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Original Research

Biosecutiy Assessment in Some Egyptian Broiler Farms in Relation to The Prevalence of Colibacillosis and Salmonellosis

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Abstract

The implementation of biosecurity practices in broiler farms is a must for its success. This study was carried out to score the biosecurity measures in three broiler farms in the Dakahliya – Egypt in relation to the seasonal prevalence of colibacillosis and salmonellosis. A cross-sectional study was conducted on randomly selected three broiler farms of different housing systems from (July 2022- June 2023). A total of 540 litter samples were collected during four successive seasons. The computed average score for the three broiler farms; A, B, & C was 14, 15 and 26, respectively, out of 39 estimated items. The findings showed that farm C had better levels of commitment and discipline to biosecurity measures than the other two broiler farms. Highly significant increases of *E. coli* ($p<0.0001$) in summer compared to other seasons in the broiler farms with the lowest prevalence rate in farm C with the highest biosecurity score. The same pattern was found for *Salmonella* prevalence of ($p<0.0001$) in broiler farms during summer months. Insufficient biosecurity measures in broiler houses were not enough to prevent the entrance and multiplication of *E. coli* & *Salmonella* spp. Disciplines, commitment, and regulations of biosecurity need to be enforced in broiler houses to prevent the introduction and spread of diseases.

KEYWORDS
Biosecurity score, Broiler farms, *Salmonella*, *E. coli*, Seasonal prevalence

INTRODUCTION

Poultry production represents an important sector in agricultural industry, Especially in developing nations (Haggag *et al.*, 2018). In 2026 will see a 14% increase in global poultry meat consumption compared to 2017 (Abouelenien *et al.*, 2020).

Biosecurity is thought to be an essential component of any effective poultry production system (Abouelenien *et al.*, 2020), In order to reduce the spread of infectious diseases among and within farms (Mohammed and El Sayed Helal, 2016) . Biosecurity measures might be structural or operational internal or external, Internal biosecurity measures, are those actions done to stop the spread of a disease already present in the flocks. External schemes are those performed to prevent the admission of new illnesses into flocks or production groups (Abouelenien *et al.*, 2020).

Biosecurity systems divided poultry farms into four sectors. Broilers, layers, and ducks were reared in a closed-in environment with an evaporative cooling system as part of the first sector's industrial integrated production system. This method offered tight disease prevention and physical security. The second industry was the contractual farming system, a semi-vertical integrated production structure. To keep birds and other animals out of the house, poultry were grown in either a closed structure with an evaporative cooling system or in an open structure with nylon or metal netting. In the third sector, broilers, layers, and ducks were raised using a conventional farming technique with low biosecurity. The houses were made without netting and were open. The flocks were occasionally left outside their homes. The fourth industry featured backyard or village production systems that were run without any biosecurity worries (Wei and Aengwanich, 2012).

The broiler production intensification, combined with challenging environmental factors and management practices, frequently lacks efficient methods for environmental pathogen control, leading to an increase in health issues (Kaoud *et al.*, 2018). Low levels of biosecurity in poultry production system lead to a higher occurrence of disease such as *Salmonella* spp. and E.coli (Van Limbergen *et al.*, 2018).

In poultry farms, depending on the local temperature and relative humidity, the quality of the litter may serve as a possible source and a means of spreading harmful microorganisms. At 37°C, 22°C, and 5°C, respectively, fecal coliforms such *E. coli* (O157: H7) were able to survive in poultry's litter for 42–49, 49–56, and 63–70 days. In poultry farms, a litter with a higher pH and moisture content can be viewed as a favorable environment for *Salmonella* Typhimurium to survive and spread (Mohammed and Elbably, 2020). *Salmonella* spp. are common in the animal environment because they can survive for long periods of time there and are frequently present in the bird litter in which they live. Infection with *S.* Enteritidis in chicken results in significant economic losses due to the high mortality rate (between 4 and 50 percent), weight loss, and decreased production, as well as the negative effects on public health (Kaoud *et al.*, 2018). Additionally, one of the major issues that seriously risks the global profit-

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ability of businesses that deal with birds is *E. coli* infection. *E. coli* belongs to the Enterobacteriaceae family. Although *E. coli* is a common resident of birds' intestinal tracts, predisposing factors like poor ventilation, overpopulation, thirst, hunger and extreme temperatures can make the poultry industry very vulnerable by increasing mortality and weight loss. (Lado *et al*., 2020) .

We deemed it was important to include season in the model-building process to account for the cyclical fluctuation in weather patterns in Egypt that could affect pathogen presence or concentration. There is limited research on the seasonality of *E. coli* prevalence in poultry barns; however, it has been stated that both biotic (competition) and abiotic (pH, temperature) factors likely impact the ability of *E. coli* to survive in its secondary environment (i.e., outside the intestinal tract of the animal). Therefore, the aim of this study; measuring indoor microclimatic factors (temperature and humidity) in broiler farms on seasonal basis, scoring the biosecurity measures applied in the examined broiler farms in Mansoura – Egypt, relating to the seasonal prevalence of *E. coli* and *Salmonella* as an indicator for the effective application of these measures.

MATERIALS AND METHODS

Ethical approval

The current protocol was reviewed and approved by the Scientific Research Ethics Committee of the Faculty of Veterinary Medicine, Mansoura University, Mansoura, Egypt, with approval number (M/103).

Study design

A cross-sectional study was conducted by visiting three broiler farms in Mansoura–Dakahlia Governorate, Egypt. The selection of the farms relied on systemic random sampling procedures, as recommended by Bellhouse (2005). Weekly visits were conducted for 12 months (July 2022- June 2023).

Farm description

This study was carried out to investigate the biosecurity status in broiler farms in Dakahlia governorate, Egypt; during the period from (July 2022- June 2023). Three commercial broiler farms raising three different breeds; Cobb, Ross, Hubbard were investigated for the possible occurrence of *Salmonella* and *E. coli* organisms and relating their existence to the microclimatic conditions (temperature and relative humidity) as an index for biosecurity status.

Birds were brooded and kept at the suitable microclimatic conditions (on day 1, kept at 35°C then reduced gradually until being constant at 24-26°C by the end of the 3rd week with the latter comfort zone of 21-24°C). Twenty-three lighting hours: one hour darkness was adapted as a lightning program using white LED lights, as recommended by Soliman and Hassan (2019). Food and water were provided to birds ad libitum. Each farm used a targeted immunization strategy, including a baseline immunization of birds against ND, IBD, AI, and infectious bronchitis. Characteristics of the farms under evaluation for biosecurity measures including farm location, size, breeds of broilers, housing design, farm units, farm capacity, bedding type, ventilation mechanism, feeding and watering systems, and lighting patterns of each farm are depicted in Table 1.

Questionnaire preparation and data collection

A structured questionnaire was prepared following the Biocheck. U Gent poultry questionnaire (Gelaude *et al*., 2014). Three commercial broiler farms located in Shawa, Silant and Nabarohh, Mansoura, Dakahlia governorate were selected based on geographical location, housing system, farm hygiene variations, and owners' willingness to allow frequent sample collection. The questionnaire was used to gather information on farms generally, health issues, sanitation, biosecurity, the program to eradicate external parasites, and antibiotic resistance as mentioned by Wei and Aengwanich (2012). The farmers were asked questions, and their responses were recorded in the questionnaire. Other details, such as the sanitary condition of the farms, were collected through direct observation.

Assessment of the Biosecurity Level

This study used biosecurity score form that was created using Dr. Les Sims' concept and in accordance with information from the FAO (2008). The information from the fields was then used to build the Biosecurity Score Form. The biosecurity score was created for a survey that was done through field management observation and farmers' use of the biosecurity systems within the farms, with some of them being interviewed. There were 10 indicators of this score form namely presence of wild birds, Hygienic measures related to workers, Hygienic measures related to visitors, Hygienic measures related to new flocks, Hygienic measures related to feed and water source, Hygienic measures for equipment's and vehicle, Distance to other farms, Hygienic measures of cleaning and disinfection, and biosecurity plans. The biosecurity development plan needs an interview with farmers regarding the development of the biosecurity system to receive observation scores. There were four levels for each scoring: 0, 1, 2, and 3. The greatest scores were the greatest number and reduced orderly (Wei and Aengwanich, 2012).

Microclimate measurement

The microclimatic factors (temperature and relative humidity) inside the three poultry farms were recorded by Clock Thermo-Hygrometer during each visit. The apparatus should be located above the ground level by about 1.0-1.5 meters (Mohammed and Elbably, 2020).

Collection of litter samples

Five hundred and forty litter samples were collected from three broiler poultry farms at different stages of production from

Table 1. Characteristics of the broiler farms under evaluation for biosecurity scores.

Farms	Location	Size	No. units	Housing (system/ age-yr.)	Capacity of farm	Bedding type	Breeds	Ventilation mechanism	Feeding & watering system	Lightning pattern
A	Shawa	1085 m^2	4	Closed-Deep litter (5)	10,000-20,000	straw/wood shaving	Cobb	Forced	Manual	23L:1D
B	Silant	985 m^2	4	Closed- Deep litter (5-6)	8,000- 10,000	straw/wood shaving	Ross	Natural	Manual	23L:1D
C	Nabarohh	2300 m^2	6	Closed- Deep litter (10-12)	30,000 – 40,000	straw/wood shaving	Cobb	Forced	Automated	23L:1D

intensively managed broiler (IMB) according to Omeira *et al*. (2006). Briefly, the farm's floor was zigzagged, and a stratified composite sample of 15 handfuls of litter from the chicken house was collected. Litter Samples were collected manually with a period of 10 days between each of the three samplings from each farm. Every 5 collected litter samples from each farm were pooled in one litter sample and samples were personally taken from each home while using plastic bags and sterile gloves. Samples were delivered to the laboratory in sterile plastic bags inside an ice-filled fridge for microbiological investigation.

Microbiological investigation

Isolation and identification of *E. coli and Salmonella*

Twenty five grams of each litter sample were homogenized with 225 ml of buffered peptone water (Terzich *et al*., 2000; Eriksson De Rezende *et al*., 2001) and incubated at 37°C for 24 h. A loopful of each diluted samples was streaked on eosin methylene blue agar media (EMB agar, Modified Levine Thermo ScientificTM OxoidTM CM0069B, weight 500 g) and incubated at 37°C for 24 h (Mohammed and Elbably, 2020) for *E. coli* isolation. On other side, for *Salmonella* isolation, one ml of each diluted sample was added to 9ml of Rapaport Vassiliadis (RV) broth and incubated at 42°C for 24 h for enrichment. A loopful of each incubated broth on Xylose Lysine Deoxycholate (XLD, Modified Levine Thermo ScientificTM OxoidTM CM0469, weight 500 g)) plates which were incubated at 37°C for 24 h. Presumptive colonies of *E. coli*, yellow green characteristic metallic sheen on Eosin methylene blue agar (Islam *et al*., 2014) and *Salmonella* black colony on XLD media (Opara *et al*., 2018) were biochemically identified using the following tests: indole, Methyl Red, Voges-Proskauer, citate utilization and triple sugar iron test (Abdallah *et al*., 2018).

Molecular detection of Salmonella and E. coli

For DNA extraction, overnight broth cultures of *Salmonella* (n=31) and *E. coli* (n= 37) were centrifuged at 15000 rpm for 5 minutes, pellets were suspended in 100 ul nuclease free water then boiled according to Ahmed and Dablool (2017). For *Salmonella* prior to PCR partial amplification of invA gene and 16S for *E. coli*. Amplification was done using DreamTaq™ Green PCR Master Mix (2X), Cat. Thermo Scientific, USA. according to manufacturer instructions as: 1ul of each primer (10pmol), 10 ul of master-mix and 5ul of template DNA and 8ul of nuclease free water. The cycling condition was done in MiniPCR TM Mini16 Thermal Cycler (Amplyus, Cambridge, MA, USA) as: 30 cycles of 1 min at 95°C, 1 min at 65°C, 30 s at 72°C, and a final extension step of 7 min at 72°C follow the initial denaturation at 95°C for 5 min. (Akbarmehr *et al*., 2010). A 1.2% agarose gel was used to resolve amplified products. The gel was stained with ethidium bromide after electrophoresis, and it was then captured in an ultraviolet (UV) image. The molecular weight (MW) of PCR products was measured using a 100 bp DNA ladder as a marker (Akbarmehr *et al*., 2010).

Statistical analysis

Statistical analysis was done with the Statistical Package for the Social Sciences (SPSS), IBM SPSS statistics version-20. The obtained data were analyzed statistically using multifactorial Analysis of Variance (Two-way ANOVA) inspecting the impacts of the housing systems based on ventilation methods and seasons along with their interactions. The significant levels were expressed as highly significant at $p<0.01$, significant at $p \leq 0.05$, and non-significant at $p>0.05$. The bacterial counts were transferred into logarithmic numbers as well as the average scores for the three farms understudy were calculated using Microsoft Excel 2016.

RESULTS

Microclimates inside the examined poultry farms on the level of season

Temperature and humidity were recorded inside the three examined farms with each visit (Table 2). In farm A, during summer, the measured temperature was 32°C, 31.6°C and 30°C at 1, 15, and 30 days of age, respectively. Where humidity was 67%, 55.7% and 73.3% at 1, 15, and 30 days of age, respectively. During winter months, the temperature was 28.2°C, 28.6°C and 29°C at 1, 15, and 30 days of age, respectively. Where humidity recorded 67.8%, 41.7% and 51.4% at the same recorded ages. Not much difference in temperature and humidity was found during autumn, where temperature was 32.5°C, 30.8°C and 27.7°C at 1, 15, and 30 days of age, respectively. While humidity levels showed 48.8%, 48% and 57% at the same age times. During spring, measured temperatures were 31.4°C, 30.8°C and 29.3°C at 1, 15, and 30 days of age, respectively. Meanwhile humidity levels were 56.2%, 51.8% and 55.9% at 1, 15, and 30 days of age, respectively.

Farm B, in the summer the measured temperature was 33°C, 31°C and 29.3°C, where humidity 68%, 63.3% and 51.2% at 1, 15, and 30 days of age, respectively. During autumn the temperature was 30.9°C, 29.1°C and 24.6°C at 1, 15, and 30 days of age, respectively. Where humidity was 56.5%, 60.3% and 46.4% at the same measured times. In winter the recorded temperature degrees were 30°C, 27°C and 22°C at 1, 15, and 30 days of age,

Table 2. Seasonal microclimate (temperature and humidity) in the examined poultry farm.

Farms	Farm A				Farm B				Farm C			
Age (days)	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
						Temperature (°C)						
1 day	31.4	32	32.5	28.2	32.4	33	30.9	30	28.3	32	29.9	25
15 days	30.8	31.6	30.8	28.6	30.3	31	29.1	27	27.8	28.7	27.2	24.3
30 days	29.3	30	27.7	29	27.1	29.3	24.6	22.2	26.8	31.6	27.7	22.9
						Relative humidity (%)						
1 day	56.2	67	48.4	67.8	60.2	68	56.5	63.3	58.5	68	53.8	57
15 days	51.8	55.7	48	41.7	57.4	63.3	60.3	56	53.6	65.7	58	55.2
30 days	55.9	73.3	57.8	51.4	50.6	51.2	46.4	66.9	40.3	44.8	43.4	51

respectively. While humidity levels were 63.3%, 56% and 66.9% at the same age times. During spring, measured temperatures were 32.4°C, 30.3°C and 27.1°C at the 1, 15, and 30 days of age, respectively. Meanwhile humidity levels were 60.2%, 57.4% and 50.6% at the 1, 15, and 30 days of age, respectively.

Farm C, in the summer the temperature was 32°C, 28.7°C and 31.6°C at the 1, 15, and 30 days of age, respectively. Where humidity was 68%, 65.7% and 44.8% at the 1, 15, and 30 days of age, respectively. In autumn, the temperature recorded as follows 29.9°C, 27.2°C and 27.7°C at the 1, 15, and 30 days of age, respectively. While humidity levels pointed out as 53.8%, 58% and 43.4% at the 1, 15, and 30 days of age, respectively. Temperatures were 25°C, 24.3°C and 22.9°C and humidity levels were 57%, 55.2% and 51% at 1, 15, and 30 days of age, respectively during winter months. In spring, temperature was found as 28.3°C, 27.8°C and 26.8°C and humidity was recorded as 58.5%, 53.6% and 40.3% at 1, 15, and 30 days of age, respectively.

Biosecurity scores for the examined broiler poultry farms

In order to assess the biosecurity standards of chicken farms in three distinct areas within the province of Mansoura, data was collected by rating the 13 indicators for biosecurity. The biosecurity ratings for each type of farming were compared. As shown in Table 3, a total score was assigned to each farm as the sum of all individual average scores for the stated evaluation items. The computed average score for the three broiler farms; A, B, & C was 14, 15 and 26, respectively, out of 39. The findings showed that farm 3 had better levels of commitment and discipline to biosecurity measures than the other two broiler farms.

Seasonal prevalence of Salmonella and E. coli in litter samples

Five hundred and forty litter samples were collected as a total number of samples from 3 broiler poultry farms, 45 samples were collected from each farm seasonally. The prevalence of *E. coli* and *Salmonella* showed seasonal variation in the three farms (Tables 4 and 5). *E. coli* prevalence revealed in Table 4, highly significant increases (p<0.0001) in summer compared to spring in the broiler farms. Where farm C, with the highest biosecurity score showed the lowest prevalence rate 44.4% followed by 66.7% in farm B and the greatest rate was at farm C, 77.8%. While no *E. coli* was detected in farm C during spring, the other farms had a 44.4% prevalence rate.

Table 3. Biosecurity scores for the examined broiler poultry farms.

Indicators	Scores		
	Farm A	Farm B	Farm C
Wild bird attractiveness to the farm	1	1	2
Protection of wild birds	0	1	2
Hygienic measures related to workers	2	1	3
Hygienic measures related to visitors	1	1	2
Hygienic measures related to new flocks	1	1	2
Types of poultry in the farm	2	3	3
Water source & treatment	1	1	2
Feed source	1	1	1
Hygienic measures for equipment's and vehicles	0	0	2
Distance to the road & other farms	2	2	3
Hygienic measures of cleaning and disinfection	2	2	2
Measures taken at the entrance to poultry units			
Biosecurity plans	1	1	2
Total score of biosecurity out of 39	14	15	26

For each of the 13 points used to evaluate the biosecurity measures, zero points was the lowest score and three points was the greatest.

Table 4. Seasonal prevalence of *E. coli* in litter samples from three broiler farms.

Farms	*E. coli* prevalence rate (number/ %)			
	Autumn	Winter	Spring	Summer
Farm A	20 (44.4)	20 (44.4)	20 (44.4)	35 (77.8)
Farm B	20 (44.4)	20 (44.4)	20 (44.4)	30 (66.7)
Farm C	0	0	0	20 (44.4)
(X^2= 44.194, df = 6 and P-value = 0.00001)				

The same pattern was observed for *Salmonella* prevalence, in Table 5, highly significant increases (p<0.0001) in broiler farms during summer seasons in comparison to the other seasons. The calculation of the average prevalence percent of salmonellosis rate in broiler farms understudy exhibited that the prevalence of salmonellosis was the highest during summer 77.8, 51.1, & 44.4% in farms A, B, & C, respectively. No *Salmonella* was detected during spring in both farms B & C. While farm A had 66.7% *Salmonella* rate.

Table 5. Seasonal prevalence of *Salmonella* in litter samples from three broiler farms.

Farms	*Salmonella* prevalence rate (number/ %)			
	Autumn	Winter	Spring	Summer
Farm A	15 (33.3)	5 (33.3)	30 (66.7)	35 (77.8)
Farm B	20 (44.4)	15 (33.3)	0	23 (51.1)
Farm C	10 (22.2)	10 (22.2)	0	20 (44.4)
(X^2= 44.194, df = 6 and P-value = 0.00001)				

DISCUSSION

Intensification in naturally ventilated (opened) and artificially ventilated (closed) housing systems linked to various floor systems, such as deep litter, battery, and slatted floor systems with or without an all-in-all out policy, is essential to poultry production both globally and in Egypt. In commercial and small yard operations, broilers are raised inside their housing unit for the full cycle before being either taken for slaughter or transported to another egg-laying facility (Sharma *et al*., 2018).

Small-scale and backyard poultry production in Egypt has grown to be a profitable industry for several reasons, comprising low maintenance needs, quick financial returns, the increasing public demand for animal protein, simple marketing, availability of high-quality fertilizer, and simplicity of control using a few preventive measures (South Taranaki District Council, 2013).

According to Astari (2017), approximately 9.5 million poultry are raised in small, confined spaces with little to no biosecurity measures in Egypt. However, the total number of household and backyard chickens in Egypt is not known, where all authorized and available governmental data referred to financial investment sizes without exact numbers. In the spread and transmission of numerous infectious and zoonotic illnesses, (ElMasry *et al*., 2017) indicated a substantial role for backyard and household production.

Biosecurity has been defined as "informed common sense," which refers to the responsibility to get familiar with the rules and principles of biosecurity as well as common management techniques. The biosecurity program is supported by three primary pillars: discipline, accountability, and belief. The final scores determined for each of the three farms were 14, 15 and 26 out of 39 items out of 43 for closed-house broiler farms and 24 out of 43 for opened-house broiler farms, indicating higher commitment in farm C than the other farms towards the application of biosecurity measures than in opened-house broiler farms. These findings generally showed that there were several unsafe practices and low biosecurity measures applied in broiler farms in the Dakahlia Governorate. According to (Negro-Calduch *et al*., 2013), the extent to which small-scale commercial chicken growers, farm and household commercial production, input suppliers, and other actors along the meat chicken value chain have adopted standard biosecurity measures has been evaluated. It was discovered that biosecurity precautions were rarely used and that there was little difference in compliance between domestic and farm-based commercial output when it came to best practices. The findings were in line with those obtained by Aiyedun *et al*. (2018), who examined the level of biosecurity in a few broiler farms based on the presence of a fence, traffic signals, dead bird disposal techniques, use of protective clothing, access to wild birds, and rodents. They clarified how improper use of fundamental biosecurity and hygiene precautions led to substantial negative effects on the health of both humans and birds. To guarantee that the biosecurity measures announced on each farm were being applied, cleaning and disinfection programs were observed in the current study. After applying dry cleaning to remove loose dirt, wet cleaning was done while paying close attention to all the corners, joints, and fissures in the walls and flooring. Regardless of farm size, it appears that most broiler farms in the research area lacked biosecurity controls and production technologies.

These findings are going in accordance with those reported by Eltholth *et al*. (2016) who assessed the biosecurity practices in 267 broiler farms, reporting that the majority of broiler farms were small-scale operations with scant or no biosecurity precautions, which raised the possibility of disease transmission between farms and between farms and home chickens as well as the danger of exposing people to potential health risks. The findings also showed that there were differences between study participants' responses and the observational data (e.g., the presence of a designated place for the disposal of chickens, the use of protective gloves and masks, and the usage of designated work clothes). This revealed a disconnect between farmers' knowledge and methods. Previous research (Radwan *et al*., 2011; Negro-Calduch *et al*., 2013) found the same inconsistencies.

Quaternary ammonium compounds and aldehydes were the most prevailing detergents that were used in the examined farms. Broiler farms understudy were disinfected using sodium hydroxide and formaldehyde spray. Proper cleaning and disinfection were effective in reducing the entry of *Salmonella* and *E. coli* spp. especially in farm C with the highest biosecurity score.

The prevalence of *Salmonella* and *E. coli* had a seasonal variation in the examined farms. The current study revealed a significantly higher prevalence in summer months compared to the other seasons without ignoring the biosecurity precautions set up in each farm, the favorable macroclimatic conditions predominated to promote the growth and survival of *Salmonella* and *E. coli* spp. According to Rothrock *et al*. (2015), with particular emphasis on *Salmonella enterica* serovar Enteritis and S. enterica serovar Typhimurium, the poultry sector has been implicated in several salmonellosis outbreaks in poultry and human populations around the world. According to Fasanmi *et al*. (2017), viruses like avian influenza survive.

The findings are consistent with those of Kloska *et al*. (2017), who indicated that the use of risk-oriented hygiene helped reduce the risk of *Salmonella* spp. to the public's health and that extensive cleaning can reduce the incidence of salmonellosis by 66%. The sanitation practices in a few commercial poultry farms in Egypt's Ismailia and Zagazig governorates were assessed by Soliman *et al*. (2009). They recovered some bacterial microorganisms such as *Klebsiella oxytoca, Citrobacter* spp., *P. vulgaris, E. coli, P. aeruginosa, Shigella* spp., *Salmonella* spp., *S. faecalis*, *Staphylococcus aureus*, and *Streptococcus pneumoniae*, and some fungal organisms such as *Yeast* spp., *Candida albicans*, *Aspergillus flavus, Aspergillus niger, Aspergillus nidulans*, Mucor, and *Penicillium* spp. The disinfection failure in the farms could be the cause of the organisms' recovery.

CONCLUSION

Enforced biosecurity measures are more successful in artificially ventilated (closed-house) broiler farms than naturally ventilated (opened-house) broiler farms. However, applying rigorous biosecurity measures in place in both types of broiler houses is insufficient to stop *Salmonella* and *E. coli* spp. from growing and multiplying. A breach where germs can enter, stabilize, develop infectious and dangerous diseases, and readily travel from one area to another inside the same farm or to neighboring farms was caused by a lack of commitment of biosecurity practices. Colibacillosis and Salmonellosis control in broiler farms depends primarily on stringent measures comprising good hygienic measures, early identification, and an efficient cleaning and disinfection program, regardless of the housing system, location, holding capacity, and ventilation system. To implement appropriate and effective biosecurity measures, policymakers should consider the perceptions and attitudes of farmers. To raise awareness of the need for biosecurity measures and to encourage players along the chicken value chain to take them, policy makers should interact with the private sector, including breeder businesses and local veterinarians. Additional research is needed to determine the knowledge, attitudes, and behaviors of various actors involved in chicken farming in Egypt regarding biosecurity measures.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest for this work.

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