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Assessment of biosecurity status of commercial chicken farms from Maharashtra, India

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Abstract

Implementing farm biosecurity practices could help prevent disease outbreaks at farms and reduce the economic burden on poultry farmers. A cross-sectional survey was conducted from January to July 2023, to evaluate the biosecurity status adopted by 72 commercial chicken farms from various districts of Maharashtra State. The personal face-to-face interview was made using a structured questionnaire on biosecurity practices. Poultry farming was found to be a male-dominated business. Amongst the 72 farmers, 30 (42%) had higher education in various fields; 47 (65%) were Agricultural; 42 (58%) had previous experience in rearing chickens; and 64% did not receive training on chicken farm management. The study's findings revealed that 83% of farmers (n=60) adopted their own farming. The farms were located near roads and water bodies. In structural biosecurity, only 22 (31%) had foot baths at the entrance of the farm. Pertaining to Biosecurity training given to the employees, Hygienic disposal of manure, measures for litter management, screening of vehicles, and labours training about vaccination were found to be followed more by the farmers of above higher secondary education group. The results indicate the impact of higher education on biosecurity measures.

Keywords: Biosecurity, survey, poultry farms, education

Introduction

Indian Broiler Industry experiences rapid growth driven by increased per capita availability reaching 7.10 kg (BAHS, 2023). The impressive growth of 6.77 and 6.13 percent in the layer and broiler poultry sector, is the result of technological breakthroughs in breeding, feeding and health, and sizeable investments from the private sector (BAHS, 2023). The Maharashtra state has shown tremendous growth in the poultry sector during the last few decades with a poultry population of 742.98 Lakh, wherein 68.48% were of an improved variety of poultry breeds (Department of animal husbandary GOM). Livestock sector is an essential sub-sector of the agriculture of Indian economy. Livestock and poultry play an important role in improving the economic conditions of rural masses of India. (Waghamare *et al.*, 2022) [48]. The poultry industry provides secured occupation opportunities and boosts household revenue in rural societies (Jat and Yadav, 2022) [26]. The broiler industry is growing with the backward integration system providing opportunities for the rural masses; these efforts have concentrated on production by neglecting several front-end activities such as disease outbreak management, prevention and control through strict biosecurity measures (Greening *et al.*, 2020) [19].

Biosecurity in poultry farming is very crucial and represents the first line of defence against the outbreak of diseases that may have consequences on bird health, food safety, environmental safety, zoonoses and economics (Tilli *et al.*, 2022) [45].

With increasing climate changeability, unpredictable weather conditions are expected to become more frequent, poultry feed quality, declined quality water availability, and the incidence of illness in livestock increase (Thornton *et al.*, 2009; Wong *et al.*, 2017) [44, 50]. A serious challenge for birds' health and welfare was observed in conventional poultry farming with increased risk of transmission of infectious diseases, because of high stocking density, low genetic variation, suboptimal ventilation, and immunosuppression (Espinosa *et al.*, 2020; Hafez and Attia 2020) [12, 20]. Proper farm management practices, such as improving biosecurity, implementing vaccination programs, and providing adequate nutrition and housing, can help prevent disease outbreaks (Khalil *et al.*, 2023) [30].

The small broiler (fewer than 5,000 birds) units are probably finding themselves at a disadvantage because of the high cost of feed, transport, veterinary care services and the low availability of credit (Chatterjee and Rajkumar, 2015) [7], which probably affects the level of biosecurity practices

adopted at farm level. FAO classified poultry production systems into four categories based on the volume of operation and level of biosecurity. Biosecurity concepts are subdivided into conceptual, structural, and operational frameworks (Maduka *et al.*, 2016 and Shane, 1997) [24, 39] described the conceptual category (location of farms), structural (building design and facilities) and operational (routine disinfection, sanitation, work procedures etc.)

Panda *et al.* (2023) [38] reported that 47.50% of farmers had a medium level of knowledge regarding overall biosecurity which inclines the farms to infectious disease outbreaks. Outbreaks result in considerable economic losses, reduced productivity, loss of interest in poultry farming, and sometimes poses a zoonotic threat to the employees on the poultry farm (Alexander, 2007; Gompo *et al.*, 2020) [3, 18].

Knowledge tests have a crucial role in evaluating the skills and competencies of individuals in our rapidly changing world (Johnson *et al.*, 2023) [28]. The ability to deal with the adoption of modern technology largely depends upon caused farmer's education (Paltasingh and Goyari 2018) [37]. The educated farmers adjust well and faster than the less educated farmers to achieve the growth (Ali and Byerlee 1991; Hojo 2004) [4, 22].

In this study, we aim to assess the biosecurity measures in commercial poultry farms in Maharashtra State, India. The main objective of this research is to evaluate the current biosecurity practices and procedures followed by farmers, and identify potential gaps and weaknesses considering the educational status of farmers. The results of this study will be beneficial for poultry farmers and other stakeholders in the industry by providing valuable insights into the effectiveness of biosecurity measures in reducing the risks of infectious diseases in poultry farms and targeting the specific knowledge gaps.

Methodology

Study Area: A cross-sectional study was carried out in 15 randomly selected districts (Central and South Central) of Maharashtra state.

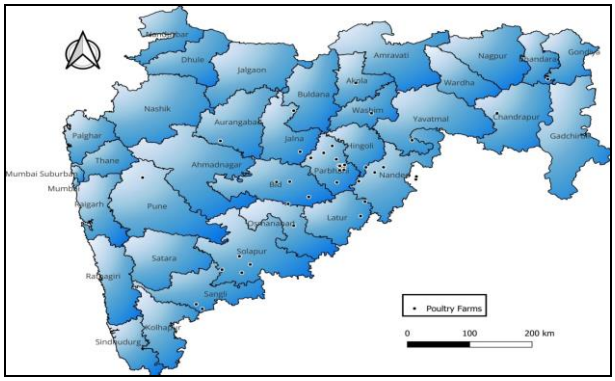

Fig 1: Geographical Distribution of farms across Maharashtra India

Study Population: The target population of the study comprised 72 commercial chicken farms from central and south central districts of Maharashtra State.

Study Design and Sampling Technique: A cross-sectional population survey was carried out from January 2023 to July 2023, to evaluate the biosecurity status adopted by commercial chicken farms in different districts of Maharashtra State. The majority of the selected farms were located in the Marathwada region, along with some other districts. The majority of farmers were visited in person and a few were interviewed telephonically. During data collection, the farmers were contacted earlier and asked for their interest in participating in the biosecurity study. A standardized questionnaire was used to collect data on the production and biosecurity characteristics of broiler chicken farms. In addition, data were collected for other biosecurity measures within the farms and the interaction with other poultry producers.

Questionnaire Development: A structured questionnaire was developed and used to collect data on the biosecurity implemented by small and large-scale commercial chicken farms in Maharashtra State. The questionnaire included owners' demography and relevant biosecurity practices like structural, conceptual and operational biosecurity for the cross-sectional survey. Specific questions included were in the demography of commercial chicken farm owners (gender, occupation, education level, experience, and training received). The biosecurity characteristics of the farm consist of two sections. Section I (Conceptual and structural Biosecurity) comprises questions related to capacity, distance from the road, nearest farms, nearest water bodies, all in all out practices, workers training and experience, shed direction, fencing, foot bath, ventilation, measures to control pest and wild animals, isolation facility, purchase and production record, visitor records etc. Section II (Operational biosecurity) comprises three sub-sections which include i) hygiene and sanitation (cleaning disinfection, cleaning tool, drinker & feeder cleaning etc) ii) waste disposal (dead bird disposal, method of disposal, garbage, manure disposal etc.) and iii) bird health (Record of bird health, vaccination, treatment etc.). In general, a total of 44 closed questions were designed to obtain "yes" or "no" answers.

Data Collection: The questionnaire was pretested in 72 chicken farms included in the survey, and care has been taken to avoid any misunderstanding or misinterpretation of the questions. The personal face-to-face interview was made with farm owners and a few were interviewed telephonically.

Data Analysis: All collected data were entered into a Microsoft Excel spreadsheet, cleaned, and coded. The level of education was the variable that is assumed to have a similar influence on the potential biosecurity measures of the farm are combined into a single variable. The Indian Council of Agricultural Research statistical Package WASP-II was used for all statistical analysis in this study; descriptive statistics were used to calculate the frequency, percentage, and standard deviation (SD). Moreover, bivariate analyses with Chi-square test were performed to assess the association between the dependent and independent variables. The significance levels for all statistical analyses were considered as $p < 0.05$.

Results and Discussion

This study aimed to assess the biosecurity measures adopted

by poultry farmers using questionnaires and checklists in a sample of poultry farms located in Maharashtra, which is one of the most densely populated poultry areas in India.

Demography of Farm Owners: Out of the 72 commercial chicken farm owners, 71 (98%) were males; 30 (42%) had higher education in various fields; whereas 42 (58%) had completed till higher secondary, 47 (65%) were Agricultural; and 42 (58%) had previous experience in rearing chickens. Among those owners, 46 (64%) did not receive training on chicken farm management. The demography of chicken farm owners is presented in Table 1.

Table 1: Demography of chicken farm owners involved in biosecurity evaluation

Sr. No.	Farm owners' demography	Category	Number of owners	Percentage (%)
1.	Gender	Male	71	98%
		Female	01	02%
2.	Owner's educational level	Primary, secondary, & higher secondary education	42	58%
		Graduate, Postgraduate	30	42%
3.	Primary occupation	Agriculture	47	65%
		Only Poultry Farm	15	20%
		Service	6	09%
		Other Business	4	05%
4.	Experience in rearing commercial chickens	More than 1 year	42	58%
		Less than 1year	30	42%
5.	Training in Poultry Farming	Yes	26	36%
		No	46	64%

Kabir *et al.* (2015) [29] reported that poultry farmers have the main occupation of agriculture (40%) and business constituted (22%), service (16%) and other business (22%) which moreover similar to our study. The dominance of males in the commercial poultry business has been reported in our study. Islam *et al.*, 2023 [24], reported 97.5 broiler poultry farmers respondents were male. Several other workers also reported majority of poultry farmers were male (Ajewole and Akinwumi, 2014; Eze *et al.*, 2017) [2, 13].

Our study found that the majority of poultry farmers were educated up to a higher secondary level (58%) nevertheless number of graduates and postgraduate are also quite sufficient in number (42%). It is also a fact that commercial broiler farming includes a lot of scientific organization practices whose acceptance requires some educational background among farmers for improved productivity. These results agreed with prior research conducted in different countries (Kabir *et al.*, 2015) [29]. Training is very important for proper poultry production and biosecurity measures but according to our results, farmers (64%) had no proper training on poultry production at the start of farming. Farmers performance would be improved if they could be trained by livestock officials (Kabir *et al.*, 2015) [29].

Farming characteristics of the poultry farmer

The farming characteristics of the poultry farm are depicted in Table 2. The findings of the study revealed that 83% of farmers (n = 60) adopted their own farming and 17% (n=12) farmers had contractual farming. Considering number of birds per farm the number of farmers in small category (<5000) were higher whereas, only 18 percent farmers have flock size more than 5000 birds. Among them, 58 and 42 percent farmers had experience more than one year and less than one year respectively. The farmers following all in all out method of production system were 76 percent whereas, 21 and 3 percent farmers followed continuous and no pattern, respectively.

Table 2: Distributions of farming characteristics among poultry farmers (N = 72)

Sr. No.	Farm Characteristics	Category	Number of farms (Percentage)
1.	System of farming	Contract farming	12(17%)
		Own farming	60(83%)
2.	Capacity of farm	Small (>5000)	59(82%)
		Large (<5000)	13(18%)
3.	Experience in rearing commercial chickens	More than 1 year	42 (58%)
		Less than 1year	30(42%)
4	Production system	All in all out	55 (76%)
		Continuous	15 (21%)
		No pattern	02 (3%)

Gokulakrishnan *et al.* (2018) [17] reported that independent poultry farming was more profitable than contract poultry farming, similarly, in our study 83% of farmers adopted their own farming. Contract broiler farming companies prefer to offer contracts to farmers who are less experienced in poultry production and thus likely to have lower negotiating power (Kumar and Anand, 2007) [31]. The number of farmers in the small category (<5000) were higher, in Egypt, 60% of broiler chicken farms were also under the similar category of rearing birds <5000/farm (Eltholth *et al.*, 2016) [11]. In the western agroclimatic zone of Tamil Nadu, India 76.3% of the respondents had below 9000 birds per batch (Thirunavukkarasu *et al.*, 2019) [43].

In India independent farmers have resource limitations and varied livelihood strategies of village poultry-keeping, implementation of biosecurity interventions shall be simple

to implement. Tsegaye *et al.* (2023) [46] reported that most farms (77.4%) practiced all-in and all-out flock movement similar to our study. This practice helps to reduce the exposure and predisposing factors for infectious diseases

Conceptual, Structural and Operational biosecurity measures among poultry farmers

Conceptual biosecurity

In order to measure conceptual biosecurity status, 05 indicators were included in the questionnaire, and their frequencies and percentages of responses are given in Table 3. Nearly 60% of the farms were located near roads with less than 2 km of distance, nearly 39 percent farms were at distance of 2 to 5 km from road this will have good impact on birds in respect to frequent noise, environmental, physical, and chemical contamination which might distresses the chickens. A significant number of farms (65%) located near water bodies and 53% of farms are in close vicinity (less than 2 Km) with other farms. This may predispose the farms for outbreak from migratory birds and local disease outbreaks. A significant number of farm owners (64%) have no training on the biosecurity concept, and (59%) of the farmers have disease outbreak experience. This indicates the importance of biosecurity training for control of diseases.

Many commercial chicken farms understudy were located away from the main roads. The close proximity to the road presents a danger of airborne transmission of diseases from animals transported along the public road and between poultry farms (Ismael *et al.*, 2021) [25]. Gelaude *et al.* (2014) [15] reported that, to minimize disease transmission, the distance to the nearest poultry farm should be at least 500m and preferably >1 km. Correia-Gomes *et al.* (2021) [8] assessed poultry farms in Scotland, and reported that most of the respondents (>50% overall) had seldom or never seen neighbour's poultry and livestock farms within 100 meters. The relative farm location remains crucial because the close proximity of the local water bodies. Migratory birds arriving at water bodies favours the increased likelihood of airborne pathogen transmission, farm owners (64%) had no training on the biosecurity concept which may impact on biosecurity measures to be adapted at farm. The government should put separate program for training especially in farm animal biosecurity, which would help for disease prevention and the adoption of modern husbandry practices suitable for the traditional or commercial poultry production system.

Table 3: The frequency and percentage of indicators of conceptual biosecurity, structural biosecurity, operational biosecurity (N=72)

Conceptual biosecurity			
Sr. No.	**Biosecurity Indicator**	**Categories**	**Number of farms (Percent)**
1.	Distance from main road (km)	Less than 2 km	43 (60%)
		2-5km	28 (39%)
		More than 5 km	1 (1%)
2.	Distance from nearest farm	0.5-1 km	13 (18%)
		1-2 km	25 (35%)
		2-3 km	7 (10%)
		More than 3 km	27 (37%)
3.	Water bodies near the farm	Yes	47 (65%)
		No	25 (35%)
4.	Biosecurity training given to employees	Yes	26 (36%)
		No	46 (64%)
5.	Experience of any disease outbreak	Yes	42 (59%)
		No	30 (41%)

Structural biosecurity

The structural biosecurity was evaluated using 09 biosecurity measurements. Amongst the poultry farms assessed, 60 (83%) had the fencing; 58 (81%) had control measures for rodent and flies; 49(68%) had control measures for wild animals; 39 (88.64%) did not exchange equipment with other farms; 67 (93%) farms had proper ventilation facility in the shed; 56(78%) had isolation facility for sick birds and 64(89%) do not allow pet and birds inside the poultry shed. However, only 22 (31%) had foot bath at entrance of the farm. Majority of the farmers 57(79%) purchase feed from outside indicate non-availability of feed mill structure**.** The details of frequency and percentage of structural biosecurity indicators are presented in Table 4.

In the current study structural biosecurity was found to be at satisfactory level as majority of farmers had fencing, control measures for flies, rodents, wild animals, ventilation facility and isolation facility for sick birds which shows that farmers are more proactive in providing adequate structural biosecurity measures for protecting the flock. The possible reason for this could be that farmers have been exposed to more information about structural part of farm and training underwent have emphasized on facility development. Amongst the poultry farms assessed, 60 (83%) had the fencing. A previous study conducted by Ibrahim *et al.* (2015) [23]. In Bangladesh 84% of farms lacked fencing. Mustafa E.A. (2013) [36], reported that a fence is the first line of defence against disease transmission, as humans and other animals with improper can act as mechanical and biological vectors for transferring infectious diseases (Hafez *et al.*, 2010; Lister, S.A., 2008; Tilli *et al.*, 2022) [20, 45, 33].

Only 31% farms had foot bath at entrance of the farm, this is not in line with the findings of a study conducted which revealed that 80% broiler farms used a foot bath (Haftom *et al.*, 2015, Ismael *et al.*, 2021; Islam *et al.*, 2023) [24, 25]. Furthermore, the presence of footbath at entrance of poultry shed shall reduce the risk of the introduction of infectious agents (Tilli *et al.*, 2022) [45]. The farms (79%) understudy used company-supplied feed, which increases the possibility of disease introduction (Islam *et al.*, 2023) [24]. This is in line

with earlier investigations conducted by (Ismael *et al.*, 2021; Tanquilut *et al.*, 2020) [42, 25] wherein more than 80% of the farms used the feed from suppliers.

Table 4: The frequency and percentage of structural biosecurity indicators (N=72)

Sr. No.	Biosecurity Indicator	Categories	Number of farms (Percentage)
1.	Direction of the shed	East	55(76%)
		West	17(24%)
2.	Fencing at farm	Yes	60(83%)
		No	12(17%)
3.	Footbath at farm entrance	Yes	22(31%)
		No	50(69%)
4.	Control Measures for rodent & flies control	Yes	58(81%)
		No	14(19%)
5.	Control Measures for wild animals	Yes	49(68%)
		No	33(32%)
6.	Proper Ventilation facility at shed	Yes	67(93%)
		No	5(7%)
7.	Isolation facility sick birds	Yes	56(78%)
		No	16(22%)
8.	Pet animal inside shed	Yes	8(11%)
		No	64(89%)
9.	Purchase of feed from outside	Yes	57(79%)
		No	15(21%)

Operational biosecurity

The operational biosecurity measurements are presented in Table 5. The operational biosecurity measures were evaluated using 11, 04 and 09 biosecurity indicators for hygiene and sanitation, waste disposal and bird health, respectively. Amongst the poultry farms assessed for hygiene and sanitation measures, 57 (79%) regularly clean sheds; 59 (82%) do hygienic disposal of manure; 65(90%) use of cleaning tools; 65(90%) regularly clean drinkers and feeders; 55(76%) took measures for litter management; 59(82%) do not exchange the equipment's and 64(89%) keep visitors' logbook. However, only 15(21%) had used separate clothing for farm employees, 27(38%) screened the arrived vehicles, 17(24%) sanitized the shed regularly and 63(88%) allowed farm labours to visit other poultry farms.

Various researchers underlined the importance of cleaning and sanitation in chicken farms to eliminate disease pathogens (Gibbens *et al.*, 2001; McCrea, 2008) [16, 35]. The farm hygiene measures under study were found acceptable and encouraging. This is consistent with prior research reports (Tanquilut *et al.*, 2020; Islam *et al.*, 2023) [42, 24]. Cleaning and disinfecting the farm is practiced by up to 90% of broiler farms farmers showed low interest in farm clothing, screening of vehicles and regular sanitation. Proper cleaning and disinfection protocols adopted at farms are crucial to limit the spread of pathogens (Gibbens *et al.*, 2001) [16]. The adoption of a spray bay with a waterproof floor for vehicle disinfection represents depth in the biosecurity plan (Tilli *et al.*, 2022) [45]. Permitting the farm labours for visits at near farms could possibly lead to outbreaks if farm is infected.

Amongst the poultry farms assessed for waste disposal measures, 66(92%) properly dispose dead birds using deep burial method (86%). However, 56(78%) do not park garbage near shed but 29(40%) farmers do the movement of dead birds.

The likelihood of disease developing on a farm could be due to including the improper management of litter, the disposal of used litter and dead birds close to farm; and shared equipment to the farm (Stephen. C, 2012) [41]. The observations of the present study dealing with waste management agreed with the study by Eltholth *et al.* (2016) [11]; Waktole *et al.* (2023) [49] and conducted in Egypt and Ethiopia, respectively. Deadstock should be carefully buried so they do not contaminate the soil or water (Eze *et al.*, 2017) [13]. Islam *et al.* (2023) [24] reported that in most farms deadstock was handled using the burial technique. As per Aguidissou *et al.* (2020) [1], incineration is the best technique for disposing of dead animals because it reduces pathogen spread and stability on farms.

Amongst the poultry farms assessed for bird or flock health measures, 50(69%) do regular health monitoring of the flock, 62(86%) keep vaccination records, 44(61%) arrange visits of veterinary doctors, 51(71%) given training to labours about vaccination, 25(38%) give antibiotics to birds on initial 3 days, 45(63%) discusses disease with neighbouring farmers and 60(83%) keep record of production & mortality. However, 33(45%) do not have isolation facilities for diseased birds and 32(44%) do not keep daily health records of the flock which was contradictory to the reports of regular health monitoring within the study.

Our data showed a generally good level of implementation of flock health measures and management in all poultry farms. However, the isolation of diseased birds and daily health records were missing in many farms. It is demonstrated that maintaining the health of birds and also the safety of animal-derived products is important for the safety of the entire value chain of poultry production (Siekkinen *et al.*, 2012) [40]. Among disease supervision practices, vaccination remains as the main preventative measure to fight pathogenic diseases of poultry (Aondo *et al.*, 2020) [5].

Table 5: The frequency and percentage of operational biosecurity indicators (N=72)

Sr. No.	Biosecurity Indicator	Categories	Number of farms (Percentage)
Sub-section I: Hygiene and sanitation			
1.	Regularly clean shed	Yes	57(79%)
		No	15(21%)
2.	Hygienic disposal of manure	Yes	59(82%)
		No	13(18%)
3.	Use of Cleaning tools	Yes	65(90%)
		No	7(10%)
4.	Regularly clean drinkers and feeders	Yes	65(90%)
		No	7(10%)
5.	Measures for litter management	Yes	55(76%)
		No	17 (24%)
6.	Separate clothing for farm employees	Yes	15(21%)
		No	57(79%)
7.	Screening vehicles	Yes	27(38%)
		No	45(62%)
8.	Sanitisation of shed.	Yes	17(24%)
		No	55(76%)
9.	Exchange of equipment's	Yes	13(18%)
		No	59(82%)
10.	Farm labours allowed to visit other farm	Yes	63(88%)
		No	23(12%)
11.	Visitors' logbook at farm	Yes	64(89%)
		No	8(11%)
Sub-section II: Waste disposal			
1.	Proper disposal of dead birds	Yes	66(92%)
		No	6(8%)
2.	Methods for disposal	Buried deep in the ground	62(86%)
		Incineration	4(6%)
		Rendering	1(1%)
		Compost	5(7%)
3.	Park garbage near the shed	Yes	16(22%)
		No	56(78%)
4.	Movement of dead birds	Yes	29(40%)
		No	43(60%)
Sub-section III: Bird/flock health			
1.	Regular health monitoring of flock	Yes	50(69%)
		No	22(31%)
2.	Vaccination records	Yes	62(86%)
		No	10(14%)
3.	Visit of Veterinary doctor	Yes	44(61%)
		No	28(39%)
4.	Isolation facility for diseased birds	Yes	39(54%)
		No	33(45%)
5.	Labours training about vaccination	Yes	51(71%)
		No	21(29%)
6.	Antibiotics given to birds in initial 3 days	Yes	25(38%)
		No	47(62%)
7.	Discussing diseases with neighbour farmers	Yes	45(63%)
		No	27(37%)
8.	Daily health record of birds	Yes	40(56%)
		No	32(44%)
9.	Record of production & bird died	Yes	60(83%)
		No	12(17%)

Correlation of selected biosecurity indicators with educational qualification of farmer

The characteristics of the biosecurity indictors and poultry farmers education under study were analysed and the findings with positive correlation are depicted in Table 5.

The Biosecurity Indicators presented in Table 6 showed a significant association with the educational qualification level of the farmers. Biosecurity training given to the employees (χ^2=11.20, P Value=0.00), Hygienic disposal of manure (χ^2=3.28, P Value=0.05), measures for litter management (χ^2=4.06, P Value=0.04), screening of vehicles (χ^2=4.40, P Value=0.03), sanitization of sheds (χ^2=6.18, P Value=0.01), and labours training about vaccination (χ^2=4.99, P Value=0.02) were found to be followed more by the farmers of above higher secondary education group. However, even though for the proper disposal of dead birds the difference between followers and non-followers was significant but a very small percent of farmers from both the

educational qualification groups did not follow this practice. The results of biosecurity indicators clearly indicate that the higher educational qualification made the farmers more aware and concerned about the importance of following these measures to avoid the health hazards due to infections and zoonotic diseases.

Several researchers reported that although data collection with structured questionnaires characterizes a picture of biosecurity implementation and the reliability of farmers' answers to some questions might be debatable, questionnaires have proven to be a useful instrument for measuring biosecurity compliance in poultry farms (Dorea *et al.*, 2010; Van Limbergen *et al.*, 2018; Tanquilut *et al.*, 2020; Waktole *et al.*, 2023) [10, 42, 49, 47] and a possible driver for enhancement even for the farmers themselves.

The level of education also determines the comfort with which someone engages and recognizes the knowledge they get. Lestari *et al.* (2019) [32] reported that in general, the higher the education level of an individual, the better their knowledge. Similarly, they observed that the level of biosecurity adoption affected significantly by education level and herd size of farms. In contrast, a survey study conducted by Garcia *et al.* (2020) [14] on larger farming operations revealed no significant associations between education level with biosecurity beliefs or behaviours.

Table 6: Correlation of biosecurity indicators with farmer's educational status

Sr. No.	Biosecurity Indicator	Categories	Number of farms	Biosecurity status correlation with Educational Qualification		Chi square value	P value
				Below higher secondary	Above higher secondary		
1.	Distance from main road (km)	Less than 2 km	43(60%)	30(72%)	13(44%)	7.2068	0.0272
		2-5km	28(39%)	11(26%)	17(56%)		
		More than 5 km	1(1%)	1(2%)	0		
2.	Biosecurity training given to employees	Yes	26(36%)	8(19%)	18(60%)	11.008	0.0009
		No	46(64%)	34(81%)	12(40%)		
3.	Hygienic disposal of manure	Yes	59(82%)	31(74%)	28(93%)	3.2855	0.0599
		No	13(18%)	11(26%)	2(7%)		
4.	Measures for litter management	Yes	55(76%)	28(67%)	27(90%)	4.0681	0.0437
		No	17 (24%)	14(33%)	3(10%)		
5.	Screening vehicles	Yes	27(38%)	11(26%)	16(53%)	4.4038	0.0359
		No	45(62%)	31(74%)	14(47%)		
6.	Sanitisation of shed.	Yes	17(24%)	5(12%)	12(40%)	6.1802	0.0129
		No	55(76%)	37(88%)	18(60%)		
7.	Labours training about vaccination	Yes	51(71%)	25(60%)	26(80%)	4.9959	0.0254
		No	21(29%)	17(40%)	4(20%)		
8.	Proper disposal of dead birds	Yes	66(92%)	39(93%)	27(90%)	3.2967	0.0499
		No	6(8%)	3(7%)	3(10%)		

Conclusion

The sufficient of the farmers started their poultry enterprise with previous experience in rearing chicken although many of the farm owners did not receive training on chicken farm management and biosecurity. This may lead to an impactful information gap in the adoption of proper and successful biosecurity measures. The independent poultry farming was more adopted model than contract poultry farming which need a technical support system. The results clearly indicate that the higher educational qualification made the farmers more aware and concerned about a disease prevention strategy through biosecurity measures adoption and improvement.

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