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Assessment of biosecurity measures and their role in chick survival in poultry farms of Maiduguri, Borno State, Nigeria

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ABSTRACT

Aim: Purpose of the study was to evaluate the biosecurity measures implemented in poultry farms across Maiduguri, Borno State, Nigeria and their impact on chick survival rates.
Method and materials: A cross-sectional survey was employed, utilizing a multistage random sampling technique to select 200 respondents from six clusters: Gwange, Mairi, Fori, Bolori, Shehuri, and the University of Maiduguri Staff Quarters. Data were collected through structured questionnaires and direct observational assessments of biosecurity practices. Statistical analyses, including percentage computations were applied to determine the relationships between biosecurity measures and chick survival.
Results: The result showed that 53.5% of respondents reported practicing regular disinfection, while only 6% adopted rodent control measures. The mortality rates varied significantly across clusters, with Gwange exhibiting the highest mortality at 43.2% and University Quarters the lowest at 13.9%. Newcastle Disease emerged as the most prevalent disease, as reported by 82% of respondents, with significant correlations identified between inadequate biosecurity practices and higher mortality rates.
Conclusion: It was concluded that the critical role of biosecurity measures is highlighted in improving chick survival and reducing mortality rates on poultry farms in Maiduguri, Borno State, Nigeria.

Keywords: Biosecurity measures, chick survival, poultry farms, observational study, cross-sectional survey

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Introduction

Poultry farming is a vital component of food security and income generation in Nigeria, particularly in the northeastern region where the demand for poultry products is rising (Ajala *et al*., 2021). In Borno State, poultry farming provides livelihood opportunities, especially in the wake of conflict and displacement that have affected traditional agricultural practices (Sheikh *et al*., 2022). However, the success of poultry production, particularly the survival rate of chicks, is heavily influenced by the implementation of biosecurity measures (Tilli*et al*., 2022; Otieno *et al*., 2023). Biosecurity is the cornerstone of disease prevention and control in poultry farms, and it encompasses a series of practices designed to minimize the risk of infectious diseases being introduced and spread (Mallioris *et al*., 2022; Poudel *et al*., 2024).

In poultry production, the first few weeks of life are critical for chick survival. During this period, chicks are highly vulnerable to pathogens, environmental stressors, and management-related factors (Yerpes *et al*., 2020; Mramba and Mwantambo, 2024). Disease outbreaks, poor management practices, and inadequate environmental control can lead to high mortality rates, impacting overall flock performance and farm profitability (Mramba and Mwantambo, 2024). Diseases such as Newcastle disease, infectious bursal disease (IBD), and colibacillosis are endemic in many regions of Nigeria, including Borno State, and these diseases can devastate poultry populations if proper biosecurity measures are not enforced (Balami *et al*., 2024; Oluwayelu *et al*., 2014; Ekiri *et al*., 2021).

Biosecurity in poultry farming includes physical, biological, and managerial components aimed at preventing disease transmission (Mohammed, 2024). These measures include restricting farm access, sanitizing equipment and vehicles, isolating new stock, vaccinating birds, and controlling the movement of personnel and animals (Robertson, 2020; Butucel *et al*., 2022). Despite the clear benefits of these measures, many poultry farms, especially small-scale and backyard farms, face challenges in fully implementing them due to resource constraints, lack of awareness, and inadequate veterinary support (Fathelrahman *et al*., 2020). Consequently, suboptimal biosecurity practices contribute to higher chick mortality rates, increased production costs, and reduced productivity in these farms (Dhaka *et al*., 2023; Faroque *et al*., 2023; Kabeta *et al*., 2024).

Maiduguri, the capital of Borno State, experiences a tropical climate with distinct dry and wet seasons, which poses additional challenges for biosecurity management (Bello *et al*., 2023; Lawal *et al*., 2024). The hot, arid environment of the dry season can lead to heat stress and exacerbate disease conditions, while the rainy season increases the risk of waterborne pathogens and environmental contamination (Levy *et al*., 2018). Furthermore, the region's socio-political instability has disrupted traditional agricultural practices and veterinary services, further complicating biosecurity implementation (Lawal *et al*., 2024).

This study was plaqnned to assess the biosecurity practices currently in place on poultry farms in Maiduguri and their impact on chick survival. By identifying the gaps in biosecurity and evaluating the relationship between these measures and chick survival rates, the findings of this research can provide evidence-based recommendations for improving poultry farm management in the region. The outcomes of this study are expected to enhance poultry production sustainability, improve animal welfare, and contribute to food security efforts in Maiduguri and beyond.

Materials and Methods

The study was conducted in Maiduguri, the capital of Borno State, Nigeria. Maiduguri is located in the northeastern region of the country and is characterized by a semi-arid climate with distinct wet and dry seasons. The city has a thriving poultry industry that provides a vital source of food and income for its inhabitants. For the purpose of this study, Maiduguri was randomly divided into six clusters to facilitate sampling. These clusters included: Gwange (Cluster 1), Mairi (Cluster 2), Fori (Cluster 3), Bolori (Cluster 4), Shehuri (Cluster 5), University of Maiduguri Staff Quarters community (Cluster 6)

*Study Design:*A cross-sectional survey was carried out from September, 2023 to July, 2024 to assess the biosecurity measures implemented in poultry farms and their association with chick survival. The study population included day-old chick distributors/vendors, poultry farmers, and field veterinarians within the six clusters of Maiduguri.

Sampling Technique: A multistage random sampling technique was employed. In the first stage, Maiduguri was divided into six clusters as mentioned above. In the second stage, within each cluster, respondents were randomly selected based on their involvement in the poultry value chain (distributors/vendors, farmers, and veterinarians).

A total of 200 respondents were sampled, with approximately equal representation from each of the six clusters. The sample size was determined based on the number of poultry farms and other stakeholders operating within the region.

Data Collection Instruments: Two primary methods were employed for data collection in this study. The first involved the use of a structured questionnaire, which had been pre-tested to ensure its effectiveness. This questionnaire was designed to gather detailed information on biosecurity measures, chick mortality rates, and survival rates. It included both closed and open-ended questions addressing various aspects such as farm characteristics (e.g., size, type of poultry, number of chicks), existing biosecurity practices (e.g., disinfection routines, isolation of new chicks, vaccination schedules), sources of day-old chicks, common poultry diseases encountered, and chick mortality and survival rates. The questionnaire was administered in person to a total of 200 respondents, comprising 50 day-old chick distributors or vendors, 100 poultry farmers, and 50 field veterinarians.

The second method of data collection involved direct observational investigations through farm visits. During these visits, the researchers assessed biosecurity practices firsthand. Key observations included hygiene practices, such as the cleanliness of pens and equipment, the presence of footbaths at farm entrances, management of sick birds, quarantine procedures, the use of protective clothing by farm staff, and the overall farm infrastructure. These observational visits provided a deeper insight into the actual biosecurity measures being implemented on the farms.

Estimation of Average Chick Mortality and Survival Rates

i. *Average Chick Mortality Rate:* The average chick mortality rate was calculated based on data collected from individual farm. Mortality data included the total number of chicks initially stocked on each farm and the number of chick deaths observed over the study period as reported by each farmer or extracted from farm record where available. For each farm, the individual mortality rate was computed using the formula:

$$\text{Chick Mortality Rate (\%)} = \left(\frac{\text{Number of Dead Chicks}}{\text{Total Chicks}}\right) x\ 100$$

This calculation provided the percentage of chick deaths for each farm. Once the mortality rate for all farms was determined, the average mortality rate (%) was calculated by summing the individual mortality rates and dividing by the total number of farms, yielding the overall average mortality rate for the sample.

ii. *Average Chick Survival Rate:* The average chick survival rate was calculated using similar data from the individuals or farms. After determining the total number of chicks placed on each farm and the number of deaths observed over the study period as reported by each farmer or extracted from farm record where available, the survival rate for each farm was calculated using the formula:

$$\text{Chick Survival Rate (\%)} = \left(\frac{\text{Total Chicks} - \text{Number of Dead Chicks}}{\text{Total Chicks}}\right) x\ 100$$

This provided the percentage of surviving chicks on each farm. The average survival rate (%) was obtained by summing the individual survival rates across the farms and dividing by the number of farms, giving the overall average survival rate for the sampled population

Data Analysis: Data obtained from the structured questionnaires and observational investigations were entered into Microsoft Excel for cleaning and preliminary analysis. Descriptive statistics such as frequencies, and percentages were calculated to summarize the data. To assess the relationship between biosecurity measures and chick survival as well as chick mortality rates, the Chi-square test was utilized to assess the statistical significance of these relationships, with the threshold for significance established at $p \leq 0.05$. Furthermore, prevalence rates were computed alongside their 95% confidence intervals to ensure reliable and comprehensive statistical analysis of the results

Informed Consent: Verbal informed consent was obtained from all respondents prior to administering the questionnaires and conducting the observational visits. Respondents were assured of the confidentiality of their responses, and participation was entirely voluntary.

Results and Discussion

It was summarized the demographic characteristics of the 200 respondents who participated in the biosecurity and chick survival survey conducted in Maiduguri, Borno State, Nigeria (Table 1). The data indicates a predominance of male respondents, accounting for 86% (n=172) of the total, compared to 14% (n=28) who were female. In terms of educational background, 54% (n=108) of the respondents had attained tertiary education, suggesting that more than half of the farmers possess a relatively high level of education. Secondary education was reported by 35.5% (n=71) of the participants, while 7.5% (n=15) had completed only primary education. Additionally, a small percentage (3%, n=6) had received informal education, indicating limited formal training among some farmers. Age distribution analysis revealed that the majority of respondents (47%, n=94) were aged between 30 and 40 years, reflecting a workforce predominantly in their prime working years. Respondents younger than 30 years represented 18.5% (n=37), while those older than 40 years comprised 34.5% (n=69). Regarding poultry farming experience, over half (52.5%, n=105) of the farmers had more than 5 years of experience, whereas 43% (n=86) had been engaged in poultry farming for 1 to 5 years. Only 4.5% (n=9) of the respondents reported having less than one year of experience in poultry farming.

Table 1: Demographic characteristics of respondents participating in the biosecurity and chick survival survey in Maiduguri, Borno State, Nigeria

Variable	**Category**	**Number of Respondents /Frequency (n=200)**	**Percentage (%)**
Sex of farmer	Male	172	86.0
	Female	28	14.0
Educational status	Informal	6	3.0
	Primary	15	7.5
	Secondary	71	35.5
	Tertiary	108	54.0
Age of farmer	<30	37	18.5
	30 - 40 years	94	47.0
	> 40	69	34.5
Experience in Poultry	< 1 year	9	4.5
	1 - 5 years	86	43.0
	> 5 years	105	52.5

It was illustrated the distribution of respondents by cluster and their roles within poultry value chain across Maiduguri, Borno State (Table 2). A total of 200 respondents were sampled, consisting of 50 distributors/vendors, 100 farmers, and 50 veterinarians, spread across six clusters. Cluster 1 (Gwange) represented 16.5% of the total respondents, comprising 16.0% of distributors/vendors (n = 8), 16.0% of farmers (n = 16), and 18.0% of veterinarians (n = 9). Cluster 2 (Mairi) contributed 16.0% to the sample, with 18.0% of distributors/vendors (n = 9), 13.0% of farmers (n = 13), and 20.0% of veterinarians (n = 10). In comparison, Cluster 3 (Fori) exhibited smallest representation at 12.5%, including 14.0% of distributors/vendors (n = 7), 10.0% of farmers (n = 10), and 16.0% of veterinarians (n = 8). Cluster 4 (Bolori) accounted for 17.0% of total respondents, comprising 16.0% of distributors/vendors (n = 8), 16.0% of farmers (n = 16), and 20.0% of veterinarians (n = 10). Similarly, Cluster 5 (Shehuri) also represented 17.0% of respondents, including 18.0% of distributors/vendors (n = 9), 17.0% of farmers (n = 17), and 16.0% of veterinarians (n = 8). Notably, Cluster 6 (University Quarters) had highest overall representation, constituting 21.0% of respondents, with 18.0% of distributors/vendors (n = 9), 28.0% of farmers (n = 28), and 10.0% of veterinarians (n = 5). Cluster 6 also exhibited highest proportion of farmers (28.0%), while Clusters 2 (Mairi) and 4 (Bolori) recorded highest percentages of veterinarians (20.0% each).

Table 2: Distribution of Respondents by Cluster and Role in Poultry Value Chain in Maiduguri, Borno State, Nigeria

Cluster	Distributors/ Vendors (n = 50) (%)	Farmers (n = 100) (%)	Veterinarians (n = 50) (%)	Total (n = 200) (%)
Gwange (Cluster 1)	8 (16.0)	16 (16.0)	9 (18.0)	33 (16.5)
Mairi (Cluster 2)	9 (18.0)	13 (13.0)	10 (20.0)	32 (16.0)
Fori (Cluster 3)	7 (14.0)	10 (10.0)	8 (16.0)	25 (12.5)
Bolori (Cluster 4)	8 (16.0)	16 (16.0)	10 (20.0)	34 (17.0)
Shehuri (Cluster 5)	9 (18.0)	17 (17.0)	8 (16.0)	34 (17.0)
University Quarters (Cluster 6)	9 (18.0)	28 (28.0)	5 (10.0)	42 (21.0)

It was presentd the prevalence of poultry diseases among chicks sourced from farms across six clusters in Maiduguri, Borno State, Nigeria, and indicating significant variability in disease occurrence. Newcastle Disease (ND) emerged as most prevalent condition, with an overall prevalence of 82.0% (n = 164/200). The highest incidence of ND was recorded in Fori (93.9%), followed by Bolori (90.9%) and Gwange (84.8%). Conversely, University Quarters exhibited lowest prevalence, with only 67.6% of respondents reporting cases of ND. Coccidiosis ranked as second most common disease, affecting 67.0% (n = 134/200) of respondents. Fori again reported highest frequency of coccidiosis (78.8%), while both Mairi and Bolori reported a prevalence of 72.7%. The lowest prevalence of coccidiosis was observed in University Quarters, at 55.9%. Fowl pox was reported by 53.0% (n = 106/200) of respondents, with the highest frequencies noted in Mairi and Bolori (63.6% each). In contrast, Gwange reported a relatively lower rate of 42.4%, and University Quarters reported 47.1%. Infectious Bursal Disease (IBD) was prevalent in 66.5% (n = 133/200) of the farms, with the highest occurrence in Bolori (78.8%) and the lowest in University Quarters (58.8%). Salmonellosis was reported by 47.0% (n = 94/200) of respondents, with Fori showing the highest frequency (54.5%) and Mairi the lowest (36.4%). Helminthiasis was less prevalent, with an overall occurrence of 32.0% (n = 64/200). Bolori reported the highest frequency of helminthiasis (48.5%), whereas University Quarters reported the lowest at 23.5%. Other disease conditions were reported at much lower rates, with an overall prevalence of 18.5% (n = 37/200). Gwange had the highest reports of these other conditions (33.3%), while University Quarters had lowest prevalence at 8.8%.

The statistical analysis of biosecurity measures adopted by poultry farmers in Maiduguri, Borno State, Nigeria, was presented (Table 4). Of 100 farmers surveyed, 37 (37.0%; 95% CI = 28.2 – 46.8) reported regular disinfection of poultry farms, while 63 (63.0%; 95% CI = 53.2 – 71.8) did not. The difference between groups of respondents was significant ($\chi^2 = 13.52$; p = 0.0002), with a relative risk (0.5873), suggesting that farmers who do not disinfect their farms are at a higher risk of health issues in their flocks. For isolating new chicks, 25 farmers (25.0%; 95% CI = 17.6 – 34.3) practiced biosecurity measure, while 75(75.0%; 95% CI= 65.7–82.5) do not. A statistically significant difference was observed ($\chi^2 = 50.00$; $p < 0.0001$) between the respondents, and the relative risk (0.3333) indicated a heigh risk of disease introduction for farmers who donot isolate new chicks.

Table 3: Common Poultry Diseases Reported in Chicks in Poultry Farms by Cluster in Maiduguri, Borno State, Nigeria

	Number of Respondents/cluster						
Disease Condition	**Gwange (n = 33) (%)**	**Mairi (n = 33) (%)**	**Fori (n = 33) (%)**	**Bolori (n =33) (%)**	**Shehuri (n =34) (%)**	**University Quarters (n =34) (%)**	**Total (n = 200) (%)**
Newcastle Disease	28 (84.8)	26 (78.8)	31 (93.9)	30 (90.9)	26 (76.5)	23 (67.6)	164 (82.0)
Fowl-pox	14 (42.4)	21 (63.6)	18 (54.5)	21 (63.6)	16 (47.1)	16 (47.1)	106 (53.0)
Coccidiosis	20 (60.6)	24 (72.7)	26 (78.8)	24 (72.7)	21 (61.8)	19 (55.9)	134 (67.0)
Salmonellosis	16 (48.5)	12 (36.4)	18 (54.5)	16 (48.5)	18 (52.9)	14 (41.2)	94 (47.0)
Infectious Bursal Disease (IBD)	22 (66.7)	23 (69.7)	20 (60.6)	26 (78.8)	22 (64.7)	20 (58.8)	133 (66.5)
Helminthiasis	8 (24.2)	10 (30.3)	13 (39.4)	16 (48.5)	9 (26.5)	8 (23.5)	64 (32.0)
Other disease conditions	11 (33.3)	5 (15.2)	8 (24.2)	6 (18.2)	4 (11.8)	3 (8.8)	37 (18.5)

Table 4: Statistical Analysis of Biosecurity Measures Adopted by Poultry Farmers in Maiduguri, Borno State, Nigeria

Biosecurity Measure	**Frequency of Farmers/Responses (n = 100)**		**χ^2**	**p-value**	**Relative Risk (RR)**
	Yes (%)	**No (%)**			
Regular disinfection	37 (37.0)	63 (63.0)	13.52	0.0002	0.5873
95% CI (LL-UL)	28.2 – 46.8	53.2 – 71.8			
Isolation of new chicks	25 (25.0)	75 (75.0)	50.00	<0.0001	0.3333
95% CI (LL-UL)	17.6 – 34.3	65.7 – 82.5			
Use of footbaths	19 (19.0)	81 (81.0)	76.88	<0.0001	0.2346
95% CI (LL-UL)	12.5 – 27.8	72.2 – 87.5			
Routine vaccination	13 (13.0)	87 (87.0)	109.5	<0.0001	0.1494
95% CI (LL-UL)	7.8 – 21.0	79.0 – 92.2			
Biosecurity signage in place	8 (8.0)	92 (92.0)	141.1	<0.0001	0.0870
95% CI (LL-UL)	4.1 – 15.0	85.0 – 95.9			
Controlled farm access	3 (3.0)	97 (97.0)	176.7	<0.0001	0.0870
95% CI (LL-UL)	1.0 – 8.5	91.6 – 99.0			
Availability of Farm record	21 (21.0)	79 (79.0)	67.28	<0.0001	0.2658
95% CI (LL-UL)	14.2 – 30.0	70.0 – 85.8			
Proper carcass disposal	28 (28.0)	72 (72.0)	38.72	<0.0001	0.3889
95% CI (LL-UL)	20.1 – 37.5	62.5 – 79.9			
Rodents control in place	12 (12.0)	88 (88.0)	115.5	<0.0001	0.1364
95% CI (LL-UL)	7.0 – 19.8	80.2 – 93.0			

Key: N = Total number of farm visited/farmers interviewed during the study period; CI = Confidence Interval; LL – UL = Lower Limit – Upper Limit; χ^2 = Chi – square
[a,b] Values with different superscripts indicate significant (p< 0.05) difference in prevalence rates

Only 19 interviewed farmers (19.0%; 95% CI = 12.5 – 27.8) reported using footbaths, while 81 (81.0%; 95% CI = 72.2 – 87.5) did not. The difference was significant (χ^2 = 76.88; p < 0.0001), with a relative risk (0.2346), revealing increased risk of disease transmission without footbath use. Routine vaccination was reportedly practiced by 13 farmers (13.0%; 95% CI = 7.8 – 21.0), while 87 (87.0%; 95% CI = 79.0 – 92.2) reported not vaccinating their flocks routinely. The difference between the respondents was statistically significant (χ^2 = 109.5; p < 0.0001), and the relative risk (0.1494) indicates a considerable risk to unvaccinated flocks. Regarding biosecurity signage, only 8 interviewed farmers (8.0%; 95% CI = 4.1 – 15.0) had signage in place, while 92 (92.0%; 95% CI = 85.0 – 95.9) do not. The difference between these groups was statistically significant (χ^2 = 141.1; p < 0.0001), with a relative risk (0.0870), suggesting that farms lacking signage are more vulnerable to biosecurity breaches. Controlled farm access was reported by 3 farmers (3.0%; 95% CI = 1.0 – 8.5), while 97 (97.0%; 95% CI = 91.6 – 99.0) reported not having farm access control in place. This difference between the group of respondents was statistically significant (χ^2 = 176.7; p < 0.0001), with a relative risk (0.0870), indicating that uncontrolled access poses a significant biosecurity risk. Farm records were reportedly kept by 21 farmers (21.0%; 95% CI = 14.2 – 30.0), whereas 79 (79.0%; 95% CI = 70.0 – 85.8) did not maintain records. The difference between the respondents was statistically significant (χ^2 = 67.28; p < 0.0001), and the relative risk (0.2658) suggests that not keeping records increases biosecurity vulnerabilities. Proper carcass disposal was reported by 28 farmers (28.0%; 95% CI = 20.1 – 37.5), while 72 (72.0%; 95% CI = 62.5 – 79.9) did not dispose of carcasses appropriately. The difference between the respondents was statistically significant difference (χ^2 = 38.72; p < 0.0001), with a relative risk (0.3889), indicating that improper carcass disposal poses a notable biosecurity threat. Finally, rodent control was reportedly practiced by 12 farmers (12.0%; 95% CI = 7.0 – 19.8), while 88 (88.0%; 95% CI = 80.2 – 93.0) did not implement rodent control. The difference between the groups was significant (χ^2 = 115.5; p < 0.0001), and the relative risk (0.1364) suggests the critical role of rodent control in mitigating biosecurity risks in poultry farms

The results of average chick mortality and survival rates by biosecurity level in poultry farms in Maiduguri, Borno State, Nigeria was presented (Table 5). The results reveal significant differences in chick mortality and survival rates correlated with the levels of biosecurity implemented on poultry farms. Among the farms demonstrated apparently adequate biosecurity measures, which comprised 31 (31.0%) respondents, the average chick mortality rate was estimated as 8.3% (95% CI: 6.6 – 10.4). The results showed statistically significant p-value (< 0.0001; χ^2 = 28.88). In explicit contrast, 69 (69.0%) of farms characterized by grossly inadequate biosecurity measures showed a considerably elevated average mortality rate computed as 49.4% (95% CI: 46.0 – 52.8%). The relative risk (RR) of mortality in farms with inadequate biosecurity was calculated at 0.4493, indicating that those farms with adequate biosecurity experienced approximately half the mortality risk compared to their inadequately secured counterparts. The average chick survival rate from farms with apparently adequate biosecurity measures was computed as 91.7% (95% CI: 89.6 – 93.4%), which was significantly higher than that of farms lacking adequate biosecurity (p-value < 0.0001; χ^2 = 28.88). Conversely, the average chick survival rate in farms with grossly inadequate biosecurity was computed as 50.6% (95% CI: 47.2 – 54.0%). The relative risk of chick survival in farms with adequate biosecurity was 0.4493, illustrating that chicks raised in farms with appropriate biosecurity had a markedly greater likelihood of survival.

The results of seasonal distribution, average age, and breed of chicks with highest mortality rates based on respondent data in Maiduguri, Borno state, Nigeria was observed (Table 6). The results reveals that the majority of mortality cases occurred among chicks aged 1-2 weeks, with 148 respondents (74.0%; 95% CI: 67.5 – 79.6) reporting this age group. In contrast, 37 respondents (18.5%; 95% CI: 13.7 – 24.5) noted mortality in the 2-4 weeks age group, while 15 respondents (7.5%; 95% CI: 4.6 – 12.0) reported losses in chicks older than 4 weeks. There is statistical significance (χ^2 = 228.7, P < 0.0001) differences among the age categories. Considering the seasonal distribution of chick mortalities, the results revealed that the cold dry season was associated with the highest mortality rate, reported by 113 respondents (56.5%; 95% CI: 49.6 – 63.2). Conversely, mortality during the rainy season was reported by 62 respondents (31.0%; 95% CI: 25.0 – 37.7), while 12.5% (95% CI: 8.6 – 17.8) of the respondent reported the hot dry season according to 25 respondents. There is statistically significant (χ^2 = 87.86, P < 0.0001) difference in mortality rates across the seasons. Regarding breed, pullets were reported as having the highest mortality rates, with 93 respondents (46.5%; 95% CI: 39.7 – 53.4) indicating this trend. Broilers followed closely, with 81 respondents (40.5%; 95% CI: 33.9 – 47.4) reporting mortalities, while noilers accounted for 26 respondents (13.0%; 95% CI: 9.0 – 18.4). The statistical analysis ($\chi^2 = 57.44$, $P < 0.0001$) indicates a significant difference in mortality rates across the different breeds.

It was presented the critical biosecurity gaps identified during observational visits to 100 poultry farms in Maiduguri, Borno State (Table 7). The analysis reveals substantial deficiencies in biosecurity practices across these farms. Specifically, 63%of the farms lacked footbaths at their entrances, indicating a failure to implement basic biosecurity measures. Furthermore, 71% of the farms utilized inadequate methods for waste and carcass disposal. Regular disinfection protocols were inconsistently applied, with 58% of the farms not adhering to these essential practices. A striking 84% of the farms did not have appropriate facilities for isolating sick chicks, and 86% failed to establish adequate visitor traffic control measures. Additionally, 92% of the farms exhibited grossly inadequate ratios of feeders and drinkers to chicks, contributing to potential health risks. Approximately 70% of the farms reported inadequate stocking densities, while 63% demonstrated insufficient husbandry facilities.

Table 5: Average chick mortality and survival rates by biosecurity level in poultry farms in Maiduguri, Borno State, Nigeria

Information	Biosecurity Level	No. of Farms (%) Observed (N = 100)	Average Frequency (%)	95% CI (LL-UL)	p-value	χ^2	Relative Risk (RR)
Average Chick Mortality Rates	Apparently Adequate	31 (31.0)	68 (8.3)	6.6 – 10.4	< 0.0001	28.88	0.4493
	Grossly Inadequate	69 (69.0)	405 (49.4)	46.0 – 52.8			
Average Chick Survival Rates	Apparently Adequate	31 (31.0)	752 (91.7)	89.6 – 93.4	< 0.0001	28.88	0.4493
	Grossly Inadequate	69 (69.0)	415 (50.6)	47.2 – 54.0			

Key: N = Total number of respondents during the study period; CI = Confidence Interval; LL – UL = Lower Limit – Upper Limit; χ^2 = Chi – square

[a,b] Values with different superscripts indicate significant (p< 0.05) difference in prevalence rates

Table 6: Seasonal Distribution, average age, and breed of chicks with highest mortality rates based on respondent data in Maiduguri, Borno State, Nigeria

Information	Parameter	Number of respondents (n = 200)	Frequency (%) 95% CI (LL - UL)	χ^2	P-value	df
Average Age (weeks)	1 -2	148	74.0 (67.5 – 79.6)	228.7	< 0.0001	2
	2-4	37	18.5 (13.7 – 24.5)			
	Above 4	15	7.5 (4.6 – 12.0)			
Season	Rainy	62	31.0 (25.0 – 37.7)	87.86	<0.0001	2
	Hot dry	25	12.5 (8.6 – 17.8)			
	Cold dry	113	56.5 (49.6 – 63.2)			
Breed of chicks	Pullets	93	46.5 (39.7 – 53.4)	57.44	<0.0001	2
	Broilers	81	40.5 (33.9 – 47.4)			
	Noilers	26	13.0 (9.0 – 18.4)			

Key: n = Total number of respondents during the study period; CI = Confidence Interval; LL – UL = Lower Limit – Upper Limit; χ^2 = Chi – square; df = Degree of freedom

[a,b] Values with different superscripts indicate significant (p< 0.05) difference in prevalence rates



Fig 1: Chicks under brooding. Fig. 2: Brooding pens with grossly inadequate biosecurity, Fig. 3: Poultry pens without footbath facility at entrance


Fig. 4a: Chicks mortalities, Fig. 4b: Chick mortalities

The findings of the present study reveals how key demographic factors, including gender, education, age, and experience, influence biosecurity compliance and management practices, ultimately impacting chick survival, mortality and farm productivity in poultry farms across Maiduguri, Borno State, Nigeria.

Table 7: Observational Findings on Biosecurity Gaps during Farm Visits in Maiduguri, Borno State, Nigeria

Observed Biosecurity Gap	**No. of Farms (n=100)**	**Percentage (%)**
Lack of footbaths at farm entrance	63	63.0
Improper waste/carcass disposal	71	71.0
Lack of regular disinfection	58	58.0
Poor isolation facilities for sick chicks	84	84.0
Inadequate traffic control (visitors)	86	86.0
Inadequate feeder-chicks and drinker-chicks ratio	92	92.0
Inadequate stocking density	70	70.0
Inadequate husbandry facilities	63	63.0

The study shows that 86% of the farmers were male, while only 14% were female. This finding is consistent with previous research indicating that poultry farming in northern Nigeria is predominantly male-dominated (Lawal *et al*., 2023; Suleiman *et al*., 2023). Moreover, Fadimu *et al*. (2020), Akpabio *et al*. (2023) and Ezekiel*et al*. (2024) in a similar study have also revealed that majority of poultry farming is dominated by male farmers compared to female farmers. However, a study by Oyelami*et al*. (2022) in Edo State, Sati*et al*. (2022) and Onidje*et al.* (2024) in North-central Nigeria and Northern Benin respectively revealed a contrasting trend, with farmers being predominantly females. Cultural norms and societal expectations may limit female involvement in poultry farming in this region, leading to fewer women participating, particularly in large-scale or commercial poultry operations. This limited involvement is likely influenced by traditional gender roles that often perceive men as the primary earners, thereby emphasizing their participation in incomegenerating activities (Eze *et al*., 2017; Akpabio *et al*., 2023). Furthermore, the labor-intensive nature of poultry farming may act as a deterrent for female participation, as the physical demands and time commitments associated with such activities may conflict with societal expectations of women's roles within the household. This gender imbalance could have implications for biosecurity practices, as some studies suggest that women, particularly in small-scale poultry production, may have different approaches to animal health and biosecurity than men (Cataldo *et al*., 2023). A balanced gender representation might promote more diverse strategies for biosecurity implementation (Buckel *et al*., 2024). Additionally, women's increased involvement in poultry farming could foster better chick survival, as they are often engaged in meticulous care practices when involved in smaller-scale farming (Garsow *et al*., 2022).

Education has been previously reported to play a pivotal role in influencing a farmer's ability to understand and implement biosecurity measures (Msimang *et al*., 2022; Pao *et al*., 2022). The study reveals that 54% of the respondents had tertiary education, while 35.5% had secondary education. This relatively high level of formal education suggests that the majority of poultry farmers in Maiduguri possess the foundational knowledge required to comprehend the importance of biosecurity and its link to chick survival. Similar trends have been documented in some parts of Nigeria, for instance, studies by Fadimu *et al*. (2020), Akpabio *et al*. (2023), Udoh*et al*. (2024) and Ezekiel*et al*. (2024), revealed that a significant population of poultry farmers in their respective study areas are educated up to post-secondary and tertiary education level. Educated farmers are more likely to be aware of modern poultry farming practices, understand disease prevention strategies, and adhere to biosecurity protocols. Those with tertiary education may also have access to resources and networks that provide them with updated knowledge about poultry health management (Tasie *et al*., 2020). On the other hand, 3% of the respondents with informal education and 7.5% with only primary education might face challenges in understanding and implementing complex biosecurity measures, potentially contributing to higher chick mortality rates in their farms.

The study revealed that the majority of respondents (47%) were aged between 30 and 40 years, with a significant proportion (34.5%) being over 40 years. Farmers within these age groups are likely to possess the maturity and sense of responsibility necessary for effectively implementing biosecurity practices. Notably, older farmers, particularly those above 40 years, often rely on traditional knowledge and experience in poultry farming. This reliance may either enhance or hinder their adherence to biosecurity measures, depending on their openness to adopting modern farming techniques. Conversely, younger farmers (<30 years), who comprised 18.5% of the respondents, may be more receptive to innovative practices, including biosecurity protocols. However, their relative lack of practical experience could limit their ability to effectively manage disease outbreaks, potentially impacting chick survival rates. These findings are consistent with the results of previous studies by Tasie *et al*. (2020), Okocha *et al*. (2022), Oyelami *et al*. (2022), Akpabio *et al*. (2023), and Udoh *et al*. (2024), which reported that poultry farmers in this age range are typically in their productive and physically active years. This demographic is well-suited to the labor-intensive demands of poultry farming, as they possess the physical strength and motivation necessary to implement and sustain stringent biosecurity measures. Moreover, younger farmers are generally more inclined to adopt innovative practices compared to older counterparts, placing them in a favorable position to incorporate disease management strategies. In contrast, Win *et al*. (2018) reported a higher prevalence of poultry farmers aged over 50 years in their study, indicating a different demographic pattern that may influence biosecurity adherence in a similar study.

Experience is a critical factor in ensuring the successful implementation of biosecurity measures. In this study, over half (52.5%) of the respondents had more than five years of experience in poultry farming, while 43% had between 1 and 5 years of experience. This finding aligns with previous studies, such as those by Attia *et al*. (2022) and Wongnaa *et al*. (2023), which reported that a significant proportion of poultry farmers in developing regions have extensive years of experience in the industry. The higher experience levels among respondents in this study may correlate positively with better biosecurity practices, as experienced farmers are more likely to have encountered disease outbreaks and learned effective mitigation strategies. Butucel *et al*. (2022) and Onidje *et al*. (2024) emphasized that experienced farmers often adopt preventive measures, such as isolating sick birds, controlling farm access, and maintaining hygiene standards, which are critical components of biosecurity.

However, a small percentage (4.5%) of respondents with less than one year of experience presents a notable challenge. Farmers in this category may lack sufficient knowledge of disease prevention and the critical role of biosecurity in chick survival. These findings are consistent with studies by Mramba and Mwantambo (2024), who reported that inexperienced farmers are more prone to management errors that can lead to higher mortality rates. Targeted training programs focusing on disease prevention and biosecurity compliance are essential to address this gap, as highlighted by Rutebemberwa *et al*. (2020), who advocated for capacity-building initiatives to improve farming practices among new entrants in the poultry sector.

The distribution of respondents across the six clusters (Gwange, Mairi, Fori, Bolori, Shehuri, and University Quarters) showed minor variations, with the University Quarters cluster having the highest representation (21%). This trend may be attributed to the proximity of University Quarters to educational and research institutions, potentially facilitating better access to veterinary services and biosecurity awareness. Similar findings were reported by Ahmed *et al*. (2021), who observed that poultry activities tend to be concentrated near institutions that offer veterinary expertise and extension services. This proximity likely enhances farmers' understanding and adoption of biosecurity practices, contributing to improved chick survival rates in such clusters.

Conversely, the imbalanced distribution of expertise across clusters raises significant concerns. For example, Mairi and Bolori had higher proportions of veterinarians (20% each), which may lead to more stringent biosecurity measures and better health outcomes for poultry in these areas. This observation supports the findings of Ahmed *et al*. (2021), who demonstrated that regions with higher veterinary presence report lower disease incidences and mortality rates due to enhanced disease monitoring and prompt interventions. On the other hand, University Quarters, despite having the highest number of farmers (28%), recorded the lowest proportion of veterinarians (10%), which could potentially undermine biosecurity compliance and chick survival in the area. This imbalance underscores the need for strategic deployment of veterinary resources to regions with a higher concentration of poultry farming activities, as suggested by Nwobodo *et al*. (2023).

Additionally, the equal representation of roles (distributor/vendor, farmer, and veterinarian) across clusters highlights the diverse stakeholder engagement in poultry farming within Maiduguri. However, variations in the availability of veterinary expertise could influence the effectiveness of biosecurity measures. Clusters with fewer veterinarians, such as University Quarters, may benefit from targeted interventions, including mobile veterinary clinics and community-based training programs, to bridge the expertise gap. Evidence from Amalraj *et al*. (2024) indicates that such interventions have significantly improved biosecurity compliance and reduced mortality rates in similar settings.

Biosecurity measures in poultry farming are pivotal for controlling disease outbreaks and enhancing chick survival rates. Effective biosecurity reduces the spread of infectious agents, minimizes economic losses, and promotes sustainable poultry farming (Otieno *et al*., 2023). In this study, the role of veterinarians in enforcing biosecurity measures was evident, particularly in clusters like Mairi and Bolori. The presence of veterinarians in these regions is likely to facilitate farmer education on critical practices such as hygiene, vaccination, and isolation of sick birds, which are essential for disease prevention (Grace Wong *et al*., 2024). However, the low veterinarian-to-farmer ratio in the University Quarters cluster is concerning, as it may compromise the effective implementation of these measures, potentially increasing the risk of disease outbreaks and chick mortality. A similar trend was observed in studies where limited veterinary oversight correlated with higher incidences of poultry diseases (Islam *et al*., 2024; Tadesse *et al*., 2024).

Distributors and vendors also serve as critical control points in the poultry value chain. Their adherence to biosecurity protocols, including maintaining sanitary conditions in holding areas and ensuring transport hygiene, directly impacts chick survival (Grace *et al*., 2024). The clusters with the highest percentages of distributors, such as Shehuri, Mairi, and University Quarters, warrant closer evaluation to determine compliance with biosecurity standards. Non-adherence to protocols at the distribution level could serve as a conduit for disease transmission, as noted in earlier research on the role of poultry vendors in disease dynamics (Gržinić *et al*., 2023).

The variation in roles across clusters reflects differing levels of biosecurity challenges. For instance, Fori, which recorded the lowest number of respondents (12.5%), might face unique biosecurity challenges due to reduced veterinary and farming activities. Such limitations could lead to higher disease prevalence, as observed with Newcastle Disease (93.9%) in this cluster. Studies have consistently highlighted the correlation between low veterinary engagement and heightened disease risks in underserved regions (Sahoo *et al*., 2022). Conversely, clusters like Gwange and Bolori, with a more balanced distribution of veterinarians, farmers, and distributors, appear better positioned to address biosecurity challenges. This aligns with findings by Alders and Pym (2009), who emphasized the importance of a coordinated approach involving all stakeholders to enhance biosecurity and improve poultry health outcomes.

The high prevalence of diseases such as Newcastle Disease (ND) (82.0%), Coccidiosis (67.0%), and Infectious Bursal Disease (IBD) (66.5%) across the clusters highlights the critical challenges facing poultry farms in Maiduguri. These findings align with existing literature indicating that poor biosecurity measures significantly contribute to disease outbreaks in poultry farms (Oluwayelu *et al*., 2014; Ekiri *et al*., 2021; Wodajo *et al*., 2023). Disease clustering in certain areas, such as Fori and Bolori, underscores the presence of regional hotspots for disease outbreaks, likely influenced by inadequate biosecurity protocols, high farm density, and limited veterinary services.

Newcastle Disease (ND) was the most prevalent disease, with incidences peaking in Fori (93.9%), Bolori (90.9%), and Gwange (84.8%). This trend reflects the widespread nature of ND in regions with insufficient vaccination coverage and inconsistent disease management practices, as reported in similar studies in parts of Nigeria (Shittu *et al*., 2016). The relatively lower prevalence in University Quarters (67.6%) suggests that improved biosecurity and vaccination programs in urban settings can mitigate disease spread. Studies by Annapragada *et al*. (2019) and Amoia *et al*. (2021) emphasize that ND outbreaks are exacerbated by lapses in cold chain management during vaccine transportation and storage, a common challenge in rural and peri-urban regions.

Coccidiosis was the second most prevalent disease, with notable occurrences in Fori (78.8%) and Bolori (72.7%). This reflects gaps in litter management and hygiene practices, which are essential to controlling this protozoan infection. Prior research has similarly identified overcrowding and wet litter as key risk factors for coccidiosis in poultry (Lawal *et al*., 2016; Wondimu *et al*., 2019). In contrast, the relatively lower prevalence in University Quarters (55.9%) points to better adherence to biosecurity protocols, including proper disposal of feces and litter. Evidence from recent studies corroborates that stringent hygiene measures and strategic use of anticoccidials are effective in reducing the incidence of coccidiosis in high-risk areas (Tilli *et al*., 2022).

Infectious Bursal Disease (IBD) was prevalent in Bolori (78.8%) and Gwange (66.7%), indicating suboptimal vaccination practices. IBD vaccines are particularly sensitive to handling errors, including improper storage and administration, as documented by Dey *et al*. (2019). This finding is concerning, as IBD compromises the immune system, predisposing birds to secondary infections and higher mortality rates. Strengthening vaccine management protocols and training personnel in vaccine handling are critical to reducing IBD incidence. Similar recommendations have been made in studies conducted in other parts of Nigeria, where IBD poses a significant threat to chick survival (Audu *et al*., 2023; Tahir and Alsayeqh, 2024).

Salmonellosis and Helminthiasis, although less prevalent, remain significant threats to chick survival. Salmonellosis was most reported in Shehuri (52.9%), likely due to feed and water contamination, as highlighted by Shaji *et al*. (2023). Addressing these issues requires stringent feed quality checks and regular water sanitization. Helminthiasis was most notable in Bolori (48.5%) and Fori (39.4%), underscoring the need for improved sanitation and routine deworming programs. Similar findings have been reported by Ola-Fadunsin *et al*. (2019), who emphasized the role of contaminated soil and litter in transmitting helminths in backyard and commercial poultry settings.

Overall, the findings suggest that biosecurity measures in the poultry farms of Maiduguri are inadequate, contributing to the high prevalence of diseases. Clusters such as University Quarters, which demonstrated lower disease burdens, benefit from structured biosecurity practices, including routine veterinary oversight and vaccination programs. In contrast, Fori and Bolori, with higher disease burdens, likely face challenges related to limited veterinary access, financial constraints, and a lack of farmer awareness. These observations align with studies by Garba and Mungadi (2023), which identified financial and knowledge gaps as critical barriers to effective biosecurity implementation in Nigerian poultry farms.

The role of veterinarians in promoting biosecurity is paramount. Clusters with higher veterinarian representation, such as Mairi and Bolori, could achieve better outcomes if veterinarians actively engage in farmer education and disease prevention strategies. Conversely, regions like Fori require strengthened veterinary outreach programs to bridge gaps in biosecurity awareness and implementation. Similar recommendations have been made in studies advocating for community-based veterinary extension programs to enhance poultry health outcomes (Gröndal *et al*., 2023)

The practice of regular disinfection, adopted by only 37% of farmers, demonstrated a statistically significant association with improved chick survival. Farms practicing regular disinfection reduced their risk of chick mortality by 41.27%. Similar findings have been reported by Gedeno *et al*. (2022) and Wang *et al*. (2024), who noted that environmental hygiene and frequent disinfection are critical in controlling the spread of pathogens like Salmonella spp. and Escherichia coli in poultry farms. Despite its proven efficacy, limited compliance in our study likely stems from financial and logistical barriers, as suggested by Swelum *et al*. (2021).

Only 25% of farmers isolated new chicks, a critical biosecurity measure in preventing disease introduction. This measure reduced disease transmission risk by 66.67%, aligning with studies emphasizing the importance of quarantine in poultry management (Yerpes *et al*., 2020; Tsegaye *et al*., 2023). The low adoption rate underscores a need for educational interventions, as noted by Tasie *et al*. (2020), who reported that lack of knowledge and infrastructure often hinders the implementation of quarantine measures in resource-limited settings.

Footbath use, reported by only 19% of farmers, significantly lowered chick mortality risk by 76.54%. This finding corroborates earlier studies, which highlighted footbaths as cost-effective barriers against the introduction of pathogens like Newcastle Disease Virus (NDV) and avian influenza (Roky *et al*., 2022). However, the low uptake of this measure, as observed in our study, is consistent with the findings of Waweru *et al*. (2023), who attributed it to misconceptions about its utility and maintenance challenges.

Routine vaccination, adopted by just 13% of farmers, yielded the highest protective effect, with an 85.06% reduction in mortality risk. Vaccination has been extensively documented as a cornerstone in controlling poultry diseases (Otiang *et al*., 2021; Ravikumar *et al*., 2022). However, challenges such as vaccine storage, administration, and mistrust about efficacy may account for the low uptake in some parts of northeastern Nigeria, as reported by Sule *et al*. (2019). Addressing these barriers through veterinary extension services could significantly enhance vaccination coverage.

Alarmingly, only 8% of farms had biosecurity signage, and just 3% controlled farm access. Both measures reduced chick mortality risk by over 90%, underscoring their importance in minimizing pathogen introduction via human and vehicular traffic. These findings align with international biosecurity standards that advocate strict access control to mitigate disease spread (Otte *et al*., 2021). The negligible adoption of these measures reflects a severe gap in awareness and enforcement, echoing findings from Tadesse *et al*. (2024).

Proper record-keeping was practiced by 21% of farmers and was associated with a 73.42% lower risk of chick mortality. Record-keeping enables proactive disease management, as highlighted by Mramba *et al*. (2024). The low adoption rate indicates a need for simplified tools and training to support farmers in maintaining essential records.

Proper carcass disposal and rodent control were implemented by 28% and 12% of farmers, respectively, significantly reducing chick mortality risks. Improper disposal and uncontrolled rodent populations are well-documented sources of disease transmission (Duh *et al*., 2017; Omang *et al*., 2021). The findings highlight the critical need for comprehensive biosecurity training focusing on waste management and pest control, consistent with recommendations by the FAO (2023).

The study highlights critical areas for intervention to improve biosecurity practices in poultry farms. Tailored educational programs, financial support for essential materials, and regular monitoring by veterinary authorities could bridge the existing gaps. The findings emphasize that a multidisciplinary approach, integrating farmers, veterinarians, and policymakers, is essential to achieve sustainable improvements in poultry farm biosecurity

The observed relationship between biosecurity measures and chick survival underscores the critical importance of implementing rigorous biosecurity practices in poultry farms. Biosecurity measures such as controlling human movement in and out of poultry areas, proper sanitation, disinfection procedures, and vaccination protocols are well-documented as crucial in limiting the spread of infectious diseases that lead to high chick mortality rates (Dhaka *et al*., 2023; Onidje *et al*., 2024). The findings of this study align with prior research emphasizing that grossly inadequate biosecurity, observed in 69% of farms surveyed, exposes chicks to various disease agents, significantly reducing survival rates.

Younger chicks (1-2 weeks old) experienced the highest mortality frequency (74%), consistent with reports by Appiah (2019) and Yerpes *et al*. (2020), which highlighted the heightened vulnerability of chicks during early life stages. This vulnerability arises from their immature immune systems and thermoregulatory challenges. The significance of proper brooding practices—such as optimal temperature control, access to clean water, and high-quality feed—is underscored by this finding. Chicks between 2-4 weeks accounted for 18.5% of mortality, while older chicks (>4 weeks) exhibited the lowest mortality rate (7.5%). Seasonal variations also significantly influenced chick mortality rates, with the cold dry season (56.5%) recording the highest mortality frequency. These findings align with studies by Appiah (2019), who reported increased susceptibility to hypothermia and respiratory infections among poultry during colder months. In contrast, the rainy season exhibited a lower mortality rate (31.0%), attributed to moderate temperatures. However, challenges such as increased humidity, promoting pathogen proliferation, were noted, as highlighted by Chowdhury *et al*. (2020) and Dos Santos *et al*. (2020). The hot dry season showed the lowest mortality rate (12.5%), potentially due to poultry's adaptation to the region's climate and effective cooling measures. This observation aligns with findings by Olanrewaju *et al*. (2015), who reported better survival during hotter periods when farms implemented appropriate biosecurity strategies.

Mortality patterns also varied by breed, with pullets (46.5%) and broilers (40.5%) exhibiting higher mortality rates than noilers (13.0%). Similar trends were reported by Forseth *et al*. (2024), who attributed higher mortality in broilers to their rapid growth and metabolic demands, which make them susceptible to infections under poor biosecurity conditions. The relative resilience of noilers, a dual-purpose breed, as observed in this study, suggests the potential benefits of breed selection in improving survival under suboptimal farm conditions.

Conclusion

It was concluded that it was highlighted the critical role of biosecurity measures in improving chick survival and reducing mortality rates on poultry farms in Maiduguri, Borno State, Nigeria. The demographic data of respondents indicate a well-educated and experienced workforce, with a majority having more than five years of poultry farming experience. Despite this, a significant portion of farmers are not adopting essential biosecurity measures, which has clear implications for chick survival rates. Newcastle Disease (ND), coccidiosis, and infectious bursal disease (IBD) emerged as the most prevalent diseases, with considerable variations in disease occurrence across the six clusters. Farms in areas like Fori, Bolori, and Gwange reported the highest incidences of ND and coccidiosis, underscoring the need for heightened disease prevention efforts in these regions. The statistically significant results from this study demonstrate that farmers who implement biosecurity practices, such as regular disinfection, isolating new chicks, and using footbaths, experience lower mortality rates and higher survival rates compared to those with inadequate biosecurity measures. The analysis of biosecurity practices reveals that a concerning majority of farms lack critical preventive measures. Most respondents did not routinely disinfect their farms, isolate new chicks, or use footbaths, significantly increasing the risk of disease transmission. Additionally, the low percentage of farmers employing controlled access, maintaining farm records, or using proper carcass disposal further exacerbates biosecurity vulnerabilities. These findings are statistically supported by significant p-values and relative risks, indicating that farms neglecting biosecurity practices are more prone to higher mortality rates. The stark difference in chick mortality and survival rates between farms with adequate and inadequate biosecurity underscores the importance of enforcing proper biosecurity measures. Farms with grossly inadequate biosecurity reported a chick mortality rate of 49.4%, whereas those with apparently adequate biosecurity had a much lower mortality rate of 8.3%. Similarly, survival rates were significantly higher in farms with adequate biosecurity (91.7%) compared to farms with inadequate measures (50.6%).

Recommendations: The study emphasizes the importance of enhancing biosecurity practices to improve chick survival rates on poultry farms in Maiduguri. Farms with robust biosecurity measures reported significantly lower mortality rates, highlighting the need for comprehensive biosecurity protocols. It was therefore recommended that poultry farmers should be encouraged to adopt essential practices such as regular disinfection, isolation of new chicks, and vaccination. Training programs focused on biosecurity education should be organized to address the gap in awareness, particularly among the 63% of farmers not engaging in disinfection practices.

Educational interventions should be tailored to the knowledge base of the majority of respondents, many of whom have secondary or tertiary education. Extension services should develop practical, hands-on training sessions that emphasize the direct impact of biosecurity on flock health and economic viability. Implementing farmer field schools could serve as a valuable platform for peer learning, where farmers can exchange best practices and apply biosecurity measures effectively in their own operations.

Collaboration between veterinarians and poultry farmers is crucial for improving biosecurity and disease management practices. Veterinarians should be involved in regular workshops and seminars to disseminate best practices and proactively manage diseases. In underrepresented areas with fewer veterinary personnel, such as Fori, increasing the presence of veterinarians would help enhance flock health. Additionally, monitoring and evaluation systems should be established to track the impact of biosecurity measures on chick survival, while investment in infrastructure, such as controlled farm access and proper carcass disposal, should be prioritized to further improve biosecurity standards.

By implementing these recommendations, stakeholders in the poultry industry in Maiduguri can significantly improve the survival rates of chicks, reduce disease prevalence, and enhance the overall productivity of poultry farms in the region. It is crucial that concerted efforts are made to integrate these practices into the daily operations of poultry farmers to ensure a sustainable and profitable poultry industry.

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