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Research article

The impact of management practices on the disease and mortality rates of broilers and layers kept by small-scale farmers in Dodoma urban district, Tanzania

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ABSTRACT

The demand for chicken products in Tanzania has increased due to population growth and rising incomes. As a result, the production of broilers and layers has been promoted to fill the gap due to their high productivity. However, exotic breeds of chicken are susceptible to diseases, thus requiring good disease management practices. The current study aimed to increase production of exotic breeds of chicken in the Dodoma region, which is growing rapidly, by identifying management factors associated with disease and chicken mortality. One hundred and four households that keep broilers or layers were selected randomly from the Dodoma urban district. The households were interviewed to gather information about chicken diseases, mortality, and management practices. The proportion of sick and dead chickens per farm was determined and used in beta regression to test its association with management practices and chicken breed. The proportion of sick chickens in a flock was low when stocking density was low and in large households, but it was higher when the farmer lacked knowledge of disease management. Further, mortality rates were high when farmers lacked disease knowledge and cleaning frequency was low, and low when farmers had extensive experience in chicken production. Improvement of extension services and education programmes for poultry farmers on good disease management practices is necessary to increase the production of layers and broilers in the region.

1. Introduction

The world population is currently estimated to be 7.2 billion, with a projected increase to 9.8 billion by 2050, and over 70 % of people are expected to live in cities [1,2]. This trend will inevitably lead to an increased demand for food, especially animal-derived products [3]. The poultry industry, with its efficient growth and flexibility, has the capacity to meet this rising demand for animal protein [1]. In many regions across the globe, the poultry industry is expanding and transitioning towards more industrialised methods [4]. Chickens, owing to their social, cultural, nutritional, and economic significance, are the most common poultry species worldwide [3,5], with the current global population estimated at 18 billion [6]. Africa, home to around 1.3 billion chickens, has witnessed rapid growth in the chicken meat market [7].

Tanzania is estimated to have 83.28 million chickens, comprising 38.77 million indigenous and 44.51 million exotic breeds (layers

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and broilers) [8]. The poultry industry in Tanzania is experiencing rapid growth in both indigenous and exotic chicken breeds [9]. Nevertheless, the demand for chicken products currently exceeds domestic production capacity [10]. Local chicken breeds are preffered by consumers over exotic breeds due to their superior taste [11,12]. However, their inherent low production potential hinders them from meeting the demand for chicken meat and eggs, especially in urban areas [13]. To address this, the government has implemented measures such as genetic improvement programmes for local chickens and the introduction of improved breeds [14–16]. Additionally, commercial production of layers and broilers has increased, particularly in urban areas [10,17]. Despite the high demand for chicken products in the country, the potential for increased chicken production remains largely untapped due to various constraints [10].

Diseases represent one of the primary constraints on expanding chicken production in Tanzania [10,17,18]. Among the most serious infectious diseases affecting chickens are viral and bacterial infections [19]. In Tanzania, some of the most devastating diseases leading to chicken mortality include Newcastle disease, coccidiosis, fowl typhoid, infectious bursal disease (IBD), and chicken pox [19–21]. Newcastle disease stands out as particularly severe, capable of wiping out entire village populations [20,22]. While commercial chickens are routinely vaccinated against this disease, it remains prevalent among village chickens [23,24]. Common diseases observed in layers and broilers include coccidiosis, fowl typhoid, and colibacillosis [20,25,26]. Given that exotic breeds generally have lower disease resistance compared to indigenous species, effective disease management practices are critical [27,28]. According to a study by Wilson et al. [10], disease prevalence is notably high in intensive systems of chicken production, emphasising the importance of implementing proper management alongside intensification efforts.

Diseases in chickens can stem from various factors, including nutrition, hygienic conditions, stocking density, and disease management practices [29,30]. Proper nutrition is vital for the proper development of the immune system, thereby enhancing disease resistance [30,31]. Layers and broilers are intensively managed in battery cages or litter systems, necessitating strict adherence to sanitary conditions and proper stocking densities [32,33]. Unclean equipment and housing facilitate the introduction and proliferation of pathogens [33]. Continuous vaccination is an effective measure for disease control [34]. However, many small-scale chicken farmers struggle to vaccinate their flocks or maintain a complete vaccination schedule, often due to financial constraints [35,36].

High stocking density increases the likelihood of disease spreading from one bird to another through contact. Additionally, high stocking densities reduce food intake, rendering the birds more susceptible to diseases [37]. Stocking density is determined based on the body weight of the birds, with the optimum stocking density for broilers being 33–39 kg m^{-2} or 17 birds m^{-2} [37,38]. Conversely, the optimum stocking density for layers is 9 birds m^{-2} [39,40]. Farmers' knowledge and experience play crucial roles in management practices that directly and indirectly impact chicken health in both direct and indirect ways [20,41,42].

Chicken production holds significant economic importance in arid and semi-arid areas due to its minimal space requirement and potential for enhancing environmental sustainability [43]. This study was conducted in Dodoma, a semi-arid region in Tanzania, where previous extensive research has been carried out on chicken diseases and mortality [17,19,44]. However, limited information exists on the impact of management practices such as sanitation, feeding, vaccination, stocking density, and housing systems, all crucial factors in the intensive production of layers and broilers. Moreover, farmers' knowledge and the adoption of extensive chicken production systems are vital elements in developing countries' poultry industry [7,10]. This study aimed to determine the influence of these management practices on disease prevalence and mortality rates among broiler and layer chickens in semi-arid areas. The findings are expected to inform the formulation of interventions aimed at boosting chicken productivity through disease and mortality reduction. It is anticipated that disease incidences and mortality will decline with increased cleaning frequency, vaccination, improved feed quality and quantity, enhanced farmer knowledge on chicken diseases, and optimal stocking density.

2. Materials and methods

2.1. Study area

The Dodoma region, characterised as semi-arid,experiences erratic and seasonal rains occurring between November and April, with a total annual rainfall ranging from 500 mm to 800 mm and exhibiting significant variation across areas, seasons, and years [45]. The hottest months record average temperatures of 31 °C, while the coldest months average around 18 °C [46]. The primary economic activities of the local people involve crop production and livestock keeping [47,48]. Among the livestock kept in rural areas, local breeds of chickens play a prominent role, serving as a vital source of meat and eggs in urban areas [17]. The region has witnessed rapid growth, particularly following the relocation of the government headquarters from Dar es Salaam to Dodoma, consequently driving up the demand for chicken meat and eggs [49]. According to the 2022 national census, the human population in the region has increased from 2,083,588 in 2012 to 3,085,625 in 2022 [50].

The Dodoma region was selected as a study area due to its status as one of the most arid regions in Tanzania, coupled with a significant population of chicken farmers. The region's rapid growth has outpaced the capacity of local chickens to meet the current demand for eggs and chicken meat [17,51,52]. However, successful production of the exotic breeds of chicken will depend on the good management of the chickens. This entails identifying and addressing existing challenges that hinder chicken productivity. In addition, numerous previous studies on chicken diseases in the region [19,20,44] provide necessary information for choosing appropriate methods.

2.2. Data collection

A cross-sectional study was conducted to gather information about chicken diseases, mortality, and management practices between

March and May 2021. Four wards, namely Kikuyu South, Kikuyu North, Chang'ombe, and Nzuguni, were randomly selected from the Dodoma Urban District. Dodoma urban district is the most urbanised district in the region, where the production of exotic breeds of chicken is high. The other districts in the region primarily keep local breeds of chicken. The study population comprised layer and broiler farmers in the selected area, aiming to identify farm-level risk factors for chicken diseases and mortality. With the assistance of district livestock officers, the total number of farmers was established to be 142. The sample size of the farmers was determined using the formula developed by Yamane [53], given as: $n = \frac{N}{1+N(e^2)}$ where n = represents sample size, N = study population, and e = sampling error (5 %). Thus, a total of 104 farmers were randomly selected from the study wards, with the sample size distributed among the wards based on the number of layer and broiler farmers. Specifically, 31 farmers were selected from Chang'ombe ward, 27 from Kikuyu North, 25 from Kikuyu South, and 21 from Nzuguni.

The selected farmers were visited, and a semi-structured questionnaire was used to collect information on the social-demographic characteristics of the households, chicken management practices, common chicken diseases experienced, and their knowledge of chicken disease management. Additionally, farmers were asked to provide details about the number of chickens that had died during the previous production cycle for broilers and within the last 4 months prior to the interview for layers, in order to link this data with the farm's management practices. Since the majority of the farmers didn't keep records, they were requested to record the number of sick and dead chickens, and weekly visits were made during the study period for data collection. The survey adhered to strict confidentiality guidelines and required participants to provide informed consent. The study did not involve clinical studies or animal experiments. Ethical approval for the study was obtained from the University of Dodoma with reference number MA.84/261/02.

2.3. Data analysis

The data was coded in Excel for viewing and cleaning, and descriptive statistics were employed to summarise the characteristics of the household. The proportion of sick chickens per farm was calculated as the ratio of the number of sick chickens to the initial flock size, while the proportion of dead chickens was determined as the ratio of the number of dead chickens to the initial flock size. These proportions served as response variables to assess their relationship with management practices and chicken breeds. Histograms were used to visualise the distribution of the response variables. The values of the response variables (proportion of sick and dead chickens per farm) lied between 0 and 1, as all the farms experienced both dead and sick chickens. Consequentially, beta regression analysis was employed, as it is suitable for response variables that present percentages or proportions within the open interval (0, 1) [54].

In both cases, a full beta regression model was fitted, incorporating chicken breed, stocking density, farmer's disease management knowledge, frequency of cleaning the chicken house, amount of feed given to the chickens per day, farmer's chicken production experience (years), and household size as independent variables. Stocking density was determined as the ratio of the number of chickens to the area of the chicken house. Q-Q plots were used to assess whether the residuals of the model follow a beta distribution. In addition, the goodness of fit test of the models was performed using the Kolmogorov-Smirnov test. The p-values from the test were found to be greater than 0.05, indicating that the distribution of the residuals matched the beta distribution.

Furthermore, the multicollinearity of the independent variables was evaluated by using a variance inflation factor (VIF). No significant collinearity was observed between the independent variables (VIF <4) [55]. The analyses were done using R version 4.2.0.

Table 1
General information of the households surveyed.

Variable	Parameter	Frequency	Proportions	Lower CI	Upper CI
Sex of the respondent	Males	28	27	0.16	0.33
	Females	76	73	0.68	0.85
Age of the respondent	20–29	31	30	0.21	0.42
	30–39	33	32	0.23	0.44
	40–49	21	20	0.11	0.31
	Above 49	19	18	0.10	0.29
Education level of the respondent	Illiterate	13	13	0.02	0.22
	Primary	57	55	0.50	0.69
	Secondary	17	16	0.10	0.26
	College	17	16	0.10	0.26
Chicken breeds kept	Broilers	58	56	0.47	0.67
	Layers	46	44	0.34	0.54
Household size	2–4	48	46	0.42	0.63
	5–7	43	41	0.32	0.52
	Above 7	13	13	0.03	1.19
Source of heat for chicks	Charcoal	60	58	0.49	0.69
	Electricity	44	42	0.32	0.52
Who take care of the chickens?	The family	81	78	0.71	0.90
	An employee	23	22	0.18	0.35
House system	Cage	22	21	0.14	0.31
	Floor	82	79	0.73	0.90

3. Results

3.1. General information of the households surveyed

The majority of the respondents (76 %) were female. About 30 % of the respondents were aged between 21 and 29 years, 32.6 % were aged between 30 and 39 years, 19.6 % were aged between 30 and 39 years, and 17.4 % were aged above 39 years. Eleven percent of the respondents were illiterate; 58.7 % had primary education, 15.2 % had secondary education, and 15.1 % had a college education. About 57 % of the farmers kept broilers, while 43 % kept layers. More details are shown in Table 1. The average flock size of broiler chickens per farm was 265 ± 144 SD, with a range of 85–600 chickens per farm. On the other hand, the flock size of layer chickens ranged from 60 to 600 chickens per farm, with a mean of 232 ± 127 SD. The main diseases identified by the farmers were coccidiosis, Newcastle disease, IBD, fowl typhoid, chicken pox, and colibacillosis. Twenty farmers stated that they treat sick chickens with homemade remedies. The remedies included aloe vera leaves (6 farmers), chill pepper (4), *Moringa oleifera* leaves (4), neem plant leaves (4), and sisal roots (2).

3.2. The relationships between management practices and chicken disease occurrence

All farmers vaccinated their chickens and used commercial feeds; thus, these variables were not included in the analyses. Table 2 demonstrates the relationships between the proportion of sick chickens on the farms and various predictor variables. The percentage of sick chickens was lower on farms where the stocking density was low (7.2 %) compared to high densities (13.7 %) (Fig. 1a) and where the farmers had a high knowledge of chicken disease management (3.4 %) compared to those who lacked disease management skills (12.7 %) (Fig. 1b). Additionally, the percentage of sick chickens in broiler production was high in farms that used cage systems, while the percentage of sick chickens in layer production was high in farms that used deep litter systems (Fig. 2). Furthermore, the percentage of sick chickens decreased with household size (Table 2).

3.3. The relationships between management practices and chicken mortality

Chicken mortality was associated with some of the farm management practices and chicken breeds (Table 3). The percentage of dead chickens was high in broiler chickens (7 %) compared to layers (3.5 %) (Fig. 3a), where farmers lacked knowledge of chicken diseases (9.5 %) compared to those who had knowledge of chicken diseases (3.3 %) (Fig. 3b), and where the chicken houses were cleaned only once per month (8.8 %) compared to where they were cleaned every week (4.1 %) (Fig. 3c). The mortality of broilers was higher where the cage system was used than in the litter system, but it did not differ between the two housing systems for layers (Fig. 4). Furthermore, chicken mortality decreased with household size (Table 3).

4. Discussion

The study determined the frequency of diseases and mortality of broiler and layer chickens and their relationship with management practices in the Dodoma Urban District. Poor management practices play a role in the introduction, growth, and transmission of pathogens in chicken flocks. As a result, we expected to see differences in disease prevalence and mortality among farmers due to

Table 2
A beta regression model predicting the proportion of sick chickens from a set of predictor variables.

Response variable	Predictors	Levels	Estimate	95 % CI of the estimate	Std. error	z-value	p-value
% of sick chickens	Intercept		−4.638	−5.71, −3.56	0.681	1.756	0.008
	Breed	Broilers	0				
		Layers	−0.588	−1.35, 0.18	0.543	−1.504	0.136
	Housing system	Cage	0				
		Litter	−1.047	−1.66, −0.43	0.448	−1.997	0.049
	Stocking density	High	0				
		Medium	0.05	−0.30, 0.39	0.254	0.738	0.462
		Low	−0.615	−1.02, −0.20	0.250	−2.043	0.044
	Disease knowledge	High	0				
		Low	1.527	0.82, 2.23	0.374	4.261	0.001
		None	1.251	0.42, 2.07	0.462	2.847	0.005
	Cleaning frequency	Once month^{-1}	0				
		Twice month^{-1}	−0.567	−0.98, −0.03	0.315	−0.847	0.399
		Once week^{-1}	−0.32	−0.70, 0.05	0.265	0.046	0.963
	Source of heat	Charcoal	0				
		Electricity	0.177	0.03, 3.62	0.020	0.868	0.387
	Feed amount (g)		0.002	−0.001, 0.004	0.001	0.764	0.171
	Experience (yrs.)		−0.081	−0.05, 0.21	0.089	−0.022	0.982
	Household size (individuals)		−0.144	−0.24, −0.04	0.066	−1.925	0.037
	Housing system* breed	Broilers * cage	0				
		Layers * litter	1.441	0.60, 2.27	0.583	2.753	0.007

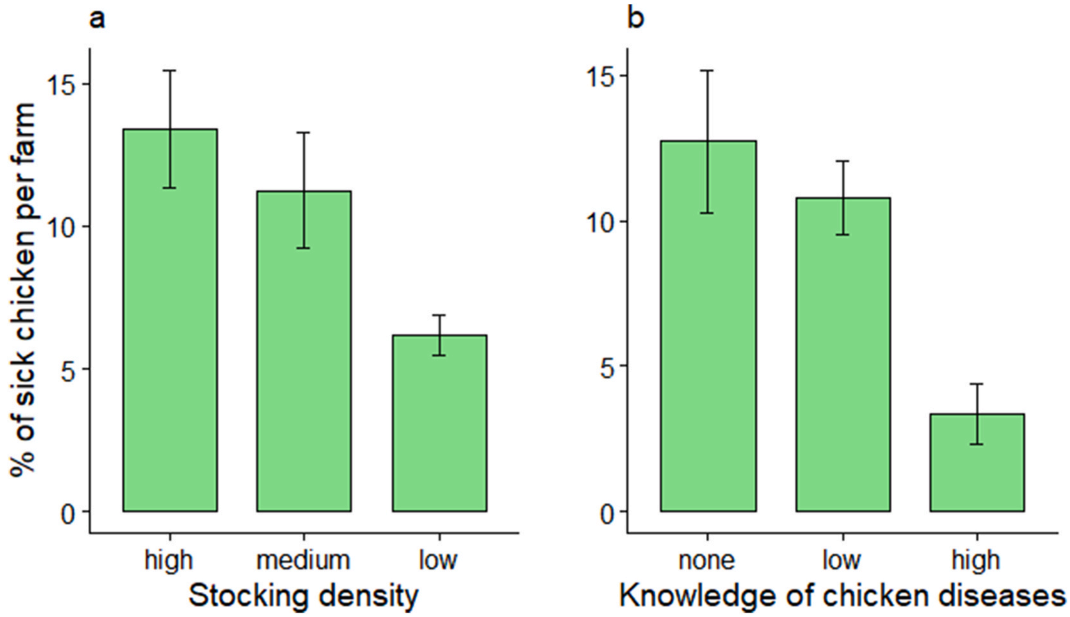

Fig. 1. Percentage of sick chickens in relation to (a) stocking density and (b) the farmer's knowledge of chicken diseases. Error bars indicate the standard deviation of the mean.

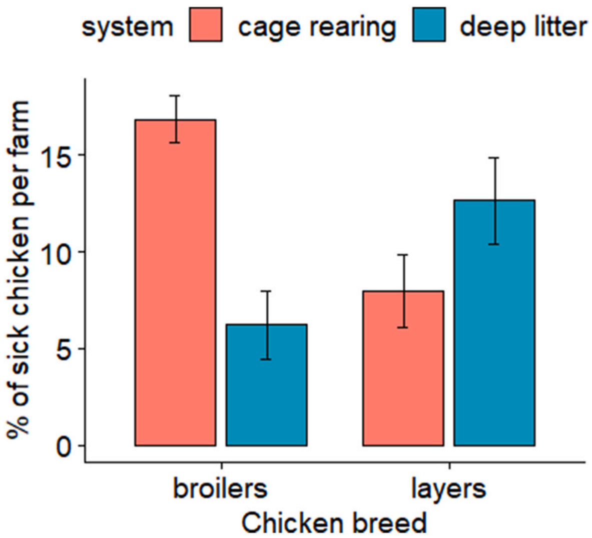

Fig. 2. The interaction effect between chicken breed and house system on the percentage of sick chickens per household. The percentage of sick chicken was higher in the cage system in broilers (a), while in layers it was higher in the deep litter system (b).

differences in management practices. According to the findings, the percentage of sick chickens in a flock was low in farms with low stocking density and in large households, but it was higher when the farmer lacked knowledge of disease management. Furthermore, mortality rates were high when farmers lacked disease management knowledge and the cleaning frequency of the chicken house was low, and low when farmers had extensive experience in chicken production and a large household.

Chicken production in developing countries is affected by a lack of knowledge in poultry management among farmers [56,57]. Since poultry production is predominantly managed by small-scale farmers, knowledge regarding poultry disease management, nutrition, and housing is crucial to improving production [58]. A study by Msoffe et al. [59] revealed that the main type of information needed by farmers in Tanzania was on chicken disease management, highlighting the importance of extension services for poultry farmers. Extension services serve as a significant source of knowledge for farmers in developing countries. However, in Tanzania, extension workers are scarce compared to farmers, leading to limited access to extension services [60]. Consequently, most farmers rely on information from family, friends, neighbours, and experience [59], leading to inadequate knowledge and increased chicken

Table 3
A beta regression model predicting chicken mortality from a set of predictor variables.

Response variable	Predictors	Levels	Estimate	95 % CI of the estimate	Std. error	z-value	p-value
% of dead chickens	Intercept		10.237	3.64, 16.83	3.312	3.090	0.002
	Breed	Broilers	0				
		Layers	−10.010	−15.46, −4.55	2.740	−3.652	<0.001
	Housing	Cage	0				
		Litter	−7.597	−12.11, −3.09	2.265	−3.354	0.001
	Stocking density	High	0				
		Medium	1.709	−0.75, 4.17	1.223	−0.454	0.650
		Low	−0.556	−2.99, 1.88	1.237	1.382	0.170
	Source of heat	Charcoal	0				
		Electricity	0.367	−1.62, 2.35	0.996	0.369	0.712
	Knowledge of diseases	High	0				
		Low	6.136	2.51, 9.76	1.822	3.367	0.001
		None	8.315	3.79, 12.84	2.271	3.661	<0.001
	Cleaning frequency	Once month^{-1}	0				
		Twice month^{-1}	−6.757	−9.84, −3.67	1.251	−2.737	0.007
		Once week^{-1}	−3.42	−5.91, −0.93	1.549	−4.361	0.002
	Feed amount (g)		0.004	−0.01, 0.01	0.002	0.298	0.507
	Experience (yrs.)		−1.117	−2.26, 1.97	0.427	−2.617	0.010
	Household size (individuals)		−0.728	−1.38, −0.08	0.326	−2.231	0.028
	Breed* housing system	Broiler*cage	0				
		Layers*litter	7.844	2.07, 13.61	2.898	2.707	0.008

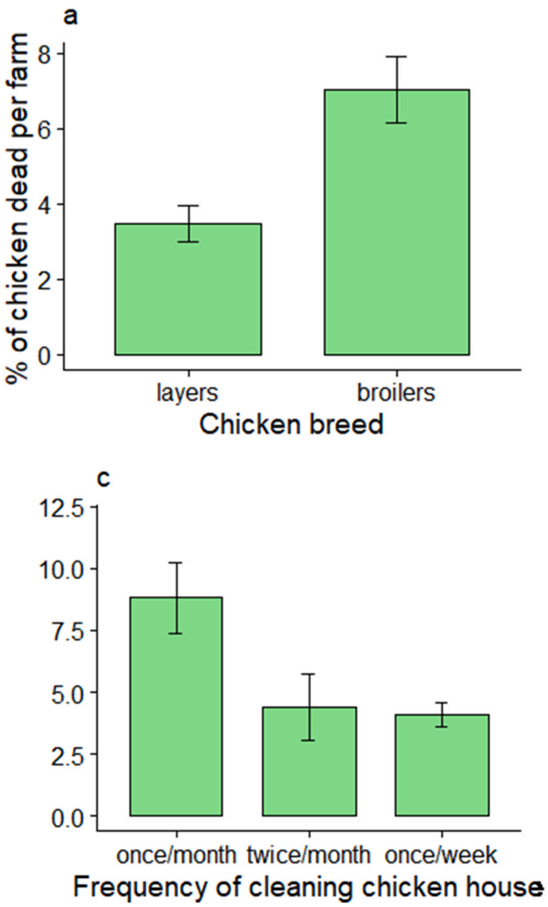

Fig. 3. Percentage of dead chickens in relation to (a) chicken breed (b) the farmer's knowledge of chicken diseases management and (c) the frequency of cleaning the chicken houses.

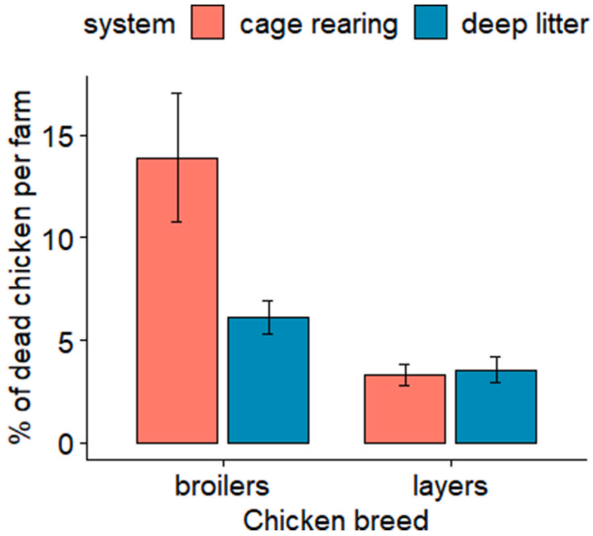

Fig. 4. The interaction effect between chicken breed and house system on the percentage of dead chickens per household. The percentage of dead chickens was higher in the cage system in broilers (a), while in layers it was higher in the litter system (b).

disease and mortality. With the advancements in information and communication technologies, tools such as computers, internet services, and cell phones are now commonly used for disseminating poultry farming information [58,61].

Stocking density is defined as the number of birds or the total live weight of birds (kg) per square metre [38]. Stocking density is a crucial management aspect in chicken production because it impacts growth, disease outbreaks, and mortality [62]. High stocking density raises nitrogen and moisture levels in the litter, promoting microbial growth [63]. In addition, high stocking density facilitates the transmission of pathogens from one chicken to another [62]. High stocking density has been associated with increased cases of coccidiosis [32,64], *Salmonella* infections [65], and airborne pathogens. Moreover, high stocking density reduces feed intake, induces stress, and compromises the immunity of the birds, making them more susceptible to pathogens [66]. Sanitation and stocking density are closely related. A high stocking density should be accompanied by frequent cleaning and changing of the litter. In Tanzania, small-scale chicken production is characterised by poor housing and sanitation conditions, which increase disease incidence and mortality [67,68].

The frequency of diseases didn't differ between the breeds, but mortality was higher in broilers than in layers. However, the frequency of disease and mortality rate of the breeds depended on the housing system. The housing systems used by the chicken farmers were the cage system and the litter system. While the disease incidences were higher in the cage system for broilers, they were higher in the litter system for layers. Additionally, the mortality of broilers was higher in the cage system, while it didn't differ between the housing systems for layers. Litter floor systems are common for raising broilers, but cage confinement is becoming more common [69]. The cage system separates the droppings from the chicken, thus reducing diseases that are transmitted through faeces. However, confining the birds in cages reduces movement, increases gait problems, and causes stress, all of which lower immunity and increase the susceptibility of the birds to diseases [69,70]. On the other hand, litter-based housing systems have greater rates of bacterial infections, viral illnesses, and coccidiosis than cage-based housing systems [71–73]. Moist litter promotes coccidia oocyst sporulation and the growth of bacteria [74]. Because layers are kept for a longer period of time, they can be infected with pathogens in the litter for a longer period of time.

Chicken diseases and mortality decreased with an increase in household size. The average family size was 5 ± 1.6 people. The majority of small-scale chicken producers in Tanzania depend on family labour [52,75]. In this study, 77.9 % of the chicken producers depended on family labour. Thus, large families increase the workforce for different management practices such as feeding, cleaning, and disease management. Jackson [52] demonstrated the impact of family size on small-scale chicken production in Dodoma. The main challenges for chicken production in the region, according to the author, are feed costs and diseases, and the level of profit increased with family size, indicating good management practices. Furthermore, chicken mortality decreased with the farmer's experience in chicken production (years). More years of experience in chicken production enable the farmers to gain knowledge of different management practices that result in good health and high productivity [76,77]. Over time, they face different challenges and learn how to solve them by sharing with other farmers. Martindah and Ilham [78] demonstrated that the incidence of the diseases decreased with the farmer's experience in chicken production. Farmer experience is important, especially when extension services are limited [79]. The average experience of the farmers in this study, however, was 2.6 ± 1.2 years, indicating that the majority of the farmers in this study were new to the industry.

The study is important in formulating interventions for improving chicken productivity in Tanzania. Farmers' education on proper management practices is crucial to reducing disease and mortality in chickens. This should include maintaining hygienic conditions to create a conducive environment for chicken health and proper feeding to boost chicken immunity. Additionally, farmers should be encouraged to maintain accurate records of their flock in order to identify trends in diseases, make informed decisions, and improve overall productivity. Improvement of the extension service is necessary to increase production of layers and broilers in the Dodoma region to meet the demand for meat and eggs. The study was conducted from March to May 2023, which was a rainy season. Since the occurrence of chicken diseases may vary between months of the year due to different weather patterns [80], we recommend further study that will consider seasonal patterns of diseases.

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Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Rosemary Peter Mramba: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Pascal Aden Mwantambo:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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