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Research

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Assessing cross-border live poultry trade as a possible factor for infectious diseases spread between Aflao and Lomé

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Abstract

Introduction: *transboundary animal illnesses may spread across long distances, threatening public health and economies in many nations. The major Ghana-Togo border crossing is one of the busiest in West Africa with illegal commerce channels including live poultry. This research investigated whether the live chicken trade between Aflao and Lomé facilitates infectious disease transmission.* ***Methods:*** *a cross-sectional study was conducted using a well-structured pretested closed-ended questionnaire to assess poultry traders' knowledge of sources of pathogens and their transmission, preventive practices, veterinary inspections, and trade routes.* ***Results:*** *the majority of traders, 45 (60.8%), traded only chicken, while the rest traded both chicken and other poultry. Most 46 traders (62.2%) bought poultry from two sources. The study found 30 (41.9%) respondents only visited selling sites during holidays. Forty-four percent (60%) traders had low pathogen knowledge, 20 (27%) moderate, and 10 (14%) high. About the transmission of infectious poultry diseases, 5 (7%) had high knowledge, 39 (53%), had low knowledge, and 30 (41%) had moderate knowledge. Only 32 (43%), kept equipment clean and isolated sick poultry. Only 12.2% of traders crossed the border after veterinary inspection, even though half used formal trade routes.* ***Conclusion:*** *this study identifies pathogen sources, transmission, and prevention gaps and shows that cross-border live poultry trade between Aflao, Ghana, and Lomé, Togo, can spread infectious diseases. Thus, a comprehensive approach to address disease spread facilitators is needed.*

Introduction

In developing nations, poultry production spans from small family production systems to large-scale industrialized ventures that supply local markets. Both production systems provide employment and serve as a source of income for many. The small production system is typically seen as an addition to other means of subsistence, a way to save money and operate as insurance since it is simple to sell birds for money [1]. In most instances, there are live poultry traders that purchase from both the large industrialized ventures and small family production systems, or solely from one of the systems. Poultry accounts for the bulk of the meat consumption in Ghana because it is widely available and relatively cheap [2].

The Economic Community of West African States (ECOWAS) has a surprisingly extensive regional animal trade [3] and the cross-border trade significantly improves the socioeconomic standing of the participating nations [4]. From the tripoint with Burkina Faso in the north to the Atlantic Ocean in the south, the Ghana-Togo boundary spans 682 miles. The main Ghana-Togo border crossing is between Aflao and Lomé, and it is considered one of the busiest borders in West Africa with several informal trade routes [5]. The estimated number of unofficial trade routes used by motorbikes (“Okada”) to move people, goods, and contraband across the border is 23. It is a popular belief that the two juxtaposed towns of Aflao in Ghana and Lomé in Togo, constantly prosper as a result of trade between the neighboring towns [6], with live poultry trade across the border being an example.

Transboundary animal movements facilitate the spread of pathogens across large distances [7]. There is proof that commercially traded animals and animal products can spread a wide range of infectious zoonotic and epizootic diseases; it has been demonstrated that the risk of transmission rises with trade volume and falls with the distance between source and sink sites and the level of biosecurity implemented in each location [8]. The two main means of international spread of highly pathogenic avian influenza across Asia and Africa are through live poultry trade and migratory birds [8]. Cross-border movement of animals in West Africa often does not involve veterinary inspection [7]. Cross-border animal trade is considered one of the main causes of the global spread of animal diseases [9] and the spread of

some transboundary avian diseases undoubtedly has great public health and economic consequences [10].

Despite the volume of live animal trade across international borders, there is little information regarding the possible factors influencing infectious diseases spread through trade in live poultry. Accordingly, this study investigates the possible factors that have the potential to facilitate the spread of infectious diseases between Aflao in Ghana and Lomé in Togo through live poultry trade.

Methods

Study area

The study was conducted in Aflao, Ghana, specifically in its three major markets, and on farms that are engaged in live poultry trade. The three major markets and their distance from the Aflao-Lomé border are the Border market (0.85km), the Aflao market (1.6 km), and the Denu market (7.1km). Aflao is located on Ghana's eastern coast and is a key border town neighboring Togo. It is situated between latitudes 6.113934 and longitudes 1.198617, with GPS coordinates of 06°08'48.4''N and 01°10'47.6''E.

Study design

A cross-sectional study was conducted using a well-structured and pretested closed-ended questionnaire. The research was carried out from December 2022 to May 2023. A questionnaire was developed to obtain information on respondents' demographic characteristics; key poultry trade information; knowledge of sources of pathogens and transmission; preventive and control practices for infectious diseases of poultry; and veterinary inspection and trade routes.

Sample size and data collection

Active live poultry traders in the three major markets in the study area and poultry farm workers who engaged in live poultry trade were enrolled as respondents in the study. Poultry farms that engaged in poultry trade were selected using the snowball sampling technique until a saturation point was reached. The purpose of the study was conveyed to all potential responders, who were free to participate or decline. Seventy-four (74) traders out of 82 possible respondents took part in the survey. In circumstances where a poultry trader was illiterate, the interviewer read out and explained the questions to the trader in the local language, and the responses were filled in by the interviewer.

Demography and key poultry trade information

Demographic information such as the trader´s gender, age, level of education, nationality, and marital status was collected. Some of the questions regarding the section of key poultry trade information included the type(s) of poultry traded; the nature of the purchasing site (Market, farms, and informal trading places); and its location (Ghana and Togo). The information also included the average number of poultry per trip across the border and the average number sent to the selling site, the nature of the selling site (Market, farm, roadside, and roaming), and the frequency of visits to selling sites (fixed market days, stationary, festive season, and occasional).

Sources of pathogens and transmission

This section included questions to assess whether or not a trader knows about sources of pathogens and modes of infectious disease transmission in poultry. The total number of traders that gave correct (Yes) and wrong (No) answers to each question under this section was represented in a table with the corresponding percentages. Also, the overall knowledge score of traders on the questions in this section was determined by using the following criteria: correctly answered questions on knowledge were awarded one (1) mark each, and "NO" responses and unanswered questions were scored zero. A total of 10 marks was attainable in both assessments on sources of

pathogens and transmission of infectious diseases in poultry. The scores were transformed into categorical variables as high (scores above 80%), moderate (between 50 and 80%), and low (below 50%), adapted from Islam *et al.* [11] and Asare *et al.* [12].

Preventive and control practices

This section included questions to assess the application of knowledge to prevent or control infectious diseases in poultry. The total number of traders that gave correct (Yes) and wrong (No) answers to each question under this section was represented in a table with the corresponding percentages. Also, the overall assessment score of traders on the questions in this section was determined by using the following criteria: The score for the preventive and control practices was based on "YES" and "NO". Positive practices were awarded one mark for a "YES" and zero marks for a "NO" or "unanswered" response. Also, negative practices were awarded one mark for a "NO" and zero marks for a "YES" or "unanswered" response. A total of 13 marks was achievable. The scores were transformed into categorical variables as “high” (scores above 80%), “moderate” (between 50 and 80%), and “low” (below 50%), from Islam *et al.* [11] and Asare *et al.* [12].

Veterinary inspection and trade routes

The information recorded by the interviewers in this section included how often live poultry traders involved a veterinarian or an animal health professional in their line of work, whether they never, sometimes, or always go through veterinary inspection while crossing the border. It also included a question to ascertain whether the traders used formal or informal trade routes while crossing the border.

Data analysis

To avoid errors, data was entered into Microsoft Excel version 2019 and cleaned. The data was then transferred to the Statistical Package for Social Sciences (SPSS) software version 26.0 for analysis, and generation of percentages, graphs, and tables. Fisher's exact test was carried out to ascertain the association between some demographic characteristics and the knowledge level and practices of the respondents. Statistical significance was tested at a 5% significance level.

Results

Demographic characteristics

Out of the 82 potential respondents, 74 traders took part in the study; 5 opted out for various reasons, including lack of necessity, lack of financial gain, and outright rejection. Three traders failed to return the questionnaire. Out of the 74 participants, 32.4% were males, and 67.6% were females. The age groupings were <21 years (1.4%) as the lowest, 21-40 years (43.2%), 41-60 years (51.3%) as the highest, and >60 years (4.1%). Most of the respondents (59.4%) either had only basic education or no formal education. Seventy-three percent (73%) of the traders were Ghanaian nationals, and 27% were Togolese. The relationship status of the respondents is as follows: married (79.7%) as the highest, single (9.5%), and divorced (10.8%). Most of the respondents (47.3%) involved their children, spouse (6.8%), siblings (20.3%), other relatives (9.5%), and non-relatives (26%) in their trading activities, as shown in Table 1.

Information on type(s) of poultry trade

Most traders (60.8%) traded only in chicken, while the rest practiced the following mixing of poultry during trading: chicken and Guinea fowl (21.6%), Chicken and Duck (12.2%), and Duck and Guinea fowl (4.1%). The source/purchasing locations of poultry by the traders were Togo (63.5%) and Ghana (36.5%). In terms of the nature of the source/purchasing location of poultry, 37.8% of the poultry traders sourced their poultry from only a farm, and most traders (62.2%) sourced their poultry from at least two sites: farm and informal trading place (23.0%), market and farm (10.8%),

market and farm and informal trading place (21.6%), and market and informal trading place (6.8%). The ranges for the number of poultry per trip across the border by the respondents are as follows: 21-40 (52.7%) as the highest, <20 (25.7%), 41-60 (17.6%), and >60 (4.1%). Most of the respondents (66.2%) traded in both Aflao and Lomé, while 23% and 10.8% traded in only Aflao and only Lomé, respectively. The nature of the selling sites of traders was a market (44.9%), farm (18%), roadside (16.9%), and roaming (20.2%). 41.9% of the respondents visit selling sites during festive seasons, followed by fixed market days (39.2%), stationary (14.9%), and occasionally (4.1%). The ranges for the number of poultry brought to the trading site per visit are as follows: <20 (28.6%), 20-40 (53.1%) as the highest, 41-60 (12.2%), and >60 (6.1%). Regarding the means of transporting poultry across the border, most traders (32.4%) used baskets or head pans, followed by cars (28.4%), motorbikes or tricycles (24.3%), and moveable cages (14.9%) (Table 2).

Sources of pathogens and their transmission, preventive and control measures

The number of traders who correctly (Yes) answered questions assessing their knowledge of sources of pathogens is indicated in Table 3 as sick poultry 69 (93.2%), dead poultry 36 (48.6%), contaminated feed 69 (93.2%), contaminated water 69 (93.2%), contaminated equipment and kits 46 (62.2%), contaminated litter 57 (77.0%), slaughter surfaces 23 (31.0%), vehicles 22 (29.7%), wild birds 16 (21.6%), and humans 46 (62.2%). Table 4 shows the number of traders that answered correctly (Yes) and wrongly (No) to the questions assessing their knowledge on the mode of spread of infectious diseases in poultry. The number of traders who correctly answered the questions is indicated as contact with infected poultry 74 (100.0%), visiting infected farms 52 (70.3%), other farmer/poultry traders visit farms 35 (47.3%), wild birds flying into farms 20 (27.0%), visit to live poultry markets 34 (45.9%), selling sick poultry 59 (79.7%), unrestricted movement of vehicles and people into farms 49 (66.2%), sharing of equipment with other farms 38 (51.4%), contaminated dust particles 48 (64.9%), contaminated feed and water 74 (100.0%).

From Table 4, the number of poultry traders exhibiting the right preventive and control practices in their line of work is indicated as 42 (56.8%) traders washed their hands with antiseptics before entering pens or handling poultry, and 71 (95.9%) washed hands upon coming out of pens or handling poultry; 36 (48.6%) used dedicated attire; and 36 (48.6%) walked through footbaths when they visited farms to purchase poultry; 56 (75.7%) covered mouth and nose while coughing/sneezing; 14 (18.9%) respondents used a facemask while in pen; 30 (40.5%) vaccinated their poultry against endemic diseases or bought vaccinated poultry; 55 (74.3%) of traders isolated sick poultry; and 22 (29.7%) quarantined new poultry; 41 (55.4%) cleaned or disinfected equipment regularly; 35 (47.3%) weeded their pen surroundings regularly and controlled rodents and insects; 32 (43.2%) poultry traders kept unsold poultry in isolation and sent it back to the market, while 42 (56.8%) mixed unsold poultry with poultry on the farm.

Overall score on the level of knowledge and preventive/control practices

In Figure 1, 44 respondents, representing 60%, had low knowledge of sources of pathogens; 20 (27%) had moderate knowledge; and only 10 (14%) had high knowledge of sources of pathogens such as sick poultry, contaminated litter, contaminated feed, and kits. The results also show that 5 (7%) respondents had a high level of knowledge about the transmission of infectious poultry diseases. Most respondents 39 (53%) had a low level of knowledge, and 30 (41%) had a moderate level of knowledge on modes of transmission or spread of infectious poultry diseases, such as sharing of equipment with other traders, wild bid birds flying close to or into a farm/pen and unrestricted movement of vehicles and other traders into a farm/pen. Most respondents 38 (51%) practiced poor prevention and control measures against

disease spread in their line of work. Only 32 (43%) and 4 (5%) of respondents, respectively, practiced good and excellent preventive and control measures such as handwashing with antiseptic, regular disinfection of equipment and isolating sick poultry.

Association between the level of education and knowledge on sources of pathogens, transmission, and preventive practices

From Table 5, all respondents who had no formal education 22 (100%) and all of the respondents who had JHS education 22 (100%) showed low knowledge of sources of pathogens. None of the respondents who had senior high school (SHS) and tertiary education showed low knowledge, while most of the respondents, 8 (57.1%) and 12 (75.0%), who respectively had SHS and tertiary education, showed moderate knowledge. The p-value of 0.000 shows that the level of education of respondents has a significant influence on their knowledge of sources of pathogens.

Table 5 shows that the highest number of respondents, 19 (86.4%) and 16 (72.7%), who respectively had no formal education and only JHS education, demonstrated a low level of knowledge on the transmission of pathogens, while none of the respondents (0, 0.0) showed high knowledge. 8 (57.1%) and 13 (81.2%), respectively, represent the highest number of respondents that had SHS and tertiary education with moderate knowledge on transmission of pathogens, while 4 (28.6%) and 1 (6.25%), respectively, represent the number of respondents that had SHS and tertiary education and demonstrated high knowledge. The results demonstrated that the level of education of the respondents is a significant factor that influences knowledge on transmission (p = 0.000).

Table 5 shows that the highest number of respondents, 20 (90.9%) and 14 (63.6%), respectively, representing respondents that had no formal education and only JHS education, demonstrated poor preventive and control practices. 10 (71.4%) and 12 (75.0%), respectively, represent the majority of respondents who had SHS and tertiary education and showed good preventive and control practices. The majority (10, 71.4%) of respondents who had SHS education showed good preventive and control practices. Using Fisher´s exact value, the relationship was statistically significant (p = 0.000). This meant that the level of education had an influence on respondents´ preventive and control practices regarding the spread of infectious poultry diseases.

Veterinary inspection and trade routes

From Table 6, only a few respondents (9, 12%) involved veterinarians in their line of work, while 16 (21%) of respondents do it occasionally, and most respondents (49, 66.2%) never involved veterinarians. From the table, it is evident that most respondents, 52 (70.3%), never went through veterinary inspection when they crossed the border with their poultry, while 13 (17.6%) respondents said their poultry was occasionally inspected, and only a few respondents, 9 (12.2%), indicated their poultry always went through veterinary inspection when crossing the border. The results revealed that an equal number of respondents (37, representing 50%) used formal and informal trade routes while crossing the Aflao-Lomé border.

Discussion

Infectious diseases of poultry are thought to spread and persist in Asia due to the live poultry trade [13], and live bird markets (LBMs) have been associated with several outbreaks and their spread in Uganda [14] The only reported infectious poultry disease outbreak that occurred in Aflao was that of highly pathogenic avian influenza (HPAI) in June 2007 [15] and 2021. Comparing one of the recent HPAI outbreaks that occurred in Lomé, as reported by the World Organization for Animal Health (WOAH) on July 1, 2021, to the recent HPAI outbreak in Aflao on July 21, 2021, it is noteworthy that the outbreaks were reported

barely a month apart, and the outbreak in Aflao could be due to a spillover from the outbreak in Lomé. However, there was no genetic characterization or any other laboratory investigation to confirm that it was a spillover.

From the results of this study, we established that there is active live poultry trade across the Lomé-Aflao border, with 66.2% of the traders selling poultry in both Lomé and Aflao and according to the traders, this routine maximizes their selling rates as well as profit margin. It is worth noting that the majority of traders (73%) were Ghanaians residing in Aflao and its environs, and 63.5% crossed the border to source their poultry from Lomé despite the cost and the difficulties involved in the movement of poultry across the border. Based on the data collected, more females (67.6%) traded in poultry than males. This shows the dominance of women in the live poultry trade, and this is in agreement with the results of a similar study by Yusuff [16] in the West African sub-region but contradicts the reports by Ipara *et al.* [17], where there is men´s dominance in the marketing of poultry in Kenya's major market outlets. Most respondents (51.4%) were between 41 and 60 years old, which is similar to the study conducted by Ipara *et al.* [17]. This demonstrates that middle-aged to elderly traders typically dominate the live poultry trade.

This study also established that respondents traded in combination with birds sourced from varied sites and this could influence disease transmission and spread. With the exception of 60.8% of the respondents who traded in only chicken and 44.6% who sourced their poultry from only a farm, the rest of the traders, respectively, practiced mixing multiple species and sourcing poultry from multiple sites; hence, there is a high risk of exposure to pathogens and disease spread. These findings are similar to earlier studies done by other researchers as indicated. Earlier researchers have established that the high concentration and interaction of a wide range of birds brought in from various sources highlighted the live bird markets as one of the high-risk places for disease transmission [18]; according to Ogali *et al.* [19] and Ogali IN *et al.* [20], the practice of mixing birds from different sources and mixing multiple species poses a high risk of exposure and disease occurrence. Regarding the frequency of visits to the selling sites by the traders, 41.9% indicated engaging in trading activities only during festive seasons such as Christmas-New Year and Easter (December-January, and April). This corresponds with the study conducted by Delabouglise *et al.* [21] that shows that, around the festive seasons, there was a surge in demand for poultry meat and to meet this demand, poultry trade activities rose, potentially facilitating the spread of infectious diseases.

The present study also investigated the knowledge of poultry traders on the sources of pathogens, transmission of infectious diseases, and their preventive and control practices. This was because awareness and knowledge of diseases are considered crucial steps in preventing and limiting potential outbreaks [22]. Our study showed that most traders had low to moderate knowledge of sources of pathogens and disease transmission. The low-moderate knowledge greatly translates into abysmal preventive and control practices, as observed by the overall poultry traders´ scores (Figure 1), hence the high risk for disease spread. Delving into the participants´ knowledge of sources of pathogens (Table 3), participants had low knowledge of most of the parameters but had a high level of knowledge of just these few variables in the section: infected poultry, contaminated litter, and contaminated feed and water as sources of pathogens that infect poultry. Also, participants´ knowledge of the spread of infectious poultry diseases (Table 4) through contact of infected poultry with healthy poultry, contaminated feed, and water, visits to infected farms, and the sale of obviously sick poultry was high, while knowledge of all other parameters was low. In similarity to the results of the study conducted by Adam *et al.* [23], live poultry traders had low knowledge of most of the variables under the section, such as wild birds flying into farms,

sharing of equipment and kits, unrestricted movement of vehicles into farms, and people such as farmers and other traders. This was an important finding that indicated a knowledge gap on the transmission and spread of infectious poultry diseases among the respondents. These findings suggest that live poultry traders in the current research have low knowledge, which increases the possibility of infectious diseases spreading easily, and it is in agreement with the study conducted by Ipara *et al.* [17].

Regarding the relationship between level of education and knowledge on sources of pathogens and transmission, we found that poultry traders that had senior high school (SHS) and tertiary education, making up the minority of 30 (40.5%), were more knowledgeable on the sources of pathogens and transmission compared to the majority of traders that had either junior high school education or no formal education. In addition, we found that the level of education of traders has a significant influence (p value=0.000) on their preventive and control practices, which is a reflection of their knowledge. This is similar to the results from a study conducted in Ghana by Ayim-Akonor *et al.* [24] that shows respondents with lower education levels were about twice as likely to have low knowledge of infectious poultry diseases and exhibit poor husbandry practices that increase the risk of infection spreading in the Ghanaian poultry industry.

According to our findings, half of the poultry traders used formal trade routes when crossing the Aflao-Lomé border; however, only 12.2% underwent veterinary inspection. This shows that cross-border live poultry trade across the Aflao-Lomé border rarely involves veterinary examination and supports the earlier statement that cross-border animal trade in West Africa rarely involves veterinary inspection [7]. Although live poultry trade across formal trade routes will always pose some risk of disease spread, the present study suggests that poultry trade over the Aflao-Lomé border poses a high risk of disease spread. According to Beltran-Alcrudo *et al.* [25], within formal trade route activities, the effectiveness of implemented measures in preventing the entry of potentially diseased animals determines the risk of disease spread. Given that cross-border live poultry trade between Aflao and Lomé rarely involves veterinary examination, it is expected that diseased animals will be able to enter neighboring countries without being detected and quarantined.

Conclusion

This study highlights the historical and current risks of avian influenza outbreaks in neighbouring cities Aflao (Ghana) and Lomé (Togo), primarily driven by cross-border live poultry trade practices such as mixing species and sourcing from multiple sites. The lack of knowledge among traders regarding disease transmission and prevention underscores the urgent need for targeted education campaigns. Heightened trading activities during festive seasons further emphasize the necessity for increased surveillance, while addressing risks associated with informal trade routes and insufficient veterinary oversight requires collaborative efforts among stakeholders to mitigate the spread of infectious poultry diseases.

What is known about this topic

- *The high volume of cross-border live poultry trade between Aflao and Lomé heightens the risk of infectious disease spread, as large bird movements create opportunities for pathogen transmission;*
- *Implementing robust biosecurity measures along the trade route is crucial for preventing infectious disease outbreaks, requiring measures such as quarantine protocols, hygiene practices, and surveillance systems;*

- *The effectiveness of trade regulations and policies significantly influences the spread of infectious diseases, with inadequate enforcement exacerbating risks and stringent measures helping to mitigate them.*

What this study adds

- *This study offers empirical insights into the dynamics of cross-border live poultry trade between Aflao and Lomé, elucidating its potential implications for infectious disease spread. The study reveals significant knowledge gaps among poultry traders regarding pathogen sources, transmission routes, and preventive measures, highlighting the need for targeted educational interventions to improve disease risk awareness;*
- *The research underscores the limited veterinary inspection practices at border crossings, emphasizing the necessity of strengthening regulatory measures to ensure compliance with health standards and mitigate disease transmission risks;*
- *Overall, the study calls for a comprehensive strategy integrating education; regulatory enforcement, and stakeholder collaboration to address facilitating factors for disease spread in the cross-border poultry trade between Aflao and Lomé.*

Competing interests

The authors declare no competing interests.

Authors' contributions

Raphael Deladem Folitse and Benjamin Obukowho Emikpe conceptualized, designed the study, and reviewed the manuscript. Prince Dela Goka designed the questionnaire, administered the questionnaire to acquire the research data, analyzed the research data, and drafted the manuscript. William Tasiame, Esther Amemor, Vitus Burimuah, and Derrick Adu Asare reviewed and edited the article critically and provided some important information.

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Tables and figure

Table 1: demographic characteristics of participants

Table 2: information on type of poultry trade

Table 3: knowledge of sources of pathogens that infect poultry

Table 4: knowledge of the spread of infectious diseases in poultry and assessment of disease prevention and control practices of the traders

Table 5: association between level of education and knowledge on sources of pathogens, transmission, and practice of preventive/control measures

Table 6: veterinary inspection and trade routes

Figure 1: level of knowledge on sources of pathogens, infectious disease transmission, and preventive/control practices of poultry traders

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Table 1: demographic characteristics of participants			
Variable	**Categories**	**Frequency (n)**	**Percentage (%)**
Age(years)	<20	1	1.4
	20 - 40	32	43.2
	41 - 60	38	51.4
	<60	3	4.1
Gender	Male	24	32.4
	Female	50	67.6
Level of education	JHS	22	29.7
	SHS	14	18.9
	Tertiary	16	21.6
	None	22	29.7
Nationality	Ghanaian	54	73.0
	Togolese	20	27.0
	Any other	0	0.0
Marital status	Single	7	9.5
	Married	59	79.7
	Divorced	8	10.8
Relations involved in trading	Spouse	5	6.8
	Sibling	15	20.3
	Children	35	47.3
	Other relatives	7	9.5
	Non-relatives	26	35.1

Table 2: information on type of poultry trade			
Variable	**Variable**	**Frequency (n)**	**Percentage (%)**
Type of poultry mixing	Chicken	45	60.8
	Chicken & Duck	16	21.6
	Chicken & Guinea fowl	10	12.2
	Duck & Guinea Fowl	3	4.1
Nature of the source/purchasing site	Farm	28	37.8
	Farm & Inf. Trading place	17	23.0
	Market & farm	8	10.8
	Market & farm & Inf. place	16	21.6
	Market & Inf. Trading place	5	6.8
Location of the source/purchasing site	Ghana	27	36.5
	Togo	47	63.5
Average number of poultry per trip across the border	<20	19	25.7
	20 - 40	39	52.7
	41 - 60	13	17.6
	<60	3	4.1
Location of selling site	Aflao	17	23
	Lomé	8	10.8
	Both Aflao & Lomé	49	66.2
Nature of selling site	Market	35	47.5
	Farm	6	8.1
	Roadside	9	12.2
	Roaming	10	13.5
	Market & farm	6	8.1
	Market & roadside	8	10.8
Frequency of visits to selling site	Fixed market days	29	39.2
	Stationary	11	14.9
	Festive seasons	31	41.9
	Occasional selling	3	4.1
Average number of poultry brought to selling site at a time	<20	14	28.6
	20 - 40	26	53.1
	41 - 60	6	12.2
	>60	3	6.1
Means of transport of poultry across the border	Car	21	28.4
	Motorbike/tricycle	18	24.3
	Basket/head pan	24	32.4
	Moveable cages	11	14.9

Table 3: knowledge of sources of pathogens that infect poultry			
Variable	**Yes (n, %)**	**N° (n, %)**	**No idea (n, %)**
Sick poultry	69(93.2)	0(0.0)	5(6.8)
Dead poultry	36(48.6)	11(14.9)	27(36.4)
Contaminated feed	69(93.2)	0(0.0)	5(6.8)
Contaminated water	69(93.2)	0(0.0)	5(6.8)
Contaminated equipment & kits	46(62.2)	12(16.2)	16(21.6)
Contaminated litter	57(77.0)	12(16.2)	5(6.8)
Slaughter surfaces	23(31.0)	23(31.0)	28(37.8)
Vehicles	22(29.7)	18(24.3)	34(45.9)
Wild birds	16(21.6)	20(27.0)	38(51.4)
Humans	46(62.2)	0(0.0)	28(37.8)

Table 4: knowledge of the spread of infectious diseases in poultry and assessment of disease prevention and control practices of the traders		
Knowledge of the spread of infectious diseases in poultry		
Variable	**Yes (n, %)**	**No (n, %)**
Contact with infected poultry	74(100.0)	0(0.0)
Visit infected farms	52(70.3)	22(29.7)
Other farmer/poultry traders visit to farm	35(47.3)	39(52.7)
Wild birds flying close to farm/pen	20(27.0)	54(73.0)
Visit to live poultry markets	34(45.9)	40(54.1)
Selling sick poultry	59(79.7)	15(20.3)
Unrestricted movement of vehicles and people into farms	49(66.2)	25(33.8)
Sharing of equipment with other farms/traders	38(51.4)	36(48.6)
Contaminated dust particles	48(64.9)	26(35.1)
Contaminated feed & water	74(100.0)	0(0.0)
Disease preventive and control practices of the traders		
Variable	**Yes (n, %)**	**No (n, %)**
Handwashing with antiseptics before entering the pen/handling poultry	42(56.8)	32(43.2)
Handwashing with antiseptics when coming out of pen/handling poultry	71(95.9)	3(4.1)
Use of dedicated attire on farms	36(48.6)	38(51.4)
Walk through footbath	36(48.6)	38(51.4)
Covering of mouth/nose on coughing/sneezing	56(75.7)	18(24.3)
Using a facemask while in pen	14(18.9)	60(81.1)
Vaccination of poultry	30(40.5)	44(59.5)
Isolating sick poultry	55(74.3)	19(25.7)
Quarantine of new poultry	22(29.7)	52(70.3)
Regular cleaning/disinfection of equipment	41(55.4)	33(44.6)
Regular weeding, rodent, and insect control	35(47.3)	39(52.7)
Unsold poultry kept in isolation and sent back to market	32(43.2)	42(56.8)
Unsold poultry mixed with poultry on the farm	42(56.8)	32(43.2)

Table 5: association between level of education and knowledge on sources of pathogens, transmission, and practice of preventive/control measures					
Educational Level	**Low Knowledge**	**Moderate Knowledge**	**High Knowledge**	**Total (100%)**	**p-value**
No formal education	22(100.0%)	0(0.0%)	0(0.0%)	22	0.000
JHS	22(100.0%)	0(0.0%)	0(0.0%)	22	
SHS	0(0.0%)	8(57.1%)	6(42.9%)	14	
Tertiary	0(0.0%)	12(75.0%)	4(25.0%)	16	
Knowledge level of transmission					
Educational Level	**Low knowledge**	**Moderate Knowledge**	**High knowledge**	**Total (100%)**	**p-value**
No formal education	19(86.4%)	3(13.6%)	0(0.0%)	22	
JHS	16(72.7%)	6(27.3%)	0(0.0%)	22	0.000
SHS	2(14.3%)	8(57.1%)	4(28.6%)	14	
Tertiary	2(12.5%)	13(81.2%)	1(6.25%)	16	
Level of practice of preventive/control measures					
Educational level	**Poor practices**	**Good practices**	**Excellent practices**	**Total (100%)**	**p-value**
No formal education	20(90.9%)	2 (9.1%)	0(0.0%)	22	
JHS	14(63.6%)	8(36.4%)	0(0.0%)	22	0.000
SHS	4(28.6%)	10(71.4%)	0(0.0%)	14	
Tertiary	0(0.0%)	12(75.0%)	4(25.0%)	16	
P-value <0.05 is significant, Fishers Exact test.					

Table 6: veterinary inspection and trade routes			
Variables	**Response**	**Frequency (n)**	**Percentage (%)**
Involve veterinarian in line of work	Yes	9	12.2
	Sometimes	16	21.6
	Never	49	66.2
Do the poultry go through vet inspection while crossing the border	Yes	9	12.2
	Sometimes	13	17.6
	Never	52	70.3
Trade route used while crossing border	Formal	37	50
	Informal	37	50

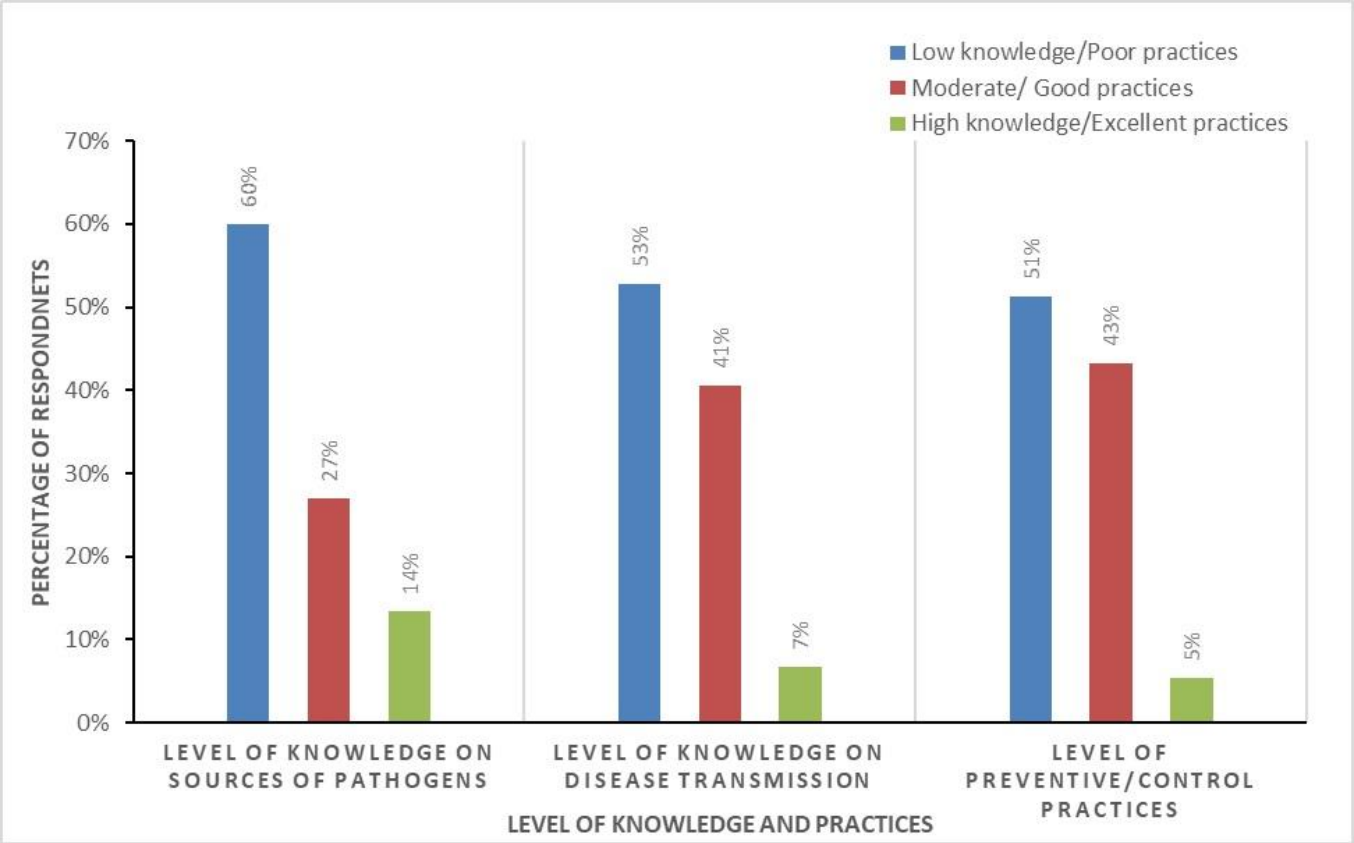

Figure 1: level of knowledge on sources of pathogens, infectious disease transmission, and preventive/control practices of poultry traders