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A retrospective study on the prevalence and risk factors associated with Marek's disease in Plateau State, Nigeria

AJ Adedeji[1], MI Okpanachi[2]*, AS Azi[3], D Kabantiyok [4], O Igah[5], GS Joel[6], ND Jahota[7] & AA Oloruntoba[3]

1. *Virology Division, National Veterinary Research Institute, Vom, Plateau State, Nigeria*
2. *Molecular Ecology Laboratory, A.P. Leventis Ornithological Research Institute, University of Jos Conservatory, Laminga, Plateau State, Nigeria*
3. *Federal College of Animal Health and Production Technology, Vom, Plateau State, Nigeria*
4. *Diagnostic Laboratory Services Department, National Veterinary Research Institute, Vom, Plateau State, Nigeria*
5. *Livestock Investigation Division, National Veterinary Research Institute, Vom, Plateau, Nigeria*
6. *Department of Biochemistry, Ahmadu Bello University, Zaria, Nigeria*
7. *Department of Microbiology, Bingham University, Abuja, Nigeria*

*Correspondence: Tel.: +2348037035135; E-mail: mondayokpanachi1@aplori.org

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Abstract

Marek's Disease (MD) is an economically important disease of poultry caused by the MD virus, a member of the genus *Mardivirus*. MD results in immunosuppression and the disease affects poultry of all ages and is characterized by neoplastic lesions in the visceral organs. In this report, the prevalence and epidemiological features of MD in Plateau State were determined. Records of poultry disease cases presented to selected veterinary clinics in 4 Local Government Areas of Plateau State from 2007 to 2016 were analyzed. In addition, data were collected using questionnaires administered to 160 poultry farmers from February to May 2017. The prevalence of MD in Plateau State was 10.92% (5,620/5,1484). Cases of MD were reported in layers (92.49%), broilers (6.98%), turkeys (0.32%), and geese (0.21%). Also, co-morbidity of MD with coccidiosis (2.24%), colibacillosis (3.26%), Newcastle disease (2.58%), fatty liver syndrome (0.36%), fowl typhoid (2.86), and chronic respiratory disease (0.34%) were documented in the records. Analyzed data from the questionnaire survey revealed that 90.63% (145/160) of poultry farmers in Plateau State were familiar with MD, and 16.88% (27/160) of farmers indicated they have experienced MD outbreaks in their farms. Additionally, 90.00% (144/160) of poultry farmers claimed their birds were vaccinated against MD of which 53.13% (85/160) have vaccinated their birds once, while 36. 25% (58/160) and 0.63% (1/160) vaccinated their birds against MD twice and thrice respectively. On the economic impact of MD, twenty-seven poultry farms had experienced MD with an overall mortality of 17.02% (12,114/71,176) and most of the affected farms claimed to frequently medicate their birds during the outbreaks. To mitigate the impact of MD on poultry in Plateau State, adequate biosecurity measures and vaccination need to be instituted in poultry farms.

Keywords: Economic, Marek's disease, Nigeria, Prevalence, Risk factors, Year 2007-2016

Introduction

Marek's disease (MD) is a widespread viral oncogenic, and immunosuppressive disease of poultry caused by the MD virus (MDV). MD was first reported by Jozef Marek in 1907 as polyneuritis that results in paralysis of wings and legs and a mortality rate of 10%- 60% in infected chickens (Song *et al*., 2022). Chickens are the most susceptible host to MD, other susceptible hosts include quails, turkeys, pheasants, game fowls, ducks, sparrows, partridges, pigeons, and red crown cranes (Schat & Nair, 2013; Schock *et al*., 2016; Lian *et al*., 2018; Adedeji *et al.,* 2019). The MDV belongs to the order *Herpesvirales*, family *Herpesviridae*, subfamily *Alphaherpesvirinae,* and genus *Mardivirus* (Davison, 2010; Gimeno & Schat, 2018). There are three members of the genus *Mardivirus*; Gallid herpesvirus 2 or MDV serotype 1 (MDV-1), Gallid herpesvirus 3 or MDV serotype 2 (MDV-2), and herpesvirus of turkeys (HVT) or MDV serotype 3 (Nair, 2005; Gimeno & Schat, 2018). All virulent or oncogenic strains of MDV belong to serotype 1 and cause tumours in susceptible birds, whereas the other two serotypes are non-pathogenic (Torres *et al.*, 2019; Nair *et al.,* 2020). Marek's disease virus is transmitted only horizontally,i.e. transmission is through direct or indirect contact between chickens by the airborne route (Witter & Schat*,* 2003; Islam & Walkden-Brown*,* 2007). Natural infection begins by inhalation of MDV embedded in the epithelial cells of the keratinizing layer of the feather follicle or feather dander and these cells serve as a source of contamination to the poultry house and environment (Witter & Schat*,* 2003; Jarosinski, 2012). MDV associated with feather dander is infectious, and contaminated poultry house dust remains infectious for several months at 20-25°C and years at 4°C (Witter & Schat*,* 2003). Four forms of MD have been documented, the neural (classical form), visceral forms (Baigent & Davison, 2004), ocular form (Grey or pearl eye), and cutaneous form (red leg syndrome) (Nair *et al.,* 2020). The neural form is characterized by paralysis of the wing, neck, and legs which may be partial or total, due to lesions in the brachial, vagus, and sciatic plexus (Song *et al*., 2022), while in the visceral form, tumours can be observed in almost all visceral organs, especially the liver and spleen (Zhuang *et al.,* 2015). In typical cases, the virus affects not only the branchial and sciatic nerves, causing spastic paralysis of the wings and legs, but also leads to the infiltration of mononuclear cells into the iris, ultimately resulting in blindness in affected poultry (Gimeno & Schat, 2018). Confirmatory diagnosis is carried out by histopathologic examination of affected tissues, and molecular assays such as polymerase chain reaction (PCR) (Zhuang *et al.,* 2015, Adedeji *et al.,* 2019). MD causes economic losses worldwide estimated to be over 1 billion USD annually (Kennedy *et al.,* 2017). These losses occur directly via weight loss, poor feed conversion, drop in egg production, carcass condemnation at slaughter, mortality, and indirectly through increased vaccination costs (Davison, 2010; Gimeno & Schat, 2018; Rozins *et al*., 2019; Yilmaz *et al*., 2020). Despite the intensive vaccination and strict biosecurity measures used to control the disease, the incidence rate has increased in many countries (Murata *et al.,* 2013; Woźniakowski *et al.,* 2015). It has been suggested that the main cause of this vaccination failure was a result of the emergence of hypervirulent strains (Woźniakowski *et al*., 2010; Gong *et al.,* 2013; Hassanin *et al*., 2013).

In Nigeria, MD was first reported in 1962, since then there have been reports in several parts of the country (Fatunmbi & Adene, 1986; Olabode *et al.*, 2009; Wakawa *et al.,* 2012; Okonkwo, 2015; Sani *et al.,* 2021; Adedeji *et al.,* 2022). In a study conducted in 2004, Nigeria was one of the 55 countries around the world that experienced economic losses from MD in the 1990s (Gimeno, 2004). Dunn & Gimeno (2013) reported that Nigeria is one of the countries with an increasing prevalence of MD, despite consistent vaccination of poultry against the disease. Adedeji *et al.* (2022) recently reported that MD cases were recorded in vaccinated poultry flocks in Plateau State, Nigeria, resulting in severe economic losses to poultry farmers. However, the prevalence of MD and the risk factors associated with the disease in Nigeria are unknown. This study was designed to determine the prevalence and epidemiological features of MD in poultry in Plateau State, Nigeria.

Materials and Methods

Study area

The study area was Plateau State, North Central, Nigeria (Figure 1). Plateau State shares boundaries with Bauchi State to the Northeast, Kaduna State to the Northwest, Nasarawa State to the Southwest, and Taraba State to the Southeast (NIPC, 2022). The State has an estimated population of over 3,000,000 people and covers an area of 26,899 square kilometres located in the tropics, but its higher altitude gives it a cooler climate, with average temperatures ranging from 18 to 22^{0}C (FRON, 2009). Plateau State is situated approximately on latitude 80°24'N and longitude 80^{0}32' and 100°38'E with a more temperate climate than the rest of Nigeria (Amusuk *et al.,* 2016). Because of the clement weather, Plateau State is very suitable for poultry production and other livestock farming activities. The State is also a major hub of poultry farming in Northern Nigeria supplying day-old chicks (DOC) and other poultry products to several northern Nigerian States and Abuja, the Federal Capital of Nigeria. The poultry production system in the study area consists of mostly smallholder backyards and some commercial farms with a population range of 50-50,000 chickens per farm primarily for egg production and supported by seasonal broiler production (Maduka *et al.,* 2016; Adedeji *et al.,* 2022).

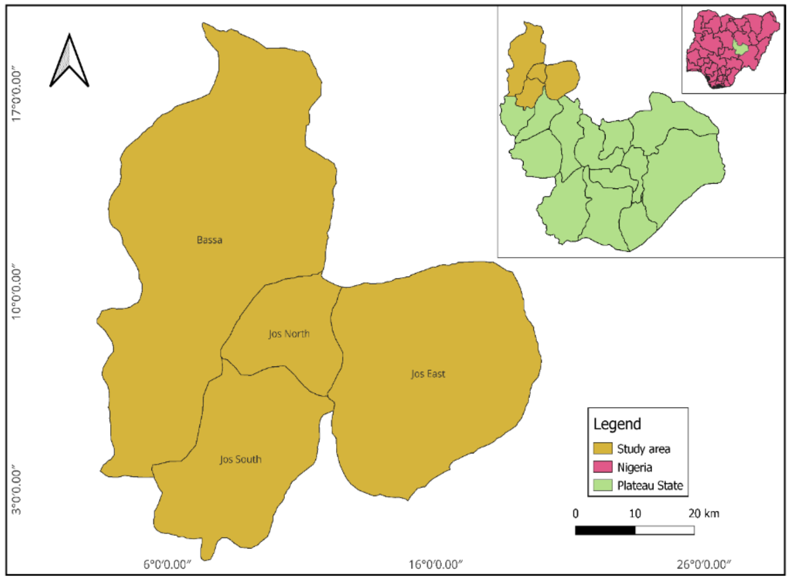

Figure 1: Map of study locations of poultry farms and farmers where the study was carried out in Plateau State

Determination of prevalence of Marek's disease

The prevalence of MD was determined based on an analysis of ten years (2007-2016) records of poultry cases diagnosed at seven veterinary clinics in the study area purposefully selected using the criterion of availability of records of poultry cases in Jos East, Jos South, Jos North, and Bassa Local Government Areas (LGAs). A case was defined as a farm in which MD was diagnosed based on clinical signs and post-mortem findings. The date, species, breed, type of birds, clinical signs, and post-mortem findings were extracted from the veterinary clinic case record books.

Epidemiological features of Marek's disease

The epidemiological features of MD outbreaks were determined by administering questionnaires to farmers. The questionnaire was binary and open-ended, designed to collect information about the husbandry system, MD vaccination history, history of previous outbreaks of MD, and determining factors predicting economic impact of MD. The questionnaires were administered to 160 farmers from February to May 2017 in the study area based on convenience sampling and the willingness of the farmers to participate in the study.

Data analysis

All data collected in this study were entered and organized in Microsoft Excel. Data were analyzed using R statistical software package version 4.2.2 (R-Core Team, 2023). A chi-square test was used to determine the association between the prevalence and risk factors, factors determining economic impact and farmer knowledge of MD with a 95% confidence interval.

Results

A total of 51,484 poultry cases were presented to the seven selected veterinary clinics during the study period, with an overall MD prevalence of 10.92% (5620/51,484). The year 2010 had the highest MD prevalence of 14.68% (729/4966) and 2016 had the lowest MD prevalence of 6.93% (337/4864) (Table 1; Figure 2). The monthly distribution of MD cases (Figure 3) shows that April had the highest MD prevalence of 13.28% (Table 2; Figure 3). Analysis of records further revealed that the type of birds affected by MD were layer chicken (92.49%), broiler (6.98%), turkey (0.32%), and geese (0.21%) (Table 3; Figure 3). Marek's disease was diagnosed concurrently with twelve different poultry diseases

Table 1: A ten-years (2007-2016) yearly distribution of Marek disease and other poultry disease cases based on records of veterinary clinics in Plateau State

Year	Marek's disease cases (%)	Total poultry cases
2007	139 (7.21)	1,928
2008	548 (13.20)	4,150
2009	1064 (14.36)	7,408
2010	729 (14.68)	4,966
2011	789 (12.66)	6,233
2012	926 (12.57)	7,368
2013	437 (7.60)	5,753
2014	297 (6.95)	4,272
2015	354 (7.79)	4,542
2016	337 (6.93)	4,864
Total	5620 (10.92)	51,484

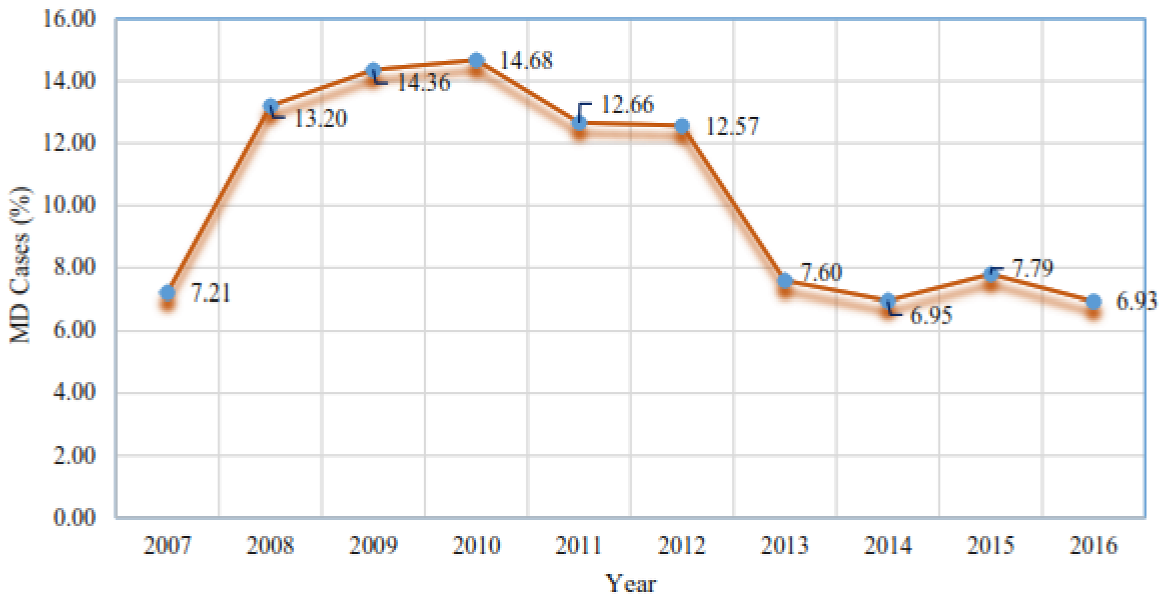

Figure 2: A yearly distribution of Marek disease in Plateau state from 2007 to 2016

Table 2: A ten-year (2007-2016) monthly distribution of Marek disease and other poultry disease cases based on records of veterinary clinics in Plateau State

Month	Marek's disease cases (%)	Total poultry cases
January	455 (12.59)	3613
February	464 (12.76)	3636
March	638(12.85)	4964
April	659(13.28)	4961
May	555(10.66)	5204
June	623 (12.42)	5018
July	513(12.38)	4143
August	411(9.30)	4417
September	331(8.73)	3791
October	349(8.02)	4351
November	322(7.42)	4339
December	300(9.85)	3047
Total	5620 (10.92)	51,484

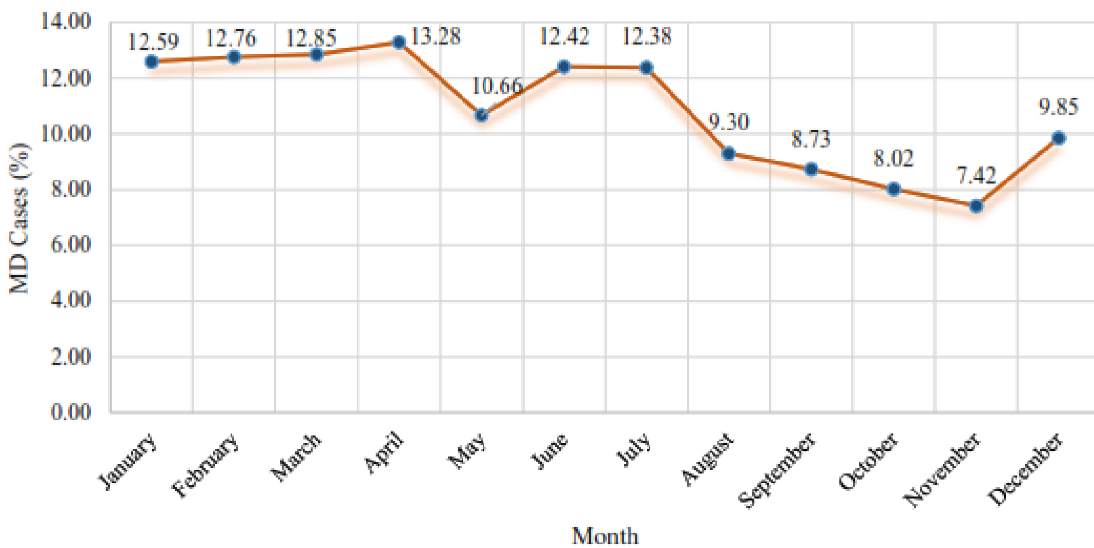

Figure 3: A monthly distribution of Marek disease in Plateau state from 2007 to 2016

which included coccidiosis (2.24%), colibacillosis (3.26%), Newcastle disease (2.58%), fatty liver syndrome (0.36%), fowl typhoid (2.86%), and chronic respiratory disease (0.34%) (Table 3).

Analyzed data from the questionnaire survey revealed that 90.63% (145/160) of poultry farmers were familiar with MD, while 68.13% (109/160) stated that MD was an economically important disease of poultry. Furthermore, 90.00% (144/160) of the farmers claimed they vaccinated their poultry against MD and 36.25% vaccinated multiple times. However, 16.88% (27/160) of farmers claimed to have experienced MD outbreaks on their farms previously, while 11.25% (18/160) experienced MD outbreaks within the last 12 months (Table 4).

The 27 poultry farms that experienced MD recorded 42.95% morbidity and 17.02% mortality (Table 5). Factors predicting the economic impact of the morbidity rate (such as mortality of birds, frequency of medication) show statistical significance. All 27 farms affected by Marek's disease (MD) claimed to frequently medicate their birds. This increased their cost of production, but there was no significant ($p > 0.05$) impact on the economic impact on the farmers. Risk factors such as biosecurity measures associated with MD outbreaks include all-in, all-out management practice (11.11%), quarantine (14.81%), use of disinfectant and fumigation (37.04%), farm fallowing (18.52%), restricted access to farm (3.70%) and footbath at farm and pen entrances (14.81%). Other risk factors included farmers' knowledge of the MD vaccination status of chicks, keeping multiple ages of birds on the farm, the hatchery where birds were sourced and the poultry management system (Table 6).

Discussion

In this study, the overall prevalence of MD was 10.92% with the lowest (6.93%) and highest (14.68%) yearly prevalence rates recorded in 2016 and 2010, respectively. Wakawa *et al.* (2012) and Musa *et al.* (2013) reported a prevalence of 8.3% and 4.9%, respectively in other parts of Nigeria. Since the first report of MD in Nigeria in 1962, studies have shown a progressive increase in the number of MD cases in the country. Despite vaccination and biosecurity measures, the number of MD cases is still on the rise. From this study, MD was diagnosed in exotic chickens (layers and broilers), turkeys, and geese in veterinary clinics in the area of study. Similar research in the Plateau State reported MD in village chicken and quail which indicates the disease occurs in different species of poultry (Adedeji *et al.,* 2019). Marek's disease was more prevalent in layers compared to other poultry types. Host genetic makeup seems to have an impact on MDV replication, as some chicken genetic makeup has been shown to be involved in the susceptibility or resistance to tumours (Payne*,* 2004). Possibly the layer chickens may be more genetically susceptible than other birds.. Cases of MD in broilers were also notable, these may be exacerbated by the practice of non-vaccination of broilers and also sometimes rearing them alongside layer chickens, therefore exposing them to MDV (Adedeji *et al.,* 2022).

Another interesting finding in this study is the co-morbidity of MD with other diseases. This may be due

Table 3: Co-infections of Marek's disease with other poultry diseases based on records of veterinary clinics in Plateau State, Nigeria

Disease condition	Layer	Broiler	Turkey	Geese	Total (%)
Marek's disease (MD) only	4524	325	18	12	4879(86.81%)
MD + Fowl Typhoid (FT)	145	16	0	0	161(2.86%)
MD + Colibacillosis	175	8	0	0	183(3.26%)
MD + Newcastle Disease (ND)	118	27	0	0	145(2.58%)
MD + Malnutrition	6	1	0	0	7(0.12%)
MD + Coccidiosis	114	12	0	0	126(2.24%)
MD + Fatty liver Syndrome (FLS)	20	0	0	0	20(0.36%)
MD + CRD	19	0	0	0	19(0.34%)
MD + ND+ Coccidiosis	17	3	0	0	20 (0.36%)
MD + FT+ Colibacillosis	3	0	0	0	3(0.05%)
MD + FLS+ FT	2	0	0	0	2(0.04%)
MD + Colibacillosis + ND	10	0	0	0	10(0.18%)
MD + Helminthosis	26	0	0	0	26(0.46%)
MD + Coccidiosis+ Colibacillosis	7	0	0	0	7(0.12%)
MD + Aspergillosis	1	0	0	0	1(0.02%)
MD + ND + CRD	6	0	0	0	6(0.11%)
MD + Pullorum	1	0	0	0	1(0.02%)
MD + Fowl Cholera	2	0	0	0	2(0.04%)
MD + Fowl Pox	2	0	0	0	2(0.04%)
Overall total	5198(92.49%)	392(6.98%)	18(0.32%)	12(0.21%)	5620

Key: CRD= chronic respiratory disease

Table 4: Knowledge of poultry farmers about Marek's disease in Plateau State, Nigeria

Questions	Frequency	%	X^2	P -value
Familiar with Marek's disease				
Yes	145	90.63	105.62	<0.001
No	15	9.38		
Marek's disease is an economically important disease of poultry				
Yes	109	68.13	21.025	<0.001
No	51	31.87		
Number of times poultry farms revaccinated their birds with MD vaccines				
None	16	10.00	111.15	<0.001
Once	85	53.13		
Twice	58	36.25		
Thrice	1	0.63		
Ever experienced an outbreak of Marek's disease on your farm				
Yes	27	16.88	70.225	<0.001
No	133	83.13		
Experienced outbreak of Marek's disease in the last 12 months				
Yes	18	11.25	96.1	<0.001
No	142	88.75		

to the immunosuppressive nature of the MDV which affects the lymphoid cells and puts the birds at risk of opportunistic and secondary infections (Gimeno & Schat, 2018; Lachheb *et al.,* 2020).

Poultry farms with a history of vaccination still recorded cases of MD. The plausible reasons for the lack of protection against MD are unknown. However, Gimeno (2008), Shittu *et al.* (2019) and Adedeji *et al.* (2022) suggested several factors including poorly administered vaccines, the wrong types of vaccine, poor biosecurity practices, early chick exposure to pathogenic MDV, and contaminated MD vaccines could contribute to vaccination failure. Interestingly, 58.63% of farmers claimed to have revaccinated their chickens against MD. Studies have shown some benefits of revaccination against MD if properly done

Table 5: Feedback on the economic impact of Marek's disease on the 27 poultry farms in Plateau State, Nigeria

Question	Frequency (%)	X^2	P= value
Number of birds in the 27 farms	71,176		
Number of birds affected by MD	30,569 (42.95)	7979.5	<0.001
Number of dead birds as a result of MD	12,114 (17.02)		
Frequency of Medication			
Everyday till disposal	9 (33.33)	7.2	0.21
Every 5 days	4 (14.81)		
Once a week	4 (14.81)		
Every 10 days	1 (3.70)		
Once a month	6 (22.22)		
Unknown	3 (11.11)		

Table 6: Risks factors associated with the outbreak of MD in 27 farms in Plateau State

Questions	Frequency (%)	X^2	P=value
Biosecurity measures			
All in and all out-policy	3 (11.11)	10.11	0.07
Isolation of sick birds	4 (14.81)		
Use of disinfectant and fumigation	10 (37.04)		
Allow farm to fallow	5 (18.52)		
Restrict access to farm	1 (3.70)		
Footbath at farm and pen entrances	4 (14.81)		
Multiple ages			
Yes	18 (66.67)	3	0.083
No	9 (33.33)		
Knowledge of MD vaccination history of birds from the hatchery			
Yes	5 (18.52)	10.704	0.001
No	22 (81.48)		
Types of vaccination used			
HVT	8 (29.63)	4.667	0.097
Rispens	5 (18.52)		
Unknown	14 (51.85)		
Source of birds			
Hatchery A	12 (44.44)	22.519	<0.001
Hatchery B	4 (14.81)		
Hatchery C	4 (14.81)		
No response	3 (11.11)		
Hatchery D	2 (7.41)		
Hatchery E	1 (3.70)		
Hatchery F	1 (3.70)		
Management system			
Battery cages	5 (18.52)	10.704	0.001
Deep litter	22 (81.48)		

(Wu *et al*. 2009; Gimeno *et al.,* 2012). However, despite the high level of revaccination of birds against MD in the study area, the prevalence of the disease is high which suggests a lack of protection. Feedback from farmers showed that there was a significant economic impact of MD on the poultry enterprise in the study area due to high morbidity and mortality, and the cost of medication.

This study shows a statistically significant association between the incidence of MD and risk factors such as vaccination history, source of birds, and management systems. Over 44% of the 27 farms that reported MD in the questionnaire survey sourced their birds from the same hatchery. Hatcheries could be a contributing factor to the occurrence of MD in farms. In Nigeria, hatcheries are expected to vaccinate DOC before sales to farms, but there is poor government regulation to ensure these DOC are vaccinated (Adedeji *et al.,* 2022).

In this study, most of the farms affected by MD did not practice measures like quarantine of sick birds, all-in and all-out management, and allowing farms/pens to fallow before the introduction of new birds. Lack of implementation of these biosecurity measures may lead to a high likelihood of contamination of the poultry farm environment, thereby predisposing chicks to pathogenic MDV (Couteaudier & Denesvre, 2014). The management system of poultry farmers also further predisposes birds to MD with a majority of farmers employing the deep litter system due to its affordability. Under commercial field conditions, young chickens are most commonly exposed to MDV by contact with MDV-contaminated residual dust and dander in the growing house or by the introduction of these materials by aerosols (from adjacent chicken houses), fomites, or personnel. After the virus is introduced into a poultry flock, regardless of vaccination status, the infection spreads quickly from bird to bird. Once infected, chickens appear to shed the virus indefinitely (Witter & Schat*.,* 2003). The deep litter production system is a very ideal environment for the spread of the MDV due to contact with susceptible poultry litter (Islam *et al.,* 2013).

Another poor practice by some of the farmers in the study area was rearing multiple-age chickens in the same pen/premises. This practice may expose chicks very early to the virulent MDV before they are fully protected following vaccination (Witter*,* 2001; Adedeji *et al.,* 2022). Likewise, most farmers who claimed to have experienced MD did not know the MD vaccination status of their day-old chicks.

In conclusion, the study shows that the prevalence of MD in Plateau State is high despite vaccination against the disease. The disease was diagnosed in different types of birds in Plateau State, namely chickens, turkeys and gesse. The immunosuppressive nature of Marek's disease (MD) can lead to co-morbidity with other diseases, which can lead to misdiagnosis and serious economic loss for farmers. Good husbandry practices, proper biosecurity measures and vaccination should be maintained on poultry farms to reduce the risk of MD cases. Poultry farmers should source their chicks from reliable hatcheries. It is important for veterinary authorities in Nigeria to ensure that hatcheries disclose the vaccination status of day-old chicks to farmers for economically important diseases such as MD.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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