mail b. Fax C. telephone d. Radio e. Electronic f. Other

14. Does the zone level describe data by person (case based, outbreaks, and sentinel)?

Yes/ No If yes, (Obs) Observed description of data by age and sex

15. Do you describe data by place? Yes/No

16.Do you describe data by time? a. yes b. no c. don't know If yes, observe description of data by time:

_____

17. Does the zone have an action threshold defined for Measles and malaria? Yes / No

18. Who is responsible for the analysis of the collected data? _____

19. How often do you analyze the collected data?

a. Daily b. Weekly c. Every 2 weeks d. Monthly e. Quarterly f. As needed

20. Do you have an appropriate denominators established? Yes / No

21. If yes, Obs presence of demographic data (E.g. population by woreda and hard to reach groups**)**

Outbreak Investigation

22. Is there any outbreak in the zone in the last year? Yes/No

If no, skip to Q # 28

If yes, number of outbreaks investigated:_____

23. List of diseases:_____.

24. Number of outbreaks investigated and which risk factors were looked for:_____.

25. Number of outbreaks in which findings were used for action [Observe report] _____

26. Number of woredas that looked for risk factors [observe in reports]

27. Number of woredas that used the data for action [observe in final report] _____

Epidemic preparedness(relevant for epidemic prone diseases)

28. Does the zone established epidemic management committee? Yes/No

29. Do you have plan for epidemic preparedness and response? Yes/No

If yes, Obs, a written plan of epidemic preparedness and response

30. Has the zone had emergency stocks of drugs, vaccines, and supplies at all times in past 1 year? Yes/ No

31. Has the zone experienced shortage of drugs, vaccines or supplies during the most recent epidemic (or outbreak)? Yes/ No

32. Does the standard case management protocol for malaria and measles exists in all health facilities? Yes/No

33. Is there a budget line for epidemic response? Yes / No

If yes, Obs. minutes (or report) of meetings of epidemic management committee

34. Does the zone have a rapid response team for epidemic? Yes/ No

Response to epidemics

35. Does the epidemic committee responded within 48 hours of notification from zone level? Yes/No

If yes, Obs(from written reports with trend and intervention)

Feedback

36.Does a report is regularly produced to disseminate surveillance data from the zone?

Yes/No

If, yes Obs: the presence of a report of surveillance data

37. How many feedback reports has the zone level produced in the last year?_____

Supervision

38. Did you conduct supervision last 6month? Yes/No

39. If yes, how many supervisory visits have you made in the last 6 months?____

40. If no, what is reasons for not making all required supervisory visits.

_____

_____

_____

Training

41. Have you received any post-basic training in epidemic management? Yes/No

If yes, specify when, where, how long, by whom?

Training tittle time place trainer/organizer

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

42. How many of your staffs trained in surveillance? _____

Resources

43. For data management

a) Computer & Printer Yes No

b) Photocopier Yes No

c) Data manager/secretary Yes No

d) Statistical package Yes No

44. Communications availability

a) Telephone service Yes No

b) Fax Yes No

c) Radio call Yes No

d) Internet Yes No: If yes, connections availability; Yes No or private or government.

Surveillance

45. Is there a budget line for surveillance in zone? Yes No

If yes, is it sufficient Yes No

46. If No, what option did you use at zonal level?_____

How could surveillance be improved? _____

47.What opportunities are there for integration of surveillance activities and functions(Core activities, training, supervision, guidelines, resources etc.)?

a._____

b._____

c. _____

Woreda (Intermediate Level) Questionnaire

Woreda_____

Respondent_____

Date _____

Interviewer _____

General Information

1. Is there a national PHEM /IDSR Guide line Or manual at this site? Yes/No

If yes, **Obs** national PHEM /IDSR Guide line/manual:_____

2. Does the woreda have the **capacity** to transport specimens to a higher level lab? Yes/No

If No, Reason _____

3. Does the woreda have guidelines Or SOP for specimen collection, handling and transportation to the next level? Yes / No

4. Have you lacked forms recommended for the country's priority disease at any time during the last 6 months? Yes/ No

5. Number of reports received in the last 3 months compared to expected number

Weekly: _____ /12 times the number of health facilities

Immediately: _____/ times the number of health facilities

6.the Number of weekly reports submitted on time: ____/12 times the number of health facilities (**On Monday)**

7. Number of immediately reports submitted on time: _____/3 times the number of health facilities (**within 30minutes of events)**

8. How do you report Weekly or immediately to the next level?

a/ Mail b/Telephone c/ Fax d/Radio e/ Electronic f/ Other

9. How can reporting system be improved?

_____

_____.

10. Did you analysis IDSR data? Yes/No

a) If yes, Is data describe by person for any case based, outbreaks or sentinel? Yes/No

If yes, Obs description of data by age and sex

b) Is description of data by place (locality, village, work site etc)? Yes / No

If yes, Obs. description of data by Place

c) Is the description of data by time? Yes/ No

If yes, observed description of data by time?

11. Is there a trend analysis for the following disease?

a) Malaria Yes/ No

b) Measles Yes/No

If yes, **Obs**. line graph of cases by time

12. Do you have an action threshold for any of the country priority diseases? Yes/ No

If yes, what is it? _____cases _____% increase _____rate

(Obs for 2 priority diseases)_____

13. Do you have appropriate denominators? Yes/ No

If yes, Obs. demographic data at site (E.g. total population by village, <5 yrs.,---)

14. Who is responsible for IDSR data analysis? _____ ___

15. How often do you analyze the IDSR data?

a. Daily b. Weekly c. Every 2 weeks

d. Monthly e. Quarterly f. As needed……..

Outbreak investigation

16. Is there any Outbreak or suspected in the woreda in the past year /6 months? Yes/No

If yes, number investigated_____ (Observe reports and take copies if possible)

Epidemic preparedness

17. Does the woreda has epidemic preparedness plan? Yes/No

If, yes,(**Obs)** a written plan of epidemic preparedness and response.

18. Has the woreda had emergency stocks of drugs and supplies at all times in past 1 year?

Yes/No

If yes, Obs, Observed the stocks of drugs and supplies at time of assessment

19. Has the woreda experienced shortage of drugs, vaccines or supplies during the most recent

epidemic (or outbreak)? Yes/ No

20. Is there a budget line or access of funds for epidemic response? Yes/ No

21. Does the woreda have a rapid response team for epidemics? Yes/No

If yes, **Obs** Observed minutes (or report) of meetings of epidemic management

22. Did epidemic response team evaluated their preparedness and response activities during the past year? Yes/ No

If yes, (observe written report to confirm)

Responses

23. Has the woreda implemented prevention and control measures based on local data for at least one reportable disease or syndrome? Yes/No 147

24. Percent of epidemic that responded by woredas within 48 hours of notification of most recently reported outbreak?_____

Feedback

25.How many feedback written reports has the woreda produced in the last year?_____

ObsObserved the presence of a written report that is regularly produced to disseminate

Supervision

26. Did you supervise the health facilities in the last 6 month? Yes/No

If yes, how many times have you been supervised in the last 6 months?_____

(Obs supervision report)

27. If No, the most usual reasons for not making all required supervisory visits.

(Text)

Reason 1_____

Reason 2_____

Reason 3_____

Training

28. Have you been trained on PHEM/IDSR disease surveillance? Yes/No

If yes, specify when, where, how long, by whom? _____.

Training tittle time place trainer/organizer

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

29. What percent of your staffs in the woreda trained on PHEM/IDSR surveillance? ____%

Resources

30. Logistics Available

a) Bicycles Yes/No

b) Motor cycles Yes/No

c) Vehicles Yes/No

d) Stationery Yes/No

e) Computer & Printer Yes/No

31. Communication available

a) Telephone service Yes/No

b) Fax Yes/No 148

c) Radio Yes/No

d) Computers that have modems Yes/No

32. Information education and communication materials

a) Posters Yes/No

b) Megaphone Yes/No

c) TV Screen Yes/No

d) Projector (Movie) Yes/No

39. Availability of hygiene and sanitation materials

a) Spray pump Yes/No

b) Disinfectant Yes/No

Surveillance

40. Is there an IDSR focal person in the woreda epidemic management committee? Yes/ No

41. Are you satisfied with the current surveillance system? Yes /No

If no,why? _____

Surveillance Attributes

I. Flexibility

1. Can the current reporting formats be used for other newly occurring health event

2. Did you think that any change in the existing procedure of case detection and reporting fo----------

III. Data quality

2. If answer for Q1 is No, how many unfilled spaces are in your 2008 EFY report? ----------

3. Percentage of unknown or blank responses to variables from the total reports of 2004 EFY report---

4. Percent of reports which are complete (that is with no blank or unknown responses) from the total reports ----------

6. If answer for Q5 is No, how many records are not clear/are difficult to understand in 2004 EFY report? --------

IV. Acceptability

1. Do you think all the reporting agents accept and well engaged to the surveillance

2. If yes, how many are active participants (of the expected)? ----------

3. If No, what is the reason for their poor participation in the surveillance activity?

A) Lack of understanding of the relevance of the data to be collected

B) No feedback / or recognition given by the higher bodies for their contribution

C) Reporting formats are difficult to understand

D) Report formats are time consuming

E) Other: ----------

4. Were all participants using the standard case definition to identify cases? Yes No

5. Were all the reporting agents send their report using the current and appropriate

Surveillance reporting system

6. Were all the health professionals aware about the surveillance system? Yes No

7. Was all PHEM officers send report on time? Yes No

V. Representativeness

1.Was the surveillance system enabled to follow the health and health related events in the whole community? Yes No

2. If answer for Q1 is no, who do you think is well benefited by the surveillance system?

The urban the rural both

3. Are all the Socio demographic variables included in the surveillance reporting format?

Yes or No

4. If the answer for Q3 is No, which a) Sex---- b) age group---C) ethnic group----d) religion---- is less represented?

VI.Timeliness

1. Are all reporting sites reporting on time? Yes No

2. Percent of Health facilities that send report of each week in 2004 EFY. ----------

VIII.Stability

1. Was any new restructuring affected the procedures and activities of the surveillance? □

2. Was there lack of resources that interrupt the surveillance system? □ Yes □ No

3.Was there any time /conditio

4.If the answer for Q3 is yes, explain why?

IX.Sensitivity

5. Does the malaria case definition able to pick all cases? □ Yes □ No

6. What was the total Malaria cases occurred in your woreda in 2008 EFY?

_____

7. What were the total numbers of suspected malaria cases examined by RDT or Microscopy?

8. How many of those cases were laboratory confirmed? PF_____ PV___ Mixed_ Total__

9. Were there Malaria epidemic in your woreda in 2008

10 .If yes, how many out breaks? ----------

X. IS THE SURVEILLANCE SYSTEM USEFUL?

1. To detect outbreaks early on time to permit accurate diagnosis? □ Yes □ No

2. To estimate the magnitude of morbidity and mortality? □ Yes □ No

3. Permit assessment of the effect of prevention and control programs? ☐ Yes ☐ No

Health facility Questionnaire (Hospital /Health center)

Identifiers

Woreda_____

Name of health facility

_____ Type of

health facility _____

_____

Respondent_____

_____ Date _

_____

Interviewer: __ **General**

Information

1. Is there PHEM/IDSR national Guide line or manual at this site? Yes / No

If yes, Obs; for the existence **PHEM/IDSR** national guide line or manual

2. Is there a clinical register in health facilities? Yes/ No If yes, **Obs**the existence of a clinical register
3. Is there the health facilities correctly register cases during the previous 30 days? Yes/No

If yes, **Obs**; the clinical register

Do you have a standard case definition for: (each priority disease)

a) Measles Yes/No

b) Malaria Yes/No

If yes, Obs the standard case definition for: (each priority disease)

4. Does health facilities use standardized case definitions for the country‘s priority diseases**.** Yes/ No

If yes, Obs; the respondent correctly diagnosing one of the country‘s

priority diseases using a standard case definition (Interview about of these)

5. Does the health facilities have the capacity to collect the following specimens?

a) sputum Y N N/A

b) Stool Y N N/A

c) Blood Y N N/A

d) CSF Y N N/A

6. If yes, Obs the presence of materials required to collect

a) Stool Yes No N/A

b) blood/serum Yes No N/A

c) CSF Yes No N/A

7. Do you have the capacity to handle sputum, stool, blood/serum and CSF until shipment atthis facility?

Yes No N/A

If yes, Obsthe presence of status cold chain at health facility

8. Does the health facility has the capacity to ship specimens to a higher level lab? Yes No N/A

If yes, Obs presence of transport media for stool at health facility.

9. Have you lacked appropriate surveillance forms at any time during the last 6 months? YesNo N/A

If yes, what the reason? ____

10. Observed that the last monthly report agreed with the register for 4 diseases (1 for each Targeted group [eradication; elimination; epidemic prone; major public health importance]

a. **Obs** Measles Yes No N/A

b. **Obs** Malaria Yes No N/A

11. Number of reports in the last 3 months
compared to expected number **Obs** Weekly: /12 times
the number of health facilities sites **Obs**
immediately: _____/--- times the number of health
facilities sites

On time (use national deadlines)

Obs Number of weekly reports submitted on time:-_/12 times the number of sites

Obs Number of immediately reports submitted on time: ___/-- times the number of sites

12. How do you report?

a/Telephone b/ Fax c/ Mail d/ Radio e/ Electronic f/ Other

13. How can reporting be improved? Your suggestion

14. Do you describe data by person, place and time (outbreaks,
sentinel) Yes No N/A If yes, Obs data

15. Is there trend analysis
Performed? Yes No N/A If yes,
Obs line graph of cases by time

16. Do you have an action threshold for any of the priority diseases? Yes No N/A

If yes, what is it (Ask for 2
priority diseases)? Malaria
cases _% increase

Measles cases_% increase

17. Who is responsible for data analysis? ___

18. How often do you analyze the collected data?

a) Daily b) Weekly c) Every 2 weeks d) Monthly e) Quarterly

f) As needed……..

19. Presence of demographic data at site (E.g. population <5 yr., population by village, total Population) Yes / No

Epidemic preparedness

20. Is there standard case management protocol for epidemic prone diseases at health facilities? Yes No N/A

If yes, Obs the existence of a written case management protocol for 1 epidemic prone disease

Epidemic response

21. Has the health facility implemented prevention and control measures based on local data for at least one epidemic prone disease? Yes No N/A

Feedback

22. Have you received feedback report in the last year from higher level? Yes No If yes, how many feedback reports has the health facility received in the last year? _ **Obs;** at least 1 report received

23. Have you conduct meeting with community in the last 6 month? Yes No N/A If yes, how often? a) Weekly b) every two weeks c) monthly d) quarterly e) as needed

Supervision

24. Did you supervise health posts in the last 6months? Yes No N/A

25. If yes, how many times have you been supervised in the last 6 months?

Obs; supervision report or any evidence of supervision in last 6 months

26. Did you get any supportive supervision from higher level in the last 6 months? Yes No N/A

If yes, Obs; supervision report or any evidence for appropriate review of surveillance

Training

27. Have you been trained in disease surveillance and epidemic management? Yes No N/A

If yes, specify when, where, how long, by whom?__

_____.

28. Number of Staffs trained in disease surveillance and epidemic management___.

Resources

29. Logistics

a) Electricity Yes No

b) Bicycles Yes No

c) Motor cycles Yes No

d) Vehicles Yes No

30. For data management

a) Stationery Yes No

b) Calculator Yes No

c) Computer Yes No

d) Software Yes No

e) Printer Yes No

31. Communications available

a) Telephone service Yes No

b) Fax Yes No

c) Radio call Yes No

d) Computers Yes No

32. Information education and communication materials

a) Posters Yes No

b) Megaphone Yes No

c) TV Yes No

d) Other: Yes No

33. Hygiene and sanitation materials

a) Spray pump Yes/No

b) Disinfectant Yes/No

34. List Personal Protection materials (PPE) available in health facility_____

Surveillance Attributes

Simplicity:

1. Is the case definition easy for case detection by all level health professionals? ☐ Yes ☐ No

2. Does the surveillance system allow all levels of professionals to fill data? ☐ Yes ☐ No

3. Does the surveillance system help to record and report data on time? Yes or No

4. Does the surveillance system have necessary information for investigation? ☐ Yes ☐ No

5. Does the surveillance system allow updating data on the cases? ☐ Yes ☐ No

6. How long does it take to fill the format? ☐ <5 min ☐5 to 10 min ☐ 10 to15min ☐ >15 min

7.How long does it take to have laboratory confirmation? ----------

II. Flexibility

1. Can the current reporting formats be used for other newly occurring health event (disease) without much difficalt Yes □ No □

2.Did you think that any change in the existing procedure of case detection and reporting formats will be difficult to implement Yes □ No □,

3.Add your explanation _____

4.Is the surveillance system easy to integrate with other systems? Yes □ No □

5.Is the recorded data clear to read and understand Yes or No

6. Percent of records which are difficult to read/ understand. ----------

IV. Acceptability

1.Do you think all the reporting agents accept and well engaged to the surveillance activities? Yes No

2. If yes, how many are active participants (of the expected)? ----------

3. If No, what is the reason for their poor participation in the surveillance activity?

A)Lack of understanding of the relevance of the data to be collected

B)No feedback / or recognition given by the higher bodies for their contribution

C)Reporting formats are difficult to understand

D)Report formats are time consuming

E) Other: ……

Informed Consent

My name is _____ this investigation is to be conducted on behalf of Residents of Addis Ababa University deployed at Ethiopia public health institute (EPHI). This study is believed to contribute on the effort to prevent and control the effects of cholera in Shire Indassilassie. For the successful implementation of this study, we are collecting data from patients and people free from the

disease as well. I assure you that there will be no harm, discomfort or possible ill effects on your health or well-being arising from participating in the study. You have the opportunity to ask questions on all aspects of the study and have to understand the advice and information given. You are free to withdraw from the study at any time without having to justify your decision and without prejudice. The information that you will provide will be kept confidential.

Are you willing to participate in this study?

I confirm that I have understood the above and freely consent to participate in this study. I have been given adequate time to consider my participation.

Participant code _____

Participant name and Signature _____ Date _____

Collector name signature _____ Date _____

Annex IV. Questionnaire for cholera outbreak

Questionnaire on cholera outbreak investigation in Shire Indassilassie, North West Tigray, Ethiopia, 2022.

Zone_____District_____Kebede_____

Data collector name _____phone number of data collector_____

Code_____ Date_____

GPS Coordinate of HH altitude_____ Latitude _____Longitude_____

Respondent status 1. case 2. Control

Section One: Demographic Characteristics

S/No	Questions	Possible response	Remarks
1	Age (in a complete year)	-----(years)	
2	Sex of the respondent?	1. Male 2. Female	
3	Residence	1.Rural area 2.Urban area	
4	Religion of the respondent	1.muslim 2.orthodox 3.protestant 4.adventist 5.catholic 6.Wakefata	

		7.others(specify)	
5	To which Ethnic group do you belong?	1.Oromo 2.Amhara 3.Gurage 4.Tigre 5.Sidama 6.Others(specify)	
6	What is your educational status?	1. no formal education 2. primary (grade 1-8) 3.secondary (grade 9-12) 4. vocational training/ diploma 5. degree 6. masters and above 7. not applicable	
7	What is your marital status?	1.single 2.married	

		3.widowed 4. separated 5. N/A	
8	Educational status of the head of the household?	1. No formal education 2. Primary (grade 1-8) 3. Secondary (grade 9-12) 4. Vocational training/ diploma 5. Degree 6. Masters and above 7. Not applicable	
9	Occupational status of the head of the household?	1.Government 2.NGO employee 3.Farmer 4.Student 5.Pity trader 6.Merchant	

		7.Daily laborer 8.Housewife 9.Other(specify)	
Section Four: Knowledge on Cholera Disease			
10	Have you ever heard about cholera?	1.yes 0.No	
11	Did you know the common symptoms of cholera? (Multiple responses are possible)	1.Watery diarrhea 2.Bloody diarrhea 3.vomiting 4.General body weakness 5.Musle cramp 6.sunke eyes 7.Others (specify)	
12	How cholera is transmitted to person?	1.contaminated food 2.contaminated water 3.contaminated hands/contacts 4.Others (specify)	
Section Five: Past History of Cholera			

13	Have ever been diagnosed with cholera in the past?	1.yes 2.No	
14	Did any member of your family catch cholera in the past?	1.yes 2.No	
15	Was there any death in your family member due to cholera in the past?	1.yes 0.No	
Section Six: Current clinical characteristics (For case only)			
16	When do you start to have the current diarrhea?	_____	
17	How much it was frequent per day?	1. Once 2. Twice 3. Three to five More than five	
18	Which of the following did you manifested?	1. Fever 2. Vomiting 3. Feeling thirsty 4. Sunken Eye 5. Headache 6. Excessive weakness 7. Loss of consciousness 8.Other(specify): _____)	More than one answer is possible
19	OCV Vaccination status	1.Yes 2.No	
20	Have you been admitted for the case?	1. Yes 2.No	
21	Dehydration status of case	1. No DHN 2. Some DHN Sever DHN	Review on patient card
22	What was the final outcome of the disease?	1.Recovered 2.Died	
Section six: WASH			
23	Do you have toilet?	1.yes	

		0.No	
24	Ownership of the latrine?	1.private 2.shared (b/n two HHs) 3.communal (shared among three and above HHs) 4.Others (specify)	
25	Overall, how many people use this latrine facility?	---------- (in number)	
26	Is there a hand washing facility near the latrine? (<3 meters, observe)	1.No 2.Hand washing devices (with water and soap) 2. Hand washing devices (with water only) 3. Hand washing devices (with water and ash)	
27	When do you wash your hands (non -probing)? (Multiple responses are possible)	1.After toilet 2.Before eating 3.After cleansing child 4.Before preparing food 5.Befere feeding child 6.Others (specify)	

28	What items are you using for handwashing? (Multiple responses are possible)	1. Soap and water 2.Ash and water 3.Never 4.Others (specify)	
29	What is the water source for your HH for drinking purpose? (Multiple responses are possible)	1.Pipe water 2.Spring 3.Hand dug well 4.Dip well 5.Pond 6.River 7.Lake 8.Bottled water 9.Others (specify)	
30	What types of containers do you use to fetch water from the source? (Multiple responses are possible)	1.Jerry cane 2.Bucket 3.Ensira (Gan) 4.Others (specify)	
31	For how long do you store water?	----------days	
32	Does the container have cover/lid? (observe)	1.yes 0.No	

33	What materials do you use to wash your water containers? (Multiple responses are possible)	1.Soap 2.Only water 3.Sand 4.Ash 5.Others	
34	How often do you wash your water container?	1.Every day 2.Every other day 3.Once per week 4.Others (specify)	
35	Do you treat the water you and your family use at home?	1.yes 0.No	If "No" skip to Q 81
36	If "yes" to Q 79, what method of water treatment do you use (non-probing)? (Multiple responses are possible)	1.Boiling 2.Filtration 3.Sedimentation 4.Water chemicals (Wuha, agar, Bishan gari) 5.Others (specify)	
Section seven: Feeding practices			
37	Age of person responsible for preparing food (in complete years)?	----------years	

38	Educational status of person who prepare food?	1. No formal education 2. Primary (grade 1-8) 3.Secondary (grade 9-12) 4. Vocational Training/ Diploma 5. Degree 6. Masters and above	
39	Do you eat raw /uncooked food?	1.yes 0.No	If "No" skip to Q 88
40	If "yes" to Q 86, what raw/uncooked food do you eat?	1.Raw meat 2.Raw tomato 3.Raw salad 4.Raw fish meat 5.Raw milk products 6.Others (specify)	
41	Where do you keep the cooked food?	1.Room temperature 2.Refrigerator 3.Others (specify)	
42	What are you doing with the leftover foods (non-probing)? (Multiple responses are possible)	1.Re-heat and eat 2.Provide for domestic animals 3.Give for baggers	

		4.Street children 5.Dump in waste substance 6.Others (specify)	
Section Eight: Oral Cholera Vaccine Use			
43	Have you ever heard of cholera vaccine?	1.yes 0.No	
44	Have you ever received cholera vaccine?	1.yes 0.No	
Section Nine: Study subjects/Patient related			
45	General health status of the patient before current condition	1.Excellent 2.Very good 3.Good 4.Poor 5.Bad	
46	Does the patient have known diagnosed chronic conditions?	1.yes 0.No	
47	If “yes” to Q 94, what was/were the condition/s?	1.Hypertension 2.Diabetes 3.Renal failure 4.Cancer	

		5.Heart failure 6.Chronic liver disease 7.Others (specify)	
48	Time to death or Discharge	---------- (in hrs.), --------- (in days)	

Annex V. Proposal for surveillance system evaluation

1. Introduction

Public health surveillance is the ongoing systematic collection, analysis, interpretation, and dissemination of health data. It is also defined as ―Information for Action‖. A functional disease surveillance system is essential for defining problems and taking action. Proper understanding and use of this essential epidemiological tool (public health surveillance) helps health workers at the woreda and health facilities to set priorities, plan interventions, mobilize and allocate resources, detect epidemics early, initiate prompt response to epidemics, and evaluate and monitor health interventions. It also helps to assess long term disease trends.

2. Objectives of surveillance-

-To detect epidemics/outbreaks so that they can be controlled in a timely manner,

-To predict epidemics so that health services can plan to respond, prevent where possible, treat and control priority diseases,

-To monitor trends of priority diseases in order that changing trends inform policy decision,

-To evaluate an intervention so that effective and efficient actions/policies are identified and supported (2).

Data from a public health surveillance system can be used to-

• guide immediate action for cases of public health importance;

• measure the burden of a disease (or other health-related event), including changes in related factors, the identification of populations at high risk, and the identification of new or emerging health concerns;

3. Methods and Materials

Filling semi-structured questionnaire, which specifically developed for collecting the city surveillance evaluation system and making interview with responsible personnel will- be used as a tool to collect the required data. Before starting filling the questionnaire on the purpose and benefit of this work data collector will be made brief discussion with city Health office. Check list will be used as tools for data collection from various governmental organizations such as Zonal and district health office, health facilities, education sector, finance office, agriculture sector, zonal and district water resource office, electric power authority and zonal and district political administration office to collect the surveillance system evaluation data.

3.1. Study Area

The study will be conducted in Oromia region,Sheger city, Ethiopia

3.2. Study Design and Duration

A descriptive cross sectional study will be conducted from April 1-April 30, 2025 in the study area.

3.3. Data Analysis Procedure

Data will be collected, compiled and analyzed using Microsoft Excel and GIS. Frequency distribution, figure and table will be employed.

Table2. Schedule for work plan Conducting Surveillance system evaluation in Sheger city, Ethiopia, April 2025

S/No	List of Activities	Time line			
		April			
		Week 1	Week 2	Week 3	Week 4
1	Data Collection				
2	Processing data				
3	Analyze data and Write report				
4	Disseminating finding				

4. Budget breakdown

Activities	Quantity/Number	No. of days	Rate per day	Total cost

Principal investigator	1	15	650	9750
Consultant costs	1	10	650	9750
Field supervisors	5	15	650	48,750
Driver	1	15	650	9750
Total	8	55	2600	78,000
Contingency (10%)				7,800
Grand Total				85,800

Annex VI. Proposal for surveillance data analysis of Rabies in Amhara region: A Five-Year Retrospective Study of Humans and Animals Rabies in Amhara.

1. Introduction

Rabies is one of the oldest and the most serious zoonotic viral disease caused by the species of rabies virus which is a fatal zoonotic disease through world-wide occurrence [1]. Humans and livestock along with other mammals (almost all) get infected to the virus chiefly by carnivores. Rabies virus infection most frequently occurs when a rabid animal bites an animal or a person [2], and causes an acute viral disease of the CNS that affects humans and other mammals [3].Infected species always die from the disease, once clinical symptoms appear. More than 95% of human rabies cases are because of dog bites and the rest associated with cat, fox and other carnivores.

The Lyssa virus (bullet-shaped RNA virus) causes rabies. It has two forms; furious and paralytic. Lipid solvents, low pH, and sunlight destroy the virus but it is resistant to some disinfectants. Rabies is transmitted only when the virus is introduced into a bite wound or mucus membranes. The transmission is based on the magnitude of the bite and the amount of virus in the saliva. The susceptibility to rabies infection depends on animal species, age, the strain of the virus, dose of the virus, and routes of exposure (Hemachudha *et al.,* 2002).

In Ethiopia, rabies is a well-known and serious illness that has been around for generations (Fekadu, 1982). Nationwide data on rabies are not available to reveal the actual magnitude of the problem. However, the distribution of vaccines to the various regions and the fragmented reports on human and animal rabies cases are strong indicators of the widespread nature of the disease in the country (Deresa et al., 2010).

Rabies is a most important public-health problem commonly in the parts of the developing world, where the dog plays a key role as a reservoir and transmitter of the disease to humans. It is well known to cause huge number of deaths in humans and animals each year [4, 5]. Also it is one of the most disastrous and major public-health diseases for both animal and human being in most parts of the developing world.

Rabies kills an estimated 59,000-60,000 people each year in the world of these countries, Ethiopia is one of the worst affected with an estimated 2,871 human lives are lost and 96,657 people are exposed to rabies each year. In Ethiopia it is a significant disease that had been documented for many centuries as a "Mad Dog Disease" and domestic dogs being the most vector of human exposure [2].

Understanding the historical trends and patterns of rabies prevalence is crucial for devising targeted intervention strategies to control its spread. This concept note outlines a retrospective investigation aimed at analyzing five years of rabies prevalence data both in animals and humans.

2. Objectives

- To examine the temporal trends and fluctuations in rabies cases among animals and humans over the past five years.

- To identify demographic characteristics (age, gender, occupation) of human rabies cases and affected animal species.

- To assess the spatial distribution of rabies cases and identify high-risk areas within the study area.

- To evaluate the effectiveness of past rabies control measures, including vaccination campaigns and community education programs.

- To provide evidence-based recommendations for enhancing rabies surveillance and control

efforts in Addis Ababa and its environs.

3. Methodology:

- Study Design. A descriptive study design will be applied to measure the size of the problem from 15 February-30 February 2024 by using rabies surveillance data of five years

- Data Collection- The retrospective data of humans and animals will be used from the Ethiopian Public Health Institute rabies case record book, Ministry of Agriculture (MoA) and Tigray Bureau of Agriculture and Rural Development that was registered between 2019 and 2023.

- Data Analysis- Data obtained from the aforementioned documents will enter into Microsoft Excel 2010 Version spread sheet will be used for summarizing and analysis of the data to describe the disease by person place and time. Employ statistical methods to analyse the collected data, including descriptive statistics, trend analysis, and spatial mapping techniques.

- Demographic Analysis- Examine demographic characteristics of human rabies cases (age, gender, occupation) and species distribution of affected animals.

- Spatial Analysis- Utilize geographic information systems (GIS) to visualize the spatial distribution of rabies cases and identify clusters or hotspots.

- Stakeholder Consultation- Engage with key stakeholders, including public health authorities, veterinary professionals, and community leaders, to validate findings and gather insights for interpretation

4. Expected Outcomes

A) Comprehensive analysis of five years of rabies prevalence data, providing insights into temporal and spatial trends in both human and animal cases.

B) Identification of demographic patterns among human rabies cases and species distribution among affected animals.

C) Assessment of the effectiveness of past rabies control measures and identification of areas

requiring improvement.

D) Mapping of high-risk areas for targeted intervention strategies, such as enhanced surveillance and vaccination campaigns.

E) Development of evidence-based recommendations to strengthen rabies surveillance, control, and prevention efforts.

5. Conclusion

The retrospective investigation of five years of rabies prevalence data in animals and humans is essential for informing evidence-based strategies to combat the spread of this deadly disease. By analyzing historical data, identifying trends, and evaluating past control measures, this study aims to contribute to the development of more effective rabies prevention and control programs tailored to the specific needs of the region. Collaboration between relevant stakeholders is vital for implementing and sustaining these interventions to reduce the burden of rabies on both human and animal populations.

Table1. Work Plan for Rabies surveillance data Analysis in Amhara region, Northern Ethiopia

Major Activities Time line	**Time line**			
	February			
	Week 1	**Week 2**	**Week 3**	**Week 4**
Develop proposal				
Literature Review				
Data Collection				

Data Entry				
Data Analysis				
Report Writing				

V. Questionnaire for the research proposal on

This questionnaire is part of a study on *Staphylococcus aureus* prevalence and antimicrobial resistance in cow's milk, human, and environmental sources. The information you provide will help identify transmission risks and develop strategies for better public and animal health. All responses are confidential and used for research purposes only.

Section 1-Farm Management and Animal Health Practices

1. **Farm Size and Herd Composition**
    - How many cattle are currently on your farm?
    - What is the average herd density on your farm?
    - What types of cattle are reared here (e.g., dairy, beef)?
2. **Hygiene Practices**
    - How often do you clean animal enclosures?
        - ☐ Daily
        - ☐ Weekly
        - ☐ Bi-weekly
        - ☐ Monthly
    - What disinfectants, if any, are used to clean the farm areas?
3. **Milk Handling Practices**
    - What measures are in place to ensure hygiene during milk collection?
    - Do you pasteurize or treat the milk before selling?
        - ☐ Yes
        - ☐ No
4. **Antimicrobial Usage on Farm**

- Are antibiotics regularly administered to cattle?
  - ☐ Yes
  - ☐ No
- If yes, which antibiotics are used most frequently?
- Are these antibiotics given for:
  - ☐ Treatment of illness
  - ☐ Prevention
  - ☐ Growth promotion
  - ☐ Other (specify): _____

Section 2- Environmental Factors

5. **Water Source and Quality**
   - What is the primary source of water for your cattle?
     - ☐ Well
     - ☐ River/stream
     - ☐ Borehole
     - ☐ Municipal supply
     - ☐ Other (specify): _____
   - Is the water treated before it is given to cattle?
     - ☐ Yes
     - ☐ No
6. **Waste Disposal Practices**
   - How do you dispose of animal waste on your farm?
     - ☐ Composting
     - ☐ Manure spreading
     - ☐ Disposed in designated area
     - ☐ Other (specify): _____
   - How often is waste removed from enclosures?
7. **Proximity to Contamination Sources:**
   - Are there any potential contamination sources nearby (e.g., landfills, sewage)?
     - ☐ Yes

- ☐ No

- If yes, please specify: _____

Section 3- Cow Attendants' Health and Hygiene Practices

8. **Demographic Information of Cow Attendants**
   - Age: _____
   - Gender: _____
   - Occupation: _____
9. **Hygiene and Health Practices**
   - Are attendants provided with personal protective equipment (PPE) for handling cattle?
     - ☐ Yes
     - ☐ No
   - How often do attendants wash their hands after handling animals?
     - ☐ Always
     - ☐ Sometimes
     - ☐ Rarely
     - ☐ Never
10. **Prior Antibiotic Use**
    - Have attendants taken antibiotics in the last six months?
      - ☐ Yes
      - ☐ No
    - If yes, please list the types of antibiotics taken, if known.

Section 4- Seasonal Patterns

11. **Seasonal and Temporal Changes**
    - Are there particular times of the year when cattle or milk production on the farm is affected by illness?
      - ☐ Yes
      - ☐ No
    - If yes, what months or seasons are these changes most evident?
    - Have you noticed any seasonal patterns in the need for antibiotic treatments?

Section 5- Zoonotic Transmission Potential

12. **Animal Handling Frequency**
    - How often do cow attendants handle the cattle?
        - ☐ Daily
        - ☐ Weekly
        - ☐ Occasionally
    - What practices are in place to minimize disease transmission between cattle and attendants?
13. **Biosecurity Practices**
    - Do you have any biosecurity measures in place to prevent disease spread (e.g., quarantining sick animals)?
        - ☐ Yes
        - ☐ No
    - If yes, please specify the practices: _____

Section 6- Observed Trends in Antimicrobial Resistance

14. **Antibiotic Efficacy**
    - Have you noticed any antibiotics becoming less effective over time?
        - ☐ Yes
        - ☐ No
    - If yes, please specify which antibiotics: _____
15. **Cross-Reservoir Transmission Awareness**
    - Are you aware of the risk of transmission of antibiotic-resistant bacteria between animals, humans, and the environment?
        - ☐ Yes
        - ☐ No

Consent form for cow milk attendants

Title of the study

Epidemiological Analysis of Salmonella enterica Serotype Typhi (S. Typhi) Prevalence and Susceptibility Profile in Cow's Milk, Humans, and Environment: A One Health Approach

Principal investigator

[Investigator's Name, Position]
[Institution/Organization]

Purpose of the study

The purpose of this study is to assess the prevalence and antimicrobial resistance profile of *Salmonella enterica* serotype Typhi (*S. Typhi*) in cow's milk, human samples, and environmental sources in selected areas. This research aims to better understand the spread and impact of *S. Typhi* in dairy farm environments and its potential health risks to humans.

Procedures

As a cow milk attendant, you are being asked to participate in this study by providing a stool sample for laboratory analysis. Participation may also include completing a short questionnaire on hygiene practices, work conditions, and potential contact with animals. The sample will be analyzed for the presence of *S. Typhi* and its resistance to antibiotics. Your identity and personal information will be kept confidential.

Risks and benefits

There are minimal risks involved in this study. Sample collection will follow strict safety and hygiene protocols to protect participants and researchers. The benefits of participating include contributing to knowledge that may improve public health measures, particularly in dairy farming and related practices.

Confidentiality

All information collected during this study will remain confidential. Personal identifiers will be removed and replaced with unique codes. Only the research team will have access to the information, and findings will be reported in a way that ensures participants' anonymity.

Voluntary participation

Participation in this study is voluntary. You may choose to withdraw from the study at any time without any penalty or impact on your work.

Contact information

If you have questions about this study or your rights as a participant, please contact [Principal Investigator's Name] at [Phone Number] or [Email Address].

Consent statement

By signing below, you confirm that you have read and understood the above information, that your questions have been answered, and that you agree to participate in this study.

Participant's signature _____ **Date** _____

Participant's printed name _____

Researcher's signature: _____ **Date**_____

Researcher's printed name_____