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Health and Economic Burden of Suspected Foodborne Bacterial Diseases in East Gojjam, Northwest Ethiopia: A One Health Assessment

Running title: Health and Economic Burden of Foodborne Diseases

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ABSTRACT

Foods of animal origin are important sources of high-quality nutrients and are widely consumed; however, inadequate production, handling, processing, and storage along the farm-to-fork continuum can increase exposure to foodborne bacterial zoonoses, particularly in low-income settings. Despite their potential health and economic consequences, the burden of foodborne bacterial zoonotic diseases remains underappreciated in Ethiopia. This study aimed to estimate the health and economic burden of these diseases in East Gojjam Zone, Northwest Ethiopia. A prospective hospital-based study was conducted among 735 identified cases of foodborne illness attending healthcare institutions in five districts of East Gojjam from September 2024 to February 2025. Health burden was estimated using an R-based DALY calculator and an incidence-based approach, while economic burden was estimated from direct medical costs and indirect productivity losses associated with illness. Simulation-based projections were used to estimate annual incidence and mortality rates in the population at risk. The estimated annual health burden was 13,213 DALYs (95% UI: 11,157-16,967), corresponding to 1,641.47 DALYs per 100,000 population. The estimated annual economic burden was US$2,085,931.60 across the study districts and was projected to US$6,817,991.98 for East Gojjam Zone. These estimates exclude losses associated with animal mortality and reduced productivity, government and donor subsidies for diagnosis and treatment, and other contextual economic factors. The findings demonstrate that foodborne bacterial zoonotic diseases impose a

substantial public health and economic burden in East Gojjam Zone. Strengthening food safety systems and implementing integrated prevention and control strategies through a One Health approach are essential to reduce this burden and improve community health outcomes.

Keywords: *Animal-origin foods, DALYs, East Gojjam, Economic burden, Ethiopia, Food safety, Foodborne zoonotic diseases, One Health*

1. INTRODUCTION

Foodborne diseases are a major global public health concern, with zoonotic pathogens contributing substantially to morbidity, mortality, and economic losses. Close human-animal interactions facilitate zoonotic transmission, with zoonotic diseases accounting for approximately 60% of known human infectious diseases and nearly 75% of emerging and re-emerging infectious diseases originating from vertebrate animals (1-4). Important bacterial foodborne zoonoses include *Salmonella* spp., *Campylobacter* spp., *Yersinia enterocolitica*, Shiga toxin-producing *Escherichia coli* (STEC), *Listeria monocytogenes*, and *Staphylococcus aureus*, which can cause gastrointestinal and systemic illness (5-7). Meat, milk, and eggs are important transmission vehicles when produced or handled under inadequate hygienic conditions (10–14).

The burden of foodborne zoonoses is particularly high in low- and middle-income countries (LMICs), where weaknesses in food safety, sanitation, surveillance, and diagnostic capacity increase exposure and underestimation of disease burden. Foodborne bacterial zoonoses associated with unsafe food are estimated to cost LMICs approximately US$110 billion annually, while up to two million deaths occur annually in low-income countries (18-19). These diseases also cause substantial direct and indirect economic losses through mortality, reduced productivity, health-care costs, loss of working time, and household income (8-9,15-17). In Ethiopia, the burden is likely amplified by extensive livestock production and variable food hygiene practices, although pathogen-specific and population-level estimates remain limited (12).

Reliable burden estimates are essential for evidence-based planning and prioritization of interventions (20, 35). The disability-adjusted life year (DALY), combining years of life lost due to premature mortality (YLL) and years lived with disability (YLD), quantifies overall health loss (21), while economic burden estimates capture the financial consequences of disease. Together, these measures provide a comprehensive basis for prioritizing food safety interventions. In East Gojjam, substandard hygiene during animal slaughter and milk and dairy-product marketing, together with inappropriate disposal of slaughter by-products and carcasses, may increase foodborne and environmental health risks (22).

Despite these risks, systematically documented evidence on the health and economic burden of foodborne bacterial zoonoses in East Gojjam is scarce. Therefore, this study aimed to estimate the public health and economic burden of foodborne bacterial zoonotic diseases in selected districts of East Gojjam Zone, Ethiopia, using DALYs and associated economic costs.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in five purposively selected districts of East Gojjam Zone, Northwestern Ethiopia: Debre Markos Regiopolitan town, Dejen, Bibugn, Hulet Eju Enebse, and Shebel Berenta (Fig. 1). These districts were selected to represent the major climatic and agro-ecological conditions of the zone. East Gojjam has an estimated population of 2,632,632 across 21 administrative districts and includes 423 health posts, 102 health centers, nine primary hospitals, and one referral hospital (23). Six hospitals and five health centers were randomly selected, with the number of facilities per district determined according to the population under study. The zone comprises four major agro-ecological categories: lowland (5.45%), midland (80.55%), highland (11.9%), and cold wave (2.1%) (Table 1). East Gojjam has substantial livestock production potential, with an estimated 2.17 million cattle, 1.11 million sheep, 250,630 goats, and 1.4 million poultry, supported by considerable dairy production and marketing (24). Communities obtain animal-source foods through local markets, butcher shops, cultural slaughtering events (Qircha), household slaughtering of sheep, goats, and poultry, and dairy products and eggs from household production or local retailers.

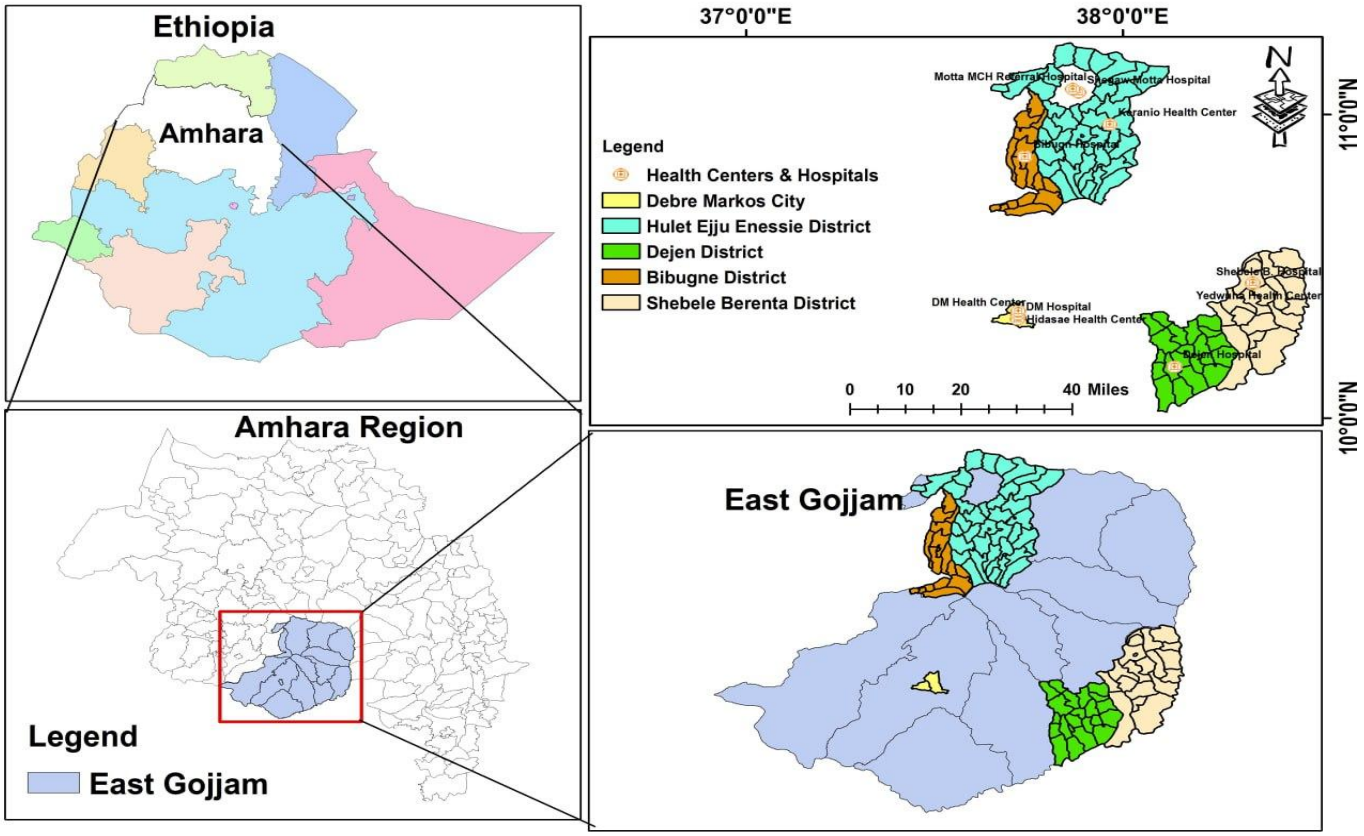


Figure 1: Location map of the study area (five districts in East Gojjam zone), source QGIS (2026)

Table 1. Geographical location, elevation, and climatic characteristics of the study districts

Descriptor	Debre Markos (DM)	Dejen	Bibugn	Hulet Eju Enesie (HEE)	Shebel Berenta (SB)
Geographical location					
Latitude	10°17′-10°21′ N	10°07′-10°11′ N	11°00′-12°24′ N	10°45′-11°10′ N	10°15′-10°30′ N
Longitude	37°42′-37°45′ E	38°06′-38°10′ E	34°70′-37°35′ E	37°45′-38°10′ E	38°15′-38°27′ E
Altitude (m a.s.l.)	2,350-2,500	1,071-3,000	1,480-4,160	1,290-4,036	1,100-2,400
Mean annual temperature (°C)	18.5	22.0	16.0	18.5	19.6
Mean annual rainfall (mm)	1,380	1,000	1,500	1,100	1,200

Source: District Agriculture Development Offices (2023).

2.2. Study Design

A prospective health-facility-based observational study was conducted in selected health centers and hospitals in East Gojjam Zone from September 2024 to February 2025 to determine the incidence of

confirmed foodborne bacterial zoonotic diseases and estimate their public health burden, expressed as disability-adjusted life years (DALYs), and economic burden. A total of 735 confirmed patients were enrolled, and simulated projections were used to estimate annual incidence and disease burden per 100,000 population.

2.3. Data Collection Technique

Data were collected through direct observation, interviews, hospital records, patient follow-up, and retrieval of annual disease reports from the District Health Information Software 2 (DHIS2) in the study area. Patients referred to bacteriology laboratories at selected health facilities with preliminary diagnoses suggestive of foodborne bacterial infections were enrolled. Demographic characteristics, food history, disease progression and outcome, and illness-related financial costs were obtained from patients or their caregivers (S1). The six-month data collection period (September 2024-February 2025) was selected to capture seasonal variation, including both fasting and non-fasting periods among Ethiopian Orthodox Tewahedo followers. Disease outcomes and mortality were monitored through direct observation, hospital records, and telephone follow-up by assigned data collectors. Disability weights for different health states were obtained from (25) and used to estimate the health burden (table 2).

Table 2: Health sequel and their respective WHO Global Health Estimate (GHE) given weights for noted diseases in the study period

Health state sequel due to food-borne diseases	**Lay descriptions used in the GBD study**	**DW of WHO GHE2019**
Mild diarrhea with signs of nausea	diarrhea three or more times a day, with occasional discomfort in the belly	0.074
Nausea, abdominal cramp and moderate diarrhea	diarrhea three or more times a day, with painful cramps in the belly, and feeling thirsty	0.188
Abdominal cramps, fever, malaise, and vomiting, severe diarrhea with dysentery and hemolytic uremic syndrome	Diarrhea three or more times a day with severe belly cramps. The person is very thirsty and feels nauseous and tired	0.247
Moderate to severe hemolytic	Low blood pressure, feels very weak, tired, and	0.149

anemia	short of breath, and has problems with activities that require physical effort or deep concentration	
Spontaneous abortion	At least one child wants to have more children. The person has a fertile partner, but the couple cannot conceive.	0.026
Headache, Meningitis, Meningo – encephalitis	Daily headaches, felt as dull pain and often lasting all day, with poor sleep, nausea, and fatigue. The person takes medicine for the headaches, which provides little relief but is needed to avoid having worse symptoms.	0.223
Reactive arthritis, fatigue (muscle weakness)	pain and deformity in most joints, causing difficulty moving around, getting up and down, and using the hands for lifting and carrying. The person often feels fatigued.	0.317

Source: WHO Global Health Estimates (GHE) 2019.

2.4. Data Management

Questionnaire data were entered into Microsoft Excel and analyzed using a DALY calculator implemented in an R package. The economic burden was estimated using the cost-of-illness equation described by McIntyre (17) and expressed in monetary terms for East Gojjam Zone, Ethiopia.

2.4.1. Estimating Public Health Burden of Food-borne Zoonotic Diseases

Disability-adjusted life years (DALYs) are widely used to quantify population-level health burden and are expressed as the number of healthy life years lost, either as an absolute value or per 100,000 population (26). DALYs are calculated as the sum of years lived with disability (YLD) and years of life lost due to premature mortality (YLL) (27):

DALY = YLD + YLL …… Equation 1

YLD represents the morbidity component and was calculated as:

YLD = Number of cases × Disease duration × Disability weight …… Equation 2

Disease duration was converted from days to years. Disability weights (DW) range from 0 (perfect health) to 1 (equivalent to death) and reflect the severity of different health states (28). Health outcomes considered included mild-to-moderate diarrhea, severe diarrhea with dysentery or hemolytic uremic syndrome, severe anemia, reactive arthritis, meningitis/meningoencephalitis, reproductive complications, and fatigue or muscle weakness (6,29-32).

YLL represents premature mortality and was calculated as:

YLL = Number of deaths × Life expectancy at age of death …… Equation 3

An incidence-based approach was used because the study focused on infectious foodborne diseases with relatively short incubation periods and acute health outcomes, including death and sequelae (15,33). DALYs were estimated using a DALY calculator implemented in an R package, incorporating age- and sex-specific population data, disease incidence, mortality, disease duration, disability weights, treatment coverage, and age at onset and death. Standard life expectancy from the WHO Global Health Estimates was used, based on a projected frontier life table for 2050 with a life expectancy of 90 years at birth (28). The population of the five study districts was 805,441, distributed into the age groups 0-4, 5-14, 15-44, 45–59, and ≥60 years, with a sex distribution of 50.1% male and 49.9% female (34). The default Global Burden of Disease age categories were applied.

Because data were collected for six months, annual incidence and mortality rates were projected by multiplying the observed six-month estimates by 2.18. Incidence was expressed per 1,000 population using:

Incidence rate = (Number of cases × 2.18 × 1,000) / Population at risk …… Equation 4

Age-specific incidence and mortality estimates were modeled using beta-PERT distributions based on minimum, mode, and maximum values. The calculator incorporated seven major disease outcomes, treatment coverage, age at onset, disease duration, disability weights for treated and untreated cases, mortality rates, and age at death, using disease weights assigned by GHE/2019 (Table 2) (36).

The DALY calculator generated mean, median, and 95% uncertainty intervals (2.5th–97.5th percentiles) for DALYs, YLLs, YLDs, incident cases, and deaths, as well as the proportional contributions of YLL and YLD to total DALYs (37). Age weighting was not applied, and results were interpreted using both undiscounted and 3% discounted estimates.

2.4.2. Calculating the Economic Burden of Food-borne Zoonotic Diseases

The total economic burden of foodborne bacterial zoonotic diseases was estimated as the sum of direct and indirect costs (17):

Economic burden = Direct cost + Indirect cost

Direct costs included diagnostic testing, treatment/medication, and transportation to health facilities:

Direct cost = Cost of diagnosis + Cost of treatment + Cost of transportation …… Equation 6

The costs of diagnosis, treatment, and transportation were calculated as follows:

$C_iDx = N_iPT \times P_iDx$ …… Equation 7

$C_iTx = N_iPT \times P_iTx$ …… Equation 8

$C_iTrns = N_iPT \times P_iTrns$ …… Equation 9

where N_iPT is the number of patients treated in study area i, and P_iDx, P_iTx, and P_iTrns are the average costs of diagnosis, treatment, and transportation per patient, respectively.

Indirect costs comprised productivity losses due to patients' absenteeism and the opportunity cost of time spent by informal caregivers (17):

Indirect cost = Cost of patients' time + Cost of informal caregivers

Productivity loss attributable to patients' illness was estimated as:

$C_iPT = [(N_iPT \times T_iIL) + (N_iPuT \times T_iIPuT)] \times P_iLh$ …… Equation 10

where N_iPT and N_iPuT represent treated and untreated patients, respectively; T_iIL and T_iIPuT represent productive time lost by treated and untreated patients; and P_iLh represents the average daily labor cost in East Gojjam (250 ETB/day; East Gojjam Zone Labor and Skill Coordination Bureau, 2024/25). Productivity losses for children aged <5 years were excluded, although their direct medical costs were included.

The cost of informal caregiving was calculated as:

$C_iIC = N_iPT \times T_iIC \times P_iLh$ …… Equation 11

where T_iIC is the time spent by informal caregivers during the illness period.

To estimate the annual economic burden, the average cost incurred during the 24-week study period was annualized using a factor of 2.18 and standardized to the population of the five study districts. The resulting per-capita cost was then extrapolated to the total East Gojjam Zone population of 2,632,632. Costs were converted from Ethiopian Birr to US dollars using the November 2024 exchange rate of US$1 = 115 ETB (Equation 12):

$C_{an} = [(C_i \times 2.18) / n] \times N$ …… Equation 12

where C_{an} is the estimated annual cost for each cost category in East Gojjam Zone, C_i is the total cost incurred in each study district during the study period, n is the population of the five study districts, 2.18 is the annualization factor for the 24-week study period, and N is the total population of East Gojjam Zone.

2.5. Ethical Considerations

Written informed consent was obtained from all participants or their parents/guardians for children after the study objectives and procedures were explained. Participation was voluntary, and confidentiality and privacy of participants and their data were strictly maintained. The English versions of the data collection tools and consent form are provided as supplementary materials. Ethical approval was obtained from the Institutional Research Ethics Review Committee (IRERC) of Debre Markos University on 05 July 2024 (Reference No. 875/10/16; Protocol No. DMU/007/2016). The study was conducted in accordance with the ethical principles of the World Medical Association Declaration of Helsinki for research involving human participants.

3. RRESULT

3.1. Descriptive Analysis of the Cohort Study Patients

A total of 735 anonymous case reports from patients referred to bacteriological laboratories at selected health centers and hospitals were reviewed during September 2024-February 2025. The highest number of cases was recorded in Hulet Eju Enesie, while the lowest was reported in Bibugn. Most patients were farmers (57%), 86.67% had no refrigerator or pasteurizer at home, and 37% reported recent consumption of one or more animal-source foods, including meat, milk products, eggs, or chicken (table 3 and fig 2).

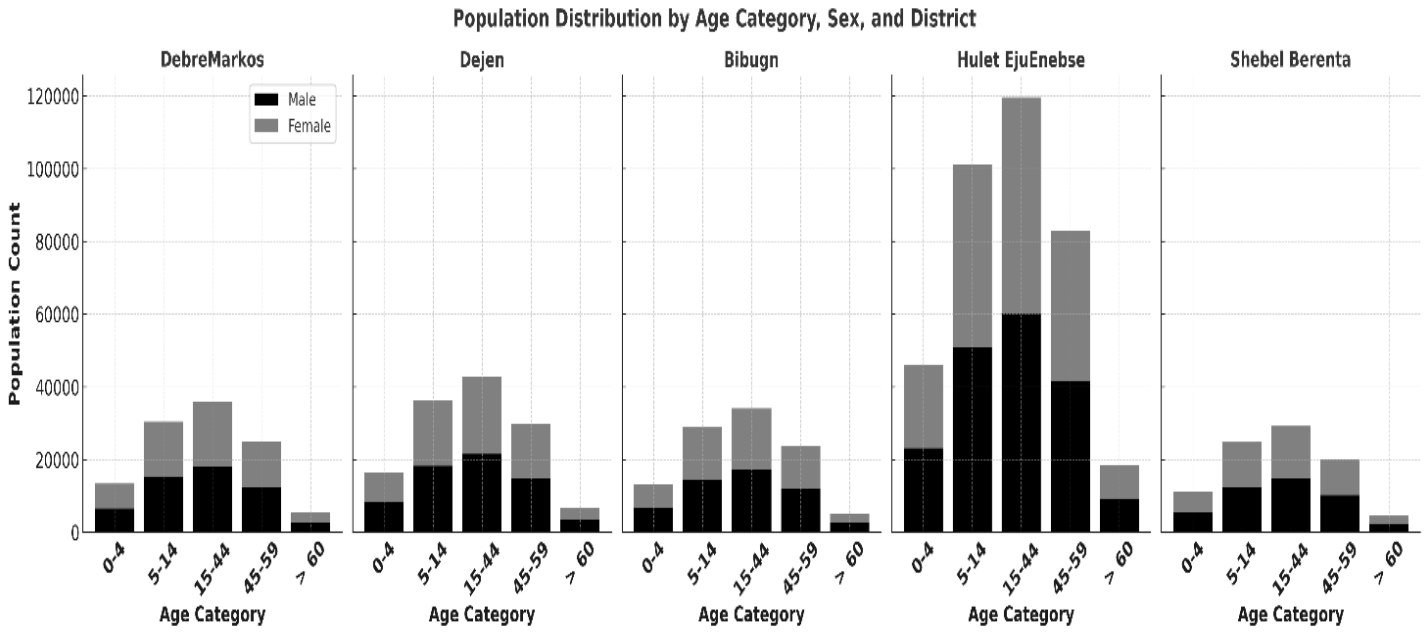


Figure 2: Population structure of each study district of East Gojjam Zone by age and sex group.

Table 3. Characteristics of patients with suspected foodborne zoonotic diseases recorded in five selected districts of East Gojjam Zone during the study period

Patient characteristics	Category	Frequency (%)	Patient characteristics	Category	Frequency (%)
Study district/hospital	Debre Markos	120 (16.33)	**Recent consumption of animal-origin foods**	Milk	272 (37.00)
	Dejen	130 (17.69)		Meat	110 (14.97)
	Bibugn	94 (12.79)		Egg only	65 (8.84)
	Hulet Eju Enebse	242 (32.93)		Chicken and egg	59 (8.03)
	Shebel Berenta	149 (20.27)		None	274 (37.28)
Symptoms following consumption of animal-origin foods	Diarrhea +	99 (13.47)	**Family livelihood**	Farmer	419 (57.00)
	Diarrhea ++	341 (46.39)		Merchant	172 (23.40)
	Diarrhea +++	131 (17.82)		Employee	78 (10.61)
	Arthritis	30 (4.08)		Other	66 (8.98)
	Meningitis	57 (7.75)	**Access to a refrigerator and/or pasteurizer at home**	Yes	98 (13.33)
	Low blood pressure	131 (17.82)		No	637 (86.67)
	Spontaneous abortion	19 (2.58)			

Where, Meat included beef and mutton; milk included raw milk, fermented milk, cheese, and yogurt. **Diarrhea+** indicated mild diarrhea; **diarrhea++** indicated moderate diarrhea with nausea and abdominal cramps; and **diarrhea+++** indicated severe diarrhea with dysentery, vomiting, abdominal cramps, and inappetence.

Based on information obtained from patients and their medical records, moderate diarrhea with nausea and abdominal cramps was the most common presentation (46.39%), particularly among children aged <5 years. Severe diarrhea accompanied by dysentery, dehydration, and hypotension occurred in 131 cases (17.82%). Other recorded clinical outcomes included meningoencephalitis, anemia, and spontaneous abortion among patients reporting recent consumption of one or more animal-source foods.

3.2. DALY Across the Study Areas

The estimated mean health burden of major foodborne bacterial zoonoses was 13,213 DALYs (95% UI: 11,157-16,967) among the 805,441 population in the study districts, corresponding to a projected 1,640.47 DALYs per 100,000 population in East Gojjam Zone (Fig 3). The highest mean burden was estimated in Shebel Berenta (8,134 DALYs; 9,037.78 DALYs per 100,000 population), followed by Hulet Eju Enese (1,323.67 DALYs; 4,871 DALYs per 100,000 population), whereas the lowest estimates were recorded in Bibugn (29.54 DALYs) and Debre Markos (53.33 DALYs) (table 4 and Fig 3).

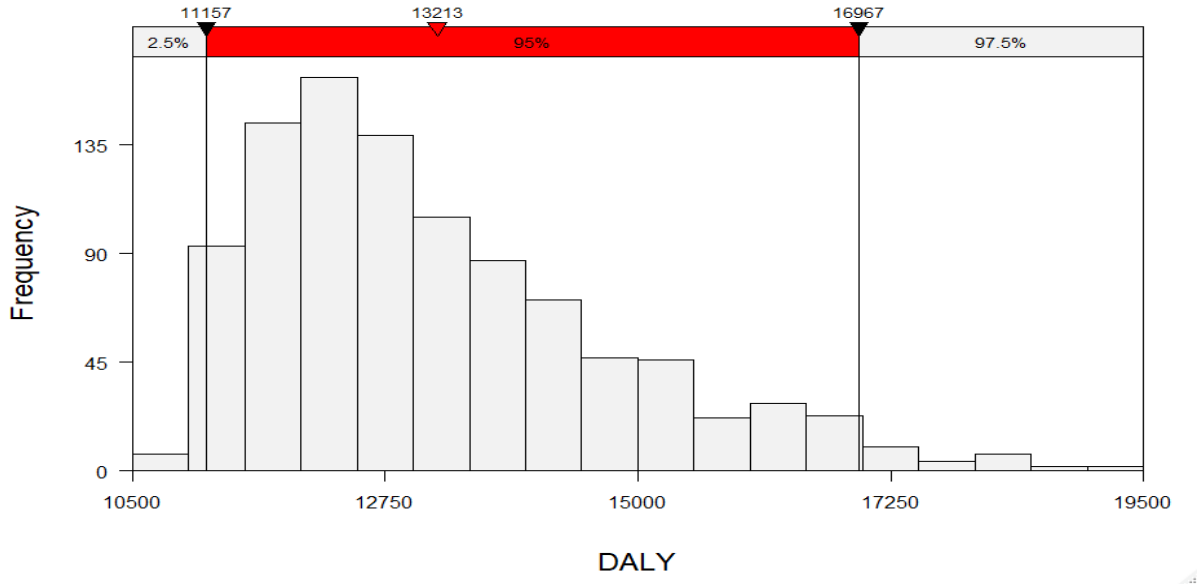


Figure 3: Overall DALY Estimation associated with animal origin foodborne bacterial zoonotic diseases across the East Gojjam zone.

Table 4. DALYs, YLDs, and YLLs associated with foodborne bacterial zoonotic diseases in the five study districts of East Gojjam Zone

Health Burden Measure	Estimation	Debre Markos	Dejen	Bibugn	Hulet Eju Enebse	Shebel Berenta
DALYs	Undiscounted	93.00	186.00	48.86	7,678.02	12,821.39
	3% discounted	59.00	118.00	31.00	4,871.00	8,134.00
	Per 100,000 population	53.33	89.44	29.54	1,323.67	9,037.78
YLDs	Undiscounted	42.56	85.12	22.07	7,488.87	12,550.20
	3% discounted	27.00	54.00	14.00	4,751.00	7,962.00
	Per 100,000 population	24.40	40.93	13.34	1,291.06	8,846.67
YLLs	Undiscounted	50.44	100.88	26.79	189.15	271.19
	3% discounted	32.00	64.00	17.00	120.00	172.00
	Per 100,000 population	28.92	48.51	16.20	32.61	191.11

DALYs = disability-adjusted life years; YLDs = years lived with disability; YLLs = years of life lost.

The highest mean YLD was estimated in Shebel Berenta at 8,846.67 per 100,000 population (7,962 YLDs in the study population), followed by Hulet Eju Enesie at 4,751 per 100,000 population (1,291.06 YLDs). The lowest estimates were observed in Bibugn (14 per 100,000; 13.34 YLDs) and Debre Markos (27 per 100,000; 24.40 YLDs). YLL showed a similar distribution to DALYs and YLDs, with estimates presented at the 2.5th-97.5th percentile uncertainty interval.

The recorded sequelae included mild-to-severe diarrhea, hypotension, hemolytic anemia, fatigue (muscle weakness), fever, photophobia, reactive arthritis, headache, and spontaneous abortion. Most non-fatal outcomes resolved within one week of treatment, contributing relatively little to YLD, particularly among adults aged 15-45 and 45-59 years. In contrast, a substantial proportion of observed deaths occurred among children aged <5 years, contributing considerably to YLL (Fig 4).

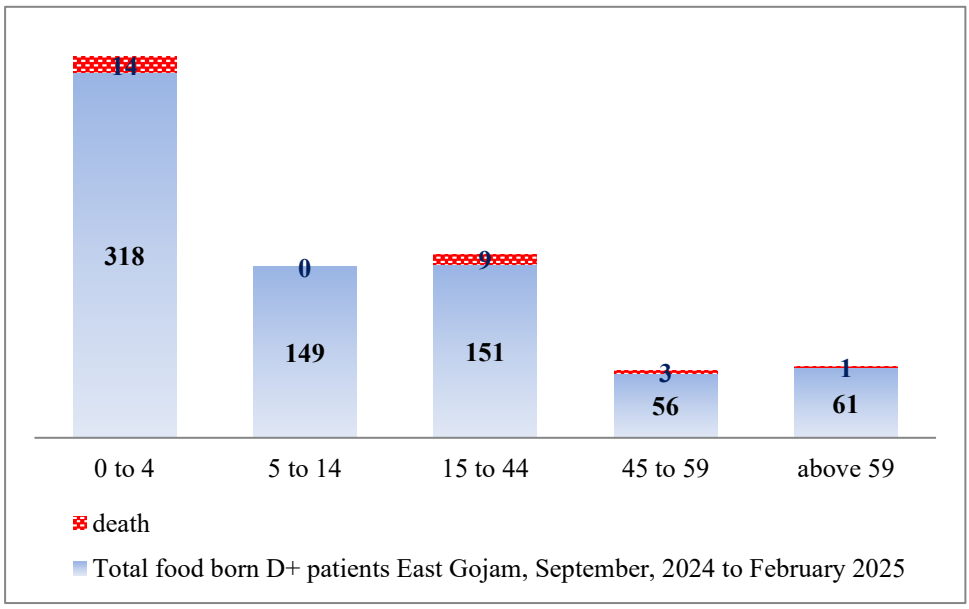


Figure 4: Mortality rate attributable to the consumption of contaminated foods of animal origin across different age categories in the East Gojjam zone, from September 2024 to February 2025.

3.3. Estimation of the Economic Burden of Foodborne Zoonotic Diseases

The estimated annual economic burden of foodborne bacterial zoonotic diseases in the five study districts was US$2,085,931.60, with patients' productivity losses contributing the largest share (US$635,583.20) and diagnostic costs the smallest (US$136,278.20) (Figure 6). Among the study districts, the highest estimated annual burden was reported in Hulet Eju Enesie (US$25,422.66) and the lowest in Bibugn (US$9,445.79). Costs varied across districts, with patient productivity losses highest in Hulet Eju Enesie (US$7,349.80), diagnostic costs highest in Debre Markos (US$4,180.54), and transportation costs highest in Hulet Eju Enesie (US$4,809.58) (Figs 5 and 6).

The estimated annual costs for treatment, informal caregiving, and transportation across the five study districts were US$12,170.36, US$31,826.31, and US$12,364.40, respectively. Treatment costs were highest in Debre Markos (US$4,180.54) and lowest in Bibugn (US$921.63), while informal caregiving costs were highest in Hulet Eju Enesie (US$10,025) and lowest in Bibugn (US$3,557.80). Transportation costs ranged from US$945.26 in Debre Markos to US$4,809.58 in Hulet Eju Enesie (Figs 5 and 6).

Extrapolation to the entire East Gojjam Zone yielded an estimated annual economic burden of US$6,817,991.98 (approximately US$6.8 million). This estimate excludes government and USAID subsidies for diagnosis and treatment, potential effects of prolonged fasting periods, and losses associated with livestock morbidity and mortality, reduced animal production and productivity, veterinary treatment and prevention, and spoilage of animal products.

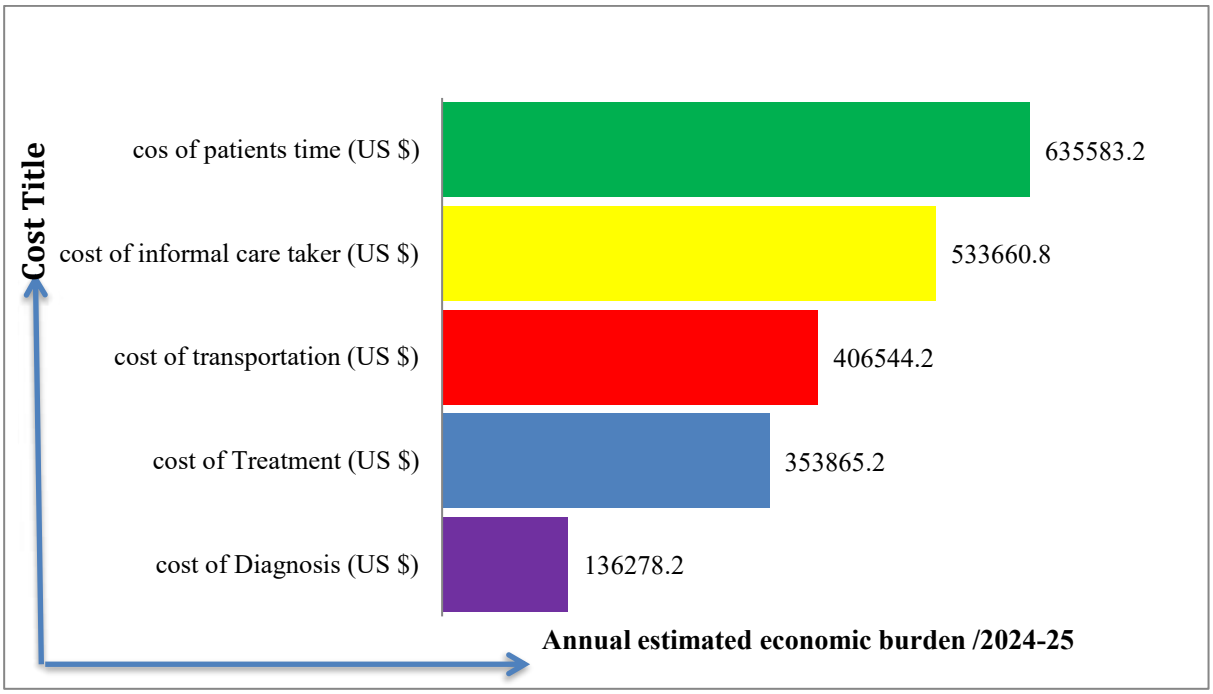


Figure 5: Estimated annual economic burden of food-borne bacterial zoonotic diseases in East Gojjam Zone, Ethiopia for the year 2024/25.

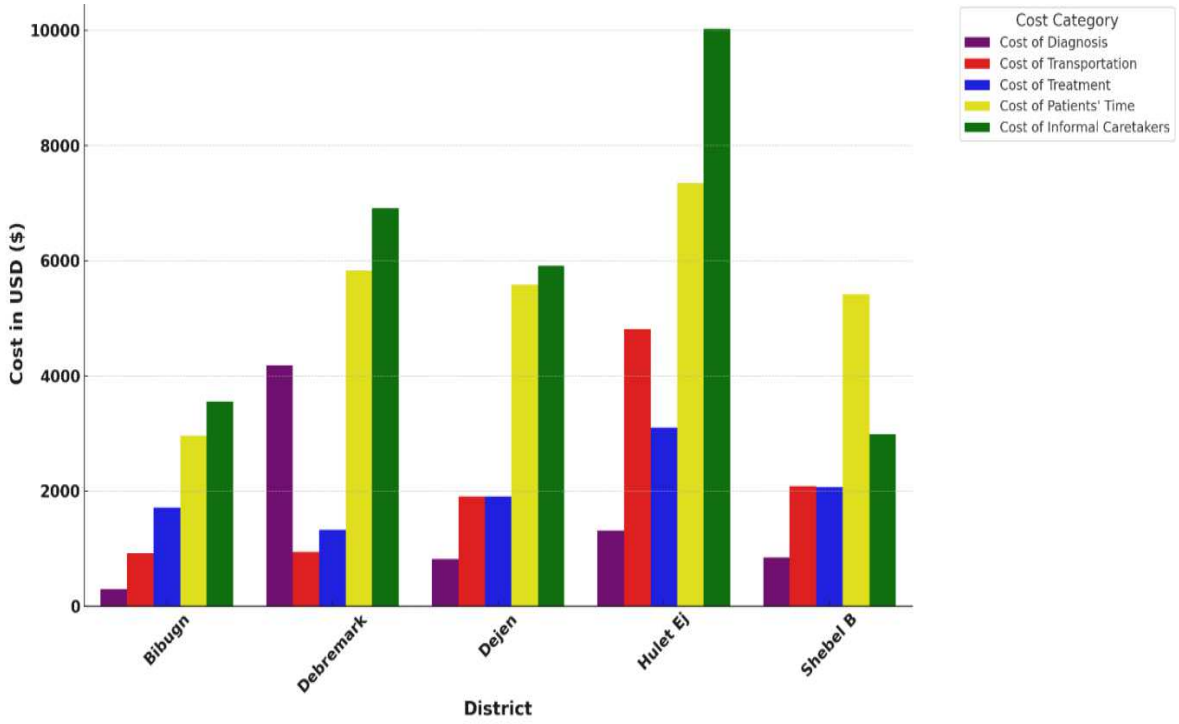


Figure 6. Estimated annual economic costs (in USD) by cost category associated with food-borne bacterial zoonotic diseases across five districts of the East Gojjam Zone, 2024/25.

4. DISCUSSION

Health-burden estimation converts mortality and morbidity data into measures that support identification of high-risk populations, health-service planning, resource allocation, and prioritization of interventions (38–41). In the present study, 37% of patients reported recent consumption of animal-source foods, while 86.67% had no refrigerator or pasteurizer at home, indicating potential food-safety risks. Lack of refrigeration can promote bacterial growth and food spoilage, increasing the risk of foodborne infections such as *Salmonella* and *E. coli* (42). Similarly, consumption of raw meat, which remains a traditional practice in Ethiopia, may increase exposure to foodborne pathogens, including *Campylobacter*, *E. coli*, *Listeria*, and *Salmonella* (43-44).

Hulet Eju Enesie accounted for the largest proportion of recorded cases (32.93%), which may partly reflect its larger population and geographical coverage. However, case numbers should be interpreted in relation to the population at risk rather than as absolute counts alone. The limited availability of diagnostic laboratories outside Debre Markos may also have influenced disease classification. Consequently, many cases were recorded syndromically rather than by specific bacterial species or strain. The present study therefore used clinical outcomes and reported histories of animal-source food consumption, supported by previous literature, to characterize probable foodborne bacterial zoonotic cases.

DHIS2 data from 2024/25 showed substantially larger numbers of reported dysentery, unspecified bacterial intestinal infections, diarrhea with dehydration among children under five, and other potentially foodborne outcomes than those observed during the six-month cohort period. This discrepancy may reflect differences in reporting periods, case definitions, health-facility coverage, under-ascertainment during prospective follow-up, or the annualization and projection procedures used in the present study. Differences in routine reporting practices may also contribute; however, over-reporting should not be assumed without further verification. These findings highlight the need for improved surveillance and standardized case definitions for foodborne bacterial diseases.

The estimated health burden of 13,213 DALYs, equivalent to 1,640.47 DALYs per 100,000 population, indicates a substantial public health impact in the study area. This estimate was considerably higher than the 89.9 DALYs per 100,000 population reported for Gondar, Lalibela, and Debark and the 82 DALYs per 100,000 population reported for the Netherlands for foodborne disease transmission (45-46). However, it was comparable to the 1,689.5 DALYs per 100,000 population reported for Debark (45). Differences may reflect variation in disease profiles, population characteristics, food-consumption practices, health-care

access, environmental conditions, surveillance systems, and DALY estimation methods. Therefore, comparisons should be interpreted cautiously because the study populations, disease categories, and analytical approaches may differ.

Marked variation was observed among the study districts, with the highest estimated DALY burden in Shebel Berenta (9,037.78 DALYs per 100,000 population) and Hulet Eju Enesie (4,871 DALYs per 100,000 population). The relatively high burden in these areas may be associated with differences in food-handling practices, livestock production, environmental conditions, population characteristics, and access to preventive and diagnostic services. In Shebel Berenta, previous evidence documented limited access to milk-cooling facilities, absence of milk cooperatives, poor hygienic handling, and substantial bacterial contamination of milk and dairy products, including *S. aureus* and coliforms (35, 47). Similar contamination associated with poor milking practices, inadequate handling, and unsanitary equipment has been reported elsewhere (48-49). Warmer environmental conditions may further facilitate bacterial proliferation and food contamination (50-51). However, these factors should be considered potential contributors rather than established causal determinants of the district-level DALY differences.

Children under five years appeared particularly vulnerable to severe disease. Although moderate diarrhea was the predominant clinical presentation, severe diarrhea with dehydration, dysentery, abdominal cramps, hypotension, and anorexia was more frequently observed among young children. This finding is consistent with previous evidence identifying young and weaning-age children as an important population at risk from foodborne disease (52-53). The WHO has estimated that approximately 33 million healthy life years are lost annually due to unsafe food, with children under five bearing about one-third of this burden (54). The greater contribution of mortality among young children in the present study also explains their relatively important contribution to YLL.

In addition to health consequences, foodborne zoonoses impose substantial socioeconomic costs. Economic-burden estimates quantify losses that could potentially be avoided through effective prevention and control (55-56). The present study estimated an annual economic burden of approximately US$6.82 million for East Gojjam Zone, equivalent to about 388.47 ETB per person and 1,553.88 ETB per household annually. This household-level estimate was higher than the 278.98 ETB previously reported for Gondar, Lalibela, and Debark (45). For comparison, the estimated cost of foodborne illness in the United States was US$74.7 billion in 2023, with approximately 60% attributed to serious illnesses with identified pathogens (57). However, direct comparisons across countries should be made cautiously because of substantial differences in population size, income, health-care systems, disease surveillance, costing methods, and valuation of productivity losses.

Patient productivity losses represented the largest economic component in the present study, whereas diagnostic costs were comparatively lower. The lower estimated diagnostic expenditure may partly reflect limited access to advanced laboratory services and the subsidization of some diagnostic and treatment services. Strengthening affordable basic bacteriological testing alongside standardized clinical diagnostic algorithms could improve pathogen identification while supporting more appropriate treatment. District-level differences in economic burden may reflect variation in population size, geographic coverage, disease severity, health-service utilization, and availability and cost of diagnostic services. Debre Markos and Motta, which have relatively larger referral facilities and more advanced diagnostic capacity, may therefore incur higher diagnostic costs than districts with more limited laboratory services.

Importantly, the estimated economic burden represents only the costs included in the present analysis. It does not account for livestock morbidity and mortality, reduced animal production and productivity, condemnation or spoilage of animal products, veterinary treatment and prevention costs, trade losses, or other costs borne by the livestock sector. Similarly, government and USAID subsidies for diagnosis and treatment and the relatively low local wage rate may have resulted in an underestimation of the true societal economic burden. Thus, the reported US$6.82 million should be considered a conservative estimate of the overall economic consequences of foodborne bacterial zoonoses in East Gojjam.

5. CONCLUSSION AND RECOMMENDETIONS

This study indicates that probable foodborne bacterial zoonotic diseases impose a substantial public health and economic burden in East Gojjam Zone, with an estimated 1,640.47 DALYs per 100,000 population and an annual economic burden of approximately US$6.82 million. The burden varied geographically, with the highest health burden observed in Shebel Berenta and Hulet Eju Enesie, while productivity losses constituted the largest component of the estimated economic burden. Strengthening food safety and hygiene across the animal-source food value chain, improving laboratory-based surveillance, and implementing targeted One Health interventions are warranted. Further studies incorporating pathogen-specific confirmation and livestock-sector losses are needed to provide more precise estimates of the overall burden in East Gojjam and Ethiopia.

Limitations of The Study

The study could not estimate direct and indirect economic losses associated with bacterial zoonoses in livestock, animal products, and productivity because of limited baseline productivity and district-level prevalence data and resource constraints. Most cases were classified based on clinical presentation, food-consumption history, and epidemiological information, with limited pathogen-specific laboratory

confirmation because of inadequate diagnostic capacity, creating potential for misclassification. Finally, data were collected for six months, and a 2.18 annualization factor was applied to incidence and mortality estimates because of financial constraints.

Declarations

Consent for publication

Consent to publish finding of the data was obtained from all of respondents or their parents if they were children during sampling and data collection.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

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Author Contributions

1. **Kifle Wondimagegnehu:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing-original draft.
2. **Dessalew Habte:** Conceptualization, Investigation, Project administration, Validation, Methodology, Writing-review and editing;.
3. **Lieul Yizengaw:** Methodology, Validation, Writing-review and editing.
4. **Haregua Yesgat:** Visualization, Writing-review.
5. **Arega Tafere:** Visualization and reviewing.
6. **Habtamu Yalew:** Writing-review.
7. **Natnael Teshager:**Visualization, Writing-review.
8. **Yibeltal Simeneh:** Writing-review and editing.

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Captions for supportive Information

S1: Questions/formats includes in Data collection Sheet