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Assessment of Biosecurity Practices and Its Status in Small- and Medium-Scale Commercial Poultry Farms in Arsi and East Showa Zones, Oromia, Ethiopia

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Abstract: Disease prevalence and seasonal outbreaks are challenging the poultry industry in Ethiopia. Proper and sustainable implementation of biosecurity practices is important to reverse such problems. This study was conducted in commercial poultry farms in two zones of Ethiopia to investigate farm characteristics, implementation of biosecurity practices, and biosecurity status (BS) using a structured questionnaire. The variables were grouped into three biosecurity factors, including conceptual, structural, and operational biosecurity, based on their homogeneity. Descriptive and inferential statistics were used to summarize the results. Most commercial farms were owned by males (69.7%). The majority of the farms (40.3%) were located at a distance <50 m from residential areas. Farm owners do not provide biosecurity training to their employees (68.8%), which results in poor biosecurity implementation. The mean conceptual, structural, and operational BS were 50.4 ± 11.62, 63.27 ± 10.51, and 44.69 ± 13.04, respectively, indicating operational biosecurity measurements were less implemented. Overall, the BS indicated that 40.7% of the farms have BS < 50% questing for interventions. Farm characteristics and biosecurity measurements were positively associated with BS, which shows substantial room for improvement. Owners' education, occupation, experience, farm flock size, and training were significantly associated with BS ($p < 0.05$). A disease prevention strategy through biosecurity improvement is an economical means for controlling poultry disease prevalence.

Keywords: biosecurity; diseases; poultry; farms; biosecurity status

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1. Introduction

Livestock plays a crucial role in the livelihoods of the farming community in Ethiopia. The livestock sector has social, economic, and cultural values for Ethiopians and is highly integrated with crop agriculture. Poultry is the dominant livestock species in Ethiopia, estimated at 57 million chickens next to cattle which is 70 million [1]. Among the huge number of chickens in Ethiopia, laying hens contributes the lion shares (34.26%), followed by chicks (32.86%), pullets (11.35%), cocks (11.12%), cockerels (5.74%), and nonlaying hens (4.59%). About 78.85% of the chicken were indigenous, 12.02% hybrid, and 9.11% were exotic [1]. Regarding productivity, the average number of eggs laid per hen per laying period was about 13 eggs, 48 eggs, and 128 eggs for indigenous, hybrids, and exotic chickens, respectively. The average annual egg production was about 369 million in the year 2020 [1], and poultry meat production in the year 2016 was 13,000 tones contributing only 2%, 0.2%, and 0.01% of the total poultry meat outputs of East Africa, Africa, and the rest of the world, respectively [2]. Livestock farming in Ethiopia has social, economic, and livelihood values and plays a crucial role in food and nutritional security. Globally,

the nutrition, food security, livelihoods, and resilience of hundreds of millions of people depend on animal products. Livestock contributes one-third of the protein that people consume in the world [3]. Worldwide, 40% of all agricultural income comes from livestock. In Ethiopia, the contribution of livestock accounts for about 15–18% of the total GDP and 40–49% of the agricultural GDP, excluding the value of animals as draught power, manure, and transport of people and products [4]. The dominant poultry production system in Ethiopia is the traditional backyard system characterized by poor management, biosecurity, health, and productivity, dominated by local chickens. There are a few numbers of small-, medium-, and large-scale commercial poultry farms in Ethiopia, and most of them are located near the capital or regional towns [2]. Very recently, business-oriented small-scale poultry enterprises were emerging to enhance the benefit of the sector. The number of chickens supplied to the market for sale and slaughtering in Ethiopia was 15.8 mil and 14.3 mil in 2020, respectively, which is very small relative to the chicken population of the country, whereas the annual mortality rate for various reasons was very high, nearly 39 mil [1]. The per capita chicken egg and meat consumption in Ethiopia were 0.36 kg and 0.66 kg, respectively, which is the lowest in Africa and in East Africa average of 1.03 kg of egg and 1.64 kg of meat in the year 2013 [2].

Among the multidimensional challenges of poultry enterprises, high poultry disease prevalence in commercial farms and household level is a critical constraint in Ethiopia for reasons such as poor farm biosecurity, inadequate health facility, lack of prevention strategies, and poor access to vaccines. Biosecurity is one of the root causes of disease prevalence and outbreaks, though its compliance is usually poor in all animal production systems around the world [5]. Biosecurity is a set of practices and strategies implemented to control, bind, and prevent the entry and transmission of infectious diseases in poultry farms and facilities [6–8]. A comprehensive biosecurity program needs to consist of an ordered set of conceptual, structural, and operational elements that are designed to stop the spread of infectious diseases both inside and across farms and facilities. Biosecurity management should be implemented primarily beginning with site selection for farm facilities, secondly with farms' physical factors (layout, drainage, and fencing), and thirdly with routine procedures such as bioexclusion and spread (biocontainment) of infection within a facility. Any disease control program should regularly assess and practice such procedures and actions. In Ethiopia, most small and medium commercial farms operate under low levels of biosecurity, which increases the risk of the spread of infectious diseases. Therefore, the current study was designed to investigate biosecurity management practices and assess biosecurity status (BS) in small- and medium-scale poultry farms in the study area.

2. Materials and Methods

2.1. Study Area

The study was conducted in the southeastern part of Ethiopia, particularly in the Tiyo, Dodota, and Hetosa districts of The Arsi zone and Adama, Bishoftu, and Boset districts of East Showa zones, Oromia regional states, Ethiopia. The altitude of the study areas ranges from 1458 masl to 2490 masl, and the latitude ranges from 7.9° N lat and 39.1° E long to 8.7° N lat and 39° E long with minimum and maximum temperatures of 8.4 °C and 31.7 °C, respectively.

2.2. Study Population

The targeted population of the study was all small- and medium-scale commercial poultry farms established by private-, micro-, and small-scale enterprises (MSEs) and cooperatives that raise exotic breeds of chickens for egg, broiler, and pullet production. Small farms own <1000, whereas medium farms own 1000–10,000 exotic/cross-breed chickens. In total, 221 poultry farms having a minimum and maximum flock size of 50–5000 were visited.

2.3. Study Design and Sampling

As a research design, a cross-sectional survey was carried out from December 2021 to February 2022 in 221 small and medium commercial poultry farms. Lists of such commercial poultry farms were collected from respective Woreda Livestock and Fisheries Development offices. In this study, we have used a checklist-based one-to-one interview method to collect data. Before proceeding to data collection, we have tried to discuss with poultry farm owners and farms' operators. We disclosed the objectives of the study, the data to be collected, and how the data were collected. In addition, we told them that the study does not harm their farm and they do have the right to withdraw at any time if they are not interested in participating. Finally, we have asked them for their willingness to provide us with the necessary data and allow us to visit their farms at some points. As a result, verbal consent was secured prior to data collection at the sampling stage, which could be witnessed through personal contact with sample poultry farm owners at random. Then, the data was collected from those farm owners who were willing to provide the necessary data based on informed consent by dropping those unwilling farm owners and operators.

2.4. Questionnaire Development

A semi-structured questionnaire was designed mainly on biosecurity practices adopted by commercial poultry farms focusing on conceptual, structural, and operational biosecurity measures/practices and some farm characteristics. The conceptual biosecurity framework includes the location of the farm facilities, distances from residential areas, roads, and other facilities, the existence of standing water, materials used and housing type, and the like. The structural biosecurity framework comprises issues related to the existence of barriers for the entry of infectious agents such as foot baths, farm gates, fences, vehicle tire baths, wild birds, no purchase of chicken, no access of rodents to feed, absence of pet animals in the farm, etc. Operational biosecurity measure includes precautions in relation to employees such as clothes, shower, glove, masks, footwear, visitors' cloth, and other operational activities such as partial depopulation, chicken examination, sanitary practices, and so on. The questionnaire associated with farm characteristics consists of farm type, farm size, chicken type, breed, farm capacity, productivity, production cycle, and the like.

2.5. Data Collection

Data collection was carried out using semi-structured questionnaires developed for this purpose comprising pertinent closed and open-ended questions that help to gather all the information regarding biosecurity measures and farm characteristics. The questionnaire was pretested before the final survey in order to refine the questionnaire to make it clear, understandable, and complete. Finally, a face-to-face personal interview was carried out with farm owners in the case of a private farm, managers/employees in the case of MSE, and cooperative-type farms.

2.6. Data Management and Analysis

In order to score biosecurity, variables in the questionnaire received an individual score of 0 (for a total absence of preventive measures) and 1 (for full presence of preventive measures), according to [9,10]. The variables were categorized into three homogenous groups depending on the nature and similarity of the variables in their influence on the potential risk of poultry disease introduction into a given poultry farm, such as conceptual, structural (facilities and equipment), and operational biosecurity factors [6,10–12]. Then, mean BS and percentages of BS were computed for structural, conceptual, and operational biosecurity measurements. The computed biosecurity scores (BS) were compared with the standard biosecurity rating "Good" if the BS of the farm was above 50% and "Poor" if the BS of the farm was less than 50% [6]. Accordingly, the final generated data were entered into SPSS version 22 statistical software and analyzed using descriptive statistics such as frequency, mean, and percentages. Analysis of variance (ANOVA) and t-test were

computed to determine the significant differences between variables. Pearson's chi-square was computed to determine the relationships between farm characteristics and BS.

3. Results

3.1. Demography of Farm Owners

A total of 221 poultry farms with different flock sizes were visited during this survey. Most of the farms (121) were privately owned, 82 farms were owned by micro- and small-scale enterprises, and 17 poultry farms were established as cooperatives. In most cases, the owners were the managers of the farms, of which the majority (69.7%) of the farms were owned/managed by males. Thirty-two percent of the respondents were less educated (illiterate or up to grade 4), which impacted the success of a business and the entrepreneurial skill of individuals.

The majority of the owners (80.5%) have previous work experience in poultry production without formal education (Table 1). Farm owners (79.7%) have gotten technical training opportunities not specific to biosecurity by government and nongovernmental organizations, and 20.4% did not obtain any training. Among these owners, only 60.6% let external professional employees supervise their farms.

Table 1. Sex, age, educational level, and experiences of the respondents.

Variables		Arsi Zone N (%)	East_Showa N (%)	Total N (%)
Sex of the respondents	Male owned	70 (70%)	84 (69.4%)	154 (69.7%)
	Female owned	30 (30%)	37 (30.6%)	67 (30.3%)
Age of the respondent (years)	15–30	26 (26%)	26 (21.5%)	52 (23.5%)
	31–45	53 (53%)	69 (57%)	122 (55.2%)
	46–60	21 (21%)	26 (21.5%)	47 (21.3%)
Education of the respondents	Illiterate	13 (13%)	13 (10.7%)	26 (11.8%)
	Grade 1–8	33 (33%)	57 (47.1%)	90 (40.7%)
	Grade 9–12	34 (34%)	40 (33.1%)	74 (33.5%)
	Above grade 12	20 (20%)	11 (9.1%)	25 (11.3%)
Do you have experience in poultry production?	Yes	65 (65%)	113 (93.4%)	178 (80.5%)
	No	35 (35%)	8 (6.6%)	43 (19.5%)

3.2. Characteristics of Chicken Farms

In this survey, three types of farms were visited depending on the type of chicken reared in the farms. These were farms rearing only egg-type (156 (70.6%)), broiler-type (30 (13.6%), and both egg-type and broiler-type chickens (35 (15.8%)). Regarding the chicken age groups, 18 (8.1%) farms keep breeders to produce day-old chickens, 66 (29.9%) sell pullets at the age of 3 months, 19 (8.6%) sell broilers at 45–60 days, 114 (51.6%) sell table eggs to market, and 4 (1.8%) of the farms rear both broiler and layer chickens and sale broilers and table eggs. Among the farm owners, only 43 (19.5%) know the weight of birds, and only 32.6% know the weight of eggs they are producing at the sale. The mean flock sizes, annual production capacity pullets, broilers, and layers of the farms were 925.3 $\pm$ 924.2, 2603.8 $\pm$ 2241, 2133.6 $\pm$ 1892.8, and 763.2 $\pm$ 809.8, respectively, with significant variability among the study areas are shown in Table 2. In most of the farms, 212 (95.5%) were reared in deep litter housing, and only 9 (4.1%) were in their own cage system. The bedding materials in the poultry houses were straw, sawdust, and wooden shaving, with a proportion of 170 (76.9%), 23 (10.4%), and 17 (7.4%), respectively. The majority of poultry buildings (36.2%) have corrugated iron sheet walls, followed by hardwood walls (34.4%) and brick walls (29.4%) in terms of structure. The chicken buildings' floors were made of concrete (51.1%), bare ground (45.7%), and laminated wood (3.2%). To control air

circulation in the poultry houses, most of the farm buildings 210 (95%) have openings for ventilation, and very few farms, 11 (5%), were without openings. The majority of the farms, 137 (62%), had their own working place, and the rest operated in a rental place. Among the farm owners, 171 (77.4%) exercised "All-In and All-Out" strategies for flock restocking and destocking.

Table 2. Production cycle of different classes of chickens, annual production, and farm flock size.

Variables	Arsi Zone		East Showa		Total	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Production cycle of pullets/year	3.0± 0.71	2–4	2.9 ± 0.97	1–6	2.98 ± 0.82	1–6
Annual production of pullets/year	1803.3 ± 1226.7	100–4800	3804.5 ± 2850.5	460–9000	2603.8 ± 2241	100–9000
Production cycle of broiler/year	2.1 ± 0.35	2–3	2.9 ± 0.90	1–5	2.76 ± 0.88	1–5
Annual production of broilers/year	1311.1 ± 534.9	300–2000	2314.2 ± 2036.2	150–6000	2133.6 ± 1892.8	150–6000
Current flock size of all chicken	741.1 ± 801.1	50–4000	1077.5 ± 992.4	50–4000	925.3 ± 924.2	50–4000
Flock size of layers	697.8 ± 638.8	50–2500	818.1 ± 930	50–3500	763.2 ± 809.8	50–3500

3.3. Poultry Disease Management Practices

The first, second, and third economically important poultry diseases in the farms were Newcastle disease (NCD), 140 (79.5%), infectious bursal disease (*Gumboro*), 58 (54.7%), and fowl cholera, 69 (88.5%), respectively as indicated by poultry producing farmers. However, there were also other important poultry diseases that were frequently observed in chicken farms, such as coccidiosis and fowl pox. In order to control disease outbreaks in poultry farms, 191 (86.4%) farm owners vaccinate their chickens for different diseases such as NCD, *Gumboro*, Marek's, and fowl pox diseases. However, only 157 (71.0%) of the farm owners follow standard vaccination schedules in terms of frequency. Among the farm owners, 65 (34%) and 58 (30.4%) vaccinate their chickens once and twice, respectively. Most of the farms, 137 (62%), provide treatment for sick birds, and in most cases, 142 (64.3%) of the farms faced disease outbreaks that caused serious mass death of birds. The mean annual occurrence of disease outbreaks in the study farms was 0.61 ± 1.0, with significant variability among the study areas. Depending on the farms' flock size, there is a continuous monthly and yearly bird death reports. The minimum and maximum annual death of chickens recorded was 1 and 150 chickens, with significant variability among the study areas Table 3.

Table 3. Monthly and yearly mortality of chickens in the farm and mass death of chickens due to outbreak.

Variables	Arsi Zone		East Show Zone		Total		*p*-Value
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	
Monthly mortality	6.74 ± 5.17 [a]	1–20	4.91 ± 4.48 [b]	1–15	5.93 ± 4.94	1–20	0.025
Annual mortality	32.31 ± 28.39 [a]	2–120	30.27 ± 33.75 [a]	1–150	31.2 ± 31.3	1–150	0.644
Mass death by outbreak at a time	100 ± 80.5	50–300	79.38 ± 50.53	50–200	89.69 ± 67.32	50–300	0.293

Values with different supper-scripts (a,b) indicated statistica differences between the colomns & same letter indicated no differences.

3.4. Biosecurity Evaluation

Biosecurity refers to actions and measures implemented to prevent and control the introduction and spread of infectious diseases causing agents to a flock in a farm [7]. Biosecurity can be applied in three stages such as isolation which deals with protecting chickens from sources of infection, traffic control which involves limiting traffic movement, and

controlling sanitation which is about cleaning and limiting movements of equipment [13]. Others stated that biosecurity measures have conceptual, structural, and operational frameworks which involve housing design and construction with management procedures that keep the flock free from infectious diseases [7,10,12].

3.4.1. Conceptual Biosecurity

In order to assess conceptual biosecurity status, 13 indicators were included in the questionnaire, and their frequencies and percentages of responses are given in Table 4. Nearly 86.9% of the farms were located near residential areas at a distance <200 m, and 53.4% of the farms were close to main public roads at a distance <500 m, which predisposes the farms to frequent noise, environmental, physical, and chemical contamination that discomforts the chickens. A significant number of farm owners (68.8%) have no training on the biosecurity concept, and 62% of the farms do not have disease management record books.

Table 4. The frequency and percentage of indicators of conceptual biosecurity.

Biosecurity Indicators	Category	Number of Farms	Percentage
Distance from residential Area (m)	<50 m	89	40.3
	(50–200) m	103	46.6
	>200 m	29	13.1
Distance from main road (m)	<200 m	46	20.8
	(200–500) m	72	32.6
	>500 m	103	46.6
Distance from nearest farm (m)	<500 m	65	29.4
	≥500 m	156	70.6
Is there no standing water near your farm	Yes	192	86.9
	No	29	13.1
Poultry house with good ventilation	Yes	164	74.2
	No	57	25.8
Poultry house orientation	East–West	143	64.7
	North–South	78	35.3
Do the poultry house water/moisture proof?	Yes	121	54.8
	No	100	45.2
Biosecurity training to employee	Yes	69	31.2
	No	152	68.8
No more than one farm gate	Yes	189	85.5
	No	32	14.5
Maintaining records for diseases management	Yes	84	38.0
	No	137	62.0
No Management of sick animals after healthy ones	Yes	32	14.5
	No	189	85.5
Availability of visitors' logbook	Yes	0	0.00
	No	121	100.0
Having poultry production experiences	Yes	157	71.0
	No	64	29.0

The conceptual biosecurity indicators revealed that the majority of the farms, 113 (51.1%), have a biosecurity score of <50%, which a is poor biosecurity level; 101 (45.7%) of the farms have a biosecurity score of 50–75%, and 7 (3.2%) of the farms have a biosecurity score of >75% demonstrating an aggregate of 48.95% of the farms have good BS. The mean conceptual BS for the farms was 50.4 ± 11.62, with minimum and maximum score values ranging from 23.08 to 84.62.

3.4.2. Structural Biosecurity

The structural biosecurity indicators are presented in Table 5. Most of the farms, 196 (88.7%), do not have tire baths for vehicle entry at the farm gate; 68.3% (151) of the farms do not control wild birds from accessing bedding materials, and 119 (53.8%) do not have access to information about disease outbreak at a regional and national level. In some farms, 102 (46.2%) do not have a standard quarantine house for newly incoming chickens. Pipe water (86.9%) and river water (13.1%) were the main sources of water for the farms. No farm has ever used water specifically microbiologically treated for chicken; instead, they have always used piped water that has been treated for human consumption. The mean structural BS of the farms was 63.27 ± 10.51, ranging from 35.29 to 82.35. The majority of the farms (70.6%) have a structural biosecurity score between 50 and 75%, 12.7% of the farms have structural biosecurity above 75%, and 12.2% have less than 50%. In general, in terms of structural biosecurity measurements, the majority of the farms, 194 (87.8%), are at good BS, having a score above 50%.

Table 5. The frequency and percentage of structural biosecurity indicators.

Biosecurity Indicators	Category	Number of Farms	Percentage
Presence of fence and gate	Yes	190	86.0
	No	31	14.0
Presence of functional footbath	Yes	144	65.2
	No	77	34.8
Presence of only one vehicle entry point	Yes	198	89.6
	No	23	10.4
Presence of tire bath/spray at the gate	Yes	25	11.3
	No	196	88.7
Prohibition of entry of visitors	Yes	173	78.3
	No	48	21.7
No purchase of day-old chicken	Yes	132	59.7
	No	89	40.3
No purchase of feed	Yes	0	0.00
	No	221	100.0
No equipment exchanges with other farms	Yes	204	92.3
	No	17	7.7
No pet animal present in the farm	Yes	136	61.5
	No	85	38.5
Presence of permanent rodent control	Yes	159	71.9
	No	62	28.1

Table 5. *Cont.*

Biosecurity Indicators	Category	Number of Farms	Percentage
Presence of permanent wild bird control	Yes	136	61.5
	No	85	38.5
No access to stored fresh litter for wild birds	Yes	70	31.7
	No	151	68.3
No access to stored food for wild bird	Yes	185	83.7
	No	36	16.3
No feeding of chicken outside	Yes	209	94.6
	No	12	5.4
Well informed regarding poultry disease outbreak in the area	Yes	102	46.2
	No	119	53.8
Surface water not used for drinking chicken	Yes	192	86.9
	No	29	13.1
Do you have quarantine for new incoming flocks	Yes	119	53.8
	No	102	46.2

3.4.3. Operational Biosecurity

The operational biosecurity measurements are presented in Table 6. Most of such measurements were not implemented by the farms. Most of the employees do not wear special farm clothes such as shoes (50.7%), hand gloves (67.4%), mouth/nose masks (85.1%), and head hats (69.2%). The majority (90.9%) of the farms do not have visitors' cloth, and 71% do not have proper dead bird disposal places and procedures. The result revealed that 146 (66.1%) of farms have an operational BS less than 50%, 73 (33.0%) of the farms have scores in a range of 50–75%, and 2 (0.9%) of the farms have scores above 75%. The mean operational BS of the farms was 44.69 $\pm$ 13.04, ranging from 16 to 84.

Table 6. The frequency and percentage of operational biosecurity indicators.

Biosecurity Indicators	Category	Number of Farms	Percentage
Employee use of special cloth (coveralls)	Yes	145	65.6
	No	76	34.4
Employee use of special footwear (boots)	Yes	109	49.3
	No	112	50.7
Employee use of hand glove	Yes	72	32.6
	No	149	67.4
Employee use of special masker	Yes	33	14.9
	No	188	85.1
Employee use of special hat	Yes	68	30.8
	No	153	69.2
Culling of different class of chickens	Yes	120	54.3
	No	101	45.7
Shower in and out	Yes	40	18.1
	No	181	81.9

Table 6. *Cont.*

Biosecurity Indicators	Category	Number of Farms	Percentage
Visitors' use of special cloth	Yes	20	9.1
	No	201	90.9
Not keeping multiple ages together	Yes	203	91.9
	No	18	8.1
Partial depopulation	Yes	50	22.6
	No	171	77.4
Presence of paved places of discharge	Yes	9	4.1
	No	212	95.9
Regular cleaning and disinfection	Yes	98	44.4
	No	123	55.7
Used cleaning water is not drained outside	Yes	82	37.1
	No	139	62.9
High-pressure sprayer used for cleaning	Yes	18	8.1
	No	203	91.9
Proper disposal of dead chickens	Yes	64	29.0
	No	157	71.0
Removed litter stored at cover shade	Yes	85	38.5
	No	136	61.5
Applying insecticide on top of new litter	Yes	25	11.3
	No	196	88.7
No access to stored food for rodents	Yes	62	28.1
	No	159	71.9
Presence of isolation room for sick chicken	Yes	118	53.4
	No	103	46.6
Regular examination of sick birds	Yes	164	74.2
	No	57	25.8
Calling veterinarian when chickens get sick	Yes	185	83.7
	No	36	16.3
Vaccinating chickens/recommendations	Yes	129	58.4
	No	92	41.6
Use of antibiotics/recommended dosage	Yes	112	50.7
	No	109	49.3
Presence of record-keeping	Yes	118	53.4
	No	103	46.6
No contact between farm and other farms	Yes	221	100.0
	No	0	0.00

3.4.4. Overall Biosecurity of the Farms

In general, most of the farms under investigation, 131 (59.3%), have an overall BS above 50%, and as a result, they are at good biosecurity management practices. On the other hand, 90 (40.7%) have an overall BS < 50%, which means they are at poor biosecurity

management, which needs more interventions. The mean overall BS of the farm was 51.78 ± 7.48, ranging from 32.73 to 72.73.

3.5. Association between Biosecurity Level and Farm Characteristics

From the lists of farm characteristics considered, poultry production experience (χ^2 = 10.90; p = 0.001), biosecurity training (χ^2 = 17.353; p = 0.000), presence of isolation room (χ^2 = 24.553; p = 0.001), proper disposal of dead birds (χ^2 = 4.546; p = 0.033), and owning disease record books (χ^2 = 20.89; p = 0.000) have statistically significant association with biosecurity level of the farm (Table 7). In addition, the occupation of farm owners (χ^2 = 9.708; adjusted p-value = 0.006), education level of owners (χ^2 = 10.143; adjusted p-value = 0.006), farms' flock size (χ^2 = 30.361; adjusted p-value = 0.008), and farm distance from the main road (χ^2 = 8.674; adjusted p-value = 0.008) have statistically significant relationship with farms' biosecurity level. Farms having <250 chickens have been graded as "poor" and farms owning >1000 chickens have been graded as "good" biosecurity level (Table 7). Farm owners' gender, the distance between farms, farm ownership (private, MSE, Cooperative), and type of chickens were not significantly associated with biosecurity level (p > 0.05).

Table 7. Association between biosecurity level and some farm characteristics.

Variables	Categories	Biosecurity Status (%)		Chi-Square Value	*p* Value/Adjusted *p*-Value
		Good (>50%)	Poor (<50%)		
Owners' gender	Male	96 (62.3%)	58 (37.7%)	1.973	0.160 ^{ns}
	Female	35 (52.2%)	32 (47.8%)		
Poultry production Experience	Yes	104 (66.2%)	53 (33.8%)	10.90	0.001 *
	No	27 (42.2%)	37 (57.8%)		
Distance from another farm	<500 m	35 (53.8%)	30 (46.2%)	1.125	0.289
	>500 m	96 (61.5%)	60 (38.5%)		
Biosecurity training	Yes	55 (79.7%)	14 (20.3%)	17.353	0.000 *
	No	76 (50.0%)	76 (50.0%)		
Farm premises	Own	77 (56.2%)	60 (43.8%)	1.409	0.235
	Rented	54 (64.3%)	30 (35.7%)		
Having isolation room	Yes	88 (74.6%)	30 (25.4%)	24.553	0.000 *
	No	43 (41.7%)	60 (583%)		
Proper disposal of dead birds	Yes	45 (70.3%)	19 (29.7%)	4.546	0.033 *
	No	86 (54.8%)	71 (45.2%)		
Having a disease record book	Yes	66 (78.6%)	18 (21.4%)	20.89	0.000 *
	No	65 (47.4%)	72 (52.6%)		
Farm ownership	Private	65 (53.3%)	57 (46.7%)	5.660	0.056 ^{ns}
	MSE	57 (69.5)	25 (30.5%)		
	Cooperative	9 (52.9%)	8 (47.1%)		
Major livelihoods of owners	Farmers	75 (64.7%)	41 (35.3%)	9.708	0.006 * (0.087)
	Nonemployee	13 (36.1%)[a]	23 (63.9%) [b]		(0.002)
	Employee	26 (63.4%)	15 (36.6%)		(0.549)
	Trader	17 (60.7%)	11 (39.3%)		(0.865)

Table 7. *Cont.*

Variables	Categories	Biosecurity Status (%)		Chi-Square Value	*p* Value/Adjusted *p*-Value
		Good (>50%)	Poor (<50%)		
Education level of owners	Illiterate	12 (46.2%)	14 (53.8%)	10.143	0.006 * (0.162)
	Grade 1–8	46 (51.1%)	44 (48.9%)		(0.046)
	Grade 9–12	54 (73.0%) [a]	20 (27.0%) [b]		(0.004)
	Above grade	19 (61.3%)	12 (38.7%)		(0.841)
Farm flock size	<250	23 (34.8%) [a]	43 (65.2%) [b]	30.361	0.008 * (0.000)
	250–1000	49 (59.8%)	33 (40.2%)		(0.920)
	>1000	59 (80.8%) [a]	14 (19.2%) [b]		(0.000)
Farm distance from main road	<1000 m	36 (78.3%) [a]	10 (21.7%) [b]	8.674	0.008 * (0.004)
	1000–2000 m	39 (54.2%)	33 (45.8%)		(0.271)
	>2000 m	56 (54.4%)	47 (45.6%)		(0.162)
Chicken type	Egg type	91 (58.3%)	65 (41.7%)	0.802	0.670 [ns]
	Broiler type	20 (66.7%)	10 (33.3%)		
	Meat and Egg	20 (57.1%)	15 (42.9%)		

Values with different supper-scripts (a,b) indicated statistical differences between the columns & same letter indicated no differences, * indicated significant statistical differences between two groups and where ns indicated non significances.

4. Discussion

The current study assessed the biosecurity status and its association with farm characteristics on private, MSE, and cooperative-based commercial poultry farms in the Arsi and East Showa zones of Ethiopia. Male-owned farms were dominant in the area, indicating gender inequalities in terms of access to finance, entrepreneurial capabilities, and socio-cultural impacts. Likewise, a study in Nigeria indicated that most of the farms were owned by males (86.4%), which is attributed to rigor, stress, and challenges that describe poultry production enterprises which many females might not be able to cope with [14]. A study conducted in the Bishoftu area of Ethiopia indicated 63.4% of commercial poultry farm owners were male [6]. Women have less access to education and are more affected by cultural issues which have a positive association with entrepreneurship. Most of the farm owners were found to have secondary education, where most of them (40.7%) were grade 1–8 and (33.5%) were grade 9–12. Such educational levels were similar to what was reported in Cameroon [15], reporting secondary education of farm owners. Though there is heterogeneity in the educational level of farm owners, education could impact the management and resource use efficiency of the farms. Previous studies in tropical areas indicated that the farm operator's educational level enhanced their ability to make use of information about production and market input and overall production efficiency [14,16].

The dominant poultry farms in the study area were the production of egg layers (70.6%), which includes layers, pullet, and breeder layer production business, followed by broiler (13.6%) and dual-type chicken (13.6%) production. A similar finding was reported in central Ethiopia, that 63.4% of the farms were layer-producing farms [6]. Most of the farms (62%) run their farm business on their own farmland, having different sizes depending on their location. The aggregate mean annual flock size of the farms, regardless of the farm type, was 916.2 ± 914.1, with a mean number of production cycles per year of 2.87 ± 0.85. The study conducted around the Debre Markos area of Ethiopia stated a farm flock size of 844.3 [17]. Similar flock sizes and production cycles were reported in Cameroon, with a size of 1181.37 ± 989.52 and 3.89 ± 1.10 [15].

Diseases were the most challenging constraint facing poultry production in Ethiopia, though there are other constraints. Poultry diseases are considered to be the most impor-

tant problem contributing to reducing both the number and productivity of chickens in Ethiopia [18]. The top three economically important poultry diseases in the commercial farms were Newcastle disease (NCD), 140 (79.5%), infectious bursal disease (Gumboro), 58 (54.7%), and fowl cholera, 69 (88.5%), respectively. A similar result was reported in Ethiopia [18,19]. Poultry disease was reported to be a critical challenge for poultry-producing farms in Cameroon [20]. The majority (86.4%) of commercial farms in selected districts of Arsi and East Showa zones practiced chicken vaccination; however, most of the vaccination schedule is below standard as 34% vaccinate once and 30% vaccinate twice for those diseases that require repeated vaccination. Proper vaccine utilization, access, poor biosecurity, and generally a lack of an organized poultry health service delivery system were the major bottlenecks for the poultry industry in the country [21].

The dominant poultry house was the deep litter type (95.5%), followed by the cage system (4.1%). Studies in Cameroon and Nigeria indicated most of the commercial poultry farms use deep litter poultry housing, 77.8% and 83.3%, respectively [20,22]. There were no pond or reservoir water sources (86.9%) near the farms as it is a source for disease outbreaks. In agreement with [6], who found 70.45% of farms were far from standing water sources in Ethiopia. A similar report in the UK indicated that 71.6% of backyard poultry producers revealed their chickens do not access pond water [23]. The level of awareness of biosecurity in small-scale commercial poultry farms in the Arsi and East Showa zones was very low, as 40.7% of farms have an overall BS < 50%. Inadequate awareness of biosecurity obstructed the proper implementation of biosecurity practices [24,25]. The conceptual, structural, and operational biosecurity frameworks proposed by [10,12] were taken into consideration in this study. Structural biosecurity practices were the most frequently implemented practices, as 87.8% of farms had BS over 50% in terms of structural biosecurity, while in terms of conceptual and operational biosecurity, only 48.95% and 33.9% of the farms had BS above 50%, respectively. The study revealed that most farms have fences (86%), footbaths at farm gates (65.2%), and prohibition of entry of visitors to the farm (78.3%), which were promising practices. This was lower than the finding of [6], who reported 90.91% of the farms to have footbaths, but it is in line with visitors' prohibition (70.45%) reported in the Bishoftu area. Similarly, this was lower than what was reported in the Mekelle area (80%) but similar to the prohibition of visitors' entry (76%) except for authorized visitors [26]. Regarding cleaning and disinfection, only 44% of the farms use disinfectant, which is by far less than what was reported in the Mekele area, which was 88% [26]. Such differences might be due to farm size and location of the farms, where the current study considered farms at the woreda level, where there is limited access to information, awareness, and inputs.

Most farms (77.4%) practiced all-in and all-out flock movement, which was higher than the 54.55% report in the Bishoftu area [6], which is encouraging as partial flock movement predisposes the farm to infectious diseases. Different studies pointed out that buying animals from different farms entails a greater risk of introduction of disease-causing agents [27]. Only 53.8% of the farm had isolation room to quarantine sick or newly coming chickens which is a risk to the full operation. A study conducted in Turkey disclosed that only 36% of producers keep disease records, and 44% of respondents used quarantine for new animals upon arrival [28]. Typical employee cloth was used by 65.6% of the farms in the current study, which was in line with the study conducted in Bishoftu town, which disclosed 65.91% [6] and 63.3% in the Debre Markos area [17]. The use of special employees' and visitors' cloth reduces the incidence of entry of diseases causing microorganisms into the farms from sources such as distant areas, household poultry, and from other farms. When uniforms and shoes were not provided to farm employees, the chance of wearing in-house clothes and shoes increased [22]. These clothes might have contact with local poultry at home or out of a home that picks an infectious agent and brings it to the farm [29]. In general, higher levels of biosecurity are associated with less prevalence and outbreak of poultry diseases.

Regarding the association between farms' BS and characteristics, in this study, gender, farm ownership type, farm premises, and farm type were not found to affect the level of

biosecurity adoption. Farm owners' poultry production experience, biosecurity training, presence of isolation room, proper disposal of dead birds, disease record, occupation, education level, farm flock size, and farm distances from the main road were found to affect BS in commercial farms. Studies indicated that farmers with larger flock sizes tended to have enhanced biosecurity practices [15,30]. Poor biosecurity score was recorded in farms owning smaller flock size, <250 chickens, compared to farms having more than 1000 chickens which might be related to higher negligence and lower commitment by owners in implementing biosecurity practices in the case of farms with fewer chickens. In line with the current study, the level of awareness of biosecurity practices was high in farms having larger flock sizes which improved the biosecurity score of the farms in Nigeria [10].

In the current study, farms located a distance above 2 km from the main road have poor biosecurity scores, unlike [9], who claimed farms located far from the main road have a better biosecurity level. This could be due to limited access to extension, veterinary services, training, information, and input supply as the farm gets far away from roads in countries such as Ethiopia, where infrastructure and facilities are less developed. The education of the farm owners impacted BS, where well-educated farmers improved their farms' biosecurity practices through better adoption rates. Education enhances the ability of farmers to analyze and understand biosecurity measures [30]. Farmers' primary occupation was significantly associated with BS, where farms owned by nonemployees have poor biosecurity scores, which might be due to financial limitations that reduced their commitment and focus. The occurrence of disease outbreaks in poultry farms decreased with increasing biosecurity scores, thereby supporting the relevance of biosecurity adoption to control diseases [10]. There have been reports of a reduction in infectious disease outbreaks with standard biosecurity protocols [12].

5. Conclusions

The practices of biosecurity are a fundamental footstep for preventing the introduction and spread of pathogenic microorganisms that initiate diseases in poultry farms. The study confirmed that most commercial poultry farms were handled by males at a small-scale level practicing under low biosecurity scores below average. The ineffective application of biosecurity procedures revealed the need for a comprehensive capacity-building program, information dissemination, and awareness raising among farming communities because the consequences of the biosecurity issue are extremely severe and result in total losses through the outbreak of diseases.

Additionally, the lack of biosecurity on commercial farms results in a higher prevalence of diseases, extensive drug use, high levels of drug resistance, increased costs, chicken deaths, and, ultimately, drug residues in chicken products that may be important for public health. Most of the farm characteristics have a positive association with biosecurity measurements which indicates that the poor biosecurity score of most of the farms could be improved by improving the production system that, ultimately, boosts the farms' productivity and reducing the economic impacts of poultry diseases. Much effort, energy, and costs need to be spent in the area of farm site determination, traffic control, and operational biosecurity measurements implementation and practices to improve the scenario.

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Institutional Review Board Statement: The current study does not involve either human beings or animals directly for data and sample collection. Rather, the study used a cross-sectional survey type that addressed through interviews and observations after being obtained informed consent from the respondents and farm owners.

Informed Consent Statement: The study was reviewed at the department and college level by professionals from animal and veterinary sciences, including the research approval committee of Arsi University. The study does not involve animals but involved farm owners on a voluntary basis having their informant consent after briefing the objectives of the study and the data to be recollected. The respondents were told that all information about farms is kept secret, no names or any personal identifier information will be mentioned in public, and the information is only used for research and publication purposes.

Data Availability Statement: For this research, we have tried to collect primary data from commercial poultry farms in two zones, and hence, it is available at the hand of the researchers. The primary data can be available at any time.

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