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Biosecurity Conditions in Small Commercial Chicken Farms, Bangladesh 2011–2012

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Abstract

In Bangladesh, highly pathogenic avian influenza H5N1 is endemic in poultry. This study aimed to understand the biosecurity conditions and farmers' perception of avian influenza biosecurity in Bangladeshi small commercial chicken farms. During 2011–2012, we conducted observations, in-depth interviews and group discussions with poultry farmers in 16 farms and in-depth interviews with seven local feed vendors from two districts. None of the farms were completely segregated from people, backyard poultry, other animals, households, other poultry farms or large trees. Wild birds and rodents accessed the farms for poultry feed. Farmers usually did not allow the buyers to bring egg trays inside their sheds. Spraying disinfectant in the shed and removing feces were the only regular cleaning and disinfection activities observed. All farmers sold or used untreated feces as fish feed or fertilizer. Farmers were more concerned about Newcastle disease and infectious bursal disease than about avian influenza. Farmers' understanding about biosecurity and avian influenza was influenced by local vendors. While we seldom observed flock segregation, some farmers used measures that involved additional cost or effort to protect their flocks. These farmers could be motivated by interventions to protect their investment from diseases they consider harmful. Future interventions could explore the feasibility and effectiveness of low-cost alternative biosecurity measures.

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COMPLIANCE WITH ETHICAL STANDARDS

CONFLICT OF INTEREST The authors declare that they have no conflict of interest.

HUMAN AND RIGHTS STATEMENT All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study protocol was approved by icddr,b's Ethical Review Committee (Federalwide Assurance # 00001468, Human Welfare Assurance # 00001822). Informed written consent was obtained from all participants included in the study.

Keywords

biosecurity; small commercial; poultry; farm; avian influenza; perception; qualitative; Bangladesh

INTRODUCTION

Highly pathogenic avian influenza (HPAI) H5N1 viruses have caused widespread mortality among poultry. In humans, the World Health Organization (WHO) reported a total of 846 HPAI cases with a 53% case fatality rate between 2003 and February 2016 (WHO 2016). Transmission of avian influenza to humans poses a risk of coinfection and genetic reassortment of influenza viruses, which could lead to the emergence of a novel influenza virus strain with pandemic potential (Jackson et al. 2009). Direct contact with infected poultry, objects and surfaces contaminated by infected droppings or slaughtering by-products is considered the main routes of human infection (WHO 2005). Smallholder commercial poultry production may be at greater risk of HPAI infection than backyard production (Alhaji and Odetokun 2011) and large industrial commercial production because of the high number of contacts with intermediaries (i.e., traders, suppliers, transporters) and the lack of physical barriers to infection (FAO 2008). From 2004 to 2007 in Vietnam, 80% of outbreaks occurred on farms with 51–3000 birds (Burgos et al. 2008). Sub-districts with small commercial farms were associated with a high risk of H5N1 infection in Thailand (Tiensin et al. 2009).

In Bangladesh, 549 outbreaks of HPAI H5N1 were confirmed in 52 of 64 districts from 2007 to 2013 (OIE 2013). Bangladesh has reported eight human cases of H5N1 (WHO 2016), including three among poultry workers (IEDCR 2012a) and one fatality (Rahman 2013). Bangladesh is particularly at risk of emerging infections because of its high population density and widespread contact between people and animals. Global connectivity through transport networks means that emerging infections in Bangladesh present global pandemic risks (Tatem et al. 2006). Small-scale commercial poultry farms (poultry population ≤2000) account for 81% of the total commercial poultry farms in Bangladesh (Department of Livestock Services 2012) and 44% of the 549 farms where confirmed cases have occurred (OIE 2013).

To reduce the introduction and spread of infectious diseases, including HPAI, into and from commercial poultry farms, the Government of Bangladesh recommended a set of biosecurity measures in 2010 (Department of Livestock Services 2010). Practices and perceptions data from small commercial farms may provide new insights into developing interventions to further reduce risk. These data may assist Asian and African countries with similar farming systems that report HPAI outbreaks (FAO 2007). This study of small commercial chicken farms explores biosecurity conditions, farmers' perception of avian influenza and biosecurity, farmers' motivation to use biosecurity measures and constraints to implementing and maintaining government recommendations.

METHODS

Study Site and Data Collection

Three anthropologists visited 16 poultry farms from Gazipur and Tangail districts in Bangladesh from September 2011 to January 2012. We selected these districts because these were among the districts with the highest number of commercial poultry farms in Bangladesh (Dolberg 2008). The Gazipur site was peri-urban, located near main traffic routes to the capital city (Figure 1). The Tangail site was rural and more remote, located in the highlands. Purposive selection of the farms was based on their close proximity to each other and geographically distributed in a way that facilitated obtaining an understanding of the interconnectedness among the participants. Eight of these farms produced broilers (raised for meat production) and eight produced layers (raised for egg production). We included two farms where the government culled birds during the avian influenza outbreak in 2008 to explore whether there was any difference between the practices and perceptions of these famers and those of other farmers.

Livestock officers at the sub-district level introduced the team to the community vaccinators and avian influenza workers, who worked closely with the farmers and introduced the team to the farmers. The team then repeatedly visited the farms over several days to build a trusting relationship with the farmers through interactive conversation about the objective of the study and our commitment to confidentiality.

The team collected data using multiple tools (Table 1). First, they conducted a spot observation by recording the presence and condition of certain farm elements to provide a ‘snapshot’ of the biosecurity conditions at each farm. Spot observation is a less-intrusive and less-reactive approach compared to structured observation and is often used in research to assess hygiene practices (Ruel and Arimond 2002). The team visited the farms without informing the farmers about the exact day and time of the visits to reduce reactivity. During the spot observations, the team also drew a map at each farm to record the layout of the chicken shed. To assess the location of the farms in relation to the different elements of its surroundings, the team recorded distances using Global Positioning System (GPS) devices.

The team conducted 57 h of observations distributed across the 16 farms in 44 sessions. The team recorded detailed descriptions of biosecurity practices and explored issues identified during the spot observations during these sessions. The number of observation sessions varied based on data saturation (i.e., the point at which no new data emerge) to explore a particular topic. The duration of observation sessions varied based on the activities under observation. Each team member observed a specific activity by rotation to ensure similar exposure of all team members to different activities. To reduce observation bias, the team spent several hours at the farms to blend in and normalize their presence prior to the actual observation; the first several hours of observation were discarded. The team conducted in-depth interviews with farmers, one at each farm, to explore practices related to biosecurity and conducted two group discussions. Issues identified during observations were explored during interviews to clarify reasons for certain behaviors.

The team also interviewed seven local vendors of chicks, feed or medicine, who the farmers mentioned as sources of information. The team used semistructured guidelines for observations, interviews (S1 Table) and discussions with topics to explore and probe. The team attended all training sessions on avian influenza and/or biosecurity that took place in the study areas during data collection. They took detailed notes of observations and audio recorded the interviews and group discussions. They discussed findings and reviewed guidelines at the end of each day to ensure consistency in their assessments.

To understand the practices of the three principle elements of biosecurity—segregation, cleaning and disinfection (FAO 2008), we followed the biosecurity guidelines for the commercial poultry industry issued by the government (Department of Livestock Services 2010) (S2 Table).

Data Analysis

The research team organized the data from the mapping and spot observations according to biosecurity indicators. They completed observation notes and transcribed the recorded data. They analyzed the data using an inductive approach (Thomas 2006). The team considered the government recommendations as a reference point and identified variations in biosecurity practices and perceptions of the participants. They repeatedly read the notes and transcriptions to identify different underlying themes and categorized data according to these themes. They then prepared a summary of each theme (Vaismoradi et al. 2013). The first two authors separately looked for similarities and patterns for analysis to identify different dimensions and to reduce researcher bias. They cross-checked the findings by comparing the data from different tools and categories of participants and explored patterns in information flow and networks among the participants.

RESULTS

Demographics

Most (81%, 13/16) of the farmers were male; their mean age was 38 years. The total monthly income of the farmers' households ranged from US$ 78 to 841 (median US$ 255). Half of the farmers had a secondary or higher level of education. Chicken farming was the main source of household income for 11 farmers. The median number of chickens raised per farm was 665 (range 320–2300). The local vendors we interviewed were all men with a mean age of 38. Only two vendors had received formal vocational training in commercial poultry farming.

Description of Chicken Sheds

The area of chicken sheds ranged from 40 to 229 m^2 (median 79 m^2 for all poultry or a median of 0.13 m^2 per chicken). The walls of the chicken sheds were constructed of bamboo, wood or cement poles with wire or bamboo mesh to allow airflow. The roofs were corrugated metal. One broiler shed had a cement floor; the rest had mud flooring. Layer chickens were raised in cages, and most sheds had cement floors; however, two layer farmers raised chickens on mud floors to minimize costs.

Segregation

Location and Layout of the Sheds—All chicken sheds were located on the owners' premises at less than the recommended distance to the household, other commercial poultry farms and water bodies (Table 2). Farmers did not follow recommendations related to human access and other animals in the shed, and 15/16 farms had incomplete or no fencing (Table 3). Farmers with incomplete fencing reported that they prioritized fencing the sides exposed to the road or walkways. The team commonly observed a gap between the roof and the mesh and/or openings in the mesh. For short-term broiler farming, farmers reported using cheaper narrower wire mesh, which did not fully cover the exposed area. Farmers reported that wild birds and backyard poultry entered the shed and ate poultry feed. Farmers considered rodents a nuisance to their chickens and poultry feed and took measures to prevent them (Table 3). The team observed rodent holes in the mud floor at three farms.

Traffic and Equipment in and Out of the Sheds—Family members entered the sheds without disinfection to help with farming activities (Table 3). Litter buyers, egg buyers and vaccinators visited multiple farms in a day and entered chicken sheds without disinfection. Vehicles carried chicks and feed to multiple farms and were usually parked adjacent to the door of the shed without disinfection. Farmers shared feed and equipment, such as feeders, drinkers and weighing tools, among farms. However, farmers did not usually allow egg buyers to bring their egg trays inside the shed. Farmers collected eggs in their own egg trays or baskets and sold the eggs to the buyer, who visited the farms 2–7 times a week and travelled the area collecting eggs from several farms.

Managing Sick and Dead Chickens—The team observed sick and healthy chickens housed separately inside the same shed or inside the farmers' bedrooms. Twelve farmers reported burying dead poultry, though the team observed only one farmer burying a carcass. Three farmers dumped carcasses in the bushes or in an open field, two farmers fed carcasses to dogs.

Cleaning and Disinfection

Preparing the Shed for the Next Batch—Broiler chickens were kept until they were 28–35 days old. Layer chickens were kept for 18–24 months. All farmers reported cleaning and disinfecting the shed before buying a new batch of chicks and mentioned using lime (calcium hydroxide) as a disinfectant (S3 Table). Their cleaning focused on the floor and equipment, although the government recommended cleaning and disinfecting the entire facility. Farmers removed the litter by scraping the mud floor with sharp-edged tools, swept the floor, smeared new mud and allowed it to dry for 2–7 days. They used water to wash feces away from cemented floors to the grounds or ditches adjacent to the shed. They also swept and dusted the walls and cages of the shed. Although the government recommended a minimum of 14 days between batches, farmers reported 4–21 days between batches. The gap was influenced by the time required for cleaning, the market rate for day-old chicks, whether diseases were reported in the area and convenience.

Regular Cleaning and Disinfection of the Shed and Equipment—Farmers used locally available materials such as lime, bleaching powder (calcium hypochlorite) and potash

(potassium permanganate) (S3 Table), as disinfectants at the concentration, quantity and frequency suggested by their sources of information (Figure 2). The only regular cleaning and disinfecting activities observed by the team were the spraying of disinfectant inside and outside of the shed and removing feces. The concentration of the disinfectant and frequency of application varied from farm to farm (S3 Table). Although farmers reported washing and/or disinfecting utensils, feed sacks, medicine packets and equipment used for collecting litter, the team rarely observed these practices. The vaccinator and debeaker used the same equipment for several farms. The vaccinator reported boiling the syringe between farms but the team did not observe this.

Litter and Feces Management—The ten farms that raised chickens on the floor produced dry litter, a mixture of chicken feces and bedding material made from rice husk and sawdust. Farms that raised chickens in cages produced semiliquid feces, which they also called litter. These two types of litter were managed differently (S3 Table). In all farms, feces were either sold or used as fish feed or dumped in open fields without treatment. In Gazipur, litter buyers bought the semiliquid feces from several farms everyday for 20 taka (US$ 0.3) per drum (approx 41 l) and sold the litter to local fish farmers for 50 taka (US $ 0.7) per drum. Tangail layer farmers washed away the semiliquid feces themselves and dug a ditch behind the shed to contain the semiliquid feces. When the ditch became full and dry, they sold the feces for fish feed and fertilizer. None used any disinfectant on the floor during regular litter disposal.

Personal Hygiene—Disinfecting hands and feet before entering and after exiting the shed was seldom observed (Table 4). When disinfection was observed, it was mainly disinfecting feet before entering the shed and disinfecting hands after exiting the shed. Although not explicitly discouraged in the recommendations, we observed farmers consuming food, touching their eyes, faces, bodies and clothes while working in the farms without first washing their hands. Nine farmers had separate footwear for the shed, and ten farms had functioning sprayers (S3 Table). Footbaths were not observed in use. No one changed their clothes or used gloves or masks while working in the shed. Five farmers reported sleeping inside the shed to protect chickens from rodents and foxes.

Farmers' Perception of Avian Influenza and Biosecurity

Source of Information—Farmers most frequently mentioned other farmers and the local vendors of chicks, feed and medicines, as sources of information and reported following the instructions of the vendors for farming and caring for sick poultry. Farmers usually paid the vendors in cash for chicks but received medicines and feed on credit, which they repaid after selling the chickens or eggs. Veterinary practitioners employed by hatchery, feed or medicine companies provided free consultancy by phone. Most (11/16) of the farmers had never received formal training in biosecurity. Two training sessions on avian influenza took place during our data collection; one was facilitated by the government and another by an NGO.

Local vendors commonly received their information from veterinary practitioners from feed, chick or medicine companies. At one site, three farmers and most (3/4) vendors stated a

government veterinarian provided private consultations outside office hours and visited the farms for a fee. Farmers' perceptions and practices related to farming and biosecurity reflected the perceptions of their sources of information (Figure 2).

Perception of Poultry Disease and Avian Influenza—Farmers considered Newcastle and infectious bursal diseases the most dangerous diseases, since chickens did not survive, and considered cold both a disease and a cause of disease (Figure 2). Farmers mentioned drowsiness, lime-like or liquid defecation, loss of appetite, difficulty breathing, runny nose, swollen head, shaking head and ruffled feathers as signs of cold. Most (15/16) of the farmers reported hearing about 'bird flu.' A Tangail broiler farmer mentioned that bird flu only affected large farms and not in small farms raising less than 2000 chickens. There were no large farms nearby. Nine farmers did not believe that bird flu could be transmitted to humans. Farmers who experienced culling and the vendors who was their source of information were skeptical whether the cause of infection in their farms was bird flu; they thought it might be Newcastle disease.

Perception of Biosecurity—Four (4/16) farmers who spontaneously mentioned bird flu also mentioned knowing the term 'biosecurity' and related it to bird flu. Two of these four farmers received biosecurity training by the government and an NGO after culling their flocks. These two farmers equated 'biosecurity' and 'bird flu prevention' with fencing, which matched with the responses of the local vendor, who was their source of information (Figure 2). The other two farmers received training from an NGO and provided a more detailed definition of biosecurity.

All farmers mentioned a number of measures used to raise plump chickens and protect them from disease and harmful gas (mainly ammonia) such as using antibiotics, nutrition supplements, anti-protozoa medications, vaccines, using a footbath before entering the shed, and maintaining rest days between batches. These measure partially or fully matched standard biosecurity measures. Vaccination for Newcastle, infectious bursal diseases, cholera and fowlpox were most frequently (14/16) mentioned. To prevent cold, which broiler farmers considered a trigger for weight loss and other diseases, broiler farmers moved the dry litter in a sweeping motion 1–3 times daily with their feet or a sickle to release gas and keep the litter dry.

Six vendors reported knowing the English term 'biosecurity' and most frequently mentioned restricting birds, animals and humans from entering the shed as measures. Some farmers, like their sources of information, emphasized spraying, while some others related biosecurity with 'gas management' (Figure 2).

Constraints, Motivation and Alternatives to the Standard Biosecurity Measures

Farmers mentioned constraints to implementing many biosecurity measures (Table 5) and reported practicing alternatives to some of the recommended biosecurity measures, such as using cheaper net instead of bamboo fencing, separate sandals instead of gumboots and sprayers for disinfection instead of footbaths. Their motivation was mostly related to reducing mortality and raising healthy chickens as opposed to preventing 'bird flu.'

The team did not find any noticeable difference in biosecurity practices between the two farmers who experienced culling and those who did not. However, the two farmers who experienced culling were more aware about ‘bird flu’ and biosecurity measures than most other farmers following their exposure to an outbreak and training.

DISCUSSION

The practices and infrastructure observed in the farms were inconsistent with the three principle elements of biosecurity. Farmers’ perception of biosecurity, transmission and prevention of avian influenza were also inconsistent with standard definitions. However, farmers’ practices and perceptions were consistent with recommendations and perceptions of local vendors. Financial constraints and inconvenience were major reasons for not complying with certain biosecurity measures.

Segregation is considered to be the most effective element of biosecurity (FAO 2008) but was not observed in the farms we studied. The proximity of poultry sheds to humans, roads or water bodies, and the movement of objects, people and other animals in and out of the sheds, allowing vehicles inside the gate, has been identified as a risk factors for H5N1 outbreaks (Alhaji and Odetokun 2011; Ahmed et al. 2012; Gilbert and Pfeiffer 2012; Osmani et al. 2014). Rodents may also be important vectors, as they can act as both reservoirs and carriers of pathogens (Meerburg et al. 2006) from chicken feces or carcasses. Movement of service providers, particularly in layer farms, could increase opportunities for exposure of the flock to HPAI, since they visit several farms daily.

Cleaning is the second most effective element of biosecurity followed by disinfection (FAO 2008). Farmers’ cleaning and disinfection practices were tailored to their convenience and were inconsistent with the government recommendations (Department of Livestock Services 2010). Farmers’ hygiene behaviors placed them and their families at risk of transmission of HPAI, campylobacter and other diseases (Sarkar et al. 2014). Improper management of litter, as observed in the study farms, can be particularly risky, since avian influenza viruses remain infectious in fecal materials for over seven days at 20°C (Webster et al. 1978). Farmers sold feces as fish feed, which served as a means of disposal and supplemented their income. However, using untreated feces as fish feed is discouraged (WHO 2006); it may contribute to the spread of avian influenza among ducks, other wild birds and humans sharing the same water bodies.

Cost and inconvenience are major constraints to practicing recommended biosecurity measures. Poultry farming was the main source of household income for most of these farmers. They maintain larger flocks compared to backyard raisers, for whom poultry raising is mainly a source of nutrition and cash in-hand for household women (Sultana et al. 2012a; Shanta et al. 2016). Small commercial farmers used measures that had an added cost to keep their poultry healthy and profitable, such as using disinfectants, rodenticides and aeration of feces. Damp litter causes emission of odorous gases, particularly ammonia, which is harmful for both poultry and human health and is one of the most important factors affecting broiler production (Ritz et al. 2004).

Farmers' practices and perceptions of measures to protect poultry show that they valued the information gained from local vendors. This reflects the 'source credibility' of the vendors over the government veterinarians and trainings that were focused on avian influenza. Other studies also reported feed vendors and the agriculture demonstrator, who spent a long time with the farmers, as credible sources of information in farming (Kakade 2013; Tikwe et al. 2015). Suppliers, hatcheries, feed and medicine companies also have an interest in supporting the poultry businesses run by these farmers. Leveraging these stakeholders' interest in a systematic way may be useful to increase awareness among these farmers and motivate them to follow stricter biosecurity.

Biosecurity conditions in these small commercial farms in Bangladesh were similar to those reported from other countries, suggesting that these practices, which increase the risk of a global influenza pandemic, are common in this sector. Small commercial farms in Egypt were often accessible to birds and rodents; workers practiced unsafe carcass disposal and inadequate personal hygiene (Negro-Calduch et al. 2013), but always applied vaccines for Newcastle disease and infectious bursal disease and did not allow collectors to enter the shed (Pagani and Kilany 2007), as found in our study farms. Like our study farms, Kenyan farms had similar poultry housing structures in close proximity to the dwellings and workers had poor personal hygiene (Nyaga 2007).

We conducted this study in only 16 farms; hence, the findings may not be generalizable to the 52,387 registered (Department of Livestock Services 2012) and likely even more numerous unregistered small commercial farms of the country. However, the high-risk practices we observed are similar to the findings of a nationwide supply chain analysis of poultry, which reported biosecurity practices of broiler and layer farms (Yunus et al. 2008), and another study reporting proximity to other farms and roads, rearing system, entry restrictions, use of disinfection, footwear and rodent control in 40 broiler farms (Rahman et al. 2010). These studies presented a quantitative assessment of knowledge and practices related to biosecurity. Our study provides an in-depth understanding of farmers' practices and perceptions of biosecurity, their reasoning behind their practices, constraints and motivation to practicing biosecurity, and the information flow from the sources to the farmers that influenced farmers' practices. These data could be useful for revising biosecurity recommendations and selecting communication channels for these farmers. These data can also give direction to what needs to be explored in similar settings in other countries in order to develop feasible recommendations and communication channels that might work.

While we seldom observed flock segregation, hand-washing, or the use of personal protective equipment, some farmers used several measures that involved additional cost or effort. Responses of the farmers reflect that despite higher awareness of avian influenza than backyard raisers (Sultana et al. 2012b), small commercial farmers also perceived bird flu as a disease that occurred in distant places and would not affect them or their farms. This might result from failure to identify the avian influenza through observation (Rimi et al. 2016), since most signs of avian influenza are similar to those of Newcastle disease (Nidzworski et al. 2013). These farmers were more concerned about diseases they perceived as more common in their flocks than HPAI and presented more salient threats to their profitability.

These findings suggest that small commercial farmers could be motivated to maintain biosecurity with interventions that protect their investment and maintain profitability by keeping their flock safe from diseases they consider harmful through the involvement of local vendors they value. A study in Egypt showed that the benefit–cost ratio for implementing biosecurity measures was 8.45 against HPAI and 4.88 against Newcastle disease for household poultry (Fasina et al. 2012). Although the government recommended different biosecurity measures for different commercial poultry sectors, the recommendations mostly included general measures for all farm sizes (Department of Livestock Services 2010), which may not be practical for small farms. Biosecurity recommendations could be tailored to account for socioeconomic realities of small commercial farmers (FAO 2008). Future interventions could explore the potential feasibility and effectiveness of low-cost alternatives to recommended biosecurity measures.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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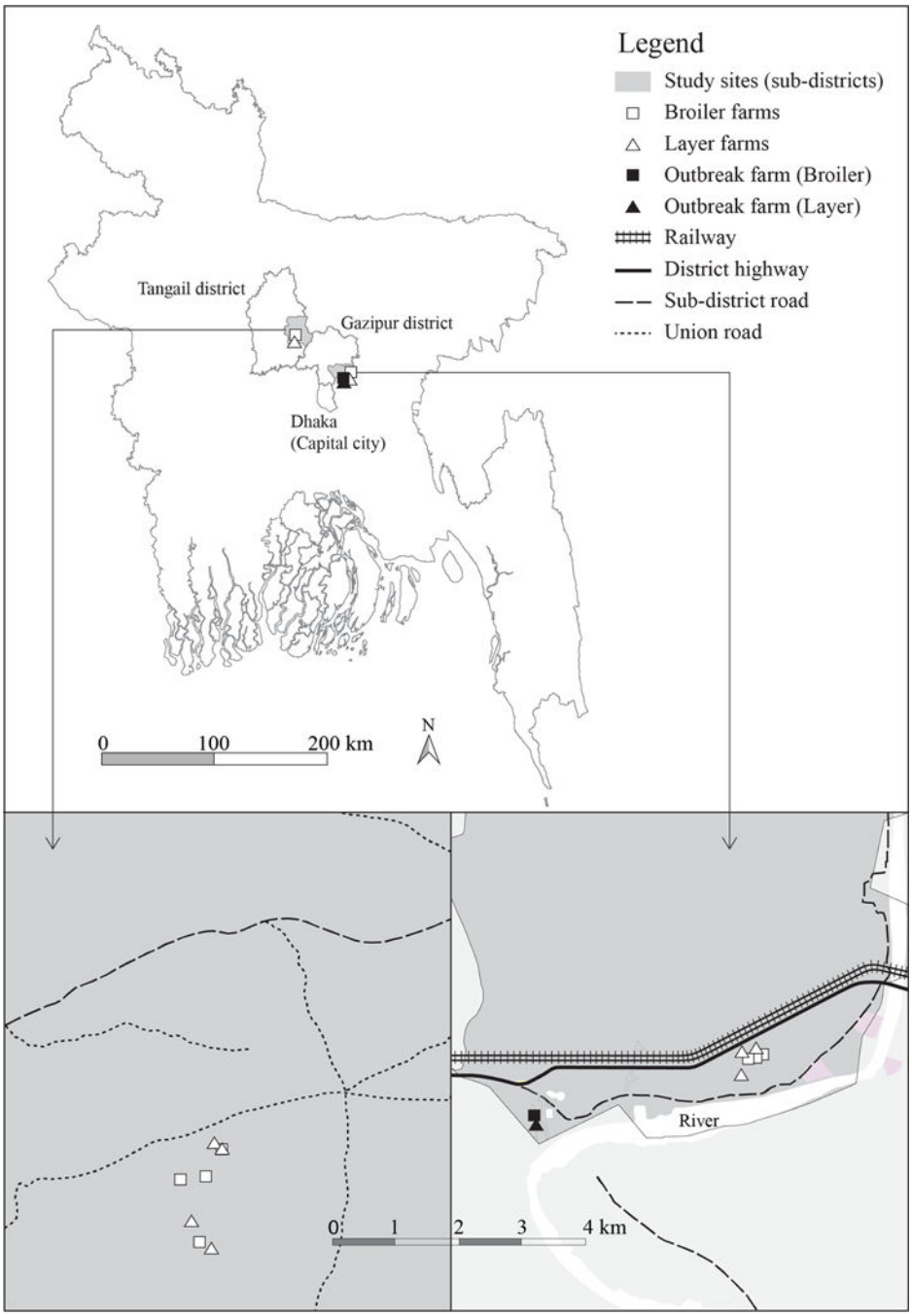

Figure 1.
Location of study farms in Gazipur and Tangail study sites, 2011–2012.

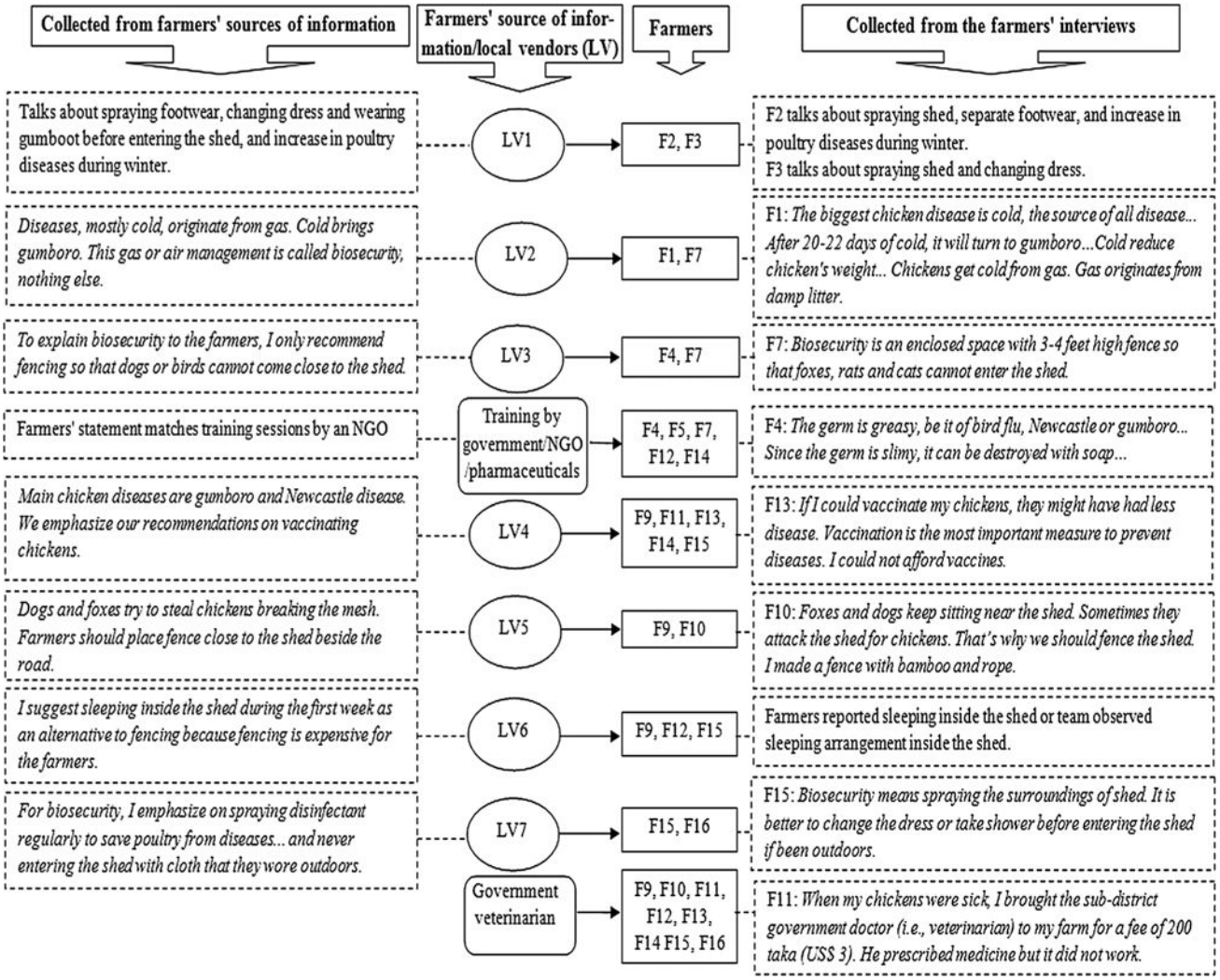

Figure 2.
Sources of information of the farmers of Gazipur and Tangail study sites, 2011–2012.

Table 1

Data Collection Tools Used in the Study in Gazipur and Tangail Study Sites, 2011–2012.

Data collection tools	Issues explored	Number/hours		
		Gazipur	Tangail	Total
Spot observation	The presence and condition of fences, mesh, door, footbath, designated footwear, disinfectant and personal protective equipment, waste disposal site, the presence of rodents, other poultry, bird or animals	8	8	16
Mapping	Layout of the chicken shed, location of the farm, distances to nearest household, commercial poultry farm, large tree hosting wild birds, live bird market, backyard poultry shed, street transporting vehicles, and water body	8	8	16
Observation	Movement of people, birds, other poultry and animals in and out of the shed, cleaning of shed, cleaning of equipment, personal hygiene, use of disinfectants, waste management, vacination and debeaking practices	31 h	26 h	57 h
In-depth interview with farmer	Self-reported practices related to biosecurity, i.e., daily measures followed to protect chickens from disease, perception of poultry disease, avian influenza and biosecurity	8	8	16
In-depth interview with local vendors of chicks, feed or medicine	Perception of poultry disease, avian influenza and biosecurity	7		7
Group discussion with farmers	Constraints to and motivation for implementing and maintaining biosecurity measures, feasible alternatives	1	1	2

Table 2

Location and Layout of the Study Farms, Gazipur and Tangail Study Sites, 2011–2012.

Farm location	**Recommended (m)**[a]	**Broiler farms *n* = 8**		**Layer farms *n* = 8**		**Total *n* = 16**	
Distance of farm from nearest (m)		Median	Inter-quartile range	Median	Inter-quartile range	Median	Inter-quartile range
Household	500	9	20–2	5	34–1	7	26–2
Commercial poultry farm	200	14	56–7	54	157–18	30.5	99–7
Large trees hosting wild birds	100	0	0	0	0	0	0
Live bird market	1000	1029	2650–287	1100	2500–324	1100	2600–287
Backyard poultry shed	200	5	19–3	10	50–3	5	19–3
Street transporting vehicles	500[b]	14	48–7	12	41–1	14	41–1
Farms oriented along east–west (recommended)			7		3		10
Farms with no water body within 200 m (recommended)			4		4		8

[a] *Source*: Department of Livestock Services, Government of Bangladesh; Biosecurity guideline for the commercial poultry industry in Bangladesh 2010.

[b] *Source*: Minutes from the workshop entitled ‘Using Public-Private Sector Partnership to Develop Bio-Security Guidelines for the Poultry Industry in Bangladesh’ held in Tangail, Bangladesh in October 2009 to develop the ‘Biosecurity guideline for the commercial poultry industry in Bangladesh.’

Table 3

Observed Characteristics of the Study Farms Related to Restricting Entry of People, Animals, Birds and Rodents into Sheds, Gazipur and Tangail Study Sites, 2011–2012.

Government recommendations	Characteristics of the study farms	Broiler farms *n* = 8	Layer farms *n* = 8	Total *n* = 16 (%)
Fencing[a]				
Farm must be surround by a 2-m high-protective fence	No fence	6	5	11 (69)
	Broken fence or fence in one/two sides of shed exposed to the road or walkways	2	2	4 (25)
Mesh of the shed[a]				
All sheds must have bird proof nettings	Broken mesh	4	3	7 (44)
	Gap (0.2–0.6 m) between the eaves of the roof and mesh	6	5	11 (69)
	26 cm^2 opening in the mesh	5	6	11 (69)
The presence of animals within the farm premise[a]				
Pet dogs and cats are not allowed on farm or to enter sheds	Stray dogs	6	6	12 (75)
Other farm animals like cattle,	Stray cat	3	1	4 (25)
goats are not allowed on farm and within 30 m of poultry sheds	Cattle/goat	6	4	10 (62)
Other birds in the household/farm premise[a]				
Birds of different species (chickens and ducks) are not allowed on the same farm	Backyard poultry roam around or enter the shed	5	2	7 (44)
	Backyard chicken raised	5	6	11 (69)
	Backyard duck raised	3	1	4 (25)
Pet birds (parrots/pigeons) are not allowed on farm or to enter sheds	Pigeon raised	1	2	3 (19)
	Broiler and layer chickens raised in different sheds of the same farm	0	2	2 (12)
Screening in the eaves of poultry houses must be checked weekly and repaired to prevent wild birds	Wild birds (starlings and sparrows) entered the shed through gaps/breakages in mesh	0	2	2 (12)
Farm must have wild birds control plan	Wild birds (starlings and sparrows) entered the shed through 26 cm^2 openings in mesh	0	3	3 (19)
Entrance of the shed				
All sheds on farm must be locked at all times	Always locked	1	3	4 (25)
	Sometimes locked	1	1	2 (12)
	Wide open while working	6	4	10 (62)
Measures to prevent rodents[a]				
Farm must have a rodent control plan	Rodenticide	1	1	2 (12)
Bait boxes and traps must be regularly checked to be sure that the bait is fresh and dead rodents removed	Electric wire	1	1	2 (12)
	Trap	2	0	2 (12)
	Elevating boundary of floor with brick	0	1	1 (6)
Human access to the shed				

Government recommendations	Characteristics of the study farms	Broiler farms *n* = 8	Layer farms *n* = 8	Total *n* = 16 (%)
No visitors are permitted on the premises except authorized personnel		156	259	415
	Farmers	54	91	145
	Family members (adult)	25	84	109
Farm manager and employees never visit other farms	Litter buyers	25	44	69
	Children	26	16	42
	Chicken/egg buyers	15	3	18
	Visitors (adult)	6	11	17
	Other farmers	5	6	11
	Vaccinator/debeaker	0	4	4

[a]Frequency includes multiple observations

Table 4

Observed Practices Related to Personal Hygiene, Gazipur and Tangail Study Sites, 2011–2012.

Practices related to hygiene	Farmer	Family member/children	Chicken/egg/litter buyer/debeaker/vaccinator	Visitor/other farmer	Total (%)
Government recommendations	*Recommendations by the local vendors to the farmers*				
All employees must wash and change footwear before entering farm or poultry houses	Use footwear to protect feet				
Street shoes must never be worn in the poultry houses	Use separate footwear and gloves				
Separate pair of boots or sandals must be used for each house and/or brooder and finisher unit	Wash and spray disinfectant on feet before entering shed after coming from outside				
Boots/sandals must be cleaned and disinfected before and after use	Spray disinfectant on feet before entering the shed				
Hands must be cleaned and disinfected (disinfectant cream/soap can be used) often and when moving be- tween units	Spray service provider before letting in the shed				
All visitors who wish to enter poultry houses must wear clean and sanitized gloves and footwear	Wash hands and feet with potash water or disinfectant before entering the shed				
Treatment to feet/footwear or use of footwear before entering the shed	*145*	*151*	*91*	*28*	*415 (100)*
Practices when disinfectant was used					
Entered shed with bare feet after spraying disinfectant on feet	0	1	0	0	1 (0.2)
Entered shed with regular sandals after spraying disinfectant on the sandal	5	3	1	0	9 (2)
Practices when disinfectant was not used					
Entered shed with bare feet	77	67	22	6	172 (41)
Entered shed with bare feet after rinsing feet with water	1	3	0	0	4 (1)
Entered shed with regular sandals	48	73	68	18	207 (50)
Used designated sandals inside the shed without disinfecting feet	8	2	0	1	11 (3)
Used designated sandals inside the shed after rinsing feet with water	3	1	0	0	4 (1)
Entered the shed wearing gumboots without disinfecting feet	1	0	0	0	1 (0.2)
Entered broiler and layer sheds bare feet/with same sandals without disinfecting before or between sheds	2	1	0	3	6 (1)
Treatment to hands before entering the shed	*145*	*151*	*91*	*28*	*415 (100)*
Practices when disinfectant was used					
Sprayed disinfectant in hands	1	0	0	0	1 (0.2)
Practices when disinfectant was not used					
Entered the shed without washing/disinfecting hands	136	149	91	25	401 (97)
Rinsed hands with water	4	2	0	0	6 (1)

Practices related to hygiene	Farmer	Family member/children	Chicken/egg/litter buyer/debeaker/vaccinator	Visitor/other farmer	Total (%)
Washed hands with soap water	2	0	0	0	2 (0.5)
Worked between broiler and layer sheds without washing/disinfecting hands	2	0	0	3	5 (1)
Treatment to feet/footwear or use of footwear after finishing working in the shed	*43*	*43*	*24*	*10*	*120 (100)*
Did not wash or disinfect feet/footwear	26	36	17	10	89 (74)
Rinsed feet with water	14	5	7	0	26 (22)
Washed feet with soap/potash-mixed water	3	0	0	0	3 (2)
Took bath	0	2	0	0	2 (2)
Treatment to hands after finishing working in the shed	*43*	*43*	*24*	*10*	*120 (100)*
Did not wash or disinfect hands	28	33	17	10	88 (73)
Rinsed hands with water	9	7	5	0	21 (17)
Washed hands with soap/potash-mixed water	6	1	2	0	9 (7)
Took bath	0	2	0	0	2 (2)
Contact with food/own body without washing or disinfecting hands during/after working in farm	*23*	*14*	*14*	*2*	*53 (100)*
Ate betel leaf/fruit/snack or smoked without washing hands after touching chicken/eggs	5	2	9	0	16 (30)
Ate betel leaf/rice/snack after rinsing hands with water after working in the shed	2	0	1	0	3 (6)
Drank water from the hose that was dropped on the floor of the shed during litter cleaning	0	1	0	0	1 (2)
Opened the cap of the vaccine container with teeth	0	1	0	0	1 (2)
Breastfed/touched the child or prepared milk or started cooking in the feeder during/after egg/litter cleaning	4	0	0	0	4 (8)
Rubbed eye during/after touching chicken/litter	1	6	0	0	7 (13)
Touched own face/body/cloth during/after vaccinating or touching egg/litter	9	3	4	2	18 (34)
Counted money with saliva from mouth after touching eggs	2	0	0	0	2 (4)
Put hand inside the mouth after playing with a sick chicken	0	1	0	0	1 (2)

Table 5

Constraints to Government Recommended Measures Reported by Gazipur and Tangail Farmers, 2011–2012.

Recommended measures	Constraints
Measures that farmers linked with financial constraints or benefit	
Restrict other birds from entering the shed	Covering whole shed with mesh is expensive Not important for broiler, since it is a short-term endeavor lasting around a month Not possible for broiler chicken, since the broiler farmers prefer cheaper available mesh, which is shorter in length than that of the layer sheds
Fence around the shed to restrict backyard poultry, dog and cat	Do not have bamboo Termites damage bamboo fence/bamboo fence is not durable Wire mesh is expensive Not feasible for densely populated locations Lack of space Involves investing large amount of money every year Not feasible for broiler, since it is a short-term endeavor lasting around a month
Spray supplies/equipment before taking inside the shed	Feed gets damp if sack is sprayed as not all feed sacks are laminated
Bury feces under soil or use after disinfecting	Earn money by selling to the litter buyers Do not have enough space Do not know how to disinfect Time-consuming Treating litter/making biogas is expensive
Do not share equipment with other farms	Borrowing feed from known person will not be harmful Save money by sharing feed/equipment
Isolate sick chickens	Do not have enough space to separate sick chickens
Build farm in open place or along east–west to ensure free flow of air	Lack of space
Burn chick box and waste paper	Earn money by selling
Measures that farmers considered inconvenient	
Lock the entrance of the farm	Need to keep door open while working as feed/other materials is kept outside the shed
Keep footbath at the entrance of the shed	Difficult to use in winter Fox/dog defecate in footbath if kept outside the shed Breeding place for mosquito Attracts fly and dust/dirt
Restrict other family members from entering the shed	Conducting farm activities alone is not possible Family members carry out caring activities in the absence of the farmers
Keep vehicle transporting egg/feed/chick away from the shed	It is difficult to carry heavy feed sack from a distance
Bury dead chickens as early as possible	Feed fox and dog, as they have right to eat Difficult when many chickens die together Time-consuming/not feasible while busy working hours Do not dispose carcass immediately while working in the shed, since they do not want to use same hand to give feed to chickens