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Evaluation of the Level of Internal and External Biosecurity Measures Adopted in Closed System Broiler Farms in Khartoum State, Sudan

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Abstract

This study was conducted to evaluate the level of biosecurity measures prerequisites adopted in closed system broiler farms in Khartoum State, Sudan. Data were collected using questionnaire from January to September, 2018 from 12 closed system broiler farms according to non-probability multistage cluster sampling method (localities, farms, respondents) in Khartoum, Khartoum North (Bahri), and Omdurman localities (4 farms for each). Results of external biosecurity evaluation in farms revealed low compliance regarding location of the farm, purchasing of one day old chicks 50% (n=6), waste and dead birds removal and sick birds isolation, depopulation of houses and demarcation between clean and dirty areas 58.3% (n=7), as well as annual water source microbial testing 66.7% (n=8), and vermin control 08.3% (n=1). Internal biosecurity evaluation confirmed high application 100% (n=12) of some disease preventive measures (vaccination protocol, regular check of disease status, sick and dead birds check). However, rearing different age categories at 58.3% (n=7) and low level of practicing efficacy check of cleaning and disinfection at 33.3% (n=4) were mostly shown. It was clearly observed that biosecurity measures were more frequently enforced for farm visitors compared to farm personnel. In conclusion, effective adoption biosecurity measures in broiler farms in Khartoum State have not been given serious attention. Therefore, formulation of suitable procedures and regulations by official authorities for implementing biosecurity measures are needed.

Keywords: Internal biosecurity; External biosecurity; Broiler farms; Sudan

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Introduction

Biosecurity refers to procedures used to prevent the introduction and spread of disease carrying organisms in poultry flocks [1]. Moreover, Permin and Detmer and Zavala considered biosecurity as protection against transmission of infectious agents, parasites, and pests either to or from a poultry production unit [2,3]. This exclusion can be achieved by avoiding unnecessary contact between birds and microbes, infected birds and healthy ones and also reducing contact between birds and humans. Biosecurity comprises two main elements; bio containment (prevention of spread of the infectious agent from infected premises) and bio exclusion (measures to exclude infectious agents from uninfected ones [4]. Pierson identified four biosecurity principles: isolation, good hygiene, flock health care and monitoring, and good management practices. Biosecurity practices cover a broad range of measures which have been divided into three categories: conceptual that including the choice of farm location, structural covering the physical facilities, and operational covering the work procedures that farm staff and visitors are expected to follow [5,6]. The closed system is adopted mainly by the intensive broiler production units of large and medium size where restricted controlled environment and advanced standards exist to provide optimal conditions. In such system, biosecurity is an initiative step to ensure continuous production of safe poultry products, otherwise it will negatively affect the quality and quantities of these products, so it is important to be secured protected and have adequate medical coverage [7]. Unfortunately, poultry production in Sudan was identified mostly to have inadequate health care, inappropriate housing, poor knowledge of management, and unsafe poultry meat production processing [7,8]. Moreover, broiler farms in Khartoum State showed medium level of biosecurity status in close system broiler farms that is far away from international standars [9]. Therefore, the aim of the

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present study was to evaluate the level of internal and external biosecurity measures adopted in closed system broiler farms in Khartoum State, Sudan.

Materials and Methods

Study site

The current study was carried out in Khartoum State which is located at the central part of Sudan. Khartoum is a tripartite metropolis including three large localities: Khartoum, Bahri (Khartoum North), and Omdurman around which most of the poultry production in Sudan is centered and is estimated as 90% of Sudan's poultry production [10].

Type of poultry production systems in the study site

There are two poultry production systems in Khartoum State, traditional type which is practiced by individual households for domestic consumption in open system and commercial type which is practiced in the closed and semi closed-systems. The current study targeted closed system broiler farms and their slaughterhouses in the three localities in Khartoum State; Khartoum, Bahri (Khartoum North), and Omdurman.

Experimental birds and management

A total of 330 day-old Arbor acre broiler chicks were procured for this study. The chicks were brooded together with a 60 W bulb in a brooding pen for the first seven days, thereafter; they were randomly divided into 33 groups of 10 birds each. Each group was raised in floor pens with wood shavings as litter material and contained feeders and drinkers for the provision of ad libitum access to feed and water respectively for duration of six weeks. Birds were vaccinated against Gumboro disease at 7th and 18th days of life while Newcastle disease was vaccinated at 12th day. Coccidiostats was administered to the birds during the experiment.

Study design

Cross sectional study was used mainly to evaluate the level of internal and external biosecurity measures adopted in closed system broiler farms in Khartoum State, Sudan using questionnaires.

Sampling method and sample size

Sampling was done with different levels (site, farms, respondents) from January to September, 2018. Hence, non-probability multistage sampling method was used according to support of the owners as described by Thrusfield [11]. Twelve closed system broiler farms were included on voluntary basis (4 farms from each locality).

Data collection using questionnaires

This study was mainly based on qualitative, semi-structured questionnaires which were constructed to evaluate the extent of implementing requirements of biosecurity measures in respondent farms. These questionnaires included two parts; the first part comprised the information on external biosecurity such as purchase of one day old chicks, export of live chicken, feed and water Supply and removal of manure and dead birds. The second part comprised information on internal biosecurity such as cleaning and disinfection disease prevention plan. The questionnaires were pretested in four farms and accordingly wordings and concepts in the questionnaires were amended.

Data analysis and management

Statistical Package for Social Sciences (SPSS) version 19.0 for Windows was used for data analysis Descriptive statistics such as frequency and percentage were used for variables and all results were presented in tables and graphs.

Results and Discussion

External biosecurity in broiler poultry farms

Purchase of one day old chicks from only one supplier was reported in half of the respondent farms (50%). Concerning frequency of delivery, seven farms (58.3%) recorded that they deliver one day old chicks 3-6 times per year. First vehicle delivery was reported only in four farms (33.3%). However, 91.7% (n=11) of farms had implemented hygienic criteria on transport vehicle reflecting high level of biosecurity. Eleven of respondents (91.7%) restricted to empty, cleaned and disinfected vehicles for live birds export. Furthermore, 75.0% (n=9) stated that the transport team wear specific clothing and shoes. Entry of transporters and traders to the chicken houses was not allowed in six respondent farms (50.0%). Seven farms (58.3%) empty the poultry house in >2 steps shown in **Tables 1 and 2**. Of the total respondents farms, it was revealed that 66.7% (n=8) were divided into a clean and dirty areas and that division was clearly demarcated in 58.3% (n=7) out of 12 farms. Direct contact between feed transporters and chicken was recorded in half of the farms (50%). Proper sealing of feed silos was observed in 83.35% of the participating farms. It was shown that 66.7% (n=8) of farms tested the quality of farm water source microbiologically, of them 41.7% tested water source more than twice a year. Nine broiler farms (75.0%) reported proper disposal of wastes through dirty area. GHPs regarding storage and removal of dead birds were also observed in all respondents farms (100%). However, workers hygiene revealed that 58.3% of them sometimes used protective wear beside washing and disinfecting their hands after removing dead birds shown in **Tables 3 and 4**. Regarding applied rules for staff and visitors access, 91.7% (n=11) of respondent farms applied good hygiene before poultry houses entry, all owners restricted to all rules for access (change clothing, change shoes or use shoe covers) and at least 24 hours contact free period when visiting other poultry farms. In addition to that, 83.3% (n=10) applied check in, hands washing and obligated to wear hygienic protective wear. Nine farms (75.0%) recorded that the producers and employees use footwear protection and do not rear home poultry or other birds shown in **Table 5**. The current study showed that chicken outdoor access was not allowed in 11 farms out of 12 (91.7%). Also, the

same percentage was obtained for keeping "backyard" poultry in the targeted farms. Although there was no documented vermin control program in most participant farms (91.7%), nine (75.0%) farms harbored limited vermin. Equal percentage of 91.7% (n=11) was recorded concerning preventive measures application of material supplied and not keeping other animals for farming shown in **Table 6**. Half of the total farms examined (50%) were at a distance between 500 m to 1 km from the nearest poultry farm. Also, the same percentage was obtained for absence of stagnant or running water around the farm and no manure spreading from neighbouring farms. However, frequent passage of other farms vehicles *via* near public road was reported in 50% of participating farms shown in **Table 7**.

Table 1: External biosecurity regarding purchase of one day old chicks in poultry farms.

Parameter	Frequency (%)
Supplier of one day old chicks	
1. Always the same	6 (50.0%)
2. Different	6 (50.0%)
First vehicle delivery	
1. Yes	4 (33.3%)
2. Sometimes	5 (41.7%)
3. No	3 (25.0%)
Vehicle hygienic criteria	
1.Yes	11 (91.7%)
2. Sometimes	0 (00.0%)
3.No	1 (08.3%)
Frequency of chicks delivery per year	
1. <3	3 (25.0%)
2. 3-6	7 (58.3%)
3. >6	2 (16.6%)

Table 2: External biosecurity regarding export of live chicken.

Parameter	Frequency (%)
Empty vehicle on arrival	
1. Yes	11 (91.7%)
2. Sometimes	1 (08.3%)
Good hygiene of export vehicle	
1. Yes	11 (91.7%)
2. No	1 (08.3%)
Good hygiene of export team	
1. Yes	9 (75.0%)
2. Sometimes	1 (08.3%)
3. No	2 (16.7%)
Houses entry of transporters and traders	
1. Yes	2 (16.7%)
2. Sometimes	4 (33.3%)
3. No	6 (50.0%)
Number of steps of emptying the house	
1. 1	3 (25.0%)
2. 2	2 (16.7%)
3. >2	7 (58.3%)
Number of exporting chicken per year	
1. <6	4 (33.3%)
2. 6-12	3 (25.0%)
3. >12	5 (41.7%)

Table 3: External biosecurity regarding feed and water supply to broiler poultry farms.

Parameter	Frequency (%)
Division into clean and dirty areas	
1. Yes	8 (66.7%)
2. No	3 (25.0%)
3. I don't know	1 (08.3%)
Clearly demarcated areas	
1. Yes	7 (58.3%)
2. No	5 (41.7%)
Feed transporters-chicken direct contact	
1. Yes	3 (25.0%)
2. Sometimes	3 (25.0%)
3. No	6 (50.0%)
Proper sealing of feed silos	
1. Yes	10 (83.3%)
3. No	2 (16.6)
Silos filling times per year	
1. <20	5 (41.7%)
2. 20-35	4 (33.3%)
3. >35	3 (25.0%)
Quality analysis of potable water	
1. Yearly	4 (33.3%)
2. Every two years	3 (25.0%)
3. >two years	5 (41.7%)
Source of water sample analysis	
1. Source+last drinking cup	3 (25.0%)
2. Source	8 (66.7%)
3. Last drinking cup	1 (08.3%)

Table 4: External biosecurity regarding removal of manure and dead birds in broiler poultry houses.

Parameter	Frequency (%)
Removal through the dirty area	
1.Yes	9 (75.0%)
2. No	3 (25.0%)
Separate dead birds storages	

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1. Yes	12 (100%)
2. No	0 (00.0%)
Well closed dead birds storage	
1. Yes	8 (66.7%)
2. No	4 (33.3%)
Regular dead birds storage hygiene check	
1. After each collection	4 (33.3%)
2. Sometimes	7 (58.3%)
Protective wear when contact dead birds and waste	
1. Always	4 (33.3%)
2. Sometimes	7 (58.3%)
3. Never	1 (08.3%)
Workers hygiene after removing dead birds and waste	
1. Always	5 (41.7%)
2. Sometimes	7 (58.3%)
3. Never	0 (00.0%)

Table 5: External biosecurity regarding entry regulations of visitors and personnel to broiler poultry houses.

Parameter	Frequency (%)
Check in before entering the houses	
1.Yes	10 (83.3%)
2. No	2 (16.7%)
Owners restricted to access rules	
1.Yes	11 (91.7%)
2. No	0 (00.0%)
3. Sometimes	1 (08.3%)
Contact free period of >24h for visitors	
1. Yes	10 (83.3%)
2. No	2 (16.7%)
Obligation to wear hygienic protective wear	
1.Yes	10 (83.3%)
2. No	1 (08.3%)
3. Sometimes	1 (08.3%)
Hands washing and disinfection before entry	
1. Yes	11 (91.7%)
2. Sometimes	1 (08.3%)
2. No	0 (00.0%)
Number of visits per year	
1. Never	7 (58.3%)
2. 1-12	4 (33.3%)
3. >12	1 (08.3%)
Staff home rearing of birds	
1.Yes	3 (25.0%)
2. No	9 (75.0%)
Staff contact with other poultry farms	
1. Yes	1 (08.3%)
2. No	11 (91.7%)

Table 6: External biosecurity regarding infrastructures and biological vectors control in broiler poultry houses.

Parameter	Frequency (%)
Possible outdoor access for the chicken	
1. Yes	1 (08.3%)
2. No	11 (91.7%)
Air inlets proofing	
1. Yes	4 (33.3%)
2. No	8 (66.7%)
Paved and clean around walls	
1. Yes	7 (58.3%)
3. No	5 (41.7%)
Vermin control program	
1. Yes	1 (08.3%)
2. No	11 (91.7%)
Harbouring vermin	
1. Much	2 (16.7%)
2. Limited	9 (75.0%)
3. None	1 (08.3%)
Keeping backyard poultry	
1. Yes	1 (08.3%)
2. No	11 (91.7%)
Keeping other animals for farming	
1. Yes	3 (25.0%)
2. No	9 (75.0%)
Materials supplied preventive measures	
1. Yes	9 (75.0%)
2. No	3 (25.0%)

Table 7: External biosecurity regarding location of the broiler poultry farms.

Parameter	Frequency (%)
Distance of the nearest poultry farm	
1. <500 m	3 (25.0%)
2. 500 m-1 km	6 (50.0%)
3. >1 km	3 (25.0%)
Water bodies within a radius of 1km	
1. Yes	6 (50.0%)
2. No	6 (50.0%)
Manure spreading from neighbouring farms	
1. Many times	4 (33.3%)
2. Sometimes	2 (16.7%)
3. Never	6 (50.0%)
Other farms vehicles passage *via* public road	

1. Many times	6 (50.0%)
2. Sometimes	5 (41.7%)
3. Never	1 (08.3%)

Internal biosecurity in broiler poultry farms

The current study confirmed that all respondent farms (100%) were restricted to application of some disease preventive measures such as complemented vaccination protocol, regular check of disease status, and isolation and check of dead birds. Furthermore, 58.3% (n=7) of respondents stated that they rear chicken of different age categories with house bird density of 35 kg/m2. Moreover, 66.7% of included farms applied regular cleaning and disinfection in poultry farms. Cleaning of houses and hygiene of loading and unloading area after each production cycle recorded 91.7% (n=11) and 83.3% (n=10), respectively. In addition to that, 66.7% (n=8) of examined farms confirmed that they sometimes apply hygienogram to determine efficacy of cleaning and disinfection processes and check the quality of disinfectants used as shown in **Tables 8 and 9**.

Table 8: Internal biosecurity regarding disease prevention plan in broiler poultry farms.

Parameter	Frequency (%)
Implemented vaccination protocol	
1. Yes	12 (100%)
2. No	0 (00.0%)
Regular disease status check	
1. Yes	12 (100%)
2. No	0 (00.0%)
Dead birds removal check	
1. Daily	12 (100%)
2. Every two days	0 (00.0%)
3. > Every two days	0 (00.0%)
House bird density	
1. Less than 33 kg/m2	3 (25.0%)
2. 35 kg/m2	6 (50.0%)
3. 39 kg/m2	3 (25.0%)
Rearing different age categories	
1. Yes	7 (58.3%)
2. No	5 (41.7%)

Table 9: Internal biosecurity regarding cleaning and disinfection in broiler poultry farms.

Parameter	Frequency (%)
Gate disinfection vehicle bath	
1.Yes	8 (66.7%)
2. No	4 (33.3%)
Cleaning of houses after every round	
1.Yes	11 (91.7%)
2. No	1 (08.3%)
Hygienogram for disinfection efficacy	
1. After each cycle	4 (33.3%)
2. Sometimes	8 (66.7%)
Hygiene of loading area after rounds	
1. Yes	10 (83.3%)
2. No	2 (16.7%)
Sanitary transition period after cycle in days	
1. <3	2 (16.7%)
2. 3-8	3 (25.0%)
3. >8	7 (58.3%)
Feed silo's cleaning and disinfection	
1. After each cycle	5 (41.7%)
2. Sometimes	7 (58.3%)
Equipments hygiene after use	
1.Yes	7 (58.3%)
2. No	5 (41.7%)
Presence of more than one house	
1. Yes	4 (33.3%)
2. No	8 (66.7%)
Specific materials storage per house	
1. Yes	4 (33.3%)
2. No	8 (66.7%)
Specific clothing room per house	
1. Yes	5 (41.7%)
2. No	7 (58.3%)

The presented study showed low compliance regarding purchasing of one-day old chicks from one supplier, frequency of delivery and first vehicle delivery in their farms (50%, 58.3%, and 33.3% respectively). However, higher level of biosecurity regarding transport vehicle hygiene implemented by most of the investigated farms. These findings were supported by Mustafa and Babeker in their study which was carried out in Khartoum North Bahri locality, Sudan to determine the efficacy of cleaning and disinfection of broiler farms between production cycles and to evaluate the present biosecurity measures in poultry houses during rest period [12]. Moreover, Mustafa evaluated the biosecurity measures related to the purchase and transportation of day-old chicks in poultry farms in Khartoum State, Sudan. They revealed that in 58.1% of participant farmers bought their day-old chicks from different suppliers, 48.6% of them bought 3-6 times a year and 81.1% posed hygienic criteria on the transport vehicles before the chicks had been loaded concluding that buying chicks from different suppliers entails a greater risk of introduction of disease-causing agents either from contamination at the hatchery or through vertical transmission (from hen to chick) of pathogens [12,13]. Our results were also in agreement with Sims who advised that populating all poultry houses from the same hatchery and breeder farm with special focus on its sanitary status is of paramount importance [14]. In contrast,

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Maduka reported lower level of vehicles hygienic practices (50%) in their study to evaluate biosecurity practices in commercial poultry farms located in Jos, Nigeria [15]. They explained that might be due to using multiple purpose vehicles beside lack of knowledge about hygiene practices among poultry farmers which are common in most developing countries in Africa. The previous findings regarding importing of day-old chicks may be attributed to price variations among supplier companies and seasonal chicks provision due to difficult climatic conditions in Sudan. Moreover, shortness of production cycle which is characteristic for broiler farms may be the reason behind the high frequency of receiving one day old chicks.

Our findings showed that depopulation of broiler houses was done in >2 steps in more than half of the studied farms. This result agrees with previous studies by Lister, McDowell and Vieira who investigated the effect of human contacts and potential pathways of disease introduction on industrial poultry farms as an essential step in GHPs [15-17]. These studies concluded that depopulation must be done in as few steps as possible. Moreover, Van Limbergen in their study that assessed the biosecurity status on conventional broiler farms in 5 member states in EU revealed that the lowest scores within the category of external biosecurity were obtained in the depopulation of broiler houses, but Maduka found high positive responses (80%-90%) in their study to evaluate biosecurity practices in terms of all-in all-out management [14,18].

Investigation of separating clean and dirty areas in broiler farms showed that most of the tested farms in the present study were not separated and even the separated farms the demarcations were not clear in most of them. A study by Van Limbergen to assess the level of biosecurity on conventional broiler farms in Europe, disagreed that only 10% of their studied farms indicated had no farm or house hygiene lock, meaning that there was no clear separation between the clean area and the contaminated area [18]. In his study in adoption of biosecurity practices in industrial poultry sector in Australia, East (2007) agreed that missing a hygiene barrier poses a threat for the entry of pathogens.

Microbiological testing of water source was found to be practiced in 66.7% of broiler farms under study. In addition to that, regular annual testing was poorly practiced. This finding was in agreement with Mustafa and Babeker in Khartoum State, Sudan who found that 100% of the farms under study didn't perform water quality testing [12]. Similar findings were obtained by Tegla and Peter and Tim who found lower implementation of water sanitizing programs in their studies which proved that drinking water for birds must be sanitized to minimize disease transmission. These results also revealed that rooftop water storage tanks are vulnerable to contamination without proper cleaning and sealing. These facts may emphasize the hypothesis of WHO (1996) that the storage of water in reservoirs may cause undesirable changes in water quality, and therefore regular monitoring of the drinking water source is recommended [19,20].

With respect to staff and visitors hygiene restrictions as they may also act as mechanical vectors of several different pathogens, our results showed that biosecurity measures were more frequently enforced for farm visitors compared to farm personnel. Lower level of visitors contact with birds was observed than farm personnel, but visitors were not restricted to free contact period and may visit several farms in the same day. Racicot in their investigation of eight poultry farms in Quebec, Canada, to evaluate compliance of existing biosecurity measures using hidden cameras, agreed that a lot of biosecurity errors happen when people enter or leave poultry farms [21]. A total of 44 different mistakes were observed from 883 visits done by 102 different individuals. They concluded that both the number of visitors and the number of people involved in the daily care should therefore be limited. The presented study revealed good hygiene implemented by owners, staff and visitors access before poultry houses entry, all owners restricted to all rules for access, and at least 24 hours contact free period when visiting other poultry farms, and applied check in, hands washing and wearing hygienic protective wear, not rearing home poultry or other birds. Gibbens demonstrated a standard hygiene protocol that must be followed by all staff who entered a populated broiler houses [22]. This hygiene protocol included a strict procedure with boot dips and specific protective clothing before entering the farm and broilers' houses. Many researchers studied the international spread of Highly Pathogenic Avian Influenza (HPAI) from the Netherlands in 2003 and they concluded that it was associated with an increased number of contacts between farms [23]. Similarly, Vieira found that visitor activities associated with access to the inside of the poultry house should not exceed three times in a week. During the grow-out period because of high susceptibility to infections [17]. Van Steenwinkel reported that poultry flocks generally have lower biosecurity levels mainly due to the poor infrastructural hygiene and the poor confinement against the outdoor environment [24]. Therefore, contact should be avoided with persons that interact with (foreign) backyard poultry.

During this study, it is found that half of the total farms examined were at a distance between 0.5-1 km and complained from frequent passage of neighbouring farms vehicles *via* near public road. The same finding was reported by Mahmoud who found that the distance to the nearest farm was more than 500 m in 75.5% of the respondents of the surveyed farms [25]. According to Stephen, there was no set distance that will uniformly eliminate the risk of disease transfer. However, to reduce the likelihood of airborne transmission between poultry farms, the distance to the nearest neighbour should be at least 500 m and preferably >1 km. This role should be applied not only nearby other industrial poultry farms but also backyard poultry which can pose a risk. It was agreed in some studies that, when poultry farms are close to each other, attention should be paid to the predominant wind direction [16,24].

Rodents may serve as biological as well as mechanical vectors of pathogens both within and between broiler farms. In agreement with a study by Mahmoud to evaluate biosecurity measures on broiler farms in Khartoum State, Sudan, the present study revealed that there was no documented vermins control program in most of the investigated farms although 75.0% of them harbored only

limited vermins. The number of rodents in and around poultry farms is also influenced by the standard of maintenance of the farm buildings. Unsealed roof eaves, broken roofs and ceilings, broken wire mesh, and poorly fitting doors may be the reasons behind increased numbers of rodents in farms [26].

The current study showed that most of the targeted farms (91.7%) were restricted to keeping "backyard" poultry in the targeted farms, preventive measures application of material supplied, not keeping other animals for farming, and no equipments sharing with other farms. In consistent with Lister, no equipment, weeds, or waste should be piled up against the outer stable walls and feed should be stored in a vermin-free place to discourage rodents from nesting in the vicinity of the stables. The same findings were also stated by Mahmoud. They concluded that, in Khartoum State, the close system was more secure than other rearing system indicating that management regarding biosecurity is highly implemented; also larger facilities are often assumed to implement more advanced biosecurity measures. In reference to prevention of susceptible birds, a strict policy for isolating sick birds, removing dead birds from the stables, and controlling the stocking density as tools for disease management, the findings of this study confirmed that all respondent farms applied these preventive measures. In agreement with Wijesingh who found that about 90% of farmers in their study were vaccinating their flocks against most common prevailing poultry diseases [27]. Moreover, Mohamed reported that, a total of 91.1% of the respondent farms in their study had a vaccination program according to FAO regulation [28]. The reason behind these high percentage scores might be due to the fact that level of education of in charge personnel makes them highly aware with the importance of vaccination. In this study, farmers were found to be well aware of the consequences of economic loss of inadequate vaccination based on their own experience. Hence, vaccination against common poultry diseases was common among the farms investigated. The findings of the presented study indicated that proper waste disposal and dead bird removal were implemented in most of the tested farms. However, low restriction to protective wearing beside hands washing and disinfecting after removing dead birds were observed or contact with waste. The same findings were also noted by Mahmoud who found that 68.9% of farmers separated sick birds from health birds and 95.5% of respondents used burring for disposable of dead birds and just two farms (4.4%) left dead birds thrown [29]. In contrast, Mustafa conducted a study evaluating the disposal of manure and dead birds in poultry farms in Khartoum State, Sudan and they found that 77.03% of farms under study disposed their manure and dead birds improperly. The author recommended that dead birds must be in appropriate site either on or preferably off farm. Almost similar findings were obtained by Sudarnika in their study that aimed to provide information on the present biosecurity measures in industrial broiler farms and to measure farmers' attitudes and opinions towards biosecurity in west Java, Indonesia found that 24 farmers (96%) separated sick birds from healthy birds and burned or buried them for disposable and just 4.4% left dead birds thrown away, while in a study to evaluate biosecurity status in commercial broiler farms in Sri Lanka, found that 45% of the farmers included in their study were practicing burring the carcasses and 26% used septic pit for disposal while 29% of farmers threw the dead birds in the farm carelessly without realizing any risk [30]. The reason behind good practicing regarding disposal of dead birds and manure in most of the studied farms is that the farmers are highly aware that dead birds and waste materials are potential sources of contamination. In addition, it was noticed that most farmers sell litter directly after removal to make extra profit. The results of this study showed that 58.3% of respondents farms rear chicken of different age categories with house bird stocking density of 35 kg/m2. Stocking density in broiler houses should not exceed 25 kg/m2 as high stocking density induces stress, which results in an increased susceptibility to infections and influences the severity of a disease outbreak and increased and an increased excretion of pathogens, also. In contrary with Dorea who found that farm size did not influence biosecurity status [31]. Our results revealed that 58.3% of respondents reared chicken of different age categories in their farms, although Gelaude stated that birds of multiple ages kept on in a single farm allows the emergence of diseases and the dissemination of pathogens among birds of a same flock and among flocks [32]. In relation to cleaning and disinfection protocol, we found that cleaning of broiler houses and hygiene of loading and unloading area after each production cycle was high. However, lower percentage (66.7%) of regular cleaning and disinfection in poultry farms was observed. In addition to that, the same percentage of tested farms confirmed that they sometimes apply hygienogram to determine efficacy of cleaning and disinfection processes and check the quality of disinfectants used. Our observations support the finding of Ali, Tabidi and Mustafa and Babeker who recommended that steps of the complete cleaning and disinfection protocol should be carried out between two production cycles including dry cleaning, wet cleaning, disinfection, vacancy period, and monitoring the disinfectants efficacy in their studies in Khartoum State, Sudan [33-36].

Conclusion

We concluded that effectiveness of adoption of biosecurity measures has not been given serious attention in most of the studied large broiler production companies. Unclear or absence of demarcations between clean and dirty areas, poor vehicle hygiene, irregular microbiological testing of water, provision of day-old chicks from different hatcheries and absence of restrictions of entry were the most prominent problems in the most studied broiler farms in Khartoum State. In most of the studied premises, more emphasis on biosecurity measures application was placed targeting farm visitors than those targeting farm personnel although workers had less concern and less attention to follow hygienic practice of food safety. It is recommended that formulation of suitable procedures for implementing biosecurity measures by specialized authorities are needed. Moreover, enforcement of biosecurity programs in broiler premises should be taken as one unit including the including all hygienic aspects ensure ideal implementation and optimum standards of food safety. Provision of infrastructure relevant to poultry production

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industry is essential to make good biosecurity practices possible to be followed during daily routines. Personnel, visitors, and vehicles restrictions are recommended before entering the broiler farms and clear demarcation zones that separate clean and dirty areas in poultry premises are essential.

Conflict of Interest

None declared

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