Effect of sex, age, diseases, and control intervention on chickens’ mortality and its financial implications in Dodoma, Tanzania

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ABSTRACT  Chicken diseases significantly contribute to the financial losses of small-scale chicken keepers in Tanzania through mortality and control management. However, little is known about the relationship between chicken mortality and disease, sex, and control measures. In addition, the financial losses for farmers in Dodoma resulted from mortality due to diseases and poor productivity due to improper management. A cross-sectional, longitudinal questionnaire survey with multistage sampling was conducted in the Kongwa district and Dodoma municipality to gather data from 400 randomly selected households (200 from each district). Semistructured questionnaires were used for data collection over four quarters of the year. Low morbidity and high mortality due to diseases were observed in first and second quarters (Q1 and Q2), whereas high morbidity and low mortality were observed in third and fourth quarters (Q3 and Q4). The Kongwa district experienced significantly higher mortality than the Dodoma Municipal district (P < 0.001). Disease mortality was negatively affected by cocks, hens and chicks (P < 0.001). Control interventions such as treatment, prophylaxis use lowered the effect of chicken mortality due to diseases and pronounced effects when at least 2 approaches were applied by the farmers (P < 0.005). The total financial loss incurred by the 400 interviewees is approximately Tsh. 119.9 million (52,146.96 USD). This study outlines the financial losses associated with mortality, poor productivity, poor performance, and increased costs of disease management and control in chicken-keeper households in the Dodoma region. To avoid these losses, farmers and other stakeholders should design proper control strategies while considering the season of the year and disease categories affecting chickens.

Key words: chicken diseases, mortality, financial losses, improper management

INTRODUCTION

Diseases are among the main challenges in chicken production. Different diseases infect chickens and can cause mortality. Studies have shown that, Newcastle disease and Infectious bursal disease are among the most devastating diseases that can cause mortality of up to 100% (Yongolo and Minga, 2002; Swai et al., 2013; Veterinary Professional VP, 2013; Sindiyo and Misisanga, 2018). Chicken diseases are anticipated to have negative effects on chicken production in livestock farmers. The effects of diseases on chicken production may lead to a decreased contribution of poultry production to local communities. The notable contributions of chicken production in Dodoma are the production of meat, eggs, manure, employment, and school fees (Ngongolo et al., 2020). Regardless of the known mortality impacts caused by various diseases in chickens, little is known about the Dodoma region of Tanzania, particularly its association with age, sex, and the control intervention applied by farmers.

Like in many parts of Tanzania, chickens in Dodoma also succumb to various diseases including but not limited to, Fowl Pox, Marek’s Disease, Coccidiosis, Fowl Cholera, Salmonellosis, Aspergillosis (Veterinary Professional VP, 2013). A study done in Morogoro, mentioned diseases as among the challenges that threaten chicken production at the household level (Ngongolo et al., 2019). Major losses in chicken production originate from mortality, feeding, and the cost of disease management and control (Dalloul and Lillehoj, 2006; Pawestri et al., 2020; Ngongolo and Chota, 2021). However, studies on the contribution and impact of each disease on chicken production and mortality have not yet been conducted.
Newcastle disease for instance, caused a loss of US$ 288.49 million per annum in Bangladesh (Khatun et al., 2018), Infectious bursal disease losses in India was observed to have an average financial loss of Rs. 18,276.96 ± 2,388.91/- per flock with 1,000 birds (Farooq et al., 2003). Likewise, Coccidiosis in chickens is estimated to cause global financial losses of up to 3 billion USD per annum (Dalloul and Lillehoj, 2006; Pawestri et al., 2020). Infestation by the parasite in chickens also increases financial loss. In Tanzania, it has been reported that endo-parasites and ecto-parasites may potentially devastate chicken production significantly. For instance, a study indicated that the mixed worm infestation rate in Tanzania ranges between 10 and 38.5% in scavenging village chickens, ducks, and pigeons (Rukambilie et al., 2020). Furthermore, the introduction of drugs into the food chain through the treatment of sick chickens has a negative impact on human health (Ngongolo et al., 2020). However, in Dodoma and other parts of Tanzania, few studies have been conducted to understand the extent of losses caused by mortality owing to diseases and improper management of chickens. In addition, the financial losses caused by mortality due to diseases at the household level, must be intensively studied in Dodoma.

In this study, we investigated the key diseases that threaten chicken production in Dodoma and the morbidity and mortality effects of each chicken production firm. We further, investigated the association existing between the chickens’ mortality due to diseases with other risk factors particularly age, sex and control intervention. In addition, the financial losses from chicken production at the household level that are caused by mortality due to diseases, management, and control costs of diseases, and chickens’ poor performance were considered. The investigation was based on the hypothesis that mortality and morbidity would differ by age group, sex, intervention, disease cause, and district. The term "mortality" refers to the number of individuals who died in a population. It relates to the occurrence of death, whereas morbidity refers to an individual's state of illness.

**MATERIALS AND METHODS**

**Study Areas**

A cross-sectional questionnaire survey was conducted in Kongwa and Dodoma Municipal from July 2020 to October 2020 through multistage sampling. The districts were randomly selected randomly from all Districts found in Dodoma because all districts in the Dodoma region are known to have farmers who keep chickens. Three wards were randomly selected in each district to represent the entire study area. The wards in the Kongwa district were Mlali, Kongwa, and Morisheni while the wards in Dodoma municipal were Nkuhungu, Chang’ombe, and Mnadani. Random selection was performed to obtain chicken keepers from each ward. Random selection was performed using a random number selector from a list of households that kept chickens obtained from the offices of livestock field officers. Livestock field officers or district veterinary officials from separate areas provided a list for each household. Chicken keeping is practiced by local communities in all districts of the Dodoma region. Chicken owners were randomly chosen for interviews. Districts, wards, and homes were randomly selected for sampling using a random number selector from the provided list. Livestock officials from the respective districts and wards assisted in compiling a list of farmers from each ward.

**Sample Size Determination**

Individuals recruited for the interviews were those who kept chickens. A total of 400 chicken keepers were interviewed, with 200 from each district. A minimum sample size of 384 was required in this study because the population of Dodoma is > 1 million (SM, 2020). The current information shows that the human population size in Dodoma is approximately 2 million (Tanzania Population and Housing Census, 2012). The sample size was calculated using the existing population of the Dodoma region, which is estimated to be approximately 2 million (Tanzania Population and Housing Census, 2012) and exceeds 1 million (Survey monkey, 2020). Of which, approximately 139,992 households are raising a total of about 1,825,867 chickens (National Bureau of Statistics NBS, 2006). The selected individuals were those that kept chickens under different management systems. The management systems considered in this study were; free-range, semi-intensive, and intensive systems. Free range refers to a method of farmed husbandry in which animals are allowed to roam freely outdoors for at least part of the day, as opposed to an extensive system wherein the animals are confined in an enclosure for 24 h each day (Free-range, 2014). That is, under the free-range system, chickens are scavenging whereas semi-intensive chickens are partially allowed to scavenge and partially kept under an intensive system (Ngongolo and Chota, 2021).

**Data Collection**

A cross-sectional, longitudinal questionnaire survey was used to gather information on chicken losses using a semistructured questionnaire with both closed and open-ended questions in four repetitive rounds (4 quarters). The income and losses from chickens were stratified on a quarterly basis. The first quarter (Q1) ranged from January to March 2020 which was the wet season in the region; the second quarter (Q2) had a time interval from April to June 2020 which was the end of the wet season and beginning of the dry season; the third quarter (Q3) ranged from July to September 2020 which was the dry season; and the fourth quarter (Q4) ranged from October to December 2020 at the end of the dry season and the beginning of the wet season. The disease information gathered in the questionnaire was as follows; Newcastle disease, Fowl typhoid, Fowl pox, infectious bursal disease, Coccidiosis, Gastrointestinal helminths, and ectoparasites. The farmers were...
required to report the number of sick chickens and those that died in each quarter. Additionally, farmers were required to report the number of chickens that died from each disease every quarter of the year. Before reporting, training on animal disease identification was provided by a veterinary Doctor to the farmers. The training focused on identifying common diseases in chickens using the clinical signs and symptoms. Postmortem information regarding the diseases reported by the farmers was validated by a veterinary Doctor from the Tanzania veterinary laboratory agency. This helped ensure the accuracy of the information gathered by the farmers. The veterinary Doctor performed the field clinical examinations, postmortem examination, and laboratory Work (Chota et al., 2021).

Field Clinical and Postmortem Examination

Clinical and postmortem examinations of chicken cadavers were undertaken free of charge during in-depth interviews in households, as described by King et al. (2006) and Chota et al. (2021). In total of 100 chicken samples were collected and sent to the laboratory for testing to determine the cause of death. The rates of morbidity and mortality of diseases per household were determined.

Laboratory Work

All laboratory tests were performed at the Tanzania Veterinary Laboratory Agency (TVLA) in Dar es Salaam, Tanzania.

Furthermore, information on risk factors such as age, sex of chickens, and control interventions was requested from farmers. Age and sex classified chickens as cocks, hens, cockerels, pullets, and chicks as suggested by Lesley (2020) and Ngongolo and Chota, (2021). The intervention was classified as vaccine, use of prophylaxis, treatment or the use of a combination of at least the 2 methods mentioned above whereas the management system was classified as free-range, semi-intensive, and intensive systems.

Financial losses from the chickens were calculated in terms of the monetary (cash) value of the chickens that died because of diseases, the costs of management and control of diseases, and losses resulting from poor productivity due to parasite infestations and improper chicken management in Tanzania Shilling (Tsh.). The exchange rate of Tanzania Shilling to USD per as per the exchange in October 2020 as indicated by the exchange rates offered by the Bank of Tanzania was approximately 1USD to 23000 Tsh. The value of chicken lost was calculated based on the existing average price of chicken at the market price in Dodoma Tanzania which was Tsh. 9500.00 (4.5 USD) in 2020. Financial losses were calculated for a quarter of the year and for each district.

Financial losses due to disease management and control were also considered. The management cost per chicken is estimated to be Tsh. 4500. The estimation considered the costs of feeding, treatment, vaccination, labor, and other costs incurred in raising chickens. The estimation was based on the responses of interviewed farmers who kept broiler chickens in Tanzania. Farmers who kept broilers and layers had better records for all costs used in production than those who kept local breed under free-range management. In addition, from the interviewed farmers, it was noted that the average cost of managing one chicken from the time of introduction to the hut (Banda) until they were sold was estimated to be Tsh. 4500.

a) Financial loss due to death of chicken due to diseases (ELD) = Average value of chicken in Tanzania (AVC) (Tsh.) × Chicken died of the disease (CDD).

b) Financial loss due to management (FLM) = Number of chickens died of the disease (CDD) × Average management cost per chicken (AMCC).

c) Total loss due to mortality and improper management (TLM) = ELD + ELM.

Note: Average value of chicken in Tanzania (AVC) = Tsh. 9500.00 (4.5 USD) in 2020, Average management cost per chicken (AMCC) = Tsh. 4500 (2 USD) in 2020.

Statistical Analysis

Means and proportions were used to report the average losses. Variations in the number of chickens that died from different diseases, the difference in financial loss among diseases and among districts were analyzed using either Kruskal-Wallis (H) or Mann-Whitney statistical tests (U) (Mann and Whitney, 1947; Kruskal and Wallis, 1952). Kruskal-Wallis and Mann-Whitney statistical tests were chosen because the data were not normally distributed (Kurtosis >3). The association between chicken mortality due to diseases and other risk factors particularly age, sex, and control intervention was analyzed using a generalized linear mixed model (GLMM) where wards were random effects (factors). Differences were considered significant if the P-value was less than 0.05.

RESULTS

Demographic Structure of Respondents

Females made up 69.64% of the 400 households polled, whereas males made up 30.36%. In addition, 43.64% of those surveyed were above the age of 40, 34.55% were between the ages of 31 and 40, and 21.82% were between the ages of 21 and 30. Individuals with a primary school level (72.22%) and above made up the majority of the families interviewed (27.78%).

General Morbidity and Mortality

A total of 400 farmers (n = 27,212 chicken) were interviewed, of whom, 80% reported disease morbidity, and mortality in their flock. The average flock size per
household was 68.03 ± 11.83, n = 400. There was significant variation in flock size among age groups whereby the highest abundance was observed for chicks (mean = 27.46 ± 6.39, n = 400), hen (mean = 26.057 ± 7.51, n = 400) followed by young hen/pullet (mean = 6.51 ± 0.92, n=400) while lowest abundance was observed for cockerels (mean = 4.19 ± 0.79, n = 400) followed by cocks/rooster (mean = 4.39 ± 0.71, n = 400) (H = 149.091, P < 0.0001). A higher average flock size was reported in the Dodoma municipality (mean = 124.56 ± 35.08, n = 200) than in Kongwa district (mean = 42.55 ± 5.54, n = 200) (H = 24.253, P < 0.0001).

The average number of sick chickens (mean = 19.94 ± 4.10, n = 400) was higher than that of dead chickens (mean = 8.05 ± 1.64, n = 400). Generally, morbidity and mortality were higher in the Dodoma municipality than in the Kongwa district, and the variations in morbidity between the 2 districts were significantly different ((U = 3193, P < 0.0001) whereas, mortality did not differ significantly (Figure 1). There was a positive relationship between sick and dying chickens (R = 0.15, F = 5.89, P = 0.02).

**Morbidity and Mortality of Chickens in the Four Quarters**

Most of the chickens that became sick in the first and second quarters died compared to those in the third and fourth quarters of the year. The mean morbidity in the third Q3, and fourth quarters, Q4 was significantly higher (KWS = 7.95, P = 0.045), but the mortality was significantly higher in the second Q2, and fourth quarters of Q4 (KWS = 7.69, P = 0.05; Figure 2).

**Diseases Causing Mortality of Chicken in Chicken Keeper Households**

The total number of interviewees was 400, of which 100%, reported Newcastle disease, Fowl typhoid, and Coccidiosis to be causing mortality in their chickens. Other reported diseases included; Fowlpox 71.43%, Infectious bursal disease 57.14%, Helminthes 5%, and ectoparasites 2%. Mortality was significantly associated with Newcastle disease, Fowl typhoid, and coccidiosis (KWS = 129.14, P < 0.0001) whereas it was low for other diseases (Figure 3). Mortality due to diseases was higher in the Kongwa district than in the Dodoma municipality. In both districts, mortality was contributed much by Newcastle diseases and Fowl typhoid and coccidiosis in either of the 2 districts (Figures 4 and 5). The number of mortalities across the 4 quarters did not vary significantly (U = 991.50, P = 0.09) between the 2 districts. For instance, the number of deaths caused by Newcastle disease was higher in Q2 for both districts but was dominant in the Kongwa district (Table 1).

**The Contribution Each Diseases on Lowering Chicken Production Through Mortality**

Overall, diseases revealed a significant reduction in chicken production through mortality with extremities

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**Figure 1.** The average number of morbidity and mortality of chicken per household per year in Kongwa District and Dodoma Municipal.

**Figure 2.** The average number of morbidity and mortality in chicken in the four quarters of the year. Note: Q1 = Interval between January and March, Q2 = April-June, Q3 = July-September, and Q4 = October-December.
being observed for Newcastle disease, Coccidiosis, and basal infectious diseases (Table 2).

**Influence of Age, Sex, and Control Intervention**

Chickens mortality was influenced by age, sex, and control intervention practices by farmers. Generally the disease significantly negatively affected the number of cocks, hens, and chicks (Table 3). In addition, the control intervention particularly the use of prophylaxis and treatment revealed a significant association with mortality of chickens due to diseases with a paramount effect being seen when the 2 methods are used by the farmers (Table 4).

**Financial Loss Due to Mortality Caused by Chicken Diseases**

Regarding the total mortality of 10,137 chicken reported by 400 farmers in the study area per year, the average total loss ($TLMI$) was Tsh. 119.9 million (52,146.96USD at an exchange rate of 1USD = Tsh. 2,300 in 2020). Of these, costs due to improper management ($FLM$) were Tsh. 38.6 million (16,761.52USD) and chicken mortality due to disease ($ELD$) was Tsh. 81.3 million (35,385.45 USD) (Figure 6). The 2 categories of mortalities was calculated as shown in the formula above. The financial loss due to mortality caused by diseases was significantly higher than that due to improper management ($U = 6554.50, P < 0.0001$). A similar trend was observed when the financial losses was compared in the 2 study districts while it was significantly higher in the Kongwa district ($P < 0.001$) than in the Dodoma municipality (Figure 7). Overall, Newcastle disease caused the highest financial loss among the chicken diseases in the study area (Table 5).

**DISCUSSION**

The average annual financial loss due to chicken diseases per household is projected to be Tsh. 300,000/= (136.29 USD). Financial losses due to chicken disease have also been reported in other studies. For example, a study in Bangladesh found that disorders like Newcastle...
Table 2. The association and contribution of different diseases to the mortality of chicken.

| S/n | Variables                      | ES   | S.E  | z value | P        | Comments |
|-----|--------------------------------|------|------|---------|----------|----------|
| 1   | Intercept                      | 0.94 | 0.068| 13.81   | < 2e-16  | ***      |
| 2   | Newcastle diseases             | 0.08 | 0.02 | 3.57    | 0.0003   | ***      |
| 3   | Fowl typhoid                   | 0.11 | 0.02 | 6.16    | 7.21e-10 | ***      |
| 4   | Lice                           | 0.14 | 0.02 | 5.98    | 2.19e-09 | ***      |
| 5   | Worms                          | 0.10 | 0.03 | 3.74    | 0.000187 | ***      |
| 6   | Fowl pox                       | 0.11 | 0.02 | 4.70    | 2.55e-06 | ***      |
| 7   | Coccidiosis                    | 0.09 | 0.01 | 5.17    | 2.29e-07 | ***      |
| 8   | Basal infectious diseases (Gumboro) | 0.06 | 0.02 | 3.34    | 0.000845 | ***      |
| 12  | Random effect                  | Wards|      |         |          |          |
| 13  | AIC                            | 801.3|      |         |          |          |

Abbreviations: EC, estimate coefficient; Family, Poisson; P, Probability value.
* = Significant; ** = High significance, *** = Very high significance.
n = 200 households in each district, n = 10,137 chicken.

Table 3. The association chickens’ mortality due to diseases with age and sex.

| S/n | Variables | ES   | S.E  | z value | P        | Comments |
|-----|-----------|------|------|---------|----------|----------|
| 1   | Intercept | 2.58 | 2.21e-01| 11.65   | < 2e-16  | ***      |
| 2   | Cocks     | 2.06e-02| 3.59e-03| 5.73    | 1.02e-08 | ***      |
| 3   | Hen       | -8.97e-03| 1.49e-03| -5.99   | 2.15e-09 | ***      |
| 4   | Cockerels | 1.37e-05| 2.91e-03| 0.01    | 0.99     |          |
| 5   | Pullets   | -1.28e-03| 2.34e-03| 0.547   | 0.585    |          |
| 6   | Chicks    | -3.26e-03| 6.54e-04| -5.019  | 5.19e-07 | ***      |
| 7   | Random effect | Wards|      |         |          |          |
| 8   | AIC       | 2012.6|      |         |          |          |
| 9   | logLik    | -999.3|      |         |          |          |

Abbreviations: EC, estimate coefficient; Family, Poisson; P, Probability value.
* = Significant; ** = High significance, *** = Very high significance.
n = 200 households in each district, n = 10,137 chicken.

Table 4. The association of diseases’ control intervention and the chickens’ mortality due to diseases.

| S/n | Fixed effects considered | Variables | ES   | S.E  | z value | P        | Comments |
|-----|--------------------------|-----------|------|------|---------|----------|----------|
| 1   | Control intervention variables | Intercept | 2.73 | 0.23 | 11.88   | < 2e-16  | ***      |
| 2   | Vaccination              | Yes       | -0.12| 0.16 | -1.73   | 0.46     |          |
| 3   | Prophylaxis              | Yes       | 0.44 | 0.17 | 2.63    | 0.009    | **       |
| 4   | Treatment                | Yes       | -0.42| 0.14 | -3.12   | 0.002    | **       |
| 5   | Vaccination + Prophylaxis| Yes       | -0.29| 0.07 | -4.06   | 4.91e-05 | ***      |
| 6   | Vaccination + Treatment  | Yes       | -1.42| 0.14 | -10.46  | < 2e-16  | ***      |
| 7   | Treatment + Prophylaxis  | Yes       | 0.19 | 0.06 | 3.27    | 0.001    | **       |
| 8   | Random effect            | Wards     |      |      |         |          |          |
| 9   | AIC                      | 1.852.1   |      |      |         |          |          |
| 9   | logLik                   | -912.0    |      |      |         |          |          |

Note: The responses of “No” by interviewees are represented by the intercept.
Abbreviations: EC, estimate coefficient; Family, Poisson; P, Probability value.
* = Significant; ** = High significance, *** = Very high significance.
n = 200 households in each district, n = 10,137 chicken.

Figure 6. The average financial loss due chicken mortality.

Figure 7. The average financial loss (Mean ± S.E, n = 200 in each district) due to management and death of chicken in both study districts Dodoma municipal and Kongwa district.
Table 5. The financial loss in Tanzanian Shillings due to various diseases in the two districts across the four quarters of the study.

| Disease          | Dodoma Municipal in millions | Kongwa district in millions |
|------------------|------------------------------|-----------------------------|
|                  | Q1  | Q2  | Q3  | Q4  |         | Q1  | Q2  | Q3  | Q4  |         |
| Newcastle disease| 3.9 | 11.1| 2.5 | 0.6 | 0.6  | 3.4 | 12.6| 3.1 | 7.56| 7.56  |
| Fowl typhoid     | 0   | 2.2 | 0.3 | 0.4 | 0.4  | 0   | 0.6 | 0.6 | 2.17| 2.17  |
| Fowl pox         | 3.1 | 5.9 | 3.4 | 6.0 | 6.0  | 2.0 | 7.0 | 1.4 | 1.82| 1.82  |
| Infectious basal disease | 0   | 1.7 | 0   | 0   | 0    | 0   | 2.2 | 0.3 | 2.31| 2.31  |
| Coccidiosis      | 1.3 | 0   | 0.6 | 0.3 | 0.3  | 0   | 2.5 | 0   | 1.12| 1.12  |
| Helminthes       | 0   | 1.68| 0   | 0   | 0    | 2.24| 0.28| 2.94| 7.14| 7.14  |
| Ectoparasites    | 1.26| 0.56| 0.56| 0.28| 0.28 | 1.26| 0.56| 0.28| 8.68| 8.68  |

Note: Q1 = Interval between January and March, Q2 = April-June, Q3 = July-September, Q4 = October-December.

n = 200 households in each district, n = 10,137 chicken.

disease might cost up to BDT 2,561 (30.20 USD) per household per year (Khatun et al., 2018). In this study, Fowlpox accounted for 28.6 million Tsh. (12,992.98 USD) per annum ranked second in causing losses in the chicken industry, which does not cause mortality but has a prolonged course and is seldom fatal. These financial losses are linked to mortality the costs involved in chicken management, and poor productivity in terms of growth rate and egg production, treatment and disease, and control. The findings from this study further revealed that Newcastle disease contributes approximately 37.1 million Tsh. (16,854.53 USD) per annum, and rearing costs. In addition, losses from Fowl pox are associated with poor growth, productivity, and mortality resulting from poor feeding (Ganguly and Praveen, 2016). It is anticipated that, the financial loss from chicken would increase or decrease if other factors such as production systems, chicken breed and production objectives are considered.

Fowl typhoid which was more linked to household keeping layers accounted for 4.0 million Tsh. (1,817.2 USD), and losses were also associated with high mortality, decreased productivity (eggs and growth), and costs of medication, which were also reported by Markos and Abdela (2016). Coccidiosis, protozoan diseases accounted for 4.6 million Tsh (2,089.78 USD) losses per annum, losses due to coccidian diseases were also reported likewise, a study in Romania, showed that the financial losses due to coccidiosis may reach up to €37,948.2 were accounted in 24 flocks of with 18,000 chicks with whereby mortality (34.8% mortality) and 65.2% poor feed conversion (65.2%) were the main reason for financial loss (Györke et al., 2016).

Diseases Morbidity and Mortality

Disease morbidity varied across the four quarters of the year, with the third and fourth quarters being the highest. However, compared to the third and fourth quarters, mortality among infected chicks was high in the first and second quarters, with the majority of sick chickens dying. In the third and fourth quarters, morbidity and mortality rates were high and low, respectively. The higher mortality in the first and second quarters can be explained by the first unprepared encounter and various weather conditions during the seasons of the year. In the first and second quarters of the year, it is anticipated that the farmers will not be repapered for vaccination, treatment, and other control measures because most of the livestock keepers are engaged in farming as it is the wet season of the year. Previous findings in this area, have revealed that, awareness, knowledge and appropriate time and means of disease control in this study area are essential (Chota et al., 2021) for diseases to be reported as major challenges apart from others such as predation, theft (Ngongolo et al., 2021).

The first and second quarters were in the wet season in Dodoma and quarters three and four were in the dry season. During the third and fourth seasons, drought and other stressors caused a high rate of infection but the farmers were prepared for the management of the diseases due to their previous experience in quarters 1 and 2. A study in Kenya showed that the prevalence of ecto- and endo-parasites in indigenous chickens was higher during the wet season than during the dry season (Chege et al., 2015). However, seasons alone are not enough to explain the cause differences, but other factors such as poor management, age, host, ecological factors, vectors, Pathogen, and immunity of the host population, breed susceptibility, concurrent disease, and human activities that influence the epidemiology of diseases need to be considered (Awan and James, 1994).

Diseases Causing Death on the Mortality in Chicken to Small Scale Livelihood

High loss of chicken due to diseases was associated with all diseases reported by farmers with pronounced effects observed for Newcastle disease, Fowl Typhoid, and Coccidiosis: these findings are in line with those reported in other studies. The fact that these diseases are extremely contagious may contribute to their high mortality rate. Newcastle disease, for example, is a highly contagious disease that infects birds and is caused by the paramyxovirus, according to studies (Agriculture and Rural Economy Directorate, 2018). Similar findings have been observed in Pakistan where common diseases that threaten broiler chicken production are Newcastle disease, Fowl typhoid, Mycoplasma, Escherichia coli infection, and Coccidiosis (Abbas et al., 2015). The find also agrees with the study done in Arusha Tanzania where they found Coccidiosis was the main cause of chicken mortality (Swai et al., 2013). However, these findings are in contrast with those of a study by Shepelo and Maingi (2014) in Kenya which...
showed that the most lethal diseases in chickens were Gumboro disease, coccidiosis, and egg peritonitis. This difference can be explained by the differences in geographical location, management practices, and breed of chickens kept by farmers. In our study, local chickens, broilers, and layers under either free-range or intensive systems were considered whereas in the study from Kenya only layers and broilers under the intensive system were considered (Shepelo and Maingi, 2014).

### Influence of Age, Sex, and Control Intervention

Age, sex, and the farmers’ control intervention all had a substantial impact on the disease-related mortality of chickens. A negative effect of chicken mortality due to diseases was observed for cocks, hens, and chicks while control interventions such as treatment and use of prophylaxes lowered the effect of mortality due to diseases in chickens. Other studies have found related trends to these findings. For instance, a study by Kalant et al. (1991) revealed that the susceptibility of chickens to Clinostomum complanatum was associated with age, sex, and breed while sex, age, and herd size were observed to be risk factors for trypanosome infection in Maasai Steppe cattle in Tanzania (Ngongolo et al., 2019). Control interventions such as treatment and prophylaxis against chicken diseases helped lower the mortality rate of chickens. For instance, studies on the efficacy of thymol have reduced the negative effect of Eimeria infection in pigeons which can lead to death (Arafa et al., 2020). The combination of 2 or more approaches during chicken disease control reduces the adverse effects of diseases in chickens. The combination can involve the use of prophylaxis and treatment of sick birds, vaccination and treatment, or the use of different drugs as recommended by specialists. The use of various drugs by farmers in Dodoma has been reported in other studies, which revealed that Oxytetracycline, enrofloxacin, and tylosin (Chota et al., 2021). This is in agreement with other findings regarding the importance of different approaches for controlling chicken diseases Seuna et al. (1980). reported that joint treatment with oxytetracycline, neomycin, and bacterial culture yielded higher efficacy in controlling salmonella infection.

### Financial Loss Due to Chicken Diseases

The financial losses due to chickens’ diseases were clearly associated with the mortality rate of chickens caused by particular diseases. Generally, Kongwa had a higher financial loss compared to Dodoma Municipal due to the high mortality observed in this area. The higher mortality in Kongwa was due to the majority of farmers who kept local chickens with less concentration in the management compared to those in urban (Dodoma) who kept more layers and broilers with serious management in terms of vaccination and treatment. In addition, much loss was associated with diseases that cause high mortality such as Newcastle disease (Tsh. 37,114,000/=million), and Fowl typhoid (Tsh. 28,630,000/=million). This is in agreement with the study conducted in Bangladesh which revealed that Newcastle disease may cause mortality of up to 100% due to its nature of being a highly contagious viral disease (Khatun et al., 2018). Similarly, in Central Java in Indonesia, it was estimated that, the financial loss due to Coccidiosis was Rp 3,371,549,813,512 which is equivalent to 229, 837,798.56 USD (Pawestri et al., 2019).

### CONCLUSIONS AND APPLICATIONS

Diseases such as Newcastle disease, coccidiosis lower the chicken’s production through mortality. Cock, hen and chick were the most affected groups because of disease-related mortality caused by diseases. Farmers who used treatment, prophylaxis and vaccination as disease control strategies, experienced lower chicken mortality rates than those who did not. Diseases cause significant financial losses to farmers who keep chickens in Dodoma Tanzania due to mortality. In addition, the season of the year was observed to have a significant impact on the financial losses caused by chicken diseases to small-scale livestock keepers in Dodoma. Four quarters (Q1, Q2, Q3, and Q4) indicated different seasons of the year in this study. However, when considering the mortality of chickens, other factors such as drowning, poor management, and predation should also be considered as factors for chicken mortality. Chicken keepers and other stakeholders involved in chicken production should observe the season, and categories of diseases when planning control interventions. Proper control intervention through treatment, prophylaxis, and vaccination for chicken diseases will minimize the financial losses caused by chicken diseases in the flocks of small scale farmers. We also recommend that, more studies should focus on the different age groups, management system, objective of chicken keeping, breed of chicken, season, production system to understand how many dies in each category and the financial value lost at that age to be included in the analysis.

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Authors’ contributions: KN organized the research project and managed to make the first draft of the manuscript while AC did the editing and organized the data analyses. Both KN and AC took the intensive responsibility in writing the manuscript, organizes the results part and made the interpretation of the findings.

Informed consent was obtained from all participants included in the study.

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DISCLOSURES

The authors declare that they have no conflict of interest.

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