



Research article

Epidemiological investigation of morbidity and mortality of improved breeds of chickens in small holder poultry farms in selected districts of Sidama Region, Ethiopia

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ABSTRACT

Background: A longitudinal study was conducted in six intensive and three semi-intensive poultry farms in Shebedino and Dale districts of Sidama Region, Ethiopia from November 2018 to May 2019. The objectives of the study were to estimate incidence rates of mortality and morbidity, identify the risk factors associated with morbidity and mortality and establish differential diagnosis of major diseases affecting poultry in the area. Chickens belonging to two breeds namely Sasso, and Bovans Brown reared in purposively selected small-scale farms was included from two districts. The chickens on the selected farms were monitored for morbidity and mortality every week. Diagnosis of different diseases was made based on the flock history, age of birds, clinical signs, characteristic gross and microscopic lesions, and fecal flotation technique for coccidiosis. Semi-structured questionnaires were also administered to gather information on the risk factors and farming practices.

Results: The incidence rate of morbidity and mortality in the studied farms was 16.14 and 12.69 per 1000 chicken-week at risk, respectively. The minimum and maximum incidence rates of morbidity were 2.02 and 58.43 cases per 1000 chicken-week at risk, respectively. The minimum and maximum incidence rates of mortality were 0.21 and 58.18 deaths per 1000 chicken-week at risk, respectively. Among the risk factors studied feed type, age of chickens, and number of sick chickens on farms were significantly associated ($p < 0.05$) with the incidence of disease. Age of chickens and number of sick chickens found on the farms were significantly associated ($p < 0.05$) with the incidence of death using multivariable logistic regression. Newcastle Disease (ND), Infectious Bursal Disease (IBD), Fowl typhoid, and Coccidiosis were the important diseases identified during the follow up period in the study area. Of the overall mortality and morbidity, 90.48% and 42% were respectively attributed to ND. Infectious bursal disease and Coccidia co-infection occurred in 31.55% of chicken in the infected farms.

Conclusions: The present study documented the incidence rate of morbidity and mortality in smallholder poultry farms in selected districts of Sidama Region. The study findings indicated that infectious diseases appear to be a major constraint to improve chicken production in the study areas. Therefore, the veterinary and livestock authorities should take this into account when planning poultry development activities and setting up systems of livestock production and health monitoring.

1. Introduction

Poultry production is an important agricultural activity for most rural communities in Ethiopia providing multitudes of services including quality protein in the form of meat and eggs and a source of cash [1]. The optimum utilization of this resource is, however, hindered by several

factors including diseases. The economic losses incurred include high mortality, morbidity, and decreased production of meat and eggs. In addition, the costs of treatment and management of flocks during the course of the disease escalate the magnitude of the losses [2]. Outbreaks of diseases are common, mostly amongst non-vaccinated flocks, leading to losses up to 70% [3]. Infectious diseases such as Newcastle disease and

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infectious bursal disease (Gumboro) are among diseases inflicting heavy losses to the poultry industry worldwide [3].

Few studies carried out in Ethiopia revealed that the overall mortality due to Newcastle disease was 32.7 %, whereas that of infectious bursal disease was 50 % [4]. Serological surveys also showed that both diseases are widespread in various production systems. For instance, a study was done by [5] and [6] revealed the seroprevalence of 11.34 % and 26.2 % in central Ethiopia and northern Ethiopia, respectively for Newcastle disease. Seroprevalence of infectious bursal disease is as high as 46 % [7] and 83 % [8] by the study conducted in central and northern Ethiopia, respectively. Reports of [9] showed that 30.1 % of the small-scale poultry farms found in the capital city of the country, Addis Ababa, are affected by disease outbreaks. Mortality ranging from 45 % [10] to 68 % [11] was reported in commercial chickens in northern Ethiopia although the specific causes of mortality were not identified. Mortality of 32 % was observed in backyard chicken in western Ethiopia [12] suggesting the widespread distribution of infectious diseases in the country. Similarly in southern Ethiopia mortality of 23.1 % was observed in backyard chicken [13].

Poultry production is a growing business in Sidama region of southern Ethiopia, which is one of the densely populated regions of the country. The poultry sector in this region is, however, affected by several technical and non-technical factors. The occurrence of infectious diseases is the most important problem posing considerable impacts on chicken production in the area. Elsewhere it has been shown that infectious diseases reduce egg and meat production thereby significantly impairing the economics of the poultry industry [14]. Optimum poultry production, therefore, requires an understanding of the epidemiology of infectious diseases such as incidence of morbidity and mortality, which are useful for quantifying the financial losses incurred. Systematic investigation into the incidence of morbidity and mortality has not been carried out in poultry in southern Ethiopia. Moreover, the differential diagnosis of the diseases that cause chicken mortality has also been not established. This study was carried out with the objectives of 1) estimating the morbidity and mortality rates in chickens in selected districts of southern Ethiopia, 2) identifying the risk factors associated with morbidity and mortality, and 3) attempt to establish the differential diagnosis of diseases inflicting mortality in the region.

2. Methods

2.1. Description of the study area

The study was conducted in Shebedino and Dale districts of Sidama Regional State, southern Ethiopia. Sidama Regional State is a newly established administrative region in southern Ethiopia (Figure 1). The region lies between 6° 10' and 7° 05' North latitude and 38° 21' and 39° 11' East longitude. The climate of Sidama Regional State is characterized by moist and humid. Two districts namely Sheberdino and Dale were selected purposively based on the number of poultry farms available and chicken population. Shebedino and Dale districts are located 295 and 315 km, south of Addis Ababa with altitude ranging from 1790 - 2950 m above sea level. The districts receive annual rainfall ranging from 800 - 1500 mm having minimum and maximum mean temperature of 12.6 °C and 30 °C. The relative humidity of the districts is 51.8 %. The chicken population of Shebedino and Dale districts was estimated to be 151,643 and 218,923 heads, respectively [33].

2.2. Study population

The study populations were chickens of all ages; both sexes reared under intensive and semi-intensive production systems from both districts. Nine small-scale poultry farms were selected for this study. The first six farms rear day old Sasso dual-purpose chicken for three months

after which they distribute the chicken to farmers in the nearby rural areas. Two farms keep adult Sasso dual-purpose chicken to egg laying age, whereas, one farm rears Bovans brown layer chickens. Three of the farms were from Shebedino district while six of them were from Dale district. The selected farms manage chickens intensively.

2.3. Study design and sampling methods

A longitudinal study was employed from November 2018 to May 2019. The flock size of the farms selected varied from 50 - 2240 chickens. The numbers of chickens recruited for the study were 400 from farm A, 400 from farm B, 1369 from farm C, 50 from farm D, 50 from farm E, 2240 from farm F, 250 from farm G, 1500 from farm H, and 1800 from farm I with a total of 8059 chickens. The poultry farms included in the study were selected based on willingness of farm owners to participate in the longitudinal study and all chicken reared on the selected farms were followed for seven months. In addition, a retrospective survey on the occurrence of poultry diseases, death, and risk factors was employed in order to have baseline information. Whenever outbreaks of diseases were encountered, individual sick and dead chickens were selected purposely for postmortem investigations. Data on the risk factors were collected by using a questionnaire administered to farm owners and key informant interviews.

2.4. Study methods used

Participatory clinical examination and diagnosis: Flock history, clinical signs of the diseases, morbidity, and mortality were explored and major disease problems were identified and prioritized through participatory epidemiology. The flocks were monitored thoroughly for clinical signs of diseases and sick chickens were clinically examined. The flock monitoring and examination of sick chickens were done weekly throughout the study period. The occurrence of any morbidity and mortality was recorded and the time lapsed before the occurrence of disease and death was recorded to compute their incidence rate.

Follow-up and data collection Incidence rate of morbidity and mortality was determined and risk factors for the occurrence of the diseases and death were identified during the study period. Chickens were visited once every week; however, urgent visits were also made upon telephone calls by the farm owners or farm attendants for diseases and deaths that occur between successive visits. During each visit, flock size, disease outbreaks, type and route of vaccination given, number of sick chickens on each farm, number of dead chickens and results of clinical examination, laboratory, and postmortem findings were recorded.

Postmortem examination: Sick chickens were randomly selected and purchased for post-mortem examinations. The postmortem examinations were carried out in the Veterinary Pathology Laboratory of the Faculty of Veterinary Medicine, Hawassa University, Hawassa, Ethiopia. Each organ was examined for the presence of lesions such as hemorrhages, exudate, and any other abnormality from eyes through mouth and nostrils up to the cloaca. Any lesion observed was recorded.

Fecal flotation technique for diagnosis of coccidiosis: Fecal samples were collected from chickens that were suspected to be infected with coccidia based on the clinical signs observed. Swabs moistened with saline were used for the collection of fecal samples. The swabs were inserted into the cloacal cavity of each chicken gently to collect fresh fecal samples for laboratory analysis. The fecal samples were placed into a plastic bottle, coded appropriately, and transported to the laboratory. The fecal samples were examined for the presence of coccidia oocysts using the simple floatation technique as described by Urquhart et al. [34].

Questionnaire survey: A questionnaire was developed to collect information on the major infectious poultry diseases and risk factors in the selected farms. Pretesting of the questionnaire was carried out in two

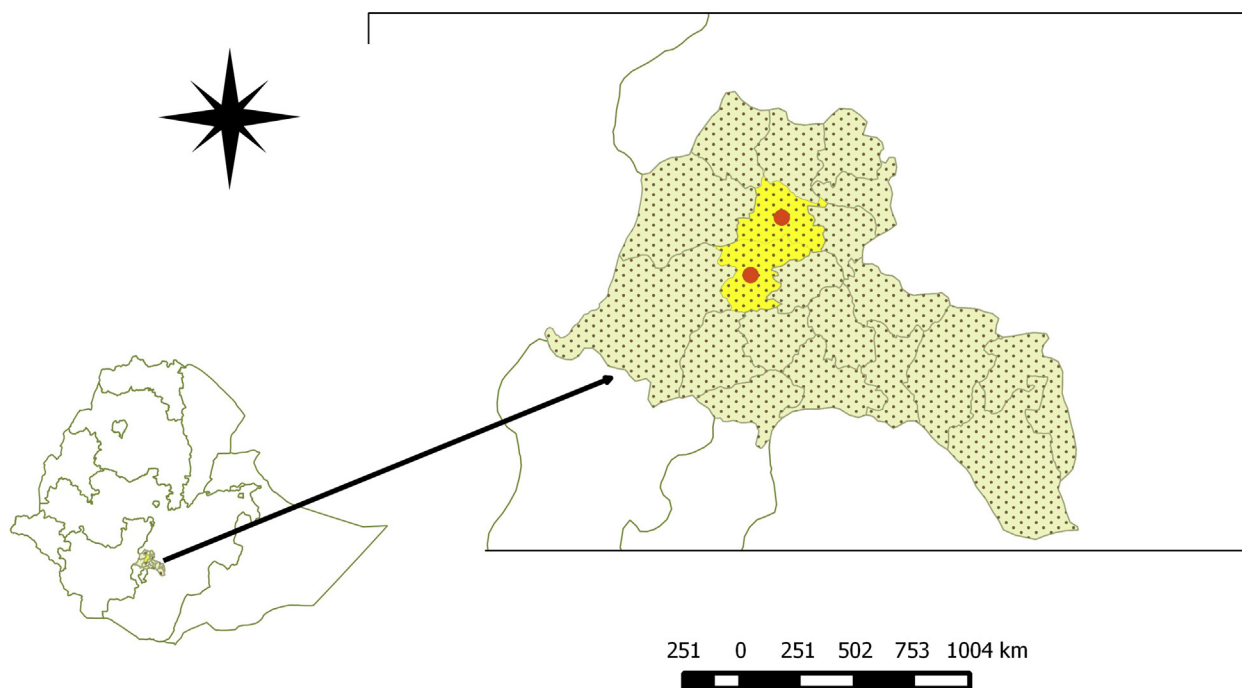


Figure 1. Map of the study area showing sampled districts (Shebe Dino and Dale), developed from Ethiopian shape files using QGIS software.

farms one from each study district. Farm owners and workers engaged in intensive and semi-intensive poultry farms were the primary respondents. Data on housing system, history of disinfection of the house, use of foot bath at the entry, isolation of sick chicken, disposal of dead birds, rodent challenge in the farms, deworming of the flock, feeding and watering system, flock density, vaccination, and history of occurrence of diseases, and season of high diseases prevalence were collected. Animal health professionals, researchers, and agricultural extension workers in the study area were questioned for secondary data.

2.5. Data management and analysis

Epidemiological data obtained from Questionnaires, follow-up, clinical investigation, and laboratory tests were summarized and analyzed using STATA version 14 (StataCorp, 4905 Lakeway Drive, College Station, Texas 77845 USA). The overall cumulative incidence, morbidity, and mortality rates as well as the cause-specific rates (CSR) were calculated using the formula described by [14]. During the analysis, all chickens that developed the outcomes of interest (became sick and died) constitute the numerator and the total chicken weeks at risk was used as a denominator for computation of the morbidity and mortality rates. The rates computed were expressed as the number of cases per 1000 chicken weeks at risk. Logistic regressions reporting odds ratio and coefficient were performed to determine the association between various risk factors (explanatory variables) and the dependent variables (disease and death). Multicollinearity of risk factors was checked using Kruskal gamma statistics and those risk factors whose gamma value ranged between -0.6 and $+0.6$ were considered in multivariable logistic regression analysis and further evaluated for confounding. Interaction factors were assessed by deviance check from $-2\log$ likelihood of models with and without interaction terms. The final model was built in the backward stepwise elimination procedure in reference to log-likelihood ratio. Control for confounders was made using a statistical method of controlling confounders looking at the change in the coefficient [14]. A probability predictive limit of less than 5% ($P < 0.05$) was set to indicate significance level. Finally, the model was assessed for goodness-of-fit using the Hosmer-Lemeshow and Pearson method and the predictive ability using log-likelihood ratio.

3. Results

3.1. The incidence rate of morbidity and mortality in chicken in the study area

During the study period, 1521 chickens became sick out of a total of 8059 chickens contributing to a total of 94228 chicken weeks at risk. Thus, the overall morbidity rate observed was 16.4 per 1000 chicken weeks. The highest incidence rate of morbidity was observed at farm I (58.43 per 1000 chicken weeks) whereas the lowest was observed at farm F (2.02 per 1000 chicken weeks). The incidence rate of morbidity in studied farms was summarized in Table 1. During the study period, 1183 chickens died yielding an overall mortality rate of 12.69 per 1000 chicken weeks. Similar to the morbidity rate the highest mortality rate was observed at farm I (58.18 per 1000 chicken weeks) whereas the lowest was observed at farm F (0.21 per 1000 chicken weeks). The incidence rate of mortality in the nine studied farms was summarized in Table 2.

Table 1. The results of morbidity rates observed in layer chicken in nine selected farms from Shebedino and Dale districts of Sidama Regional State, Southern Ethiopia.

Name of farm	Chicken at Risk	No sick	Chicken Weeks	Morbidity Rate per 1000
Farm A	400	46	5055	9.10
Farm B	400	44	5207	8.45
Farm C	1369	336	16170	20.78
Farm D	50	9	625	14.40
Farm E	50	30	744	40.32
Farm F	2240	58	28782	2.02
Farm G	250	38	3783	10.04
Farm H	1500	121	19503	6.20
Farm I	1800	839	14359	58.43
Total	8059	1521	94228	16.14

Table 2. The mortality rates observed in layer chicken on nine selected farms from Shebedino and Dale districts of Sidama Regional State, Southern Ethiopia.

Name of farm	Chicken at Risk	No of death	Chicken weeks	Mortality Rate per 1000
Farm A	400	43	5059	8.50
Farm B	400	36	5160	6.98
Farm C	1369	103	15873	6.49
Farm D	50	5	628	7.96
Farm E	50	19	630	30.16
Farm F	2240	6	28515	0.21
Farm G	250	16	3491	4.58
Farm H	1500	120	19522	6.15
Farm I	1800	835	14351	58.18
Total	8059	1183	93229	12.69

3.2. Risk factors of morbidity and mortality in chicken

Among the risk factors considered; the number of sick chickens per farm during observation, types of feed provided, and age of chicken were significantly associated with the occurrence of diseases. The odds of morbidity were about 38 times higher in farms with more number of sick chickens remaining on the farm than those which have less number of sick chickens. Chicken maintained on processed feed had higher odds of succumbing to diseases than those maintained on homemade feeds. As the age of the study chicken increased by one week their odds of developing diseases also increased 1.37 times (Table 3).

A similar analysis was done to capture the association between risk factors and mortality. The results showed that a number of sick chickens and the age of chicken were significantly associated with mortality (Table 4). The odd of death was 1.536 times higher in chickens reared on farms having more sick chicken than those with less sick chicken. In contrast as age increase by a week, the odds of death decreased by a factor of 0.871. During the analysis of the effects of potential risk factors on the occurrence of mortality; the housing system and purpose of keeping chickens were dropped from the analysis due to multi-collinearity with age, season, education level of the owner, sex of the respondent, and feed ($\gamma = 1$ and -1). The level of education of the owner was also dropped due to multi-collinearity with the sex of the owner, isolation of sick, and disposal of the dead ($\gamma = -1$).

Table 3. Results of Multivariable logistic regression analysis of risk factors of the morbidity in chicken.

Variables	Category	No of observation	Odds Ratio	P-value	CI for OR
No. of sick chickens per farm	quantity	126	38.344	0.001	4.560–322.408
Flock size	quantity	126	0.998	0.156	0.995–1.001
Type of feed	Processed feed (ref) Homemade	126	0.003	0.018	0.00029–0.15
Breed	Bovans brown (ref) Sasudual	126	113.42	0.091	0.471–2732.74
Age of chicken	In number	126	1.307	0.034	1.021–1.673
Season	Rainy season (ref) Dry season Short rainy season	126	0.894	0.845	0.289–2.767

Ref = reference category, Area under ROC curve = 0.9793, prob > chi (2) = 0.8764, CI = Confidence Interval.

Table 4. Results of Multivariable logistic regression analysis of risk factors of mortality in chicken.

Variable	Category	No of observation	Odds Ratio	P-value	CI for OR
No. of sick chickens per farm	quantity	126	1.536	0.000	1.24–1.91
Flock size	quantity	126	0.999	0.844	0.99–1.00
Age of chicken	quantity	126	0.871	0.001	0.81–0.94
Season	Rainy season (ref) Dry season Short rainy season	126	1.145	0.718	0.55–2.39
Isolation of sick	Isolate and treat sick (ref) Treat without isolation	126	0.325	0.325	0.05–2.77

Ref = reference category, Area under ROC curve = 0.9049 prob > chi(2) = 0.4320, CI = Confidence Interval.

3.3. Differential diagnosis of major infectious diseases identified using clinical and necropsy examination

3.3.1. Newcastle disease

During the study period, 21 clinical cases of Newcastle Disease (ND) were observed in chicken on one farm. Out of those 21 chicken that showed clinical signs of Newcastle disease nineteen of them died yielding a case fatality of 90.48% and mortality of 42%. Postmortem examination was done on 7 randomly selected chickens revealing necrotic enteritis, petechial hemorrhage on the proventriculus, and cloacal mucosa (Figure 2).

3.3.2. Infectious bursal disease (IBD)/Gumborbo

During the follow-up period 432 suspected clinical cases of the infectious bursal disease were encountered in chicken on one farm where chicken are intensively managed. The incidence of the clinical cases of IBD was 31.5%. The results of postmortem examination revealed enlarged and inflamed bursa of fabricious (Figure 3) and hemorrhage in leg muscles. All of those chickens affected with IBD also showed typical lesions of coccidial infection suggesting the occurrence of co-infection.

3.3.3. Fowl typhoid

Clinical cases of fowl typhoid were encountered chicken reared on two farms were 129. Out of those 129 chickens that showed clinical signs of fowl typhoid thirteen of them died yielding a case fatality of 10%. The major clinical signs observed were reluctance to move, loss of appetite, and watery and mucoid diarrhea. The postmortem examination revealed petechia on the liver (Figure 4).

3.3.4. Coccidiosis

During the study period, clinical cases of coccidiosis were encountered in three farms affecting 63 chicken yielding case fatalities of 46%. The affected chickens exhibited bloody diarrhea, ruffled feather, depression, and weight loss. Fecal samples were collected from 85 chickens and examined using fecal flotation technique. *Eimeria* oocysts were identified in 57 (67.1%) fecal samples.

3.3.5. Miscellaneous causes of death

The highest mortality of chickens was observed among the farms that practiced poor management in terms of feeding, watering, and high stocking density. Management-related deaths were encountered predominantly due to feeding and watering problems (time of feed provision and amount of feed provided to chickens and access to feed by all chickens on the farm). Farm I registered high mortality (46.38%), which

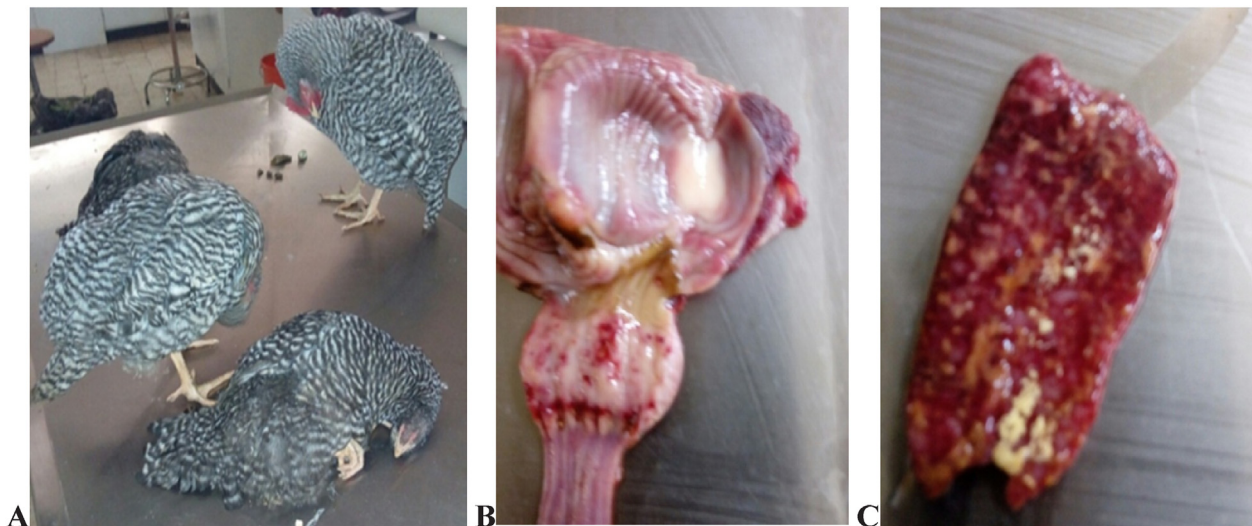


Figure 2. Twisted neck and paralytic clinical appearance (A), Petechial haemorrhage on the proventriculus (B) and Necrotic enteritis (C) from in chicken that suspected and died due to cases of ND.

has very poor management practices. Factors that aggravated death in this farm could perhaps be attributed to inefficient brood management and stress due to overstocking in the farm.

4. Discussion

Poultry production plays an important role in attempts made to achieve household nutritional and social security in all parts of Ethiopia. Taking this into account the Ethiopian government has prioritized poultry production in its livestock master plan for sustaining food security. Due emphasis is given to smallholder poultry enterprises, which are an interesting businesses in highly growing urban centers and densely populated regions such as Sidama Region. The success of poultry farms is dependent on the prevention and control of diseases. This study provided preliminary results on the magnitude of morbidity and mortality in chickens reared under smallholder farms in selected districts of Sidama Region. It has also identified factors that were associated with the occurrence of diseases and death and provided a differential diagnosis of major diseases responsible for illness and death in chickens in the area. The incidence rate of morbidity and mortality (16.14 cases and 12.69 deaths per 1000 animal-weeks at risk, respectively) observed in chickens in this study was lower than the reports of [15] who reported 113.2 deaths per 1000 chicken-months at risk in village chickens in central

Ethiopia. In contrast, our findings are higher than incidence rate of mortality reported by [16] who reported a mortality rate of 19.76 deaths per 1000 birds-months at risk in semi-scavenging chickens in Bangladesh. The difference observed in morbidity and mortality rates between this study and the previous ones could be attributed to the vaccination practices used in the current study areas. On contrary, the previous studies were conducted on backyard chicken where vaccination is not frequent practice or not available. Since the smallholder farms are market-oriented than the backyard production system the better management provided from the owners and/or the attendants could have also contributed to decreased morbidity and mortality rate observed in this study.

The present study revealed a significant association between the age of chicken and the occurrence of disease and death. The lower morbidity in younger chicken and higher incidence in older ones showed that once introduced or started the disease agent remains on the farm and can spread among the flock mates as chicken become older. This suggests the need for close monitoring of the flock for evidence of disease occurrence and applies the necessary measures to contend the pathogens. In contrast, mortality decreased as age increase suggesting the development of immunity in older chicken. Our observation is in agreement with the results of [15, 17, 18], who reported a significant association between the age of chicken and the occurrence of diseases. Similarly, the association

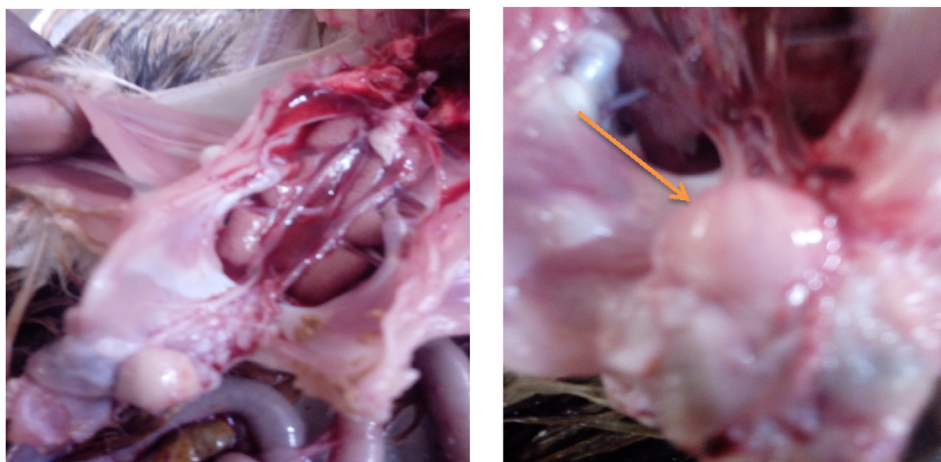


Figure 3. Enlarged bursa of fabricius from chicken infected with IBD.

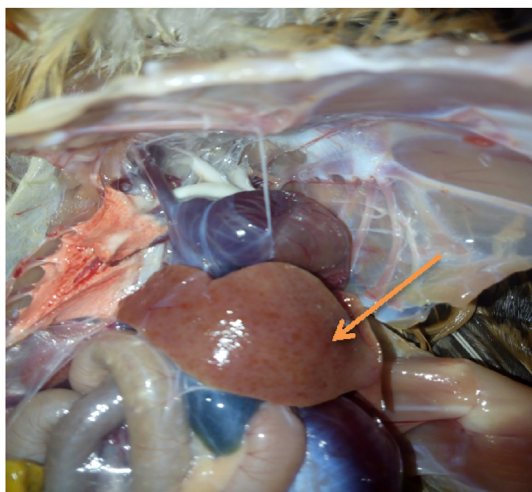


Figure 4. Liver petechial from chicken suspected of Fowl typhoid infection.

observed between the age of chicken and mortality is in consent with the results of [19, 20, 21] who reported decreasing mortality as age increases in the order of laying period (8.34%), growing (6.32%), pullet (4.65%), and brooding (3.78%) ages.

The present study found there was no significant association in the incidence of diseases and death with the breed of chicken (Bovans brown and Saso dual chickens). This finding agrees with a study made by [17, 20] who reported no significant association between breed and disease occurrence. It also coincides with study conducted by [22] in central Nigeria who reported no significant association between mortality and breeds of chicken. However, studies conducted by [20, 23, 24, 25, 26, 27] observed a significant association between mortality and morbidity and breed of chicken. The absence of significant association of morbidity and mortality with the breed in the present study could perhaps be attributed to the diseases in the study area affects all types of breeds in the study similarly.

The current study revealed a significant association between the number of sick birds on the farms and the incidence of diseases and death. A higher rate of morbidity and mortality was registered in the farms with more number of sick chickens remaining on the farm than those which have less number of sick chickens. As the number of sick chicken increases per farm, infections can easily spread by the close contact and droppings from sick or carrier birds to healthy birds. This suggests the need for immediate separation of sick chicken from the flock and keeps them in contention. The extension program should consider this scenario into account and include animal health services into its program and create awareness of the importance of the separation of diseased chicken.

There was also a significant statistical association between the types of feed provided to the chicken and the incidence rate of diseases. The odd of diseases was higher in chicken provided with processed feed purchased from suppliers than those which were provided with homemade feed. This could be attributed to the possibility of contamination of the processed feed during storage and transportation suggesting the need for quality control and assessment of commercial feeds. In contrast, homemade feeds are usually prepared on daily basis and are less likely to be contaminated. In consent to our observation [28] reported that pelleted feed was shown to be associated with increased disease development in broiler chicken. The incidence of diseases can be reduced with the use of feed type with sufficient nutritional requirements and proper maintenance of the feed quality.

The present study identified Newcastle disease, Infectious bursal disease, Coccidiosis, and Fowl typhoid were the major important diseases resulting in 23.4% overall morbidity and 18% overall mortality. This revealed the significance of these diseases in the morbidity and mortality

of chickens in intensive and semi-intensive poultry farms in the area. A comparable study conducted by [29] from North-Western Amhara [16], and [30] from Bangladesh reported 32.7%, 15.81%, and 21.6% general mortality rates of ND and IBD, respectively. A similar study by [31] reported a higher prevalence of Fowl typhoid in intensive and backyard production systems in Eastern Ethiopia. These diseases were also reported in different parts of Ethiopia indicating they are endemic [5, 6, 8, 32].

5. Conclusion

In conclusion, the present study documented the incidence rate of morbidity and mortality in smallholder poultry farms in Sidama Region. The occurrence of diseases and death in the farms included in this study are affected by the age of chicken, the number of sick chicken found on the farm, and feed type used. The high incidence of morbidity and mortality observed could be attributed to infectious diseases complemented by the low level of management practices. Therefore, the veterinary and livestock authorities should take this into account when planning poultry development activities and setting up systems of livestock production and health monitoring.

5.1. Ethics approval and consent to participate

Ethical clearance for this study was obtained from University of Hawassa, College of Natural and Computational Sciences, Faculty of Veterinary Medicine, Minutes of Animal Research Ethics and Review committee. Before conducting the research, participants were informed of the objectives of the study and written and signed consent was obtained from the farm owners or managers of the poultry farms to be involved in the follow-up study, taking samples from their chicken and farm managers to be included in the questionnaire survey.

Declarations

Author contribution statement

Gizachew Hailegebreal, Teshale Sori: Analyzed and interpreted the data; Wrote the paper.

Bereket Molla Tanga: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Wubit Woldegiorgis: Performed the experiments; Analyzed and interpreted the data.

Mishamo Sulayeman: Conceived and designed the experiments; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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