Vol. 12(4), pp. 168-175, October-December 2021
DOI: 10.5897/IJLP2021.0769
Article Number: 5ABA65468350
ISSN 2141-2448

http://www.academicjournals.org/IJLP

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International Journal of Livestock Production

Full Length Research Paper

Assessment of the effects of Newcastle disease vaccination on chicken mortality and egg production rates in Machakos town sub-county, Kenya

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Received 16 February, 2021; Accepted 29 October, 2021

A study was done to evaluate the effects of the Newcastle disease vaccine on chicken mortality and egg production in Machakos Town Sub-County. Kola and Kalama wards were chosen, and the data was collected from rural poultry farmers using a semi-structured questionnaire and Women Empowerment Livestock Index (WELI). The sample size was determined using $N= Z^2 (1-P) P/L^2$ statistical formula. A total of 261 chicken household farmers were interviewed. Fifty-nine-point four percent of the households reported a Newcastle disease (ND) outbreak among their flock in 2018. In addition, 25.3% of the respondents reported that their chicken stopped laying after being infected with the disease. In comparison, 14.9% reported average egg production, and 10.7% reported a 50% reduction in egg production. Furthermore, 56.3% of farmers diagnosed ND by observing clinical symptoms instead of seeking veterinarian advice. Sixty-five (98.5%) of the respondents failed to vaccinate their poultry flock, while 1.5% reported chicken vaccination against ND. Rural farmers' lack of ND vaccination was due to the long distance between their homestead and the agrovet shops. In addition, the vaccine providers were located in urban areas. Furthermore, the I-2 vaccine and the Lasota strain were the two primary vaccines sold in agrovet shops in Machakos town. Although there is a relationship between chicken vaccination against ND, egg production, and mortality rates among chicken flocks, vaccine suppliers' access to a significant barrier to vaccine uptake in both wards.

Key words: Women's Empowerment in Livestock Index (WELI), vaccination, gender.

INTRODUCTION

Poultry, a significant animal industry in Kenya, contributes about 8% of agricultural value addition through annual processing of 25000 tons and 1.3 billion of poultry meat and eggs, respectively, jointly valued at Kenyan Shilling (KES) 28.5 billion (FAO, 2017). In addition, village chickens in developing countries play an essential role in most rural households (Alders et al., 2010). Therefore, women traditionally reared and owned extensive poultry production (Vincent et al., 2011). Egg production has scaled by 24.4% globally over the last decade, reaching 76.7 million tonnes in 2018 (Dilawar et al., 2021).

Intensive chicken farming has become necessary

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because of the increased demand for animal-derived protein, resulting in an increase in illness, chronic stress, and compromised production (Dilawar et al., 2021). In addition, chickens are susceptible to Newcastle disease (ND), a viral infection that causes devastating losses in Kenya's commercial and indigenous chickens. However, it has been demonstrated that this disease can be controlled by poultry flock vaccination (Grimes, 2002).

Several ND vaccines are available, including the I-2, NDV 4-HR, La Sota, Hitchner B1, and ITA-NEW (Ahlers et al., 2009). However, vaccination is rarely given priority in rural communities, although it is an effective method of controlling ND in commercial and village poultry (Nwanta et al., 2008). However, ND still has high morbidity and causes high mortality and egg production reduction (Sharif et al., 2014). For example, in Kenya, Newcastle disease is endemic at the village level, with Newcastle disease virus (NDV) accounting for more than half of all chicken deaths (Otiang et al., 2021). Furthermore, the rate of mortality and morbidity in a flock varies from 90-100% depending on the strain of NDV, with a decrease in egg production (Ashraf and Shah, 2014). Thus, indigenous poultry farmers are demoralized by the yearly loss of large birds to ND infectious outbreaks (Alders and Spradbrow, 2001).

Poultry production is the primary source of livelihood for many Kenyans. According to Nyaga (2007), Kenyan smallholder farmers ranked poultry keeping as the most crucial household occupation affecting their livelihoods in numerous ways. However, the influence of Newcastle disease vaccine in different parts of the country, especially in Machakos Town sub-county, has not been adequately studied. Therefore, the objective of this study was to evaluate how the use of the Newcastle disease vaccine influenced egg production and layer chicken mortality.

MATERIALS AND METHODS

Study area

The study was conducted in Machakos Town sub-county, which has seven wards. Two of those wards were selected, Kola and Kalama ward. The County population is estimated to be 1,098,584 (Kenya National Bureau of Statistics, 2010). The climate is semi-arid, and the county has an altitude of 1000 to 2100 m above sea level. It lies between latitudes of 0.45'S and 1.31'S and longitudes 36.45'E and 37.45'E and covers an area of 6,850 km^2 (County Report, 2018). The average rainfall ranges from 500-1300 mm, and the average temperature is 18-25°C. Subsistence agriculture is the leading farm activity. In addition to such drought-resistant crops as sorghum and millet, maize is grown due to the area's semi-arid state (County Report, 2018). Figure 1 shows the map of the study area.

Sampling procedure and sample size determination

A purposive sampling method was used to select the study area of Machakos sub-county. From Machakos sub-county, two wards were selected, Kola and Kalama wards, using the same method. During the survey, smallholder farmers who keep between 10 and 100 chickens and live in Kola and Kalama wards were interviewed. While selecting the households for the survey, a simple random sampling technique was used to select the households that participated in the study. The livestock and agriculture officers in both wards provided a list of households in Kola and Kalama ward villages. The households were numbered, and the numbers were randomly selected using excel random number generator. The calculated sample size was determined using proportional probability to an unknown population formula (Pfeiffer, 2010) stated below:

$n= Z^2 (1-P) P/L^2$
$= 1.96^2[1-0.5) [0.5/0.05^2] = 384.16$ or 384

Where N is the sample size for respondents; Z-value is the desired level of Confidence of 1.96 (expected of the normally distributed population); P is an estimate of the proportion of the population keeping chickens; L is the absolute size of the error in estimating, which is 5%.

In this study, a P-value of 50% was used. In Machakos County, determining the exact number of poultry farmers was challenging because of most households rear chickens. However, the sample size represented the study population since their roles and responsibilities are similar within the same category; hence any variation in the study population's data was insignificant.

Data collection

Semi-structured questionnaires and the Women's Empowerment in Livestock Index (WELI) were used to collect the households' data in the sub-county. Among the information collected were records of disease outbreaks concerning vaccination and other preventive measures against Newcastle disease. Questionnaires were administered through face-to-face interviews with the households by the researcher and enumerators.

Data analysis

The data collected was cleaned, edited, sorted, coded, and entered into Excel. It was then imported into The Statistical Package for Social Sciences (SPSS version 21.0) for analysis. Descriptive statistics were used to generate means, percentages, and frequencies. Cross tabulation was used for different variables, thus displaying their relationship in tabular form. The Chi-Square test was used to test the hypothesis that the Newcastle disease vaccine has no effect on chicken mortality and egg production and establish the association between the variables. An independent sample T-test was also used to compare the means in vaccinated and non-vaccinated chicken. For the WELI questionnaire, only module 10 was analyzed for this study.

RESULTS

Demographic characteristics

Due to respondents, availability, time, and financial constraints, only 261 out of the 384 targeted households were interviewed. The majority of the respondents (72%) were female. However, the male respondents were more educated than the female ones, with 43.8% having

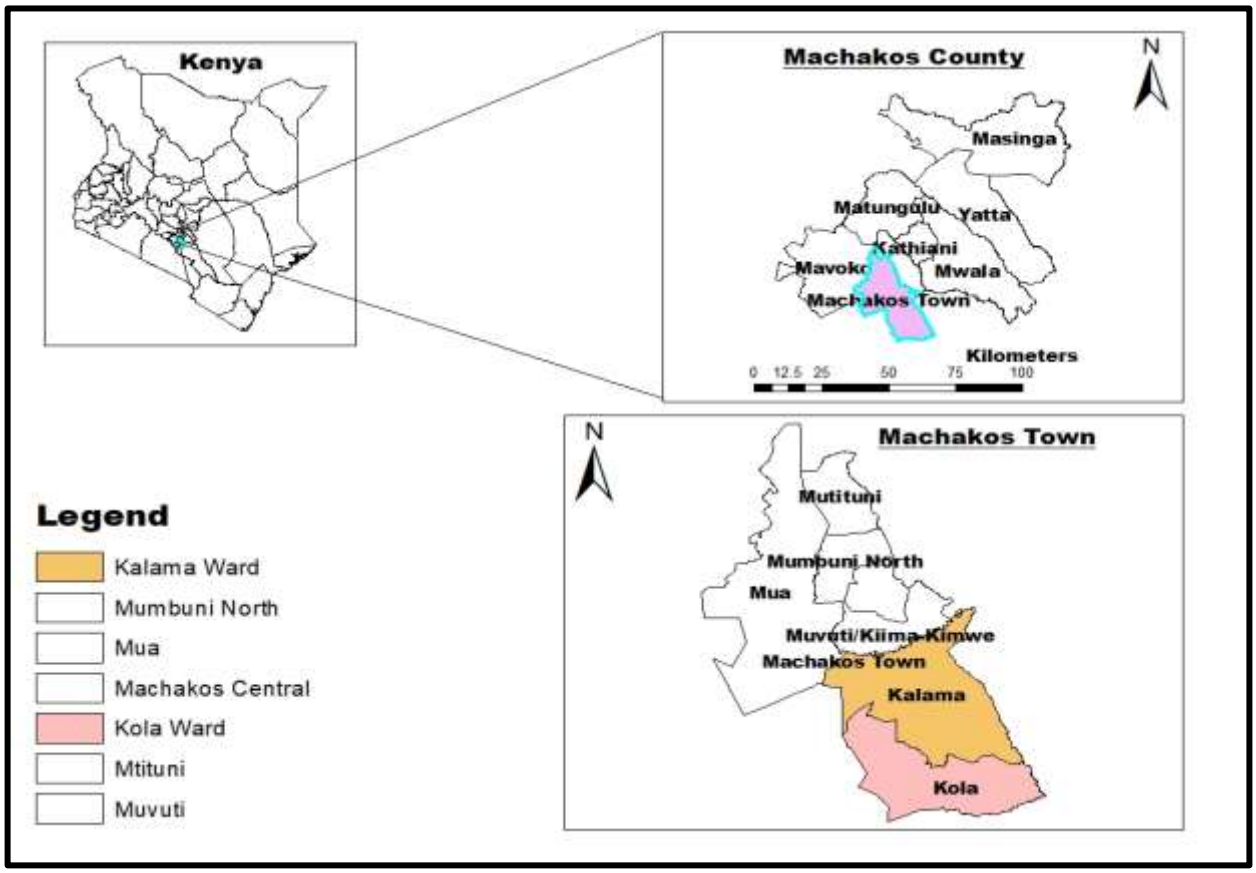

Figure 1. A Map showing Machakos County.

completed secondary education than 19.1% of the female. Thus, the majority of women-only had primary school education level, as shown in Table 1.

Disease outbreak, diagnosis, and determination

Table 2 shows the farmers' responses on their experience of disease outbreaks, ND diagnosis, and who determined the disease. Disease outbreaks were reported by 59.4% of the respondents among their flocks in the year 2018. However, of the respondents who said they had disease outbreaks, 59.4% said it was Newcastle disease. Still, only 3.1% of the cases were diagnosed by a veterinary doctor, the rest being (56.3%) self-diagnosed using clinical signs.

The relationship between egg production and ND vaccination

Table 3 shows the percentage of people who reported a change in egg production after the disease outbreak. In contrast, Table 4 shows the relationship between ND vaccination and the change in egg production. Of the 59.4% who reported that their chicken got ND, 25.3% of the respondents said their chicken stopped laying after the disease, 14.9% reported normal laying, and 10.7% reported a 50% reduction in egg production compared to the standard rate. The 25.3% reported that the chicken stopped laying, 65 (98.5%) of those said they do not vaccinate, while only one respondent said they vaccinate.

Chicken mortality and ND vaccination

An independent sample T-test was conducted to compare the mortality rate in chickens in vaccinated and non-vaccinated conditions. There was a significant difference ($P < 0.05$) in mortality between vaccinated and non-vaccinated chicken (Table 5).

Handling of a sick chicken

Table 6 shows the responses of the farmers when asked how they handled sick chickens. Seventy-one-point six percent reported the use of herbal medicine. The herbs were a mixture of Aloe-vera, red chili pepper, and other medicinal plants given in drinking water. However, 13.0%

Table 1. Respondents gender distribution and their education level.

Gender of the respondent	Frequency	Percentage
Male	73	27.9
Female	188	72.1
Total	261	100
Education level (Male)		
Primary	39	53.4
Secondary	32	43.8
College	1	1.4
Illiterate	1	1.4
Total	73	100
Education level (Female)		
Primary	146	77.7
Secondary	36	19.1
College	3	1.6
Illiterate	3	1.6
Total	188	100

Table 2. Responses On Disease Outbreak, Diagnosis, And Determination.

Variable	Frequency	Percentage
Outbreak		
Yes	155	59.4
No	106	40.6
Diagnosis		
ND	155	59.4
N/A	106	40.6
Determined		
By a Veterinarian	8	3.1
By the farmer	147	56.3

of the respondents reported the Aloe-Vera plant's sole use, and 10.3% used antibiotics.

Indigenous preventive measures for Newcastle disease

When farmers were asked if they used other preventative measures to prevent Newcastle disease, 72% said they used Aloe-Vera as a preventive measure for ND. In comparison, 16.5% said they do not use any preventative measure, and 10.3% said they use other herbal medicines (chili pepper, Aloe-vera) as a preventive measure. Table 7 shows the percentages and frequencies.

The most appropriate time to vaccinate the chicken

Table 8 shows the responses on the best time to vaccinate the chicken. Farmers were divided as to the best time to vaccinate, including before disease outbreak (34.9%), sick chickens after disease outbreak in the farm (31.8%) and the neighborhood (6.9%), and (6.1%) would vaccinate when birds in the village were sick. However, (11.5%) of the farmers did not know the best time to vaccinate.

Barriers to chicken vaccination

Table 9 shows the barriers to indigenous chicken

Table 3. Percentage effect on egg production due to ND outbreak.

Drop-in egg production (%)	Frequency (N)	Percentage
100%	66	25.3
75%	8	3.1
50%	29	11.1
25%	14	5.4
0%	39	14.9
N/A	105	40.2
Total	261	100.0

Table 4. Relationship between egg production and ND vaccination.

Variable	Drop-in egg production (%)	Do you vaccinate them against ND?		
		No (Frequency)	Yes (Frequency)	Total
How was egg production affected? And by how much?	100	65	1	66
	75	6	2	8
	50	23	6	29
	25	10	4	14
	0	30	9	39
	N/A	91	14	105

* Represents Significance at P<0.05.
Survey data (2019).

Table 5. Mortality and vaccination against ND.

Variable	Vaccinated		Not-vaccinated		Mean difference	P-value
	Mean (A)	SD	Mean (B)	SD	(A-B)	
Mortality rate	32.78	14.93	49.68	25.51	-16.89	0.003*

Note: *Represents Significance at P<0.05.
Survey data (2019).

vaccination. The main barriers included; access to vaccine supply, vaccine cost, and lack of resources. Eighty-three point five percent of the farmers reported a lack of access to vaccine supply; 51.3% could not afford the vaccine. However, when asked if they have access to chicken vaccines, 47.9% had no chicken vaccination information. Finally, when asked if vaccination can prevent the disease, 55.9% said yes, but their main barrier was lack of finances and access to the vaccine.

DISCUSSION

This study was done to assess of effects of the Newcastle disease vaccine on chicken mortality and egg production. The study shows that the most reported disease by the poultry farmers was ND. This corroborates other published research that reported ND as one of the most important viral diseases in chickens worldwide, devastatingly impacting poultry development in most countries (Barman et al., 2010). However, Atela et al. (2016) reported that women participated more in chicken farming than men; a similar trend was also observed in this study. Furthermore, a study done by Ipara (2019) reported that Newcastle disease outbreaks were common among Machakos farmers compared to Kakamega farmers by 50.6%.

Respondents noted that the most common clinical sign they observed was a discharge of greenish diarrhea by the chicken; the symptoms listed by the farmers were consistent with the clinical signs of ND infection. This compares with this study as most farmers (56.3%) diagnosed ND using only clinical signs. A survey in Myanmar stated that only 11% of respondents experienced Newcastle disease outbreaks; 48% reported no outbreaks, while 42% were not sure if they ever had

Table 6. Handling of a sick chicken.

Variable	Frequency	Percentage
Antibiotics	27	10.3
Aloe-Vera	34	13.1
herbal medicine	187	71.6
Isolation from flock	4	1.5
Did nothing	2	0.8
N/A	7	2.7
Total	261	100.0

Table 7. Indigenous practices for prevention of ND outbreaks.

Variable	Frequency	Percentage
No	43	16.5
Aloe-vera	188	72.0
Herbal medicine	27	10.3
Separate flocks	1	0.4
sell chickens off early	1	0.4
Antibiotics	1	0.4
Total	261	100.0

had the disease in their current flocks (Henning et al., 2007). Again, this contrasts with this study because 56.3% of the farmers reported that they had experienced ND, and it was self-diagnosed. The diagnostic technique that the farmers used was based on the clinical signs exhibited by the chickens. Laboratory diagnostics tests seemed impossible in their rural setup. FAO (2009) reported that diseases in rural areas are identified mainly using their symptoms, and little confirmatory diagnosis is made, partly because diagnostic support is rarely available.

ND outbreak was more frequent in the Kalama ward than the Kola ward, at 72.3 and 27.7%; this corroborates a study carried out by Ipara (2019), who reported that Kola had recorded the least number of farmers who experienced ND outbreaks compared to other wards. The Kalama ward is more significant than the Kola ward, which could be why ND outbreaks were more frequent in Kalama than in the Kola ward.

Alexander et al. (2004) reported that ND could cause a fall in egg production, perhaps leading to complete cessation of egg-laying, and may precede more apparent signs of disease and deaths in egg-laying birds. A research carried out by Sharif et al. (2014) also reported that ND causes high mortality in layer birds and produces softshell or shell-less eggs. In layer poultry flocks, there may be a 90% drop in egg production. The Chi-square analysis test revealed an association between ND vaccination and egg production in the respondents who reported that their chicken stopped laying. The test showed a significant ($P<0.05$) difference between vaccinating chicken and egg production. However, the test also revealed that the vaccinated birds sustained lying despite being affected by the disease. A study carried out by Barman et al. (2010) corroborates this study, who reported that mortality resulting from ND was significantly higher ($P<0.01$), and the risk of dying from ND was 4.4 times higher in non-vaccinated compared to vaccinated birds. Mortality in birds that have been vaccinated against ND might be due to improper handling of the vaccine and not receiving proper dosage when being vaccinated. The improper handling might be due to failure to maintain the cold chain, which compromises vaccine efficacy. Many studies in developing countries reported that ND is the primary cause of mortality in village poultry (Hailemichael et al., 2016; Van den Ende, 2010). Mortality due to ND could range from 24-100%, although in most outbreaks, 45- 100% of birds in a flock have been reported to have died of the disease (Nwanta et al., 2008). As in this study, FAO (2009) wrote that farmers' initial attempt to treat their sick poultry was using medicinal plants. However, they later sought animal health services from animal health assistants.

It was observed during the study that farmers used Aloe vera and hot pepper to treat their sick birds instead of getting medicines. This was corroborated by a study that reported that most farmers used herbs (Aloe-vera, pepper, and sisal leaves) to control indigenous chicken diseases (Olwande et al., 2010). Also, Magothe et al. (2012) reported that herbs are used to treat sick birds, with the most commonly used herb being Aloe-vera, croton, milkweed, and hot pepper.

FAO (2009) reported that farmers accredited that those who follow proper vaccination procedures rarely lose their poultry. These included vaccinations when poultry is not sick, vaccinating within two hours of receiving the vaccine, and attending training sessions. Vaccine costs were a challenge to most farmers who said they could not afford to vaccinate against ND. A study carried out by Mutua et al. (2019) reported that costs are a critical determinant of vaccine uptake in households where the cost of vaccinating livestock is higher than available disposable income. This can be partially attributed to the packages/vials available versus the farmers' number of chickens. Furthermore, Ipara et al. (2019) wrote that the average distance to the nearest agro vet is 2 kilometers, showing that farmers faced challenges in accessing inputs for production due to the long distance between their homesteads and agro vets. This contrasts with this study, which showed that the most significant barrier farmers were facing was the access to vaccine suppliers near them. More research is needed to investigate why ND fails and how small-scale poultry farming can be advanced.

CONCLUSION AND RECOMMENDATION

Farmers had a perception that ND outbreaks in chickens

Table 8. Responses on the most appropriate time to vaccinate the chicken.

When is the best time to vaccinate	Frequency	Percentage
When an animal is healthy	91	34.9
When an animal is sick	83	31.8
When a member of a flock is sick	23	8.8
When a neighbor's animal is sick	18	6.9
When an animal in the village is sick	16	6.1
Other	30	11.5
Total	261	100

Table 9. Barriers to vaccinating chicken.

Vaccine barriers	Frequency	Percentage
Do you have access to vaccine suppliers against ND		
Yes	43	16.5
No	218	83.5
Can you afford the vaccine against ND		
Yes	91	34.9
No	134	51.3
Do not know	36	13.8
Do you think that vaccination can prevent ND in chicken		
Yes	146	55.9
No	37	14.2
Do not know	78	29.9
Do you have access to information on vaccinating chicken		
Not at all	125	47.9
Small extent	109	41.8
Medium extent	23	8.8
High extent	4	1.5

cause high mortality and low egg production. Moreover, there was a correlation between ND vaccination, egg production, and mortality rates in chickens. Although most farmers did not vaccinate against ND, the main reason was the access to vaccine suppliers and the distance to the agrovets; efficient policies should be established to support the veterinary extension service to improve access to vaccines in rural farmers. In addition, thermostable vaccines are manufactured, yet they are still not very popular among farmers probably because they are not yet stocked by the agrovet shops who have not yet been provided with sufficient data on their efficacy and quality.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

The author would like to express heartfelt gratitude to supervisors, and everyone who participated in this study and deepest gratitude to the University of Nairobi and staff. Thank you to all the participants who took the time to meet to discuss the ND.

COMPLIANCE WITH ETHICAL STANDARDS

Ethical approval as per University guidelines was met.

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