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# Awareness and perceptions of poultry keepers about the prevalence of Fowl typhoid in chickens kept in Dodoma, Tanzania

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## Abstract

Chicken production in Tanzania provides opportunity to local communities in terms of employment, increased income, food security, and manure for cropping. However, diseases like fowl typhoid remain a challenge to livestock keepers. This study was aimed at understanding the attitude and awareness of Poultry keepers about the prevalence of fowl typhoid in chickens kept in Dodoma. A cross-sectional survey using semi-structured interviews was employed to understand farmers' perception of the prevalence of fowl typhoid and associated risk factors amongst poultry farmers in three wards in Dodoma, namely, Nkuhungu, Msalato, and Mnadani. The overall prevalence of fowl typhoid among farmers was 22.30%, with significant differences being noticed in the first quarter (January–March) and the third quarter (July–September) ( $P < 0.05$ ). Factors such as age and sex, flock size, and management practices influence the prevalence of fowl typhoid significantly ( $P < 0.05$ ). Furthermore, the farmers had challenges accessing the veterinary services due to their unawareness, the availability of the service, and their distance from the service. The control strategies for fowl typhoid should consider the influencing factors while improving the accessibility and availability of veterinary services to farmers.

**Keywords** Chicken diseases, Fowl typhoid threat to chicken, Treatment and management of diseases

## Introduction

Fowl typhoid, also known as avian typhoid or *Salmonella gallinarum* infection, is a bacterial disease caused by the bacterium *Salmonella gallinarum* that affects chickens and other poultry. The disease is transmitted through contaminated feed, water, or direct contact with infected birds, and it is transmitted vertically from infected hens to their chicks through the eggshell or during hatching [1]. The infected chicken tends to show a range of symptoms, including weakness, depression, loss of appetite, weight loss, diarrhea (sometimes bloody),

increased thirst, and reduced egg production. Mortality rates can vary but may be significant in severe cases [2]. Due to mortality, low productivity in chickens, the cost of controlling the diseases, trade restrictions, and the safety of chicken products, the diseases can cause significant socio-economic losses to farmers. For instance, it has been previously reported that chicken farmers in Dodoma incur financial loss due to poultry diseases [3]. A previous study conducted in Dodoma revealed a total financial loss of approximately Tsh. 119.9 million (52,146.96 USD) incurred by 400 farmers per year [4]. However, there was need to understand farmers' perceptions of the burden imposed on them by different diseases in their flocks, and particularly fowl typhoid, which is known to be common in Dodoma and other areas in Tanzania.

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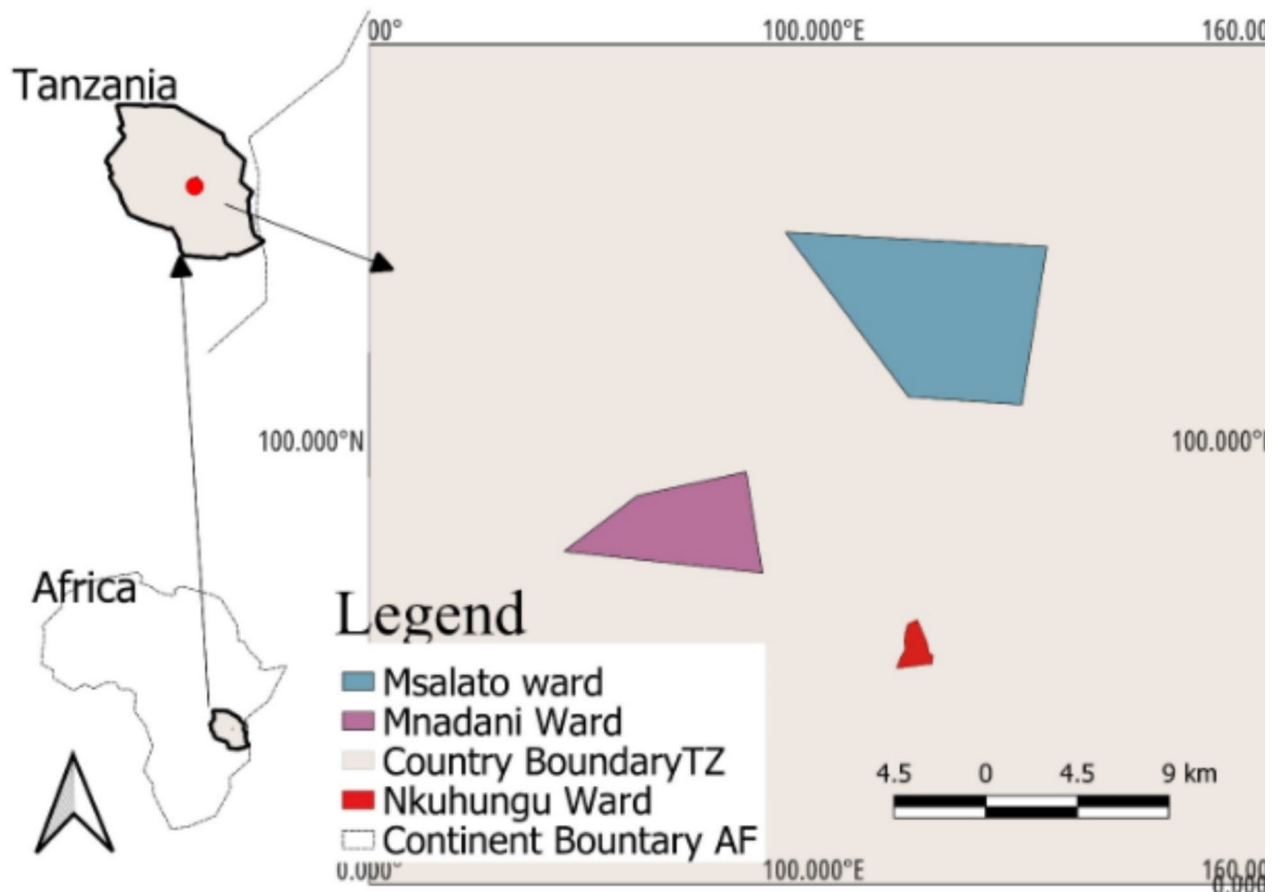
The prevalence of fowl typhoid is reported to be influenced by different risk factors. For instance, a study in Zaria-Kaduna State, Nigeria, showed that the prevalence of fowl typhoid was influenced by species of poultry and season, with the highest number of outbreaks being reported in the rainy season (July–September) [5]. The prevalence of fowl typhoid in Eastern Ethiopia was influenced by the poultry production system, with backyard production system exhibiting a higher prevalence of fowl typhoid as compared to the intensive production system [6]. Regardless of the prevalence and the associated risk factors reported in other studies, little is known about the perception of smallholder Poultry farmers in Tanzania, particularly in Dodoma, on the prevalence of fowl typhoid and the association risk factors.

This study, therefore, focused on understanding the perception and awareness of Poultry farmers in Dodoma about the prevalence of fowl typhoid and associated risk factors. Specifically, factors such as age group, flock size, seasons, management system, and treatment intervention were evaluated for their association with the risk of occurrence of fowl typhoid.

## Materials and methods

### Study area

The study took place in Dodoma from December 2022 to May 2023 in three wards, namely, Nkuhungu, Msalato, and Mnadani (Fig. 1). The Dodoma region is located in central Tanzania, South of the equator, between Latitudes 6°57' and 3°82', and longitudinally, the region is situated between 36°26' and 35°26' East of Greenwich. Dodoma features a semi-arid climate with warm to hot temperatures throughout the year. While average highs are somewhat consistent throughout the year, average lows dip to 13 °C (55.4 °F) in July. Dodoma secures an average of 556 mm (21.9) of rainfall per year. The driest months are June, July, August, and September. Reddish clayey soils occur on the foot slopes of basic metamorphic hills of the Dodoma formation, while reddish loamy soils occur on the foot slopes of granitic hills. Wherever granite has been contaminated by basic inclusions of the Dodoma Formation, more reddish and clayey soils may be present. The communities in the area practice poultry keeping as a means of livelihood. Other activities apart from livestock keeping include crop production and business,



**Fig. 1** Map of the study area showing Mnadani, Msalato, and Nkuhungu Wards (Created by Kelvin Ngongolo using QGIS 3.28, 2024)

of which the agricultural industry continues to dominate the economy of the Dodoma region. It is noteworthy that there is subsistence farming as well as commercial farming. For instance, the 2012 census revealed that a total of 376,924 (84%) out of 450,305 private households in the area were involved in agriculture. According to a survey by Mgomezulu (2024) [7], 33.1% of Tanzania's 1,423 crop-farming households—471 out of them—were commercial farmers.

### Study design

A cross-sectional research design was employed in this study, and data from selected farmers in the study area was collected through a cross-sectional survey. Sampling of respondents was done randomly from the people who were known to be keeping chickens in the study area. The list of Poultry keepers in the study areas was identified with the help of local government leaders. The sampling frame was prepared by listing all the farmers identified in each ward. In the sampling frame, simple random selection using the random function in Excel was used to select the respondents.

### Data collection

Data collection involved using a semi-structured questionnaire administered to selected respondents. The questionnaire aimed to assess the extent of fowl typhoid within farmers' flocks. It required farmers to specify the number of chickens suspected to be affected in each quarter of 2022, with the study divided into four periods: January–March, April–June, July–September, and October–December (Supplementary 1: Questionnaire). Analyzing these distinct quarters enabled a thorough understanding of the seasonal impact on fowl typhoid prevalence in chickens. This quarterly breakdown allowed for precise evaluation, helping researchers comprehend the disease's fluctuation throughout the year, potentially revealing patterns related to specific seasons and aiding in the formulation of targeted interventions and preventive measures. Farmers identified the disease through common symptoms such as decreased egg production, lethargy, loss of appetite, weight loss, ruffled feathers, diarrhea, swollen abdomen, respiratory distress, increased thirst, and high mortality, particularly in poorly managed flocks. To confirm these symptoms, an animal health specialist conducted a detailed examination. Additionally, postmortem examination was performed, and samples from suspected chickens were submitted to Tanzania Veterinary Laboratory Agency (TVLA) for confirmatory tests. In the laboratory, bacterial culturing was to identify pathogenic bacteria was conducted in the laboratory after the postmortem session. This thorough process ensured accurate identification of fowl typhoid cases,

enabling precise understanding and management of the disease's impact on poultry in the studied region.

### Associated risk factors to fowl typhoid

Risk factors influencing the prevalence of fowl typhoid were identified and recorded during data collection. Data was collected on the following; Number of chickens affected in the year 2022; sex; age group; flock size; management system (Free range, semi-intensive, and intensive system); and breed of chicken (Local, layer, and broiler).

### Statistical data analysis

Shapiro Wilk W was used to test for normality of the data. The Shapiro-Wilk W value was 0.81 with a p-value of less than 0.00001, indicating that the data was parametric ( $P < 0.05$ ). In this case, the parametric statistic test was used to evaluate the variation in prevalence among age groups, sexes, management systems, seasons, and breeds of chicken. To understand the influence of these risk factors on the prevalence of fowl typhoid in chickens, a generalized linear model was used, where the significant level was considered to be 0.05.

## Results

### Demographics structure respondents

Out of the 300 farmers interviewed, 51% ( $n=153$ ) were female, while 49% ( $n=147$ ) were male. Also, 38% ( $n=114$ ) of respondents in this study were aged between 20 and 40 years, and 62% ( $n=186$ ) were above the age of 40 years. 28% ( $n=84$ ) were from Mdadani, 45% ( $n=135$ ) from Msalato, and 26% ( $n=78$ ) from Nkuhungu.

Considering women, who are the majority and most important group in society, the result revealed that 31.37% ( $n=26$ ) of women farmers were interviewed in Mdadani, 43.14% ( $n=58$ ) in Msalato, and 23.53% ( $n=20$ ) in Nkuhungu.

Participation across the ward varied across the age groups. For example, 41.38% ( $n=129$ ) of the population in Mdadani were youth aged 20–45 years, while the rest were adults and elders aged 45 years and above.

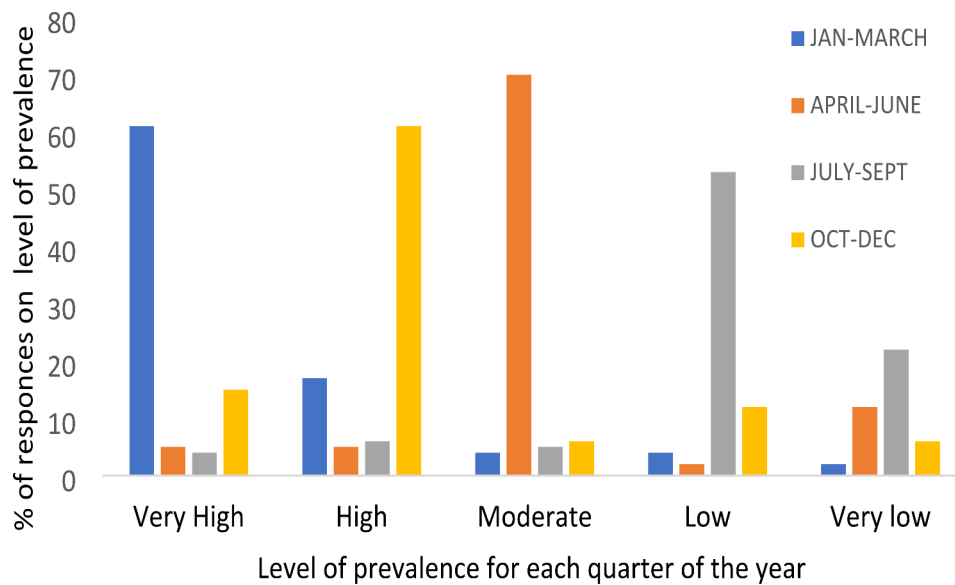
### Flock size kept by farmers in the study area

In general, the average flock size among the 300 respondents was a Mean of 491.69 ( $\pm 51.43$ ). The highest flock size was observed in Msalato (Mean=595.78  $\pm$  88.58,  $n=135$ ), followed by Mdadani (Mean=453.10  $\pm$  93.54,  $n=84$ ) and Nkuhungu (Mean=354.58  $\pm$  62.35,  $n=78$ ). The variation in flock size among the three study wards was not statistically significant ( $f$ -ratio=1.977,  $p=0.15$ ,  $df=2$ ).

Regarding the age and sex group, the results revealed that hens were the dominant group (mean=252  $\pm$  25.85), followed by chicks (Mean=136.20  $\pm$  26.58), pullet (Mean=42.26  $\pm$  6.57), Cockerels (Mean=29.31  $\pm$  4.95)

**Table 1** Prevalence of fowl typhoid in three wards (Mnadani, Msalato and Nkuhungu) under different sex, age group management system and breed of chicken

Variable	Classification	Mnadani (%)	Msalato (%)	Nkuhungu (%)	F	d.f	P-value
Group of chicken (Age/sex)	Hen	13.85	15.56	33.12	2.76	7.78	0.12
	Cock	19.2	23.48	30.77			
	Cockerel	27.62	25.24	21.49			
	Pullet	24.44	23.18	28.78			
	Chick	22.133	36.84	40.43			
Management system	Free-range	18.74	2.93	0	0.94	2.88	0.49
	Semi-intensive	23.33	17.53	7.41			
	Intensive	20.24	19.26	35			
Breed of Chicken	Local	35.26	19.59	35.11	491	3.40	<0.0001
	Layer	46.04	19.31	35.14			
	Broiler	19.93	19.18	35.37			



**Fig. 2** Awareness on the level of prevalence of fowl typhoid in chicken by farmers in four quarters of the year (January-March, April-June, July -September and October -December for year 2022)

and cocks (Mean=16.37±4.95). The one-way ANOVA revealed that, the variation among the sex and age groups was statistically significant ( $f=28.05$ ,  $d=224.3$ ,  $p<0.0001$ ).

**Prevalence of fowl typhoid in chicken**

Out of the 300 respondents, 84% ( $n=252$ ) revealed that the fowl typhoid exists in their flocks. The overall prevalence of fowl typhoid was 22.30% ( $n=10963$ ). The prevalence of the disease varied across the study wards. The highest prevalence was observed in Nkuhungu (34.04%), followed by Manadani (20.43%), and then Msalato (19.17) %. Prevalence varied significant across the wards when the breed of chicken infected were compared. For instance, highest prevalence was reported to layers in Mnadani, local chicken in msalato and Broiler in Nkuhungu (Table 1).

**Prevalence of fowl typhoid disaggregated by four quarters of the year 2022**

There were four quarters involved in this study. These included the following: January–March, April–June, July–September, and October–December for the year 2022. There was variation in the level of prevalence for the diseases in the first three quarters of 2022. A very high prevalence was reported to occur from January to March. April to June experienced moderate prevalence, while low prevalence was observed in the months between July and September (Fig. 2). However, the variation across the four quarters was not statistically significant ( $F=0.01$ ,  $df=8.83$ ,  $p=0.99$ ). Tukey pairwise analysis showed that the prevalence was significant when the comparison was performed between the first quarter (January–March) and the third quarter (July–September) ( $P=0.04$ ).

### Access to veterinary services

The respondents were asked if they do access veterinary services. About 69% ( $n=207$ ) reported having access to veterinary services, while 31% ( $n=93$ ) did not. Out of those people who access the veterinary services, 61% ( $n=126$ ) reported that access to the veterinary services were rarely available, while 39% ( $n=81$ ) did get them whenever needed. The main challenge for not accessing the veterinary services was the expense of services. Other challenges included availability, distance from the service source, and low awareness of where they could get the services (Fig. 3).

### Influence of different risk factors on the number of infected/diseased chicken

Different risk factors had various effects on the number of chickens affected by fowl typhoid. In this study, it was clear that whenever there is a large flock size, dominated by hens and pullets, the association is positive and there is a likelihood of an increase in the number of chickens diseased with fowl typhoid (Table 2).

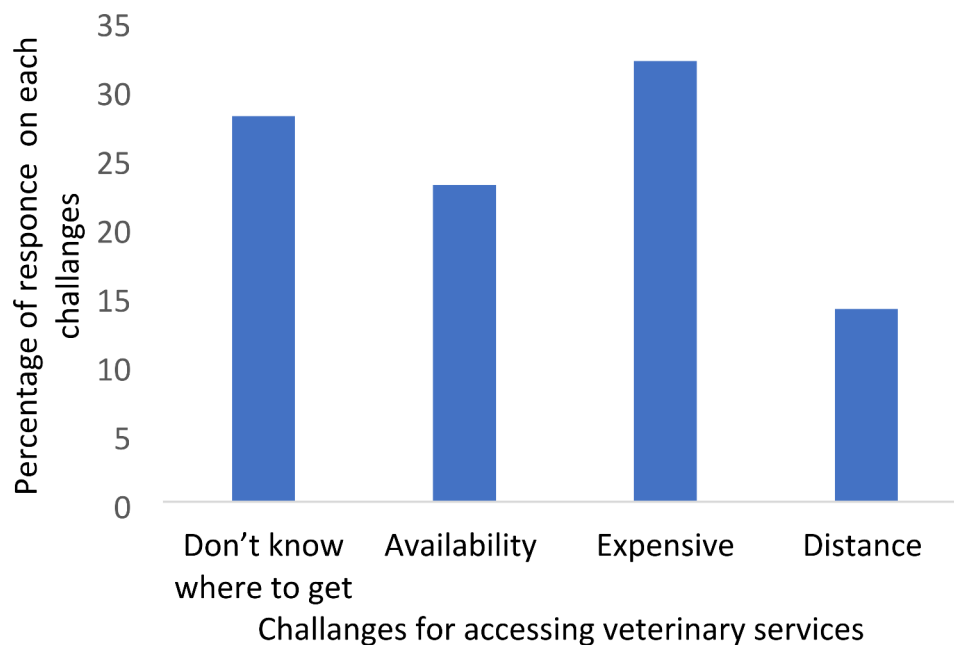
### Discussion

Overall, the prevalence of fowl typhoid of 22.30% revealed in this study was comparable to 18.4% reported in an earlier study conducted in Zaria-Kaduna State, Nigeria. Similarly, the highest number of outbreaks was recorded in the rainy season (July–September). However, this prevalence of fowl typhoid was much lower than 31.1%, previously reported in Dodoma [8]. This difference can be explained by the difference in the sample type for which the prevalence was sought. In our study,

we focused on chickens that are diseased with fowl typhoid, while Mramba in 2023 investigated the prevalence of the feed consumed by chickens in Dodoma.

In addition, this prevalence of fowl typhoid (22.3%) was much lower than 29% reported in an earlier study conducted in Ilala Dar es Salaam. The difference can be accounted for by the difference in localities of the study, ecological and climatic variations, and the breed of chicken involved [9].

In this study, women were the majority involved in poultry rearing. This suggests that poultry rearing is an important economic activity for women in the rural setting. In a previous study, it was reported that chicken contributes socio-economically to Women and youth [3, 10, 11]. Related findings were reported in Zambia whereby youth and women were observed to be the key beneficiaries in chicken production [12]. Raising chickens in Kenya significantly empowers women and youth by increasing their involvement in smallholder poultry value chains. This empowerment is supported by training in poultry management, improved access to credit, and cooperative formation, with additional success achieved through addressing societal norms and providing financial support [13]. According to a study in Kenya, although livestock offers social, financial, and food security, it requires significant time and labor, mainly from women and children. Gender disparities restrict women's benefits from livestock ownership, underscoring the need for equitable development initiatives [14]. In Enugu State, Nigeria, women manage most village chicken production tasks, such as selling and disease prevention, while men build chicken houses. Addressing challenges like diseases



**Fig. 3** Percentage of respondents on different reasons for not accessing the veterinary services

**Table 2** The association of number of diseased chickens with fowl typhoid with the associating factors

s/n	Variable	Classification	Coefficients Estimate	Standard Error	Z-value	P-value
1		Intercept	-1.36e+01	5.69e+02	-0.02	0.98
2	Flock Size	Number of chickens kept	2.53e-04	3.84e-05	6.61	3.92e-11 ***
3	Infected chicken by sex and age group	Hen	5.61e-03	1.91e-04	29.39	<2e-16 ***
		Cocks	-7.15e-03	2.86e-03	-2.50	0.01 *
		Cockerel	-6.181e-03	1.298e-03	-4.762	1.92e-06 ***
		Pullets	1.664e-02	1.017e-03	16.365	<2e-16 ***
4	Season; January-March	Chicks	-7.039e-04	1.793e-04	-3.926	8.63e-05 ***
		Low	5.99e-01	1.20e+03	0.001	0.99
		Moderate	-4.35e-01	1.93e-01	-2.248	0.03 *
		Very High	3.25e-01	7.91e-02	4.11	3.96e-05 ***
5	Season; April -June	Low	-1.48e+00	2.46e-01	-6.02	1.73e-09 ***
		Moderate	-8.72e-01	1.53e-01	-5.71	1.11e-08 ***
		Very High	4.29e-01	1.95e-01	2.20	0.03 *
6	Season; July-September	Low	-4.75e-01	5.60e-02	-8.48	<2e-16 ***
		Moderate	-2.230e-01	6.212e-02	-3.591	0.00033 ***
		Very High	-2.42e-01	5.36e-02	-4.51	6.55e-06 ***
7	Season; October-December	Low	-1.28e+00	9.87e-02	-12.98	<2e-16 ***
		Moderate	-6.14e-01	2.20e-01	-2.80	0.01 **
		Very High	1.77e-01	8.56e-02	2.07	0.04 *
8	Management System	Intensive	2.87e-02	2.03e-01	0.14	0.89
		Semi-intensive	3.39e-01	1.544e-01	2.20	0.03 *
9	Challenges for getting veterinary services	Don't get services	-1.51e+00	2.61e-01	-5.78	7.42e-09 ***
		Expensive	8.25e-03	3.01e-02	0.274	0.78
		Distance from the Services	2.33e-01	3.50e-02	6.67	2.61e-11 ***
		Don't know about the services	1.88e-01	9.61e-02	1.96	0.05
	Breed of chicken	Layers	-5.123e-01	3.939e-02	-13.005	<2e-16 ***

Note. The risk factors considered included flock size, age/sex, Season (Four quarter of the year), Management systems, Challenges of accessing veterinary services, and Breed of chicken kept by the farmers

and inadequate services through better housing and vaccination is crucial for improving outcomes and supporting women's roles in poultry farming [15].

Poultry rearing is a crucial economic activity for women and youth in rural areas, playing a significant role in their empowerment and involvement in smallholder poultry value chains. Despite its benefits, gender disparities and the substantial demands on time and labor highlight the need for equitable development initiatives. The study reveals that awareness and perceptions of fowl typhoid impact poultry enterprises, affecting the livelihoods of these vulnerable groups. Limited access to veterinary services exacerbates this issue, leading to challenges such as higher disease prevalence and potential drug residues, which further undermine productivity. Addressing these challenges through improved awareness, better housing, and enhanced support services is essential for optimizing poultry farming and supporting the economic well-being of women and youth.

#### Prevalence of fowl typhoid in chicken

The prevalence of fowl typhoid in chickens varied between chicken breeds across the study wards. The influencing risk factors for the prevalence were: season,

management factors, flock size kept by farmers, sex, and age of the chickens under study. For instance, it was clear in this study that there was a significant increase in prevalence in the months of January–March and October–December. Regarding the management system, a positive increase in prevalence was observed in the chickens that are kept in semi-intensive conditions. This is in agreement with other studies that revealed the prevalence of poultry diseases to be influenced by different factors, including age, sex, flock size, and management practices [3]. The breed of chicken, particularly layers, negatively influences the prevalence of chicken typhoid in the study area. This may be due to differences in the care and management these breeds receive, such as treatment and vaccination, intensive management system used as well as cleanliness [16–18]. A study in Zaria, Nigeria, showed that the prevalence of fowl typhoid in chickens was significantly influenced by age and breed [5].

#### Access to veterinary services

Veterinary services in chicken production are crucial. Proper provision of proper veterinary services is anticipated to reduce the prevalence of fowl typhoid in chickens and increase productivity and benefits accrued from

chicken production. In this study, it was clear that farmers access to veterinary services is low. For instance, more than 60% of the farmers declared that they had less access to veterinary services. The other group of about 40% didn't have access to veterinary services for their chickens. The lack of accessibility to veterinary services was driven by the cost of veterinary services, distance from the farmers localities to the point of accessing the veterinary services, and unawareness of the veterinary services. A study in Mbombela Municipality, South Africa, revealed that livestock keepers faced significant challenges in accessing medicine. Additionally, they encountered difficulties with drug withdrawal, dosage, and overall administration [19]. A study in Dodoma revealed that the farmers are less knowledgeable on the proper use of drugs in the treatment of chicken, thus posing a threat of drug residues in chicken products and by-products [18, 20–22]. Overall, adequate veterinary services are crucial for reducing the prevalence of fowl typhoid and enhancing productivity in chicken production. However, limited access to these services—due to factors such as cost, distance, and lack of awareness—hinders farmers' ability to effectively manage poultry health, potentially leading to issues like drug residues in chicken products.

### Conclusion and recommendation

It is evident from this study that the prevalence of fowl typhoid in Dodoma is high and needs proper intervention for the betterment of chicken production and productivity. Fowl typhoid need to be addressed by proper treatment, controlling strategies, and providing proper education to poultry keepers about treatment and control strategies for the disease. Based on the highlights of this study, it is recommended that veterinary services need be made accessible and affordable to farmers. Furthermore, in an effort to control fowl typhoid in chickens and increase production and productivity, factors that influence the prevalence of fowl typhoid need to be considered for an effective control strategy. Among these factors for consideration are the season of the year, breed of chicken, age, flock, and management practices.

### Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12917-024-04299-y>.

Supplementary Material 1

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### Author contributions

K.N. wrote the main manuscript text and prepared figures. The author reviewed the manuscript.

### Funding

Not applicable.

### Data availability

The Data are available at the Department of Biology, The University of Dodoma.

### Declarations

#### Ethical approval

The ethics clearing committee at the University of Dodoma issued the ethical clearance with reference number MA.84/261/02. An ethical clearance committee at the University of Dodoma is in charge of reviewing the planned study and giving it ethical approval. The study was carried out in conformity with the Declaration of Helsinki's ethical guidelines from 1964.

#### Consent to participate

All participants in the study were informed about the nature, purpose, and procedures of the research. They were made aware of the objectives, potential risks, and benefits associated with their participation. The participants provided their voluntary consent to take part in the study.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare no competing interests.

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### References

- Berhanu G, Fulasa A. Pullorum disease and fowl typhoid in poultry: a review. *Br J Poultry Sci.* 2020;9:48–5.
- Jawale CV, Chaudhari AA, Lee JH. Generation of a safety enhanced *Salmonella Gallinarum* ghost using antibiotic resistance free plasmid and its potential as an effective inactivated vaccine candidate against fowl typhoid. *Vaccine.* 2014;32:1093–9.
- Ngongolo K, Chota A. Chicken production, flock size, management systems, and challenges in the Dodoma region in Tanzania. *Poult Sci.* 2021;100:101136.
- Ngongolo K, Chota A. Effect of sex, age, diseases, and control intervention on chickens' mortality and its financial implications in Dodoma, Tanzania. *Poult Sci.* 2022;101:101785.
- Mbuko IJ, Raji MA, Ameh J, Saidu L, Musa WI, Abdul PA. Prevalence and seasonality of fowl typhoid disease in Zaria-Kaduna State, Nigeria. *J Bacteriol Res.* 2009;1:1–5.
- Tadele G, Asrade B, Bayleyegn G, Ali MS. Typhoid and pullorum disease from apparently healthy chickens in eastern Ethiopia. *J Vet Sci Technol.* 2014;5:156.
- Mgomezulu WR, Chitete MN, Maonga M, Kachingwe BB, Phiri L, Mambosasa HH. Does shifting from subsistence to commercial farming improve household nutrition and poverty? Evidence from Malawi, Tanzania and Nigeria. *Res Globalization.* 2024;8:100201.
- Mramba PR. The role of feeds in the transmission of chicken pathogens in Dodoma Urban District, Tanzania. *Poult Sci.* 2023;102:102558.
- Mdemu S, Mathara JM, Makondo ZE. Isolation of *Salmonella* in commercial chicken feeds in Ilala district. *Am Sci Res J Eng Technol Sci.* 2016;19:1–8.
- Ngongolo K, Kitojo O, Chota A. Social-economic impact of chicken production on resource-constrained communities in Dodoma, Tanzania. *Poult Sci.* 2021;100:100921.
- Ngongolo K, Sigala E, Mtoka S. Community Poultry Project for Conserving the Wildlife Species in Magombera Forest, Tanzania. *Asian J Res Agric Forestry.* 2019;2:1–7.
- Queenan K, Alders R, Maulaga W, Lumbwe H, Rukambile E, Zulu E. An appraisal of the indigenous chicken market in Tanzania and Zambia. Are the

- markets ready for improved outputs from village production systems. *Livest Res Rural Dev.* 2016;28:1–3.
13. Garsow AV, Kim EG, Colverson KE, Ilic S, Kunyanga C, Bainah A et al. A review of the roles of men, women, and youth in ensuring food safety in the small-holder poultry value chain in Kenya. *Front Sustain Food Syst.* 2022;6.
  14. Dumas SE, Maranga A, Mbullo P, Collins S, Wekesa P, Onono M, et al. Men are in Front at Eating Time, but not when it comes to rearing the chicken: unpacking the gendered benefits and costs of livestock ownership in Kenya. *Food Nutr Bull.* 2018;39:3–27.
  15. Chah JM, Anugwa IQ, Itodo C, Asadu AN, Dimelu MU, Ezeibe A. Gender roles and challenges of village chicken keeping among farmers in Enugu State, Nigeria. Volume 6. *Sustainability, Agri, Food and Environmental Research;* 2018.
  16. Chota A, Ngongolo K, Mmbaga NA et al. CHICKEN PRODUCTIVITY UNDER IMPROVED HEALTH CARE AND MANAGEMENT PRACTICES IN DODOMA REGION, TANZANIA. 2023.
  17. Ngongolo K, Omary K, Andrew C. Drug used in controlling chickens diseases, the withdrawal periods, and the threats of drugs residues in food chain. A review. *Berkala Penelitian Hayati.* 2020;26:39–44.
  18. Chota A, Kitojo O, Ngongolo K. Knowledge on diseases, practices, and threats of drugs residues in chicken food chains in selected districts of Dodoma region, Tanzania. *J Appl Poult Res.* 2021;30:100186.
  19. Gulwako MS, Mokoete JM, Ngoshe YB, Naidoo V. Evaluation of the proper use of medication available over the counter by subsistence and emerging farmers in Mbombela Municipality, South Africa. *BMC Vet Res.* 2023;19.
  20. Beyene T. Veterinary drug residues in Food-Animal products: its risk factors and potential effects on Public Health. *J Vet Sci Technol.* 2015. <https://doi.org/10.4172/2157-7579.1000285>.
  21. Mongi RJ, Meshi EB, Ntwenya JE. Consumer awareness and production practices of farmers on antimicrobial residues in chicken eggs and Chinese cabbage in Dodoma, Central Tanzania. e0272763. *PLoS ONE.* 2022;17:e0272763.
  22. Ngongolo K, Kitojo O, Chota A. Drug used in controlling chickens diseases, the withdrawal periods, and the threats of drugs residues in food chain. A review. *Berkala Penelitian Hayati.* 2020;26:39–44.

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