The role of unregulated chicken marketing practices on the frequency of Newcastle disease outbreaks in Kenya

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ABSTRACT In developing countries, chicken trade is characterized by complex chains comprising of many actors with limited biosecurity. This increases the spread of chicken diseases like Newcastle disease (**ND**). In Kenya, there is lack of uniformity in practices used in live bird markets, leading to increased disease outbreaks. This study aimed at assessing the effects of the chicken marketing practices on the frequency of ND outbreaks. A Poisson regression (**PRM**) was used on data collected from 336 traders selected using multistage sampling in Kakamega, Machakos, and Nairobi. Results highlight the low access of trainings and credit by traders. From the PRM results, breed composition, market channel, transportation, origin of birds, mixing of birds, slaughter of birds, disposal of waste, and housing as well as trader attributes like ND awareness, licensing, gender, and age had significant effects on the frequency of ND outbreaks. The study recommends that County governments collaborate with development partners to develop innovative ways of disseminating information on ND. The County governments should invest in market infrastructure such as slaughter facilities, special shelters and waste disposal equipment. There is also need for enforcement of biosecurity and hygiene measures through regular market inspections.

Key words: unregulated practice, live bird market, biosecurity, marketing channel

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INTRODUCTION

Poultry subsector is an important livelihood enterprise that provides food, income, and other economic benefits to millions of smallholder farmers in Sub Saharan Africa (Magothe et al., 2012). It also plays an important socio-cultural and religious role for millions of households in rural areas. In Kenya, the sub-sector contributes to 7.8% of the overall national gross domestic product (GDP) as well as 24% of the agricultural sector's GDP (MoALF, 2015).

According to Omiti and Okuthe (2009), the poultry sub-sector in Kenya is classified into 4 systems; industrial integrated, hatcheries, semi-commercial, and free range. Industrial integrated system is characterized by large scale commercial birds and high levels of biosecurity. Hatcheries have high levels of biosecurity and include Kenchic and Muguku farms, among others. Semi-commercial enterprises are dominated by small-scale producers, with minimal to low levels of biosecurity. The free-range sector is the most dominant one and mainly characterized as a low input- low output system with minimal or no biosecurity measures. Free range systems of production pose difficulties in terms of management of diseases because the birds are exposed to direct contact with parasites and disease-causing pathogens (Ogada et al., 2016).

Despite the important role played by the chicken subsector through provision of incomes and food as well as poverty reduction, production is hampered by challenges such as high disease incidences and lack of extension and trainings (Ochieng et al., 2013; Olwande et al., 2010; Ogali et al., 2018). Newcastle Disease (**ND**) is the main challenge for the backyard poultry in most households across Kenya (Olwande et al., 2016). Outbreaks of the disease result in 80 to 100% mortalities in unvaccinated flocks causing high economic losses to farmers and traders (Njagi et al., 2010). Prevailing chicken rearing and marketing practices applied by farmers and traders provide an avenue for spread and outbreaks of ND. This is due to the lack of uniformity in the practices, thereby providing conditions that favor the outbreaks of ND.

In Kenya, markets can be generally grouped into 3 categories: urban, peri-urban, and rural markets. This

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can be determined based on the degree of market integration which can be measured by the distance to the nearest town/urban center and the main marketing outlets city centers and urban areas, degree of market integration (Omiti et al., 2006). These aspects play a role in determining the practices carried out by the traders. Urban markets are mostly located in cities and major towns such as Nairobi. The demand for chicken in most urban areas in Kenya is high due to increased purchasing power in peri-urban and urban households (Otieno and Kerubo, 2016). Broiler and indigenous chicken are the most dominant breeds sold, with most chicken originating from other regions. The customers also prefer chicken in slaughtered form rather than in live form, due to the lack of time to slaughter and dress chicken before cooking. The markets also have basic infrastructure such as slaughter facilities. This results in practices such as slaughter of birds within the markets. Urban markets such as those in Nairobi are also dominated by actors like city council and government sanitary inspectors and who ensure hygiene practices are followed (Carron et al., 2017).

Peri-urban markets are mostly located in the periphery of urban centers and towns with close proximity to urban areas. Most peri-urban markets are transit and collection points for chicken from different origins, for final transportation to urban markets. The market activities are dominated by middle men who collect chicken from multiple traders. Such markets have limited infrastructure such as sheds and slaughter facilities, as well as limited inspection by health officials. Rural markets are mostly located in rural areas, along major highways and roads. The markets are mostly live bird markets with activities held on specific days, resulting in the frequent movement of traders and live birds to different markets. Indigenous chicken are the most dominant breeds sold in such markets. Birds originate from different farms within the areas where the markets are located. The markets lack basic infrastructure such as sheds and slaughter facilities with no inspection by animal health and meat inspectors.

According to Okello et al. (2010), trade in poultry and poultry products in Kenya is characterized by extensive movement of live birds and their products. The dominance of the indigenous poultry production system in Kenya with its limited biosecurity and the nature of the poultry trade poses a potentially significant challenge to the design of strategies necessary to prevent possible outbreaks. Several studies have highlighted the potential role of unregulated transportation, marketing and handling practices on frequent outbreaks of ND. For instance, Mulisa et al. (2013) in Ethiopia found that practices like mixing of new and old batches of birds, mixing of poultry originating from different areas, poor biosecurity practices as well as transportation were leading causes of the disease spread and outbreaks.

In Kenya, Munyua et al. (2013) and Ogali et al. (2018) showed that improper cleaning and disinfection of markets, mixing of new and old birds as well as trading multiple poultry species in the same market were responsible for spread of Influenza virus.

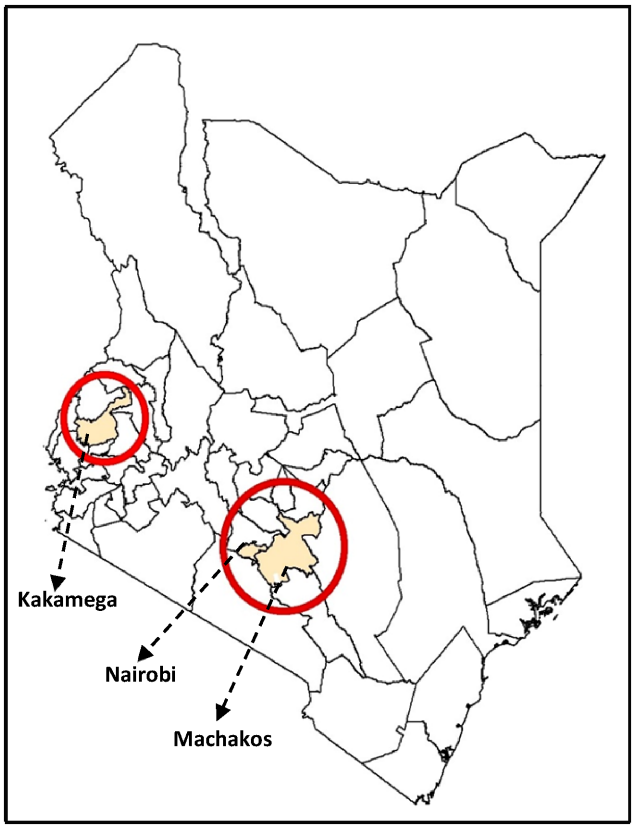

Figure 1. Map of the study areas. Source: Survey Data (2018).

However, in the case of ND and especially in Kenya, there still remains a dearth of empirical knowledge on the role played by chicken transportation, marketing and handling practices on the frequency of outbreaks. It is also unclear how traders respond to disease outbreaks in markets. Considering the severe economic losses and human health hazards associated with food-borne diseases, the need to understand how value chain practices especially at marketing stage contribute to ND spread is of utmost urgency. This study thus offers insights to address the aforementioned gaps.

MATERIALS AND METHODS

Study Area

The study was conducted in Kakamega, Machakos, and Nairobi counties of Kenya (See Figure 1). In these counties, chicken production has been prioritized as a value chain (CIDP, 2018a,b). Kakamega County is located in the western part of Kenya, and is the second most populous county after Nairobi with the largest rural population. The county mainly relies on agricultural production and is ranked ninth in terms of agricultural output produced across the counties, contributing to 2.4% of Kenya's GDP (KNBS, 2019). Poultry is the main source of animal proteins in the area and has

cultural and traditional significance to the native communities of western Kenya, where close to 92% of the household rear chicken under the free-range system of production.

Machakos County is located in the eastern part of the country bordering the capital city of Kenya, Nairobi. Indigenous chicken is one of the prioritized value chains in the County with the number of indigenous chickens in the past few years estimated at 862,392 birds (CIDP, 2018b). It is ranked eighteenth in terms of agricultural output across the counties, it contributing 3.2% to Kenya's GDP (KNBS, 2019). It's a major origin of chicken supplied to urban areas like Nairobi.

Nairobi is the capital city of Kenya where there is a large urban population providing a high demand for chicken. Despite the county being ranked forty-fifth in terms of agricultural output across the counties. It contributes the largest proportion to Kenya's GDP at 19.8% due to contribution of the manufacturing and service sectors that are largely concentrated within the urban set-up (KNBS, 2019). Nairobi is also a final destination for poultry from across the country as well as being a transit point for poultry within the East African region (Carron et al., 2017).

Study Design, Sampling, and Data Collection

A focus group discussion (FGD) was conducted in Kakamega County. The insights from the FGD were utilized to refine and validate the survey tools to be used during data collection. A representative group of different actors involved in the chicken value chain were involved, in order to get relevant insights regarding the different aspects in chicken value chain. The FGD had 27 participants comprising chicken farmers, traders and transporters, agrovets, County government veterinary and livestock extension officers. The issues discussed included characteristics of traders, marketing and handling practices, disease awareness and outbreaks, disease response as well as institutional and support services available to chicken traders.

To account for differences in perspectives due to the involved nature of agriculture in Kenya, key informant interviews were conducted in all the three counties. The interviews were conducted to get information regarding chicken marketing activities, practices and disease outbreaks within the counties. The key informants included the County directors of veterinary services, animal production officers, leaders of trader associations within the different markets and veterinary officers within the respective counties. Insights from the FGD and the key informant interviews were also used to validate the eventual results from the study.

A 3-stage sampling procedure was used in this study. In the first stage, purposive sampling was used to select Kakamega, Nairobi, and Machakos counties. Kakamega was purposively selected because of the large number of households (92%) keeping indigenous chicken in area. Poultry is the main source of animal proteins in the area and has cultural and traditional significance to the communities around the county. Indigenous poultry is also a prioritized value chain in the county (CIDP, 2018a). Machakos County was selected because indigenous chicken is one of the prioritized value chains by the County government. Nairobi County was selected due to the large number of live bird markets where chicken slaughtering is also being carried out. Nairobi is also a final destination for poultry from across the country as well as being a transit point for poultry within the region.

In the second stage, markets within the three counties were selected based on the number of traders and the volumes of chicken traded in each market. Proximity to nearest towns/city centers and the main market outlets was used to categorize the markets (Omiti et al., 2006). Markets within a 2 km distance to city centers or major towns were classified as urban markets. Markets that were located beyond two kilometers from major towns but with close proximity to residential areas and market outlets like supermarkets were classified as peri-urban markets. Markets located in areas with rural and informal set ups were classified as rural markets.

In Kakamega, most market activities are conducted on specific days hence the frequent movement of traders and chicken to different markets/points of sale. Eight markets for live birds were selected within the county. Kakamega town and Mumias markets were selected as urban markets, Bukura and Butali were selected as peri urban markets while Musoli, Shikambi, Ogalo and Koyonzo were selected as rural markets (See Figure 2).

In Machakos, most markets activities are also conducted on specific days. Seven markets were selected within the county. Machakos town market was selected as an urban market, Kangundo and Masii were selected as peri-urban markets while Mwala, Wamunyu, Kola and Katangi were selected to represent rural markets within the county (See Figure 3). In Nairobi, most markets operate throughout the week hence the limited movement of chicken. markets. Thirteen such markets were selected. Due to their proximity to the city center, Burma, Maziwa and Kariakor were selected as urban markets while Kawangware, Kona, Uthiru, Kibera, Kangemi, Mutindwa, Kayole, Umoja, Kariobangi North and Githurai were selected as semi urban markets (See Figure 4).

Determining the actual population of traders in live bird markets was difficult due to the nature of the chicken trade as it involves multiple actors and frequent movement of traders. This provided problems in estimating the sample sizes for the study. According to Mendoza (1995), there are no agreed sampling procedures or sample sizes to be used in different marketing chain segments. For this study, challenges such as the unwillingness of traders to participate in the survey and low number of traders, leading to the relatively low sample sizes in each area.

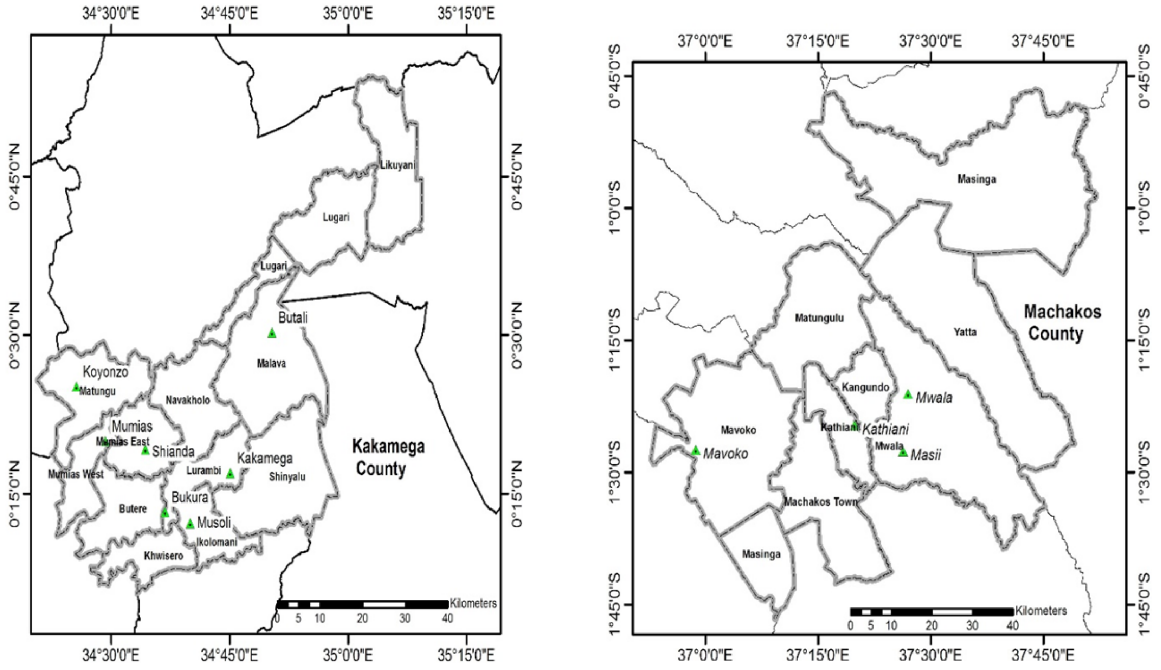

Figure 2. Map of markets in Kakamega.

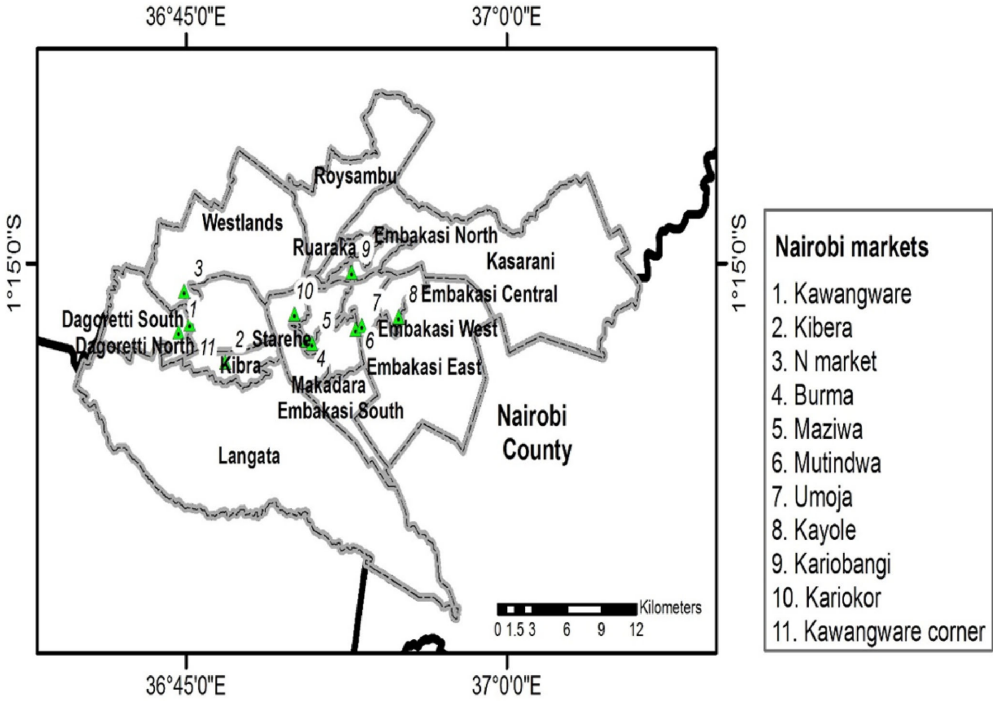

Figure 3. Map of markets in Nairobi County. Source: Survey Data (2018).

A simple random sample was used to select 119, 105, and 112 traders for interview in Kakamega, Machakos, and Nairobi, respectively using semi-structured questionnaires. The questionnaires were administered through face-to-face interviews and observations. The key information captured in the questionnaire included market characteristics, traders' socioeconomic characteristics, marketing and handling practices, ND awareness, outbreaks, and response measures as well as institutional support services available for the traders.

Empirical Analysis

In order to determine the effects of chicken marketing practices on the frequency of ND outbreaks, a count data model—the Poisson regression model (**PRM**) was applied. The dependent variable was measured as the

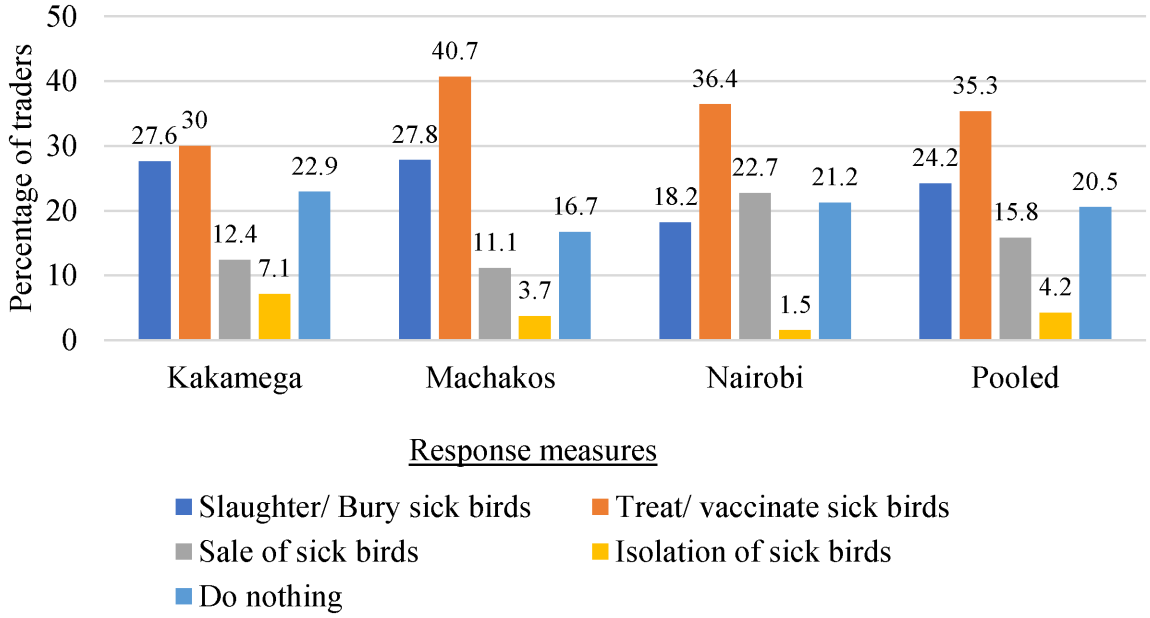

Figure 4. Response measures used by chicken traders during Newcastle disease outbreaks. Source: Survey Data (2018).

number of times a trader had experienced outbreaks of ND (birds had exhibited symptoms consistent with the clinical signs of ND within the last 6 mo). Trader attributes were also included together with the marketing practices in the model to estimate their effects on the frequency of ND outbreaks alongside the attributes used.

The PRM assumes that the dependent variable y_i given a vector of predictor variables X_i has a Poisson distribution. According to Greene (2008), the probability density function of y_i given X_i is completely determined by:

The conditional mean $E(y_i \mid x_i = \lambda_i)$ and its equi-dispersion

$$Var\ (y_i \mid x_i) = \lambda_i \tag{1}$$

with the density function as

$$f\ (y_i \mid x_i) = \frac{e^{-\lambda(x)}\lambda_i(x)^y}{\Gamma\,(1+y_i)} \tag{2}$$

where;

$\lambda_i = \exp\,(\alpha + X'\beta)$ and $y_i = 0, 1, \ldots,$ i is the number of ND outbreaks experienced by traders,
X = vector of explanatory variables, and
$\propto$ and β = the parameters to be estimated.

Wooldridge (2002) and Greene (2008) show that the expected number of events y_i (i.e., number of ND outbreaks in this case) is given as;

$$\begin{aligned} E\ (y_i|x_i) &= \text{Var}\ [y_i \mid x_i] = \lambda_i \\ &= \text{Exp}\,(\alpha + X'\beta)\ \text{for i} = 1, 2, \ldots, n \end{aligned} \tag{3}$$

where X' is a vector of the explanatory variables. The empirical equation was estimated as;

$$\begin{aligned} &ND\,frequency \\ &= f(breed\,composition,\ sale\,other\,markets,\ market \\ &channel,\ form\,birds,\ mode\,transportation,\ market \\ &type,\ origin,\ sale\,of\,other\,poultry,\ mix\,birds, \\ &slaughter\,point,\ slaughter\,birds,\ waste\,disposal, \\ &biosecurity,\ housing,\ ND\,awareness,\ training, \\ &licensing,\ experience,\ education\,level,\ gender, \\ &age + \varepsilon'). \end{aligned} \tag{4}$$

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Chicken Traders

Table 1 presents the selected characteristics of traders selling chicken in Kakamega, Machakos, and Nairobi counties. From the pooled sample, slightly over two-thirds of the traders were male; with a higher proportion in Kakamega compared to Machakos and Nairobi. This shows the dominance of men in the chicken trade. This is consistent with the findings of Bett et al. (2011) and Ochieng et al. (2013) that observe the dominance men in the marketing of chicken in major market outlets in Kenya. The average age of the respondents was 41 yr in the pooled data. The average age of traders was higher in Kakamega and Machakos compared to Nairobi (38 yr). This shows that chicken trade is generally dominated by older traders.

Table 1. Socio-economic and institutional characteristics of chicken traders.

Characteristics	Kakamega (n = 119)	Machakos (n = 105)	Nairobi (n = 112)	Pooled (n = 336)	Significant difference
Gender (% male)	83.2	71.4	58	71.1	0.012**
Average age (years)	44 (12)	41 (12)	38 (14)	41 (13)	0.116
Education level (% above primary)	31.4	48.5	61.1	49.7	0.711
Experience (% above 5 yr)	70.6	66.7	64.3	67.3	0.859
Access to training (% yes)	18.5	9.5	16.1	14.9	0.012**
Access to credit (% yes)	23.5	29.5	35.7	29.5	0.424
Group membership (% yes)	80.7	591	66.1	68.8	0.003***
Awareness on Newcastle disease (% yes)	66.4	81.9	51.8	74.1	0.061*
Licensing of trader (% yes)	86.6	59.1	95.8	81.2	0.000***
Description of trade activities (% regular)	90.2	752	88.2	84.8	0.000***

*Note: ***, **, * denote significant differences at 1%, 5%, and 10%, respectively.*
Source: Survey Data (2018).

The education level attained was generally low with almost half of the traders in the pooled sample having attained above primary education. The proportion of traders who had attained above primary level of education was significantly higher in Nairobi compared to traders in Kakamega and Machakos. The results for Nairobi are consistent with Bett et al. (2011) where majority of the traders had attained secondary school education. About two-thirds of the traders in the pooled sample had practiced chicken trading for more than 5 yr. Traders with more years of experience are likely to use better practices during transportation and sale of chicken in the market.

Access to training on animal health and chicken marketing was low with only less than a fifth of the respondents in having accessed trainings in all the three counties. Trainings of traders on disease process, animal health and marketing practices are relevant in improving chicken marketing and reducing disease outbreaks. Lack of training on such aspects leads to adoption of poor practices that lead to flaws, resulting in disease introduction and spread.

Access to credit was also low with less than a third of the respondents in the pooled sample having accessed trainings. Lack of capital is generally considered a challenge faced by traders during marketing. Farhana (2015) also reports the lack of capital as one of the challenges facing microentrepreneurs. Carron et al. (2017) also reported difficulties by poultry traders in accessing credit in Kenya.

Group membership among traders was very high; four-fifths in Kakamega, three-fifths in Machakos, close to three quarter for the pooled sample and two-thirds for Nairobi. From the FGD and key informant interviews, it was evident that most traders belonged to trader associations as they were regarded as avenues by traders to increase their bargaining power with authorities in charge of the markets. Traders in groups had better negotiating power in terms of allocation of stalls and selling points within the markets. Carron et al. (2017) reports the existence of trade associations as an avenue by traders to champion for their rights in relation to marketing and administrative matters as well as improving negotiations with the authorities.

Awareness to ND was higher among traders in Machakos, compared to Kakamega and Nairobi. In this study, traders who had knowledge about ND and could identify the disease based on the signs and symptoms consistent with ND were deemed to be aware. Traders in Nairobi were least aware of ND. The low awareness in Nairobi compared to Machakos and Kakamega could be explained by the fact that most chicken traders in Machakos and Kakamega also rear chicken at home, hence have prior knowledge regarding the ND at the production stage. Awareness and knowledge of the disease is considered a major step in preventing potential outbreaks (Omiti and Okute, 2009). Limited awareness and perceptions of diseases leads to flaws in management, contributing to increased outbreaks. Most traders in Kakamega identified the disease using the local name "*muyekha*", and in Machakos the disease was identified as "*mavuii*". In Nairobi, traders commonly identified the disease using the local name "*kihuruto*" among the Kikuyu community.

Description of Marketing Practices Included in the PRM

As highlighted in Table 2, three-quarters of the traders sold multiple breeds of chicken compared to single breeds. The traders sold a mix of different breeds of chicken such as indigenous, spent layers, improved, and broilers together within the markets. This practice was highly common especially in Kakamega and Machakos because of the large number of chicken farmers who rear different breeds of chicken. This leads to the availability of multiple breeds for sale. The sale of chicken in multiple markets was practices by most traders in Kakamega and Machakos. In Nairobi, slightly above half of the traders sold chicken in one market. In Kakamega and Machakos, most markets operate on specific days hence the constant movement of traders to different markets. In contrast, most markets in Nairobi operate daily hence most traders sold chicken in specific markets.

Most of the traders in the pooled sample as well as in Kakamega and Machakos used direct channels to source

Table 2. Description and summary statistics of marketing practices included in Poisson regression.

Variable Practices	Description of variables	Kakamega (n = 119) %	Machakos (n = 105) %	Nairobi (n = 112) %	Pooled (n = 336) %
Breed	Types of breeds sold:				
	1 = Single breed	16.0	17.4	33.0	22.1
	0 = Otherwise	84.0	82.6	67.0	77.9
Sale in other markets	Sale of chicken in multiple market				
	1 = Yes	79.8	77.1	48.2	68.5
	0 = Otherwise	20.2	22.9	51.8	31.5
Market channel	Market channel to source chicken				
	1 = Direct	64.7	58.1	48.2	56.8
	0 = Otherwise	48.2	41.9	51.8	43.2
Form of birds	Form of birds sold by trader				
	1 = Live	99.0	93.3	66.1	86.3
	0 = Slaughtered	1.0	6.7	33.9	13.7
Transportation mode	Transport mode used:				
	1 = On foot	6.7	14.3	2.7	7.7
	2 = Motorcycle	22.7	36.2	80.4	46.1
	3 = Motor Vehicle	98.9	381.	13.4	40.8
	4 = Others	1.7	11.4	3.5	5.4
Market type	Type of market:				
	1 = Open air	99.0	93.3	78.6	90.5
	0 = Otherwise	1.0	6.7	21.4	9.5
Origin of birds	County where birds are sourced from				
	1 = Within county	50.4	81.9	78.6	69.6
	0 = Otherwise	49.6	18.1	21.4	30.4
Sale of other poultry	Sale of other poultry varieties:				
	1 = Yes	33.6	8.6	12.5	81.3
	0 = Otherwise	66.4	91.4	87.5	18.7
Mix of birds	Mixing of birds from different sources				
	1 = Yes	91.6	86.7	92.7	90.5
	0 = Otherwise	8.4	13.3	7.1	9.5
Designated slaughter point	Availability of designated slaughter point within market				
	1 = Yes	13.5	14.3	65.2	30.9
	0 = Otherwise	86.5	85.7	34.8	69.1
Slaughter of birds	Slaughter of birds within market				
	1 = Yes	26.1	31.4	97.3	51.5
	0 = Otherwise	73.9	68.5	2.7	48.5
Disposal of wastes	Disposal of chicken waste by trader				
	1 = Yes	17.6	29.5	86.6	44.4
	0 = Otherwise	82.4	70.5	13.4	55.6
Biosecurity	Presence of disease preventing measures				
	1 = Yes	76.5	64.8	61.6	67.8
	0 = Otherwise	25.5	35.2	38.4	32.2
Housing of birds	Provision of shelter to chicken in market				
	1 = Yes	30.3	24.7	65.2	40.2
	0 = Otherwise	69.7	75.3	34.8	59.8

their stock compared to other sources. Direct sourcing of chicken involved traders using their own stock at home or sourcing their birds directly from farmers at the farm gate. In Kakamega and Machakos, most traders were also chicken farmers hence relied on the birds reared at home as stock. In contrast, approximately half of the traders in Nairobi used indirect channels to source their chicken. Traders sourced their chicken from middlemen/brokers and fellow traders. Results in Nairobi are consistent with Munyua et al. (2013) who report that the birds sourced by traders in Nairobi were supplied by middlemen.

The most dominant form of birds sold by traders in Kakamega, Machakos as well as the pooled sample was live birds. Most consumers in Kakamega and Machakos preferred chicken in its live form compared to slaughtered chicken. This can be due to the lack of slaughter facilities (Murekefu, 2013). However, Nairobi had a significant proportion of traders who sold slaughtered chicken. The most dominant transport mode used for transportation in the pooled sample as well as in Kakamega and Machakos was bicycle and motor cycles. In Kakamega and Machakos, bicycles and motorcycles are the cheapest and most convenient forms of transport. In Nairobi, most traders used public vehicles and pick-up trucks to transport their chicken to live bird markets. Studies like Okello et al. (2010) and Aila et al. (2012) report that the transportation process relies on bicycles, public transport, open carriers, and hand carts.

In the pooled sample, most of the traders sold their chicken in open air markets compared to closed markets. However, there were a significant number of traders in Nairobi who sold their chicken in closed markets. Markets like Kariakor in Nairobi are closed air markets. Live bird markets are considered sources of

disease outbreaks as the birds come into contact with disease causing pathogens as well as waste. The lack of sanitation in open air markets also provides an avenue for disease outbreaks. Majority of the farmers sold chicken that originated within the counties they traded. In Kakamega, there were a significant proportion of farmers (49.6%) who sourced their stock form neighbouring counties namely Nandi, Busia, Bungoma, and Uasin Gishu. Few traders across all the 3 counties sold other types of poultry such as turkey, geese, ducks, and Guinea fowls.

The practice of mixing birds from different sources was commonly used by most traders across the 3 counties. Traders also mixed newly acquired bird together with those that have been in the market longer. This practice may result in the interaction between sick birds and healthy birds, increasing the frequency of ND. According to Swai et al. (2011) and Ogali et al. (2018), mixing of chicken during transit and at point of sale in markets is a source of disease spread and outbreaks.

Slaughter of birds within the market place was highly practiced by traders in Nairobi compared to Kakamega and Machakos. Most consumers in Kakamega prefer live chicken compared to slaughtered chicken due to cultural reasons, resulting in the limited slaughter activities within the market place. In Nairobi, most consumers preferred slaughtered chicken compared to live chicken due to time constraints, as chicken requires time to slaughter and dress before cooking. This is consistent with Otieno and Kerubo (2016). Similarly, most traders in Nairobi (65.2%) sold chicken in markets that had designated slaughter points compared to Kakamega and Machakos. Most markets in Kakamega and Machakos lacked the infrastructure to facilitate the slaughter of birds within the markets. Inadequate infrastructure is highlighted as one of the characteristics of emerging markets (Bang et al., 2016).

Disposal of waste was mainly practiced by traders in Nairobi. In Kakamega and Machakos, most traders left waste within the premises of the markets. Proper disposal of the wastes reduces the likelihood of birds coming into contact with disease spreading pathogens. Studies by Njagi et al. (2010) and Mulisa et al. (2014) have reported inappropriate disposal of infected birds, carcasses and fecal matter as factor associated with outbreaks.

Majority of the traders across the 3 counties had put in place basic measures to prevent outbreaks and spread of diseases within the markets. Such measures include isolation of sick birds from healthy birds, disinfection of premises, screening of birds for symptoms of diseases and the separation of flock according to age. Limited biosecurity is one of the factors that pose a challenge in preventing disease outbreaks (Okello et al., 2010). In the pooled sample, 53% of the traders did not provide housing for their chicken in the market places. This was generally the status of housing in most markets across Kakamega and Machakos where birds were rarely housed in the market place. However, most traders in Nairobi provided housing and shelter for their birds within the markets by special cages and shades.

Effects of Marketing Practices and Trader Attributes on the Frequency of ND Outbreaks

Table 3 highlights the effects of marketing practices used and the trader on the frequency of ND outbreaks in Kenya. Breed composition had a negative effect on ND frequency in Kakamega, Nairobi as well as in the pooled sample. Traders who sold single breeds of chicken were likely to experience less ND outbreaks compared to those who sold multiple breeds. A mix of breeds increases the risk of outbreaks as it creates a challenge in disease monitoring. Some breeds like the exotic and cross breeds are more susceptible to diseases compared to indigenous breeds. The mixing of multiple breeds together increases the risk of exposure to disease which increases the frequency of disease. Similar results were reported by Munyua et al. (2013) which reckons that trading multiple breeds in the same market could promote disease transmission among birds.

Marketing channels had a positive effect on the ND frequency in Kakamega as well as in the pooled sample. As compared to direct sourcing of chicken, traders who used other channels were likely to experience more outbreaks of ND. The use of indirect channels such as multiple middle men is a common practice of traders to source chicken. This provides an avenue for disease outbreaks. Akinwumi et al. (2009) noted that collectors and distributors mix poultry and deliberately sell sick birds to retailers thus encouraging outbreaks of diseases. Results show that the traders who used bicycles and motorcycles (*boda-boda*) to transport chicken to the markets experienced more outbreaks compared to those who used other modes in Kakamega. In chicken marketing, there is lack of specialized transport systems. Traders in Kakamega use bicycles and motorcycles so as to reduce the transportation cost, as it is the most common and cheapest transport mode in the county. The birds are tied upside-down and transported and this exposes the birds being transported and those in areas where they pass through to infectious disease. According to Nyaga (2007), such unregulated transportation is considered a source of biosecurity breach thus contributing to high incidences of ND outbreaks.

The number of origins of birds had a negative effect on ND frequency in Kakamega. Traders who sourced their birds from a single origin were likely to experience less outbreaks of ND compared to those who got their birds from multiple sources. Traders who source birds within the county of trade have more incentive to inspect birds for diseases compared to those who source from other counties due to the fear of losing their trade licenses for non-compliance with sanitary and biosecurity measures prescribed by the

Table 3. Poisson regression results for effects of chicken marketing practices and trader attributes on frequency of Newcastle disease (ND) outbreaks.

	Kakamega (n = 119)		Machakos (n = 105)		Nairobi (n = 112)		Pooled (n = 336)	
Variable	Coef.	*P*-value	Coef.	*P*-value	Coef.	*P*-value	Coef.	*P*-value
Marketing practices								
Breed composition	−.231	0.020**	.102	0.578	−.219	0.062*	−.167	0.010**
Sale in other markets	.198	0.482	.100	0.770	−.146	0.515	.034	0.802
Market channel	.527	0.021**	.452	0.114	−.149	0.563	.336	0.008***
Form of birds	11.776	0.989	−1.279	0.023**	−.246	0.382	−.409	0.045
Transportation mode								
Motorcycle/bicycle	.865	0.031**	.443	0.341	.465	0.525	−.011	0.963
Motor vehicle	−.245	0.466	.226	0.606	.318	0.661	.168	0.436
Others	−.564	0.363	.143	0.789	.964	0.250	−.126	0.674
Market type	.207	0.845	−.376	0.592	−.448	0.177	−.286	0.205
Origin of birds	−.390	0.043**	−.377	0.284	−.403	0.174	−.268	0.031**
Sale of other poultry	.003	0.987	.458	0.324	.327	0.280	.315	0.019**
Mix of birds	1.424	0.010**	.830	0.105	−.444	0.333	.772	0.002***
Designated slaughter point	−.456	0.371	−.217	0.758	.099	0.711	.038	0.835
Slaughter of birds	.261	0.532	−1.468	0.012**	−.971	0.070*	−.416	0.026**
Disposal of wastes	−1.584	0.001***	−.039	0.929	−.469	0.283	−.216	0.263
Presence of biosecurity	−.175	0.390	−.057	0.829	−.232	0.372	−.077	0.516
Housing of birds	.039	0.061*	.604	0.104	.008	0.760	.362	0.013**
Trader Attributes								
ND Awareness	−.176	0.411	−.131	0.723	−.824	0.003***	.234	0.092
Access to training	−.079	0.757	.850	0.014**	−.364	0.263	.127	0.422
Licensing	−.951	0.024**	−.659	0.028**	−.304	0.440	−.196	0.197
Trade description	−.138	0.622	.071	0.881	−.124	0.684	−.381	0.270
Education level	.158	0.425	.029	0.918	−.232	0.302	−.283	0.031**
Gender	−.128	0.654	−.014	−0.197	−.569	0.016**	. −009	0.053*
Age	.005	0.557	1.386	0.288	.0216	0.007***	.415	0.411
Constant	−11.503	0.989	−.131	0.723	2.277	0.030	.234	0.092*
Log likelihood	−167.046		−114.537		−126.002		−451.157	
Pseudo-R^2	0.170		0.012		0.1498		0.077	
Prob> Chi^2	0.000		0.062		0.004		0.000	

Source: Survey Data, 2018.

animal and meat inspectors. Those who source from multiple origins mostly rely on brokers and middle men for their source hence the likelihood of getting sick birds. This is consistent with the findings of Mulisa et al. (2014) who observed that the mixture of birds from different origins creates avenue for exchange of pathogens.

The mixing of birds from different places was found to have a positive effect on ND frequency traders who mixed birds from different sources together at the market place were likely to experience more outbreaks compared to traders who separated their flock. Birds from the different and unknown sources are mixed together during transportation and at the market, without screening. Traders also mix newly acquired bird together with those that have been in the market longer. This results in the interaction between sick and healthy birds, increasing the frequency of ND. According to Swai et al. (2011), mixing of chicken during transit and at point of sale in markets is a source of disease spread and outbreaks. This result is also consistent with those found by Munyua et al. (2013) and Ogali et al. (2018).

Proper disposal of waste by farmers was found to have a negative effect on ND frequency in Kakamega. Traders who properly disposed waste were likely to experience less outbreaks compared to traders who did not. Birds come in contact with wastes that form intermediate hosts of various diseases. Proper disposal of the wastes reduces the likelihood of birds coming into contact with disease spreading pathogens. Similar results were reported by Mulisa et al. (2014) in Ethiopia where inappropriate disposal of infected birds' carcasses and faecal matter was highlighted as a factor associated with high disease outbreaks in live bird markets.

Provision of housing to chicken within the market place was also found to have a positive effect on ND frequency in both Kakamega and the pooled sample. In most live bird markets, makeshift houses and cages are used to confine the birds. Such houses have poor sanitation and lack adequate ventilation. This provides an avenue for spread of viruses within the market place as the birds come into contact with waste, external parasites, and disease carrying pathogens. This increases the likelihood of disease spread hence increase in ND frequency.

ND awareness was found to have a negative effect on the frequency of ND outbreaks among traders in Nairobi. Traders who were aware of ND were likely to experience less outbreaks of ND compared to those who were not aware. Traders with knowledge about ND are likely to put measures in place at markets to reduce the risk of disease occurring. This reduces the frequency of disease outbreaks. Traders with limited awareness are likely to experience more outbreaks of ND due to

their limited knowledge regarding disease prevention and control; hence they use practices that increase the risk of disease spread.

Training was found to have a negative effect on the frequency of ND outbreaks experienced by traders in Machakos. Farmers who had undergone training regarding chicken marketing and handling were likely to experience less outbreaks of ND compared to those who had not undergone training. Trainings of traders on disease process, animal health, and management practices are relevant in improving chicken production. Lack of training on such aspects leads to adoption of poor practices that lead to flaws, resulting in disease introduction and spread. According to Ochieng et al. (2013), trainings facilitate the adoption of management interventions in rural areas.

Licensing of trader was found to have a negative effect on the frequency of ND outbreaks in Kakamega and Machakos. Traders who had licenses to practice chicken trading in markets were likely to experience less outbreaks of ND compared to those without licenses. Licensed traders have the incentive to comply with hygiene and sanitation standards hence employ implement biosecurity measures and better practices. Compliance with the standards results in reduced outbreaks of ND. Lack of compliance provides an avenue for disease spread hence increased outbreaks of diseases in markets.

Education level was found to have a negative effect on the frequency of ND outbreaks in the pooled data. Traders with higher levels of education were likely to experience less outbreaks of ND compared to traders with low education levels. Farmers with high levels of education have a better understanding of the disease process and animal health. An increase in years of education among traders increases the rate of adoption of improved practices, resulting in reduced risk of outbreaks. Kyule et al. (2015) report that high level of education influences the level of understanding of disease process and the factors affecting health as well as their attitude towards disease. Highly educated farmers are expected to be more aware of ND hence invest in better management and feeding practices.

Age of the trader had a positive effect on the frequency of ND outbreak at 10 percent in both Kakamega and the pooled sample. Older traders experienced more outbreaks compared to younger traders. Older traders are more risk averse and have negative attitudes towards embracing modern practices and technologies to prevent outbreaks of diseases. Older traders are also limited in terms of accessing information regarding disease and preventive mechanisms, making them lack proper measures to prevent disease spread and outbreaks. This increases the likelihood of older traders experiencing more outbreaks.

Gender of the trader had a negative effect on the frequency of ND outbreaks in Nairobi as well as the pooled sample. Male traders were likely to experience less outbreaks compared to female traders. Chicken trade and marketing is a male dominated activity hence male traders are mostly involved in the day-to-day marketing of chicken. This increases the likelihood of men being aware of ND, its outbreaks and preventive measures, hence the use of better practices within the markets. This reduces the frequency of ND outbreaks. Ochieng et al. (2013) and Bett et al. (2011) reported that men dominate chicken marketing.

Traders' Response Mechanisms to Manage ND Outbreaks in Live Bird Markets

Traders generally use different response measures during suspected ND outbreaks within their flock in live bird markets. Figure 4 highlights the different measures used by the chicken traders. The most common response measure was treatment of the birds that exhibit symptoms of ND. There was also slaughtering of sick birds as a salvage measure as well as their sale, *albeit* without disclosure to potential buyers; thus, knowingly contributing to further spread of diseases among the chicken flock as well as deliberately endangering the lives of potential consumers of such infected chicken meat. According to Otim et al. (2007), the sale and salvage slaughter are some of the actions taken during suspected ND outbreaks. Some traders did not have any response measures during outbreak of the disease. They would let the birds die, and salvage the remaining birds after the outbreaks.

CONCLUSION

This study assessed chicken traders' characteristics, their marketing practices and how these contribute to spread of ND. Results showed that access to institutional and support services training were very low. There is need to create more awareness among traders on aspects like disease detection, disease response strategies as well as mitigation measures during outbreaks. The Counties through their respective agricultural and veterinary departments should collaborate with private extension providers and development partners to explore innovative ways of disseminating information regarding ND.

County governments can invest in market infrastructure through construction and provision of market facilities such as designated slaughter points, shelters, and waste disposal equipment such as waste bins within the markets. There is also need of authorities in charge of live bird markets to ensure the enforcement and compliance to biosecurity, sanitation and hygiene practices by traders within markets. This can be done through regular inspection and monitoring of live bird markets to ensure compliance by traders to sanitation and health regulations.

Traders should be sensitized on hygiene, sanitation and safety measures during transportation as well as the slaughter stages during marketing. Traders should also

be trained on how to screen birds from different sources for signs and symptoms of diseases. This will reduce the likelihood of getting sick birds from the different sources and origin.

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ETHICAL CONSIDERATIONS

All interviewed persons gave their informed consent prior to their inclusion in the study. All procedures performed in studies were in accordance with the ethical standards of the animal welfare committee of the Kenya Agricultural and Livestock Research Organization.

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