Cogent Food & Agriculture

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/oafa20

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To cite this article: Billy Okemer Ipara, David Jakinda Otieno, Rose Adhiambo Nyikal & Nabwile Stellah Makokha (2024) Farmers' awareness and perceptions on Newcastle disease in chicken: Evidence from high and low rainfall regions of Kenya, Cogent Food & Agriculture, 10:1, 2292869, DOI: 10.1080/23311932.2023.2292869

To link to this article: https://doi.org/10.1080/23311932.2023.2292869

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Cogent Food & Agriculture (2024), 10: 2292869

cogent oa

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Ipara et al., *Cogent Food & Agriculture* (2024), 10: 2292869
https://doi.org/10.1080/23311932.2023.2292869

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ANIMAL HUSBANDRY & VETERINARY SCIENCE | RESEARCH ARTICLE

Farmers' awareness and perceptions on Newcastle disease in chicken: Evidence from high and low rainfall regions of Kenya

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Received: 25 August 2023
Accepted: 05 December 2023

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Reviewing editor:
Pedro González-Redondo, University of Seville, Spain

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Abstract: Newcastle disease (ND) poses a major challenge to Kenyan farmers who raise local chicken in a free-range system. The lack of consistent poultry rearing practices makes it unclear how farmers manage the disease. Insufficient awareness and negative perceptions contribute to the problem, leading to poor management and increased disease outbreaks. The extent of Kenyan farmers' awareness and perceptions of ND also remains poorly documented. This study examined ND awareness, perceptions, and factors influencing awareness using a binary logit model on data from 332 farmers in high rainfall (Kakamega) and low rainfall (Machakos) regions in Kenya. Limited access to support services (34% extension, 25% training and 25% credit) was observed. The ND was perceived as a significant chicken disease, causing high mortality and losses during outbreaks. Awareness of ND was higher in high-rainfall areas. The household type, access to extension services and credit, training, and group membership significantly influenced ND awareness. Strengthening group membership is recommended for improved access to relevant information. Kakamega and Machakos county governments should invest more in targeted extension services, potentially collaborating with private providers and development partners. Financial institutions should also tailor their products to fit chicken farmers' needs.

ABOUT THE AUTHOR

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Billy Okemer Ipara is an agricultural economist specializing in Food Systems, Livestock Economics, Financial Inclusion, Policy Analysis, and Rural Development. He is currently a Ph.D. candidate in Agricultural and Applied Economics at the University of Nairobi. He also serves as an Assistant Lecturer at the University's Department of Agricultural Economics, and as a consultant for The Alliance of Bioversity-CIAT. Billy's previous experience includes positions at International Crops Research Institute for Arid and Semi-Arid Tropics, and the Kenya Agricultural and Livestock Research Organization. He holds a Bachelor in Agribusiness Management and a Masters in Agricultural and Applied Economics. His Master's thesis focused on Farmers' and Traders' Awareness, Perceptions and Effect of Chicken Value Chain Practices on Newcastle Disease Outbreaks in Kenya. The paper's findings are vital for stakeholders involved in designing interventions to address challenges faced by poultry farmers who struggle with managing Newcastle disease due to limited awareness.

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Subjects: Agriculture & Environmental Sciences; Rural Development; Economics and Development

Keywords: awareness; perceptions; newcastle disease; chicken; Kenya

1. Introduction

Poultry farming in Kenya holds significant importance as a vital source of sustenance and income for many small-scale farmers (Kariithi et al., 2020; Macharia et al., 2020. This sector serves as an economically efficient means of producing protein through eggs and meat while simultaneously generating revenue from the sale of poultry and related products. Moreover, chicken farming in numerous regions of Africa has made substantial contributions by serving as a vital source of protein, ensuring food security, generating employment and providing income to communities with limited resources (Ngongolo et al., 2019, 2021). What sets poultry apart from other livestock is its cost-effective nature and minimal space requirements, particularly beneficial in regions constrained by land availability (King'ori et al., 2010; Nduthu, 2015).

Notably, poultry farming assumes a pivotal role in the livelihoods of small-scale farmers in Kenya, responsible for about 80% of the nation's overall poultry production (Njuguna et al., 2017). It is important to note that while agriculture contributes 25% to Kenya's Gross Domestic Product (GDP), the poultry sector singularly accounts for one-third of this (Netherlands Africa Business Council [NABC], 2019). Moreover, this industry exhibits a high degree of integration within the broader economy, encompassing various upstream and downstream activities involving input suppliers, feed manufacturers, breeders, processors, traders and consumers (Wachira & Nyingi, 2017).

The predominant chicken production system in Kenya involves small-scale farmers who rear indigenous chicken breeds in their backyard environments. This system is characterized by a prevalence of smallholder farmers who raise indigenous chicken in free-range conditions, without the implementation of biosecurity measures. The utilization of free-range production system poses difficulties in disease control as the birds are directly exposed to disease-causing pathogens (Ogada et al., 2016). There are also fewer commercial farms in Kenya that focus on raising layers and broilers, and a very small number of large-scale integrated farms that produce both layers and broilers (Snel et al., 2021). Kenya has an estimated total of 39 million poultry units. Among the population, about 20.6 million people reside in households that engage in the rearing of free-range poultry. According to the Food and Agriculture Organization of the United Nations (FAO), approximately 3.4 million people are associated with households practicing semi-intensive poultry farming. Notably, households involved in intensive broiler production consist of fewer than 100,000 individuals (FAO, 2018).

Poultry farming, especially in Kenya, encounters numerous obstacles. Previous research like Mutua (2018), have identified challenges such as disease and parasite issues, high feed costs, inadequate housing skills, predation and limited knowledge on chicken rearing. Similar challenges have been observed in East Africa, as documented by studies like Ngongolo and Chota (2021) in Tanzania, which also reported issues related to diseases, the absence of a market for chicken products, the rearing system, predators and parasites. The primary challenge facing chicken production in Kenya revolves around high incidence of diseases, with Newcastle disease (ND)[1] being the biggest constraint. The disease is not only the most widespread but also the most severe affecting chicken in Kenya (Atela et al., 2016; Ipara et al., 2019; King'ori et al., 2010), and also within other countries in the region like Tanzania (Ngongolo & Chota, 2022).

The ND is a highly contagious disease that primarily targets the respiratory and nervous systems, affecting chicken and other poultry species (Mbabazi et al., 2012). Outbreaks of ND typically result in mortality rates ranging from 80% to 100% among unvaccinated poultry, thereby causing

substantial economic losses due to poultry deaths (African Union Inter-African Bureau for Animal Resource [AU-IBAR], 2013). The disease rarely leaves survivors in unvaccinated flock (Guèye, 2002). The disease can be transmitted through various routes, including bird droppings, excretions, direct contact, airborne transmission, and contaminated materials such as footwear, vehicles, food, or infected cages (Mbabazi et al., 2012). Despite the well-documented losses associated with the ND, the efforts aimed at its management remain insufficient.

Vaccination is advocated as a crucial biosecurity measure (Dimitrov et al., 2017) and is mostly carried out by commercial poultry farmers. The recommended vaccination regimen represents the sole effective means of controlling ND. Moreover, implementing poultry vaccination substantially reduces the risk of bird mortality and its associated economic losses (Okata & Al-Hassan, 2023). Swai et al. (2011) reported that the absence of a regular vaccination program creates favourable conditions for the disease to spread. However, a significant hindrance is observed among most small-scale chicken farmers, who rarely vaccinate their flocks. This reluctance is partly attributed to their limited financial resources, which makes them unable to afford the mandatory refrigeration services essential for the storage and transportation of commercially available vaccines. Additionally, unregulated vaccination can lead to adverse consequences for production and present a significant public health risk. This can occur because of high drug usage, potentially resulting in the development of drug-resistant pathogens and consumption of drugs by humans due to presence of drug residues in chicken meat and eggs (Falowo & Akimoladun, 2019; Muñoz et al., 2014).

The free-range poultry farming system, as a result, poses considerable challenges in the management of ND, as it exposes the birds to direct contact with parasites and disease-causing pathogens (Ipara et al., 2021; Ogada et al., 2016). Additionally, the lack of uniformity in poultry management practices among these farmers makes it difficult to monitor and control the disease, creating an entry point for ND. Controlling ND in Kenya faces various challenges such as the absence of basic preventive measures, inadequate animal health training and insufficient knowledge about the disease. The lack of awareness and negative perceptions of ND result in poor poultry management and increased disease outbreaks.

To develop effective strategies for controlling ND, it is crucial to have a clear understanding of stakeholders' awareness and perception of the disease (Omiti & Okuthe, 2009). Small-scale farmers' attitudes towards ND impact decision-making by influencing their perception of the disease and the benefits associated with management choices (Chilonda & Van Huylenbroeck, 2001). Studies like Lawal et al. (2015) and Ibrahim et al. (2016) likewise documented relatively limited levels of awareness on ND and its preventive measures, including vaccination, as well as the repercussions associated with the disease. Similar findings were reported by Chengula et al. (2013) in Tanzania, where farmers exhibited a limited understanding of livestock diseases, thereby exposing their poultry farms to the potential risk of disease outbreaks.

Further, provision of information and recommended vaccination timetables can serve as a potent method for managing ND. Studies like Okata and Al-Hassan (2023) in Ghana have revealed that greater awareness of vaccination schedule increased the likelihood of farmers adopting and complying with vaccination schedules. However, in Kenya, there is a lack of precise documentation on farmers' awareness levels and perceptions of ND. Understanding the levels of awareness and perception pertaining to ND is unquestionably a crucial approach in formulating targeted interventions and strategies, enabling the expansion of vaccination initiatives and developing effective approaches to assist farmers in disease management.

To address the existing knowledge gap, this study aimed at evaluating farmers' perceptions of the ND in chicken and identified the factors influencing awareness of the disease in high and low rainfall regions of Kenya. Previous research conducted in Tanzania by Campbell et al. (2018) and de Bruyn et al. (2017) emphasized the importance of information access and awareness creation in

promoting vaccine adoption and reducing disease outbreaks. Gaining insights into the knowledge and perceptions towards ND in Kenya can support county governments in prioritizing the chicken value chain. This understanding will aid in the development and implementation of targeted training programs, extension services and information dissemination systems. These initiatives will focus on enhancing disease detection, control, and management for farmers and other stakeholders involved in the chicken value chain. By providing farmers with the necessary technical knowledge and information through these programs, they will be better equipped to respond efficiently to disease outbreaks and enhance overall disease management.

2. Methodology

2.1. Study area

The study was carried out in Kakamega and Machakos counties, both of which have prioritized chicken production as a significant livelihood activity, as indicated in their respective County Integrated Development Plans [CIDP] (Republic of Kenya, 2018a, 2018b). Kakamega County, situated in the western region of Kenya (as illustrated in Figure 1), is the second most populous county after Nairobi, characterized by a substantial rural population. The county's economic foundation predominantly relies on agriculture, it contributes 2.3% to the national GDP and is ranked 9th in terms of average contribution to agriculture output in Kenya (Kenya National Bureau of Statistics [KNBS], 2023). Geographically, Kakamega County falls within a humid climate zone, receiving ample rainfall throughout most of the year. This county is delineated by two primary ecological zones: The Upper Midlands (UM) and the Lower Midlands (LM) (as depicted in Figure 2). The UM encompass the central and northern regions, including areas such as Ikolomani, Lurambi, Malava, Navakholo, and Shinyalu. These regions predominantly engage in intensive small-scale farming, while Lugari and Likuyani are known for their large-scale farming practices.

The LM, constituting a substantial portion of the southern area of the county, encompass regions such as Butere, Khwisero, Mumias East, Mumias West, and Matungu. Kakamega County experiences an annual rainfall ranging from 1280.1 to 2214.1 mm per year (as shown in Figure 2). Rainfall is consistently distributed throughout the year, with pronounced heavy rainfall occurring in March and July, while lighter rains fall in December and February. In this study, Kakamega County was selected to represent the high-rainfall regions in Kenya. The prevalent chicken production system in the region is predominantly free-range, with a preference for indigenous chicken breeds. Notably, the county boasts tropical rain forests such as Kakamega and Malava forests,

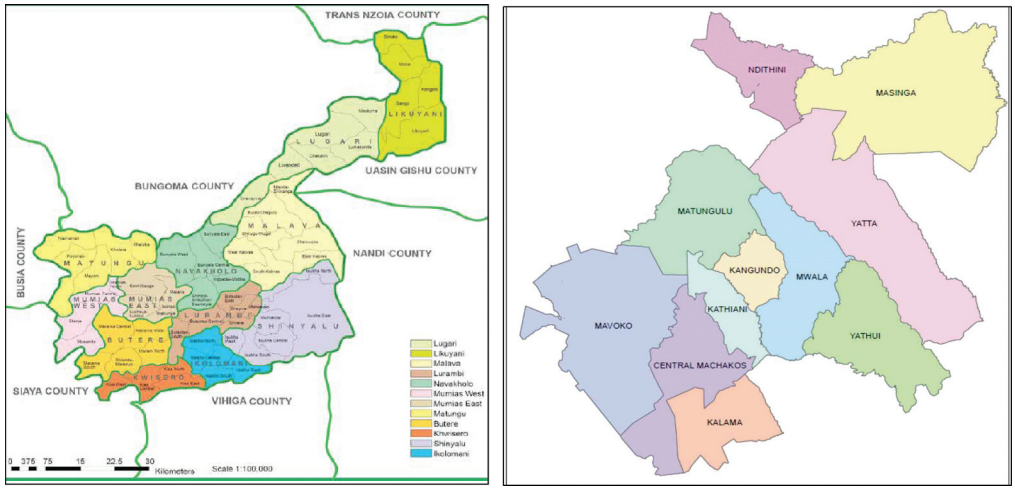

Figure 1. Maps of Kakamega and Machakos counties.

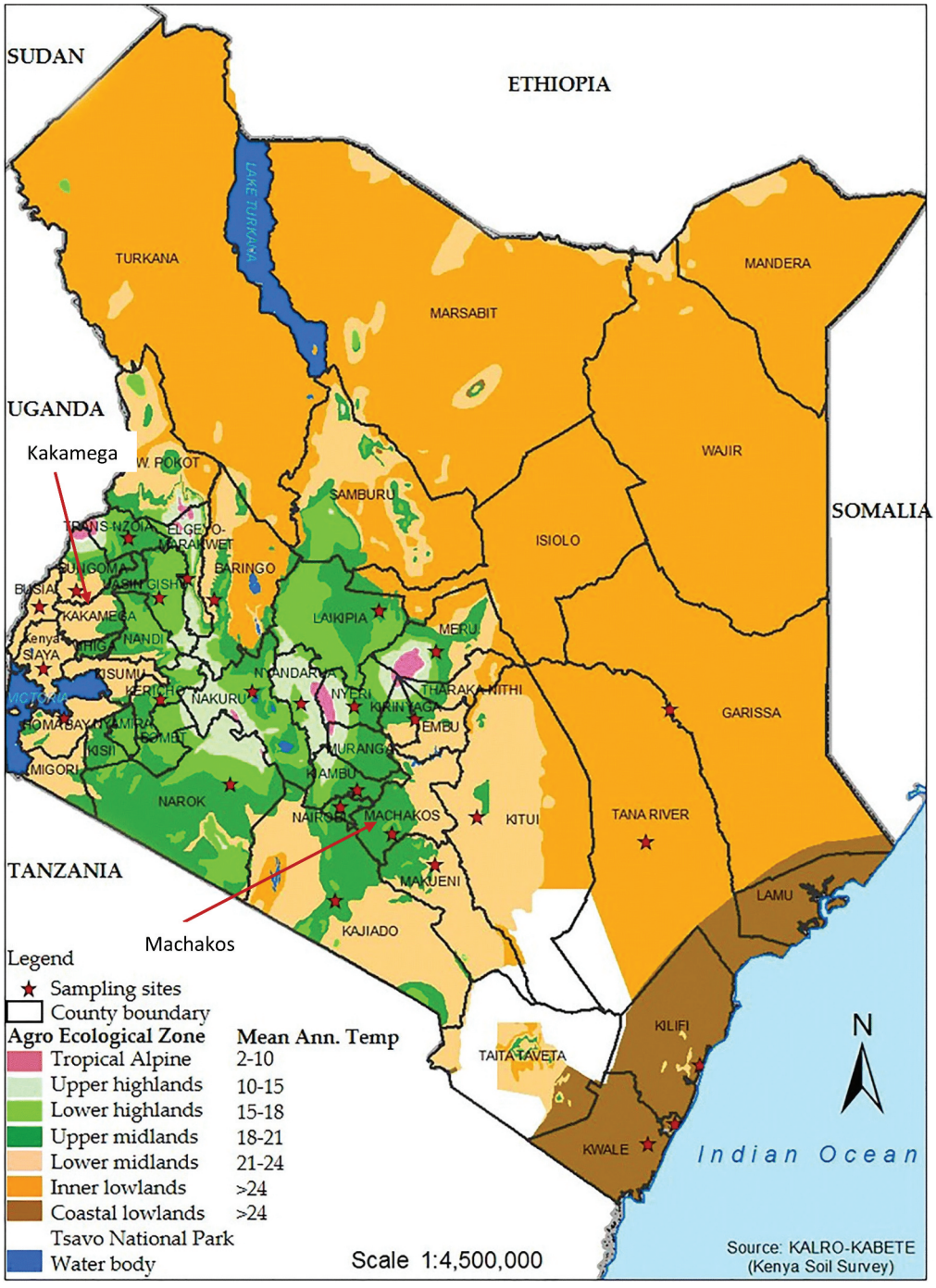

Figure 2. Classification of agro-climatic zones in Kenya.

fostering interactions among wild birds, migratory birds, and domesticated birds. These interactions held significant relevance for the study of ND outbreaks.

Machakos County, situated in the eastern part of Kenya, as illustrated in Figure 1, heavily relies on agriculture as its principal economic activity, serving as a vital source of employment, food security, and income generation. Indigenous chicken production is regarded as a prioritized value chain within the county. In recent years, the average number of birds produced in this value chain was approximately 862,392 (Republic of Kenya, 2018b). Machakos County plays a substantial role in supplying chicken to urban centres like Nairobi. In 2018, the value of poultry meat sourced from

Machakos was estimated to be 1,590 million Kenyan Shillings (Republic of Kenya, 2018b). This prominence in poultry production is noteworthy given the county's classification as a semi-arid zone, primarily due to its low levels of rainfall, as depicted in Figure 2.

Machakos County exhibits a bimodal rainfall pattern, characterized by short rains occurring in October and December, and extended rains falling between March and May. The annual rainfall in the region ranges from 500 to 1250 mm but is notably inconsistent and unreliable, as evident in Figure 2. In this study, Machakos County was selected to represent a low-rainfall region in Kenya. Moreover, Machakos County lies along a traditional migratory corridor used by both wild animals and pastoralists who periodically move their livestock in search of pasture and water resources. This dynamic creates an environment in which wild animals and domesticated poultry can interact, potentially facilitating the spread of diseases in the event of an outbreak. These interactions were a key focus of the study. Within the county, the predominant chicken production system is the free-range, with a preference for both indigenous and improved chicken breeds.

2.2. Study design, sampling and data collection

A focus group discussion (FGD) was organized in Kakamega County to gather valuable perspectives from different stakeholders involved in the chicken value chain. Participants included farmers, traders, transporters, agro-veterinary service providers, and government officers. The discussion covered a wide range of topics, including production systems, chicken management practices, disease awareness, disease outbreaks, and the availability of institutional support services for farmers. Through the FGD, the study obtained in-depth insights from the selected stakeholders, which were instrumental in developing and refining survey questionnaires and validating the study's findings. To account for the decentralized structure of agriculture in Kenya, key informant interviews (KIIs) were conducted in both Kakamega and Machakos Counties. The participants in these interviews included County directors of veterinary services, animal production officers, leaders of farmer groups, and disease reporting officers. The objective of the KIIs was to collect data pertaining to chicken production activities, practices, and disease occurrences that are unique to each county. These interviews contributed essential insights into the local context, enriching the overall understanding of the subject matter.

The selection of study counties, sub-counties, and sample villages was carried out using a three-stage sampling procedure. In the first stage, Kakamega and Machakos Counties were purposively chosen due to the inclusion of chicken production as a prioritized value chain in their respective CIDPs. Sub-counties were then selected in the second stage, based on the distribution of households involved in chicken rearing, as well as their proximity to relevant factors like forested areas and wildlife migratory corridors. Within Kakamega County, six sub-counties (Butere, Ikolomani, Lurambi, Matunguu, Mumias, and Shinyalu) were specifically identified (Figure 1). In Machakos County, five sub-counties (Kathiani, Machakos Town, Mavoko, Mwala, and Masii) were selected for the study (Figure 1). The villages within these sub-counties were chosen at random, with the assistance of agricultural officers assigned to each sub-county. This systematic approach ensured representative sampling across the study area.

Semi-structured questionnaires were employed to conduct face-to-face interviews with 192 farmers in Kakamega County and 140 farmers in Machakos County. These questionnaires were designed to gather comprehensive data on various aspects, including farmers' socio-economic characteristics, production systems, awareness of ND, experiences with disease outbreaks, response measures, and access to institutional support services. The perception of ND among farmers who had encountered outbreaks was evaluated using a 5-level Likert scale.

During the study, several challenges were encountered in determining the precise number of poultry-keeping farmers, which affected the estimation of sample sizes. Additionally, factors like unwillingness to participate and the long distances to sub-counties had an impact on the sample sizes, particularly in Machakos County. Despite these challenges, the sample sizes utilized in the

study were deemed adequate, compared to some previous studies on poultry farming that used sample sizes below 200 farmers. The collected survey data was analyzed using STATA 14 software.

2.3. Empirical analysis

The dependent variable in this study had two potential outcomes: awareness of Newcastle disease (ND) or lack thereof. Individuals who demonstrated knowledge of ND and could accurately recognize the disease based on clinical signs and symptoms consistent with it were categorized as being aware.

Empirically, the dependent variable was specified as follows:

$$Y_i \begin{cases} 1 & if \quad aware \\ 0 & if \quad otherwise \end{cases} \tag{1}$$

In such instances, logit and probit models are typically employed. In this study, the logit model was chosen due to its straightforward mathematical structure that allows ease of convergence of the log-likelihood as opposed to the probit. Specifically, the binary logit model was utilized because the dependent variable had discrete outcomes.

According to Greene (2003), the probability that an individual is aware is given by the reduced form equation below:

$$\text{prob}\left[y_{ij} = 1\right] = \frac{exp\, B' X_1}{1 + exp\, B' X_1} = AB' X_1 \tag{2}$$

where *i* and *j* represent the farmer and the farmer's awareness (with values 1 indicating awareness, and 0 indicating otherwise), and the X_i is the vector of explanatory variables encompassing both socio-economic and institutional factors for the i^{th} farmer. The non-observed *e's* accounts for potential errors in perception and measurement.

Table 1. Expected signs of variables hypothesized to influence farmers' awareness on Newcastle disease

Variable	Description of the variable	Expected sign
Region	Dummy (1= Urban, 0 = Otherwise)	+
Gender	Dummy (1= Female, 0 = Otherwise)	+
Household type	Dummy (1= Female headed, 0 = Otherwise)	+
Experience	Dummy (1= Above 5 years, 0 = 5 years and below)	+
Motive for rearing	Dummy (1= For commercial, 0 = For subsistence)	+
Access to extension	Dummy (1= Yes, 0 = Otherwise)	+
Access to training	Dummy (1= Yes, 0 = Otherwise)	+
Access to credit	Dummy (1= Yes, 0 = Otherwise)	+
Group membership	Dummy (1= Yes, 0 = Otherwise)	+
Age	Respondent's age in years	+/-
Education level	Dummy (1= Above primary, 0 = Primary and below)	+
Marital status	Dummy (1= Married, 0 = Otherwise)	+/-
Distance to agrovet	Distance to agro-veterinary service providers in Kilometres	+
Record keeping	Dummy (1= Yes, 0 = Otherwise)	+

The empirical estimation of the probability that an individual possesses awareness can be expressed as follows:

$$pr[Y_i = 1] = B'X_1 + e_i \tag{3}$$

Where X is a vector comprising socioeconomic and institutional traits that are theorized to impact an individual's likelihood of being aware or unaware of ND. The vectorB_i represents the parameters that need to be estimated, while e_i is the statistical random term unique to each respondent. The factors that were hypothesized to influence ND awareness among farmers are highlighted in Table 1.

The marginal effects were computed to determine how changes in the explanatory variables would impact the predicted probability of awareness, all while maintaining the other explanatory variables constant. The method used for computing these marginal effects is based on Anderson and Newell (2003), and computed as follows:

$$B_m = \left[\frac{\delta(B'X_1 = \theta_i}{\delta B'X_1}\right] B_i \text{ for continuous independent variable} \tag{4}$$

or

$$B_m = P_r[Y_i = 1] - P_r[Y_i = 0] \text{ for dummy coded variables} \tag{5}$$

The variables included in the models were tested for multicollinearity using variance inflation factors (VIFs):

$$VIF_i = \frac{1}{1 - R_i^2} \tag{6}$$

Since all VIF values were below the threshold value of 10, there was no evidence of multicollinearity in the sample data (Gujarati & Porter, 2009).

3. Results and discussion

3.1. Socio-economic characteristics of farmers

Table 2 displays the characteristics of the farmers rearing chicken. The results show that the majority of chicken farmers were female, highlighting the significant role of women in chicken production. Women's involvement in subsistence farming, including chicken production, is influenced by gender roles within households. Culturally, in Kenyan households, women are typically responsible for rearing poultry. They sell the eggs and meat to generate income for other household needs (Snel et al., 2021). Studies by Olwande et al. (2010), Islam et al. (2014) and Odhiambo (2020) also documented the dominance of women in chicken production and agriculture as a whole. The respondents' average age was 47 years, which aligns with the findings of Waweru et al. (2023), therefore highlighting that older farmers dominated chicken production. Older farmers tend to have more experience in chicken production and management activities, making them more aware of challenges such as ND outbreaks compared to younger farmers.

Over half of the respondents had attained education beyond the primary level. In Kakamega, a higher proportion of farmers had education beyond the primary level compared to Machakos. Similar results have been reported by Waweru et al. (2023) in their study in Southeastern Kenya The farmers exhibited relatively high levels of experience in chicken rearing, with most of them having more than five years of experience in chicken production. Farmers with greater experience were more likely to employ better practices in raising their flocks. More than three-quarters of the farmers were married, indicating the significance of chicken farming and production as a livelihood source for married individuals. In Kakamega and Machakos Counties, married farmers were motivated to participate in poultry management due to cultural expectations, particularly for women, to rear and manage poultry in their households. Insights from the FGD revealed that

Table 2. Socio-economic characteristics of farmers in Kakamega and Machakos counties

Characteristics	Kakamega (*n* = 192)	Machakos (*n* = 140)	Pooled (*n* = 332)	Statistically significant differences between sites (*p-value*)
Gender (% female)	64.0	56.4	60.8	1.407
Average age (years)	46 (15)	48 (16)	47 (15)	−1.023
Education level (% above primary)	55.2	51.7	53.3	0.811
Experience (% 5 years and below)	44.8	49.3	46.7	−1.305
Marital status (% married)	75.5	81.4	78.0	−1.284
Average land size (acres)	1.9 (2.8)	3.8 (4.5)	2.7 (3.6)	4.816***
Production system				
Free-range/extensive	58.9	57.9	58.4	0.945
Intensive	8.3	3.6	6.3	
Semi-intensive	19.3	19.3	19.3	
Mixed	13.5	19.2	16.0	
Distance to agro-veterinary service providers (Km)	2.7 (3.1)	2.3 (2.9)	2.7 (3.6)	1.388
Access to extension (% yes)	35.4	32.9	34.3	0.485
Access to training (% yes)	20.8	31.4	25.3	−2.193**
Access to credit (% yes)	25.5	24.3	25.0	0.257
Membership to group (% yes)	70.3	71.4	70.8	0.221
ND awareness (% yes)	81.2	67.8	75.6	2.831

Note: ND- Newcastle Disease. Standard deviations are in parentheses. Asterisks ***, **, * denote statistically significant differences between Counties at 1, 5 and 10%, respectively.

married farmers often had additional family responsibilities, which further motivated their engagement in chicken activities to fulfill their families' socio-economic needs. Chicken production therefore offered a quick source of income for them.

Results of the pooled sample indicated an average land size of more than two and a half acres. There was a statistically significant difference in average land size between the two counties, with Machakos having a higher average land size (3.8 acres) compared to Kakamega (1.9 acres). The smaller land sizes in Kakamega were attributed to its high population density and the fertile soils in the county (Republic of Kenya, 2018a). These findings collectively suggest that most farmers owned relatively small land plots, making chicken production a suitable agricultural activity. This aligns with the observations of Nduthu (2015) who highlighted chicken production as an ideal enterprise, especially in areas where land is scarce, given its minimal space requirements.

The dominant production system in both counties was the free-range system. This system is characterized as a low-input, low-output approach, where birds are allowed to search for food during the day and are confined at night in makeshift shelters and undefined housing structures (Onono et al., 2018). This system is primarily favoured by small-scale farmers due to its low capital requirements, minimal input utilization, and space-efficient nature. It proves to be a cost-effective approach for these farmers to engage in poultry production, especially since they face budgetary constraints and have limited income for investment in alternative systems. Previous studies by Magothe et al. (2012), Okeno et al. (2012), and Ipara et al. (2021), highlighted the prevalence of the free-range system among small-scale farmers in Kenya. This trend is also observed in

neighbouring countries within the region, as highlighted by Mahoro et al. (2017) in Rwanda and Ngongolo et al. (2021) in Tanzania.

Additionally, about one-fifth of farmers (19%) adopted the semi-intensive production system. According to King'ori et al. (2010), the semi-intensive system is primarily favoured by financially capable households, typically raising crossbreeds of exotic and indigenous chicken. Some farmers also mentioned using mixed production systems, which involve a combination of different production methods on the farm. This approach was common among farmers rearing multiple chicken breeds, including indigenous (*kienyeji*), broilers, layers, and improved indigenous breeds.

The average distance to the nearest agrovet shop was around two kilometres. The road networks in both counties primarily consisted of secondary roads, facilitating the use of motorcycles and bicycles for transportation. Despite the importance of extension services, access to these services was limited. This finding is consistent with the observations of Kyule et al. (2015) and Waweru et al. (2023). Farmer-to-farmer interactions served as the main avenue for accessing extension services. The availability of animal health training was also limited, with only a quarter of the respondents receiving such training within a 6-month period. In Kakamega, a smaller proportion of farmers had access to training compared to those in Machakos. Training focused on disease management, chicken health, and overall management practices is critical for enhancing chicken production. The absence of such training often leads to the adoption of suboptimal practices, resulting in errors and disease outbreaks. These findings are consistent with the observations made by Mutua (2018), who also noted limited access to and insufficient training among chicken farmers, aligning with the present study's findings.

Access to credit services was notably limited, with only a quarter of the respondents in both Kakamega and Machakos Counties having utilized such services. The restricted access to credit was attributed to factors like the absence of collateral, limited availability of credit facilities, and high interest rates. This observation corresponds with the findings of Tsegaye et al. (2014), who reported similarly low access to credit among chicken farmers in Ethiopia and Nigeria. Slightly over two-thirds of the respondents were members of social organizations. The membership rate in such groups was generally higher in Machakos compared to Kakamega. These groups facilitated access to essential services for chicken farmers, including credit, collective input procurement, joint disease vaccinations, and extension services, as indicated by Ochieng et al. (2013).

3.2. Farmers' perception of Newcastle disease outbreaks

In this study, we utilized a Likert scale to gauge the perceptions of farmers who had encountered ND outbreaks in both counties. This Likert scale consisted of five levels of perception: *"very severe," "severe," "neutral," "not severe,"* and *"not very severe."* As depicted in Figure 3,

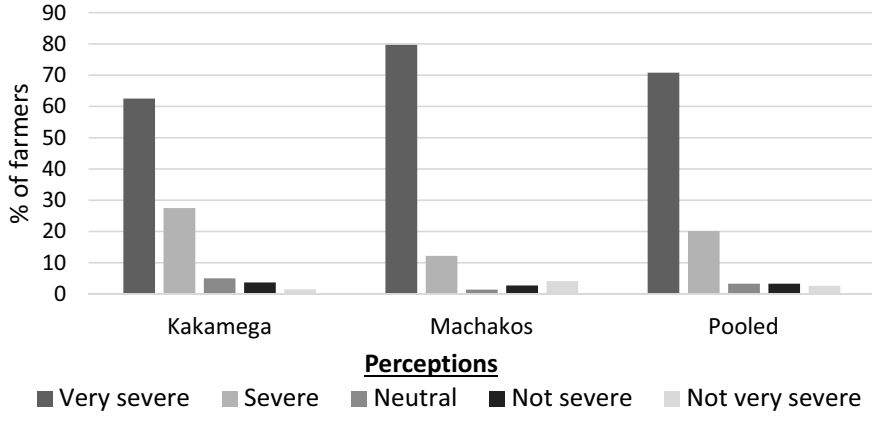

Figure 3. Farmers' perceptions of Newcastle disease outbreaks in Kenya.

a majority of the farmers who had experienced ND outbreaks regarded them as "very severe." The proportion of farmers perceiving the disease outbreaks as "very severe" was higher in Machakos in comparison to Kakamega. The farmers' perceptions of the disease were influenced by how it impacted their livelihoods in terms of economic losses and mortalities in the flock. According to Fadiga et al. (2013), these perceptions played a pivotal role in determining the extent to which farmers invested in disease treatment and control measures, including payment for veterinary services, participation in vaccination campaigns, and engagement in public disease control initiatives.

Attitude and perceptions also play a crucial role in the selection of veterinary interventions, entailing the stance of small-scale farmers towards diseases, the effectiveness of control strategies, and their perspective on veterinary service delivery systems. For instance, Waweru et al. (2023) found that the perception of the effectiveness of ND vaccines significantly influences their adoption. In both Kakamega and Machakos Counties, the majority of farmers perceived ND as a highly severe disease impacting their chicken production. Furthermore, ND was deemed the most economically impactful chicken disease due to the significant mortality rates during outbreaks, depriving them of income and food.

3.3. Farmers' awareness of Newcastle disease and its symptoms

The findings presented in Figure 4 and Table 3 reveal that awareness of ND was higher in Kakamega (81.2%) compared to Machakos (68.7%). In Kakamega, ND is commonly referred to

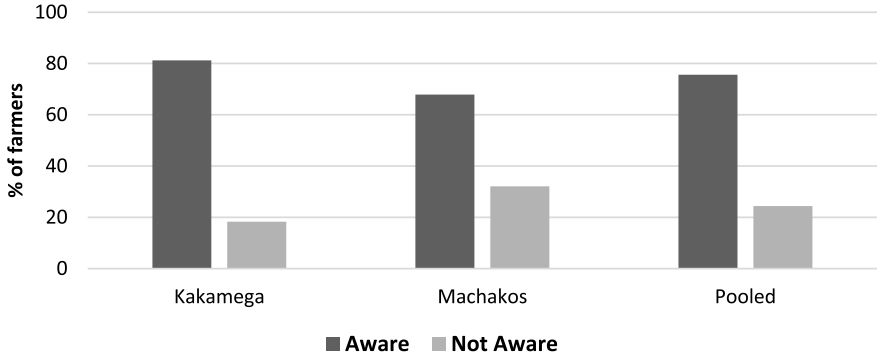

Figure 4. Newcastle disease awareness levels among chicken farmers in Kenya.

Table 3. Newcastle disease outbreaks and symptoms experienced by farmers

	Kakamega	Machakos	Pooled sample
Characteristics	**(*n* = 192)**	**(*n* = 140)**	**(*n* = 332)**
ND outbreaks experienced (% yes)	46.9	55.7	50.6
ND symptoms observed (% yes)			
Loss of appetite	23.4	36.6	25.0
Drop in egg production	11.5	8.7	9.3
Increased respiration and gasping	29.2	39.4	29.2
Greenish diarrhoea	40.6	48.1	38.5
Twisted necks	22.4	38.5	25.0
Sudden death	23.9	28.8	22.8

Note: ND- Newcastle Disease.

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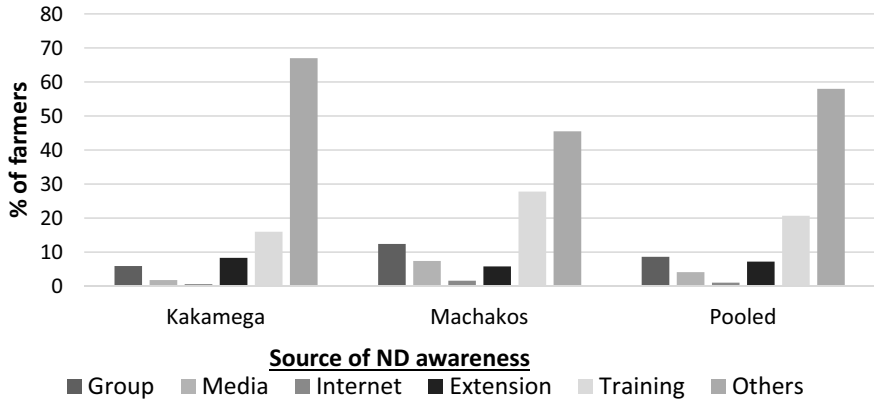

Figure 5. Sources of Newcastle disease awareness among chicken farmers in Kenya.

as "*muyekha*," while in Machakos, it is known as "*mavuii*." In both counties, ND is considered as the most devastating disease affecting chickens. Otim et al. (2007) stressed the importance of chicken flock owners being acquainted with the clinical signs associated with ND, as they identified it as the most significant chicken disease.

Farmers in both Kakamega and Machakos Counties utilized various sources to acquire information about chicken diseases, as illustrated in Figure 5. In both counties, the majority of farmers relied on non-institutional and informal sources, such as fellow farmers, neighbours, and friends, to gather information about chicken production. Further, farmer training on animal health aspects and ND significantly contributed to the farmers' awareness of ND. This training covered areas like ND detection, management, and control, equipping the farmers with fundamental knowledge about the disease.

3.4. Newcastle disease outbreaks among chicken farmers

As shown in Table 3, half of the farmers in the pooled sample had encountered ND outbreaks among their chicken flocks. The proportion of farmers who had experienced this disease was higher in Machakos in comparison to Kakamega. The responses from the farmers who had experienced ND outbreaks showed that the most common symptom observed on the birds was the discharge of greenish diarrhoea. Other symptoms included increased breathing rate and gasping for air by the birds, twisted necks, loss of appetite and sudden death. These symptoms were in accordance with the clinical manifestations typically associated with ND infections.

The findings revealed that farmers demonstrated a degree of ND awareness, but they lacked the necessary knowledge to accurately identify the disease. This observation corresponds with similar results reported by Ameji et al. (2012) regarding Avian Influenza in Nigeria. Consequently, it is imperative to offer education and training to chicken farmers, equipping them with the ability to recognize Newcastle disease (ND) through the clinical signs and symptoms characteristic of the disease.

3.5. Factors influencing farmers' awareness of Newcastle disease

We employed a binary logit model to analyze the factors that were hypothesized to influence the probability of farmers being aware of Newcastle disease (ND), as highlighted in Table 4. The VIF values from the test for multicollinearity in the sample data are presented in Table 5. The variables included in the model had VIF values below the threshold value of 10, indicating the absence of multicollinearity in the sample data. Therefore, the variables were not highly correlated with each other, and therefore suitable for inclusion in the model.

Interestingly, the region of residence had an unexpected negative impact on farmers' awareness of ND in Kakamega. Contrary to expectations, farmers living in urban areas were found to be less

likely to be aware of ND compared to their rural counterparts. This discrepancy can be attributed to the fact that in most urban households, poultry farming is not prioritized. In contrast, in rural areas, chicken production holds significant importance in terms of income generation and food provision.

As expected, household type positively influenced farmers' awareness of ND in both Kakamega and the overall sample. Female-headed households (FHHs) exhibited a higher probability of being aware of ND compared to male-headed households (MHHs). Chickens play a substantial role in the context of female-headed households in Sub-Saharan Africa, where women actively participate in their daily care and management. This heightened involvement of women in poultry-related activities contributes to an increased likelihood of being aware of ND and its associated symptoms. Previous studies by Islam et al. (2014) and Waithanji et al. (2020) have also underscored the ownership and day-to-day management of poultry by women, particularly within FHHs. These findings provide further support for the concept of heightened disease awareness among FHHs.

Access to animal health training had a significant influence on farmers' awareness of ND in Machakos County and the overall sample. Farmers who had received training in animal health exhibited a higher likelihood of being aware of the disease compared to those who had not undergone such training. Training sessions covering aspects of animal health and disease, including detection and control, contributed to an enhanced awareness of ND among farmers. Conversely, the absence of such training led to the adoption of suboptimal practices, increasing the risk of disease introduction and transmission. Previous studies like Waweru et al. (2023), have highlighted that increased knowledge, particularly regarding ND vaccines, can enhance the regularity and adoption of ND vaccination.

As expected, access to credit had a positive impact on ND awareness among farmers in Machakos County and the overall sample. Farmers with access to credit were more likely to be aware of ND compared to those without access. Both formal and informal credit access played a role in influencing awareness. Farmers sought credit as an additional source of income to invest in sound practices for chicken production, thereby heightening their awareness of ND. Access to credit facilitated the adoption of management interventions, including strategies for poultry disease prevention and control, thereby increasing the likelihood of farmers being aware of ND.

Membership in farmer groups had a positive effect on ND awareness among farmers in Kakamega County and the overall sample. This outcome was anticipated because farmer groups provided a platform for information exchange regarding chicken production and conducted group-based training sessions on production-related topics. Strong farmer groups exposed their members to issues related to animal health. According to Branckaert et al. (2000) and Ochieng et al. (2013), these groups enhance collective action, benefiting members through information sharing, joint vaccination initiatives, collective input purchases, advocacy for improved practices, and heightened awareness among farmers.

Marital status had a positive impact on ND awareness among farmers in Kakamega County. In Kakamega, married farmers had a greater incentive to participate in poultry management due to cultural expectations within the communities of the county, which place the responsibility for rearing and managing poultry, especially among women, in married households. Through their regular involvement in chicken production, these farmers became more aware of the risks associated with poultry farming, including diseases like ND.

The proximity to agro-veterinary service providers had a positive impact on the awareness of ND among farmers in both Kakamega and Machakos Counties, as well as in the overall sample. Farmers residing in closer proximity to agro-veterinary service providers exhibited a greater

Table 4. Factors influencing chicken farmers' awareness on Newcastle disease

	Kakamega		Machakos		Pooled sample		
Variables	**(*n* = 192)**		**(*n* = 140)**		**(*n* = 332)**		
	Coef.	***p*-value**	**Coef.**	***p*-value**	**Coef.**	***p*-value**	**Dy/dx**
Region (1= Urban)	−1.207**	0.042	.962	0.211	−.236	0.589	−.019
Gender of respondent (1= Female)	.001	0.998	−.768	0.128	−.201	0.216	−.028
Household type (1= Female-head)	1.589*	0.060	.818***	0.064	1.109**	0.029	−.046
Experience (1= Above 5 years)	−.644	0.187	.754	0.167	−.062	0.850	−.010
Motive (1= Commercial)	−.569	0.224	−.200	0.715	−.413	0.194	−.081
Access to extension (1= Yes)	.674	0.258	.094	0.865	.561	0.128	.083
Training on animal health (1= Yes)	.120	0.804	1.781***	0.002	.889**	0.010	.139
Access to credit (1= Yes)	.151	0.792	1.777**	0.011	.826**	0.040	.128
Group membership (1= Yes)	1.257**	0.011	.342	0.496	.682**	0.029	.117
Age (years)	−.005	0.742	.021	0.185	.002	0.859	−.001
Education level (1= Above primary)	.445	0.350	.006	0.990	.197	0.520	.013
Marital status (1= Yes)	1.091*	0.099	−.489	0.483	.405	0.361	−.047
Distance to agrovet (Km)	.585***	0.003	.555**	0.018	.483***	0.000	.076
Constant	.056	0.964	−.366	0.776	−.071	0.926	−.019
Log likelihood	**−73.181**		**−67.310**		**−155.542**		
***Pseudo-R*^{2}**	**0.210**		**0.231**		**0.186**		
Prob> Chi2	**0.000**		**0.000**		**0.000**		

Note: Asterisks ***, ** and * denote statistical significance levels at 1, 5 and 10%, respectively.

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Table 5. Variance inflation factors for variables in the binary logit model

Variable	VIF
Household type	1.740
Marital status	1.730
Access to extension	1.320
Group membership	1.210
Gender	1.200
Access to training	1.190
Education level	1.190
Access to credit	1.170
Age	1.160
Experience	1.140
Record keeping	1.090
Motive	1.070
Distance to agrovet	1.070
Region	1.030
Mean VIF	**1.240**

likelihood of being aware of the disease compared to those living farther away. The close physical distance to these agro-veterinary service providers facilitate easier access to vital information concerning strategies for preventing and controlling poultry diseases, thereby enhancing farmers' awareness of ND. Conversely, farmers situated at greater distances from these agro-veterinary input suppliers encounter challenges in accessing information related to diseases and veterinary inputs. This finding is in line with the results reported by Waweru et al. (2023), who highlight that the proximity to agro-veterinary input providers, specifically vaccine vendors, influences knowledge and control of ND. Additionally, Kamau et al. (2018) observed that regular interaction with service providers like extension services which is influenced by proximity contributes to the dissemination and adoption of knowledge pertaining to improved practices in poultry production.

4. Conclusion and recommendations

This study assessed chicken farmers's awareness and perceptions on Newcastle disease in two regions of Kenya. From the results, it is evident that chicken farming in both Kakamega (high rainfall area) and Machakos (low rainfall area) is dominated by women, older farmers, and farmers possessing education above primary level. Most of the farmers viewed ND outbreaks as highly severe, with their perceptions shaped by the disease's impact on their livelihoods. It was evident that these farmers had an awareness of ND, and a significant portion of them relied on non-institutional sources for information. The level of farmer awareness was mainly influenced by their access to training in animal health, credit and distance to agro-veterinary service providers.

Based on the findings, it is recommended that Kakamega and Machakos County governments invest in institutional and support services, including the recruitment and deployment of extension officers who can readily assist poultry farmers. Innovative methods for disseminating information to reach a broader audience of farmers should be adopted, including collaborations with private extension providers, development partners, and the use of information communication technologies. Financial institutions operating in the counties should also be encouraged to tailor their financial products to be more appealing to chicken farmers in terms of amounts disbursed, cost, timeliness and flexible repayment terms.

Given the low adoption of vaccines due to issues like vaccine storage costs and the distance to agro-veterinary services, county governments should consider developing essential infrastructure, such as vaccine storage facilities at the sub-county level, to facilitate efficient cold chain systems and ensure the delivery of high-quality and effective vaccines. Additionally, this study recommends further research to assess the factors contributing to the low adoption of vaccines and to gauge farmers' willingness to adopt conventional ND vaccination. Such research will provide insights into farmers' perceptions regarding vaccine pricing.

Acknowledgement
We extend our gratitude to the Défense Threat Reduction Agency (DTRA), through the United States Department of Agriculture (USDA), Kenya Agricultural and Livestock Research Organization (KALRO), The Department of Veterinary Services (DVS) – Kenya, and Kenya Wildlife Services (KWS) for their generous financial support, which facilitated data collection for this study as part of their collaborative project on the "Surveillance, Molecular Epidemiology, and Control of Newcastle Disease in Kenya".

Funding
This research was supported by the Defense Threat Reduction Agency (DTRA) – USA, as part of the project on Surveillance, Molecular Epidemiology, and Control of Newcastle Disease in Kenya: Grant number BAA # FRCALL 12-6-2-0015.

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Disclosure statement
The authors did not disclose any potential conflicts of interest.

Data availability statement
The data supporting the findings of this study can be obtained from the corresponding author, [B. O. I], upon reasonable request.

Ethical considerations
Prior to their participation in the study, all individuals who were interviewed provided informed consent. All procedures conducted during the study adhered to the ethical standards established by the animal welfare committee of the Kenya Agricultural and Livestock Research Organization.

Supplementary material
Supplemental data for this article can be accessed online at https://doi.org/10.1080/23311932.2023.2292869

Citation information
Cite this article as: Farmers' awareness and perceptions on Newcastle disease in chicken: Evidence from high and low rainfall regions of Kenya, Billy Okemer Ipara, David Jakinda Otieno, Rose Adhiambo Nyikal & Nabwile Stellah Makokha, *Cogent Food & Agriculture* (2024), 10: 2292869.

Note
1. Virulent Newcastle disease (ND) is a contagious and fatal viral disease affecting the respiratory, nervous and digestive systems of birds and poultry. The disease is so virulent that many birds and poultry die without showing any clinical signs. Source: USDA (2023)- https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/avian/virulent-newcastle/vnd.

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