CHAPTER 14

Biosecurity Strategies for Backyard Poultry: A Controlled Way for Safe Food Production

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1 Introduction

1.1 Backyard Poultry

The Food and Agricultural Organization of the United Nations (FAO) classified poultry production system into four sectors based on the level of biosecurity and marketing of birds and their products (FAO, 2004). Apart from commercial poultry maintained in integrated farming systems with moderate to high levels of biosecurity (sector 1–3), there is a "backyard" or "village level" poultry sector with minimal biosecurity (sector 4). In this backyard sector, native birds or locally available breeds are maintained, and the birds or their products are mostly consumed locally. The concept of backyard farming is as old as civilization. Many families in the villages of the rural world keep a small chicken flock of various ages. The majority of these birds are kept in free-range systems, in which the birds scavenge around the house or in the backyard during daytime. The term *backyard farming* is originated from it. A primitive type of poultry house is offered to the birds during night. The feed consists of household wastes or kitchen scraps like raw vegetables, cooked rice, insects, larvae, seeds, and so on (Samanta et al., 2016).

The World Organisation for Animal Health (OIE) considered the backyard system as the most familiar system of poultry rearing throughout the world because the system is highly adaptable to local climate, and it requires less capital and other inputs to establish (FAO, 2008a). In the economy of developing countries this kind of poultry plays a major role by means of income generation and household food security. It is an important component of small farmers' livelihoods and a tool for poverty alleviation (Sambo et al., 2015). It can provide meat and eggs throughout the year and ready cash in times of hardship or emergency, which may make the difference between life and death. The ready cash is also used for school expenditure, daily household need, buying of other domestic animals, etc. (FAO, 2008a).

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The supply of eggs and meat can be maintained by backyard farming to meet the rising demand. Sometimes the products are consumed by the owners or used as gifts to the friends and relatives during festival and as sacrificial offer to traditional deity (Hamilton-West et al., 2012). In Bhutan, backyard products also act as a source of protein for the female members of the household during pregnancy and postparturition period (Tashi and Dorji, 2014). Backyard chicken eggs are popular among urban and educated consumers due to their higher nutritional quality. These eggs contain higher concentration of vitamins, omega-3 fatty acids, and β-carotene (Long and Alterman, 2007). The backyard farming reduces environmental pollution by the conversion of kitchen scraps into proteins (meat and eggs), and the use of chicken manure as garden fertilizer. Moreover, production of meats and eggs locally reduces the transport of the items from distant places and thus reduces carbon emission (Fukumoto, 2009).

Besides rural backyard farming, in the urban area of developed countries, also, there is a growing trend for keeping chickens in backyards. This rearing system is known as "hobby/peridomestic/fancy poultry" or "urban backyard farming." In urban backyard farming, the birds are primarily kept for a homemade source of food, for fun, or as a hobby or companion pet to improve psychological health of the owners. This last purpose is usually a family tradition, exposing children to the food production process and general affection for birds, and functioning as insect control (USDA, 2004). This kind of farming is not associated with economical benefit because their rearing costs are often higher than the production (Pollock et al., 2012). In urban United States, keeping backyard poultry flocks have been steadily increasing in popularity. The study in the United States detected that 31.5% of urban and 30.1% of suburban residents prefer to keep backyard poultry (Elkhorabi et al., 2014). Even a number of cities in the United States, such as Columbia, Missouri, Ann Arbor, Michigan, Denver, Colorado, and Auburn, Alabama have passed regulations allowing chickens to be kept at residences (Bartling, 2010). The trend of keeping urban backyard poultry is also detected in the greater London area in the United Kingdom (Karabozhilova et al., 2012), Canada (Burns et al., 2011), and New Zealand (Lockhart et al., 2010). In British Columbia (Canada), an authorized person may keep up to 400 egg-producing hens and may produce up to 3000 kg of chicken meat per year (British Columbia Farm Review Board, 2009).

1.2 Contribution of Backyard Farming in Rural Economy

Backyard poultry farming is considered as an integral part of livelihood for many rural families throughout the world. In Ethiopia (Africa), chicken constitutes the largest share among the farm animal species (Mammo et al., 2008) and 99% of the chicken population is maintained under a scavenging system (Yemane et al., 2013). Similarly, in Asian countries, such as in Vietnam, Thailand, and Bangladesh, 90% of rural households rear poultry in their backyard and it makes a contribution to the monthly income of rural families and to the national economy (Chakma, 2008; Chantong and Kaneene, 2011; Edmunds et al., 2013).

In India, the majority of families (44%–67%) in West Bengal, Tripura, and Assam practiced backyard poultry production (NSSO, 2006). In Pakistan, after textiles, the poultry industry is the biggest commercial sector in the country and it contributes considerably to the national economy. Pakistan also maintains a large backyard poultry sector and it is observed that every rural family and every fifth urban family breed poultry at home (Sadiq, 2004).

In developing countries, this kind of farming system also offers women empowerment, because women directly control the farming and the income generated from the sale of chickens and chicken products. Studies in Ethiopia and other African countries showed that this is the only source of independent income for women due to scarcity of resources (Wilson, 2010). In rural Bangladesh, poultry rearing is an occupation of 50% of women (Sultana et al., 2012a). No literature is currently available regarding the economic importance of this means women empowerment through backyard farming. In developed country, such as in Chile, 14%–18% of the studied farms were maintained by men alone or jointly with women (Hamilton-West et al., 2012).

In Bangladesh, 67% of the total egg production is contributed by backyard sector with an annual egg production of 4.4 billion from this sector itself (Dolberg, 2008). In India, this rural poultry sector contributes 23% of the total national egg production (Ngullie and Sharma, 2012) and the income per bird per annum ranges between US$ 0.6–2.3 (Indian rupees 4–13 per bird/month) (Ahuja et al., 2008). This contribution is considerably low for a rural livelihood, but it can be increased by expanding the egg production level. The major constraint in increasing the egg production in backyard birds is microbial infection due to lack of biosecurity practices followed by the farmers (Conan et al., 2012). Similarly, in developed countries, such as Chile, the farmers mostly sell their products to their neighbors during any occasion or to the tourists who occasionally visit the farms (Hamilton-West et al., 2012). Thus, the income is not sustainable and considerably low.

1.3 Species and Breeds Kept in Backyard Farming

Chicken (*Gallus* sp.) is the most common species kept in backyard farming throughout the world. For example, the majority of the backyard farmers in Chile, New Zealand (North Island) and Egypt prefer to rear domestic chicken (Abdelwhab and Hafez, 2011; Hamilton-West et al., 2012; Zheng et al., 2010). In Ethiopia, however, cattle are the most common species reared by backyard farmers, which is followed by chickens (Sambo et al., 2015).

Other species of birds, such as turkeys (*Meleagris gallopavo*), geese (*Aseranser*), ducks (*Anas* sp.), Muscovy ducks (*Cairina* sp.), quail (*Coturnix* sp.), pigeons (*Columbidae* sp.), and guinea fowl (*Numididae* sp.) are also reared in some countries and sometimes housed together. Ducks are the second predominant species after chicken kept by backyard farming in Southeast Asian countries (e.g., Thailand). In Thailand, ducks are raised on rice fields after the harvest to feed on leftover rice grains. The ducks are moved by truck or other vehicle from one rice field to another during the postharvest season (5–6 months out of the year) (Gilbert et al., 2007). The ducks are also reared on ponds or channels with or without fish/pig farming on the same site. Rearing pigs in an enclosure within the backyard farm was also observed in New Zealand (Zheng et al., 2010). In some countries (e.g., India), fighting cocks are reared for income generation in places where cock fighting is a traditional recreation among villagers. Cockerels (male chickens less than 1 year of age) are reared for cultural and religious purposes in some places (FAO, 2008a). A small number of people (e.g., 3% of studied population in Chile and some people of Thailand) prefer to keep wild birds, such as austral thrush (*Turdus falcklandii*), shiny cowbird (*Molothrus bonariensis*), austral blackbird (*Curaeus curaeus*) and common diuca finch (*Diuca diuca*), and ostrich (*Struthio camelus*) as backyard pets (Gilbert et al., 2007; Hamilton-West et al., 2012).

Selection of livestock or poultry breeds is an age-old practice that depends on the folk traditions, needs, agroclimatic zone of the country, and availability of the breeds (Banerjee et al., 2014). Among the domestic chicken breeds, indigenous or native or nondescript breeds are preferred for backyard farming due to easy availability, higher adaptability to the local environment, resistance to some diseases, good egg and meat flavor, hard eggshell, high fertility and hatchability, and high dressing percentage (Abdelqader et al., 2007). In West Bengal (India), common indigenous breeds that are maintained in backyard farming are native feathered chickens (*Desi*), naked neck chickens (*Galakata murgi*), frizzled fowls (*Sojaru murgi*), muffed/bearded fowl (*Dariwala murgi*), creeper chickens (*Bete murgi*), crested fowls (*Khopa murgi*), rumpless fowl (*Bocha murgi*), and feathered shank fowl (Aseel, Haringhata Black/Black Haringhata) (Figs. 14.1 and 14.2) (Banerjee, 2012; Samanta et al., 2016).

Similarly in Bangladesh, indigenous or nondescript breeds of chickens are the preferable choice for rearing. Sometimes, the farmers keep Fayoumiand Sonali (cross-breed of Rhode Island Red and Fayoumi) chickens in a semiscavenging system (Biswas et al., 2009). In Bhutan, native breeds, such as Seim (SM), Phulom (PL), Yuebjha Narp (YN), and Khuilay (KL) are ideal breeds for backyard farming (Tashi and Dorji, 2014). The most common backyard chicken breeds in Thailand are native and mixed breed chickens (e.g., three-blood-breed). Three types of duck breeds are reared in Thailand—namely, egg-laying ducks (Khaki Campbell), crossbreed of khaki Campbell and native laying ducks, and a small number of meat type ducks (Pekin, White Cherry Valley) (Gilbert et al., 2007). In Sudan and Ethiopia (Africa), large Beladi (LB), bare neck (BN), Betwil (BT) dwarf, naked neck, and Gasgie and Gugut breeds of chickens are kept in backyard farms (Getu et al., 2014; Wani et al., 2014).

Some temperate/artificial breeds of poultry were introduced in tropical countries, such as in India and Ethiopia for better production and up gradation of native breeds, which altered the traditional husbandry systems. In India and Ethiopia, the Rhode Island Red (RIR) breed was introduced through government-sponsored developmental schemes, such as

Figure 14.1: Aseel Chicken of West Bengal, India.
Courtesy: Dr. Swarup Singh, Veterinarian.

Figure 14.2: Naked-Neck Chicken of West Bengal, India.
Courtesy: Dr. Swarup Singh, Veterinarian.

Figure 14.3: Kuroiler Chicken of West Bengal, India.
Courtesy: Dr. Pratik Ghosh, Veterinarian.

Rastriyo Krishi Vikas Yojana (RKVY), a self-help group developmental program in India and poultry extension package in Ethiopia (Dinka et al., 2010; Samanta et al., 2016). The better egg production (150 eggs per bird/annum) of RIR chicken than the native breeds (80–90 eggs/bird/annum) was observed in West Bengal (India) when the birds were provided with supplemented feed along with scavenging (Das et al., 2014). In Ethiopia, RIR breeds of chicken showed poor tolerance to the local climate. Moreover, supply of RIR hen's eggs, pullets, and cocks in the localities reduced the brooding capacity of the native breeds and their adaptation to the local feeding system (Dinka et al., 2010). Moreover, a synthetic breed (Kuroiler) developed by a private organization was introduced in India for backyard rearing. Kuroiler is a dual type bird having higher production capacity than the indigenous (*desi*) chickens with some features of native birds, such as feather color and alertness (Fig. 14.3) (Ahuja et al., 2008).

In urban backyard farming, chickens are the most preferred species in the United States. Layer breeds of chickens producing colored eggs, such as RIR, Plymouth Rock, Ameraucana, Orpington, and Wyandotte are preferred (Elkhorabi et al., 2014), although in Minnesota (USA), meat-type chickens are also reared (Yendell et al., 2012). Other birds, such as turkeys, ducks, pigeons, doves, game birds, and guinea fowl are also reared (Beam et al., 2013). In some countries, raptors (hunting birds) are reared in the backyard (FAO, 2008b).

1.4 Management Practices in Rural Backyard Farming

The management practices for keeping backyard birds vary between the countries throughout the world. In Chile, the birds are kept in three types of systems—namely, permanent confinement, free-range, and a mixed confinement. In mixed confinement, the birds scavenge freely in the courtyard of the farmer's house during daytime, and at night they are kept in an indigenous pen. Among these three systems, the mixed confinement is the most common one (Hamilton-West et al., 2012). The indigenous pens are mostly made of bamboo with or without an asbestos shade in Asian countries (Samanta et al., 2016). In Thailand and Sudan, at night the birds are kept under a bamboo basket also (Chantong and Kaneene, 2011; Wani et al., 2014). On the North Island of New Zealand, most of the farms (68%) allow free movement of chickens and ducks in nearby pastures, including access to waterways, such as ponds, streams, rivers, and drains (Zheng et al., 2010). In Bangladesh, most of the farmers (55%) keep the birds within their houses, and others keep them in a coop in the front yard. The coop is made of soil or wood and it has a tin shade (Alam et al., 2014; Sultana et al., 2012a). The majority of the farmers prefer to keep the birds on a wooden perch constructed inside their own houses in Ethiopia (Yemane et al., 2013). Resting of the birds on treetops at night was observed in South Pacific island countries (Ajuyah, 1999). Development of brick houses for the poultry is rarely observed (4%) in India (West Bengal) (Banerjee, 2012). During crisis periods, such as flooding the farmers keep the chickens in a cage and hang the cage inside the room as observed in Bangladesh (Sultana et al., 2012a).

The average flock size of the birds in rural backyard farming is variable. In Ethiopia and Sudan, the average flock size per household was 8.5 and 16.7, respectively (Wani et al., 2014; Yemane et al., 2013). In another study in Ethiopia, a lower average flock size (4.1) was detected (Sambo et al., 2015). In other countries, such as in Bangladesh and Belgium, the mean flock size of small holdings of poultry was observed to be less than 11 (Alam et al., 2014; Van Steenwinkel et al., 2011). In a study in some districts of West Bengal (India), such as Jalpaiguri, Dinajpur, West Medinipur, Howrah, and South 24 Parganas, the average flock size was observed as 20–25 (Samanta et al., 2014b).

Scavenging in yards, animal sheds, bushes, neighbouring houses and the nearest grain field is the major source of feed for the backyard birds. Mostly small worms, insects, snails, rice, fallen cereal brans, kitchen wastes, household vegetables, and green grasses are taken by the birds during the scavenging period and are considered as scavenging feed resource base (SFRB). In Asian countries, such as in India, Bangladesh, and Thailand, women also offer the supplementary feed and drinking water from local ponds to the birds once or twice in a day (Chantong and Kaneene, 2011; Sultana et al., 2012a; Samanta et al., 2016). In developed countries, such as in New Zealand (North island), however, the birds were mostly provided with drinking water collected from bore (40%), rivers, and streams (24%). Only a few people (4%) use ponds or dams as a source of drinking water for their birds (Zheng et al., 2010).

The birds are mostly bred within the flock to increase the flock size. The breeding activity of the birds is conducted by the women of the family, as observed in Ethiopia and Chile (Aklilu et al., 2008; Hamilton-West et al., 2012). In New Zealand, chickens were usually homebred (39%) (Zheng et al., 2010). In Bangladesh, the women of the family select a space within their bedroom or on the windowsill for the chickens to lay and brood eggs. However, ducks prefer to lay the eggs where they stay at night (Sultana et al., 2012a). The farmers utilize other sources of birds to introduce new birds in the existing flocks. Examples of other sources include neighbors, local markets, commercial farms, breeders, shows/auctions, and government supported developmental schemes. In Chile, 32% of the studied population used the other sources to purchase new birds (Hamilton-West et al., 2012). In New Zealand, 37% of the owners obtained the chickens privately, and a few people (11%) bought the chicken from local commercial dealers (Zheng et al., 2010). In Ethiopia, an average of 28.3 chickens were added to a flock annually (Yemane et al., 2013). During the introduction of new birds, no quarantine or other preventive measures to reduce the transmission of infections are followed.

1.5 Management Practices in Urban Backyard Farming

Urban backyard farming is a little different than the rural farming. Most of the persons keeping the birds have high income, higher education, and in the United States only 4% people were associated with agriculture. The flock size is almost the same as it is in rural backyard farming. In the United States, most of the people rear 1–5 birds (Elkhorabi et al., 2014). In New Zealand too, small flock size (median, 6; range, 1–33) was detected (Lockhart et al., 2010). However, higher flock size (12–800) was detected in Minnesota (USA) (Yendell et al., 2012). The age range of chickens in the flocks surveyed in the United States was 0–11 years with predominantly female chickens. Among the studied flocks, 68% of flocks had no rooster, 15% had 1, and 17% more than 1 rooster in a flock (Elkhorabi et al., 2014).

Most of the bird keepers in the United States prefer to keep the birds indoor in a shed/coop. Some of them (35%) provided enclosed run space along with the coop, 49% of them provided free-range during daytime and a small proportion of keepers (7%) preferred both of them (Elkhorabi et al., 2014; Yendell et al., 2012). Very few bird keepers used portable housing or cages for rearing the birds. In a US-based study, perches (93%) and nest boxes (99%) were mostly used as roosting and egg-laying space, respectively (Elkhorabi et al., 2014). Similarly, in New Zealand, the majority of the bird keepers rear the birds by free-range within the boundaries of the property during daytime (Lockhart et al., 2010). The women even with high educational background mostly take care of the birds like rural backyard farming.

In the United States, the birds (75%) mostly receive a mixed ration of feed (purchased and kitchen scraps). Although a small fraction of keepers (0.5%) did not offer any supplementary feed to the birds in expectation that the birds will collect their feeds from free range. Similarly, majority of the keepers (82%) provide fresh water to the birds and only 0.3% of the keepers allowed the birds to obtain the drinking water from natural sources. The bird keepers (50%) also used supplemental grit and calcium for their birds, especially for the laying hens (Elkhorabi et al., 2014). In New Zealand, the majority of the keepers use purchased feeds (Lockhart et al., 2010). In the European Union, countries feeding kitchen scraps (except raw vegetables from the garden) to the food-producing animals, including chickens kept as pets, is banned since 2001 to prevent the transmission of zoonotic infections. Access of poultry to the compost mass containing kitchen waste is also restricted (Whitehead and Roberts, 2014).

2 Diseases of Backyard Birds

2.1 Infectious Diseases

In developing countries, the backyard poultry sector mostly suffers from two infectious diseases, such as Avian influenza (AI) and Newcastle disease (ND) due to lack of biosecurity and proper vaccination (Alexander, 2001). Surveillance of infectious diseases (such as AI) in backyard and free-grazing poultry is challenging due to the reluctance of the farmers to report outbreaks (Kanamori and Jimba, 2007).

2.1.1 Avian influenza

Avian influenza virus (AIV) infection is reported from poultry and wild birds in Asia, Africa, and Europe (OIE, 2013). The transmission of zoonotic AIV has so far (January 2014) generated 650 human cases with 386 deaths (WHO, 2014.). Among different subtypes of AIV, H5 and H7 are considered as pathogenic and are frequently isolated from chicken, turkeys, quails, and pheasants (Suarez et al., 2003). Ducks and shorebirds mostly carry H3, H4, H6, H9, H11, and H13 sybtypes of AIV (Suarez and Schultz-Cherry, 2000). Genetic reassortment between Avian and swine influenza can occur and generate a new subtype. H2N3 is an example of a reassorted subtype that was detected in backyard birds and swine in Ohio (Killian, 2009). China, Indonesia, Vietnam, Bangladesh, India, and Egypt are considered as endemic countries for highly pathogenic Avian influenza (H5N1) infection in poultry. In addition, sporadic outbreaks of H5N1 infection are observed in Lao People's Democratic Republic, Myanmar Cambodia, and Nepal (FAO, 2013).

Among the African countries, Egypt is considered as endemic for AIV in spite of several attempts to eradicate the virus. In 2007, backyard flocks accounted for 89% of the AI outbreaks in poultry. The infection was further confirmed in human patients having exposure to the backyard flocks (Kandeel et al., 2010). Moreover, higher infection rates of AIV (H5 and H9) were observed in backyard birds and birds from local bird markets in comparison to birds from commercial farms in Egypt (Osman et al., 2015). Furthermore, a higher prevalence of AIV was reported in backyard flocks that had mixed populations of chickens and waterfowls together (El-Zoghby et al., 2013). Two clades of HPAI-H5N1 are circulating in Egypt, known as Classic 2.2.1 and Variant 2.2.1 strains (Hafez et al., 2010). The Classic strain originated from ducks (Saad et al., 2007) and currently is maintained in backyard birds. The Variant strain has been circulating in commercial poultry since late 2007 (Hafez et al., 2010). The phylogenetic analysis of HPAI strains from Egypt revealed close relationship with the H5N1 viruses circulating in Gaza and Israel, suggesting a common virus progenitor (El Bakrey et al., 2015). Similarly in Libya, HPAI-H5N1 belonged to 2.2.1 lineage having similarities with Egyptian isolates. It was detected in backyard flocks (Kammon et al., 2015).

H5N1 infection was detected in backyard poultry in other African countries (Niger, Cameroon, Burkina Faso, Côte d'Ivoire, Djibouti, Ghana, Togo, and Benin) during 2006–07. The serosurveillance study in backyard chicken in Côte d'Ivoire detected the presence of low pathogenic H5 and H7 strains (Couacy-Hymann et al., 2012). A serosurveillance study of AIV in Ethiopia showed positive correlation between smaller backyard flock size and the presence of viral antibody (Chaka et al., 2013). Furthermore, in Central Africa (Cameroon, Central African Republic, Congo-Brazzaville, Gabon), evidence of AIV was detected in chickens, ducks, songbirds, and kingfishers (Fuller et al., 2015). In Mali (West Africa), AI seroprevalence was significantly higher in backyard birds than the commercial farms (Molia et al., 2011).

Severe H5N1 outbreaks were detected in all kinds of poultry in Thailand (Asia) during 2004–05, which was later controlled, and in 2009, tOIE declared Thailand as free of H5N1 infection (OIE, 2011). The study with the scenario of the tree modeling approach in backyard flocks in Thailand also revealed the high probability to be free from H5N1 infection (Goutarda et al., 2012). However, the backyard flocks in other Asian countries possess the AIV. Evidence of H5N1 AIV was observed in a village backyard flock in Kandal province in Cambodia (Theary et al., 2012). In Pakistan, two highly pathogenic subtypes (H5N1 and H7N3) caused a sporadic AI outbreak in poultry in 1999. Vaccination was done in poultry against H5, H7, and H9 subtypes to control the infection. As a consequence of reassortment with vaccine strains a more virulent subtype (H9N2) of the virus appeared, which crossed the species barrier and further infected human. This reassorted subtype (H9N2) possessed a nonstructural gene segment of H5N1, which increased the capacity of the virus to adapt to new hosts (due to IFN-β inhibitory activity) and environments (Munir et al., 2013). Currently the existence of H9N2 subtype is also detected in apparently healthy backyard flocks in Pakistan. So, the backyard flocks in Pakistan act as asymptomatic carrier of H9N2 with increased possibility of human transmission (Munir et al., 2013). The H9N2 virus circulating in Pakistan belonged to the G1 lineage of virus (Qa/HK/G1/97), which was also common in Hong Kong (Iqbal et al., 2009). H9N2 originated in turkeys in 1966 (Homme and Easterday, 1970). Since then it has been considered as a low pathogenic strain (LPAI) and is panzootic in multiple Avian species in Asia, Middle East, Africa, and Europe (Capua and Alexander, 2004). The property of cross species transmission to human was first detected in 1997 in Hong Kong and China, which also originated from poultry (Peiris et al., 1999; Butt et al., 2005).

In Bangladesh (Asia), H9N2 subtype of LPAI is frequently detected in commercial poultry and backyard flocks that are phylogenetically related to South Asian and Middle East isolates (Parvin et al., 2014). Moreover, H9N2 isolates of Bangladesh also possessed the evidence of reassortment between H7N3 and H5N1 subtypes like their counterparts in Pakistan (Parvin et al., 2014). A low proportion (7%) of backyard birds in Bangladesh die every day due to HPAI infection. Clinical study showed that cyanotic comb and wattle are frequently observed in both commercially farmed and backyard poultry ($P = 0.44$), but edema of the head and face, drowsiness, and huddling were more common in backyard farms ($P = 0.03$; $P = 0.02$) (Biswas et al., 2011a,b). Furthermore, full genome analysis of HPAI viruses (H5N1) isolated from poultry including backyard flocks in Bangladesh revealed the evidence of reassortment between two circulating clades of viruses (2.3.2.1 and 2.3.4.2) and also between HPAI (H5N1) and LPAI (H9N2) strains (Gerloff et al., 2014). The virus clade 2.3.2.1 was introduced in Bangladesh after 2010 and the strain spread into different places and species (chickens, crows) in the country (Islam et al., 2012). The AIV belonged to similar lineage with Bangladeshi isolates were also detected in Nepal suggesting the transboundary transmission either through trade or wild birds (Nagarajan et al., 2012). Similarly in India (neighbouring country of Bangladesh) the existence of HPAI-H5N1 clade 2.3.2.1 was observed in poultry since 2011 (Nagarajan et al., 2012). Until 2010, the clade 2.2 dominated in Indian poultry (Chakrabarti et al., 2009; Pattnaik et al., 2006).

In Europe, AI virus belonging to clade 2.2 was most prevalent among poultry and wild birds (Brown, 2009). However, in Romania, HPAI H5N1 virus of clade 2.3.2 was detected in backyard flocks (Reid et al., 2011). In Italy, eight HPAI outbreaks in backyard poultry flocks infected with H5N2 virus were reported in 1997–98 (Alexander, 2000), while chickens raised for recreational purposes in the urban localities in the Netherlands acted as major risk factors for a HPAI outbreak in 2003 (Slingenbergh et al., 2004).

In Maryland (United States), low seroprevalence (4.2%) of AIV was detected in backyard birds. No evidence of subtypes H5, H7, and H9 was observed. The seroprevalence was positively correlated (not statistically significant) with exposure to waterfowl, pest control, and location (Madsen et al., 2013).

In New Zealand also, low seroprevalence (3.6%) of HPAI was detected in backyard chickens and no influenza A virus was detected by molecular technique (Zheng et al., 2010).

2.1.2 Newcastle disease

Newcastle disease virus (NDV) belonged to the genus *Avulavirus* and family Paramyxoviridae (Niewiesk and Oglesbee, 2013). All the NDVs come under a single serotype but based on phylogenetic analysis it is divided into two classes: class I and class II. Class

I strains are mostly apathogenic for chicken except one isolated from waterfowl and shore birds. All the pathogenic strains belonged to class II, and this class is further divided into 11 genotypes (I-XI). Among them, I, II, III, IV, and IX genotypes are considered as "early/old" (appeared between 1930 and 1960) and the genotypes appeared after 1960 are considered as late/recent (V, VI, VII, VIII, X, XI) (Kim et al., 2007). Backyard flocks throughout the world, especially in Asian and African countries suffer or carry the NDV infection (Permin and Pedersen, 2002).

Pakistan (Asia) is considered as endemic for NDV infection in poultry. Both commercial and backyard flocks can carry the infection, and all the virus isolates from both of the sectors belonged to genotype VII. The backyard flocks, however, do not show any syndrome of ND, but the virus isolated from the backyard flocks possessed a typical motif in F-protein associated with virulence. Frequent contact with commercial poultry might be responsible for the transmission of virulent NDV into the backyard flocks and the virus was later adapted in the backyard flocks (Munir et al., 2012). However, in Nepal, ND was detected to be responsible for 90% mortality in backyard flocks during 1992 (Alexander, 2001). In Iran (Bushehr province), 40% seroprevalence of NDV antibody was detected in unvaccinated backyard chickens (Saadat et al., 2014).

In Africa, studies revealed an average ND serological prevalence of 0.67 [95% (CI) 0.58–0.75] in poultry, which is more prevalent in the area with low altitudes, high humidity, and high human and poultry population densities. These predisposing factors are also favorable for persistence of NDV in backyard flocks because high humidity enhances virus survival and further transmission through the oral route. Comparison of the NDV transmission rate within the flocks revealed more rapid transmission in the commercial sector than in the backyard flocks (Miguel et al., 2013). In a study in Ethiopia, overall seroprevalence of the NDV antibody in backyard flocks was detected as 5.9%–6% in different seasons, which is higher than the average NDV seroprevalence (0.67%) in Africa (Chaka et al., 2012). The backyard farmers also identified ND as the most prevalent infection among the birds in Ethiopia (Sambo et al., 2015). Moreover, in Mali, among unvaccinated backyard birds, ND seroprevalence was 58.4%, and the seropositivity was more associated with adult, female chickens than the ducks (Molia et al., 2011).

In the Middle-East countries, NDV has been circulating in poultry populations since the last century. In Oman, high seroprevalence (90%) of NDV was detected in backyard flocks with mild or no symptoms. The management practices, such as introduction of new birds into existing flocks, direct contact with neighboring poultry and feeding of uncooked poultry waste were correlated with this high seroprevalence (Al Shekaili et al., 2015).

The seroprevalence data of NDV in backyard flocks in other countries is variable. In New Zealand, 8.3%–100% of the studied backyard chickens were seropositive for NDV antibody. All the chickens reared with ducks were found seropostive (Dunowska et al., 2013).

In the periurban area of Madagascar, a study showed that NDV was responsible for 44% of annual mortality in local backyard chickens (Maminiaina et al., 2007). In Brazil, higher seroprevalence of NDV was detected in backyard flocks in which the farmers introduced their own poultry to restock the flock. This replacement caused the continuous presence of virus in the flock. Further, proximity to water bodies (estuary) provided direct contact with other infected birds and favored the transmission of NDV (Marks et al., 2014).

2.1.3 Parasitic infestation

The ectoparasites were the most commonly reported health problem in backyard flocks in developed countries, such as in United States and Canada (Garber et al., 2007; Burns et al., 2011). In a study in California (United States), 80% of the backyard premises were observed to be infested with ectoparasites. The permanent ectoparasites detected in the study were six species of chicken louse, such as *Menacanthus stramineus* (50%), *Goniocotes gallinae* (35%), *Lipeurus caponis* (20%), *Menopon gallinae* (15%), *Menacanthus cornutus* (5%), and *Cuclotoasterheterographus* (5%). Among the chicken mites, three species were most prevalent [*Ornithonyssus sylviarum* (15%), *Knemidocoptes mutans* (10%), *Dermanyssus gallinae* (5%)]. It is noteworthy to mention that these parasites were exclusively detected in backyard flocks, not in commercial layers in California (Murillo and Mullens, 2016). Backyard flocks kept in and around the Mississippi river delta suffered from black fly (*Simulium* spp.) infestations. The external signs, such as cutaneous hemorrhagic lesions and a huge numbers of black flies within the digestive tract of the birds (after post mortem) were found. Black flies can also transmit some blood protozoa (*Leucocytozoon* spp., *Haemoproteus* spp.), which cause further infection in the affected poultry. Moderate occurrence (26%) of *Leucocytozoon* spp. was detected in black fly infested backyard flocks (Jones et al., 2015).

In the United States, *Toxoplasma* was detected in 27%–100% of backyard chickens although clinical cases of toxoplasmosis are rarely reported in poultry (Dubey and Jones, 2008).

In tropical countries, humid climatic conditions favor the growth of helminths, which reduce the egg and meat production of backyard poultry. In a study in India (Jammu and Kashmir), 72% of the backyard flocks were determined infested with gastrointestinal helminths. In the studied state of India, *Ascaridia galli* was the most prevalent helminth (29.6%) among the flocks. Other helminths, such as *Heterakis gallinarum*, *Raillietina cesticillus,* and *Raillietina echinobothrida* were also detected. The backyard chickens of the studied area take various insects as feed present in the soil, which may act as intermediate hosts for helminths (Fig. 14.4) (Katoch et al., 2012).

Similarly, in other tropical countries, such as in Ethiopia (Africa), 89% of the backyard flocks were infected with several cestode and nematodes (Hussen et al., 2012). Low occurrence (12%) of *Histomonas meleagridis*, a blood protozoon, was detected in backyard flocks in Vietnam (Nguyen et al., 2015). *Triatoma dimidiata*, a vector of *Trypanosoma cruzi* causing

Figure 14.4: A Backyard Bird Drinking Water From Gutter.
Courtesy: Dr. Swarup Singh, Veterinarian.

Chagas disease in humans was identified in the chicken coops in Mexico (Koyoc-Cardeña et al., 2015).

In Australia, the study showed that 81% of the backyard flocks suffer from coccidiosis (*Eimeria*). The weather of Australia, such as ambient temperatures around 25°C and high humidity (>60%), favors the growth of *Eimeria* and three species, such as *E. mitis*, OTU-Y, and *E. acervulina* were most prevalent (Godwin and Morgan, 2015).

2.1.4 Salmonella

Meat and poultry products are recognized as the major sources for transmission of *Salmonella* spp.(a Gram-negative zoonotic bacterium) to human with 40% of the clinical cases attributed to the consumption of egg and poultry products (Sanchez et al., 2002). Nontyphoidal *Salmonella* spp. is reported to cause 1.2 million sufferings, including 19,000 people admitted to hospitals and 370 deaths in a year in the United States (Scallan et al., 2011). Sometimes, poultry birds, although infected with *Salmonella* spp. and appearing healthy, can shed the bacteria through the faeces (Behravesh et al., 2014). Human outbreaks of Salmonellosis, especially between the caretaker and children associated with backyard poultry, are a global concern nowadays (CDC, 2009). Moreover, many serovars of *Salmonella* spp. can produce serious diseases and deaths in chickens too, especially at a young age (Samanta, 2013).

The seroprevalence rate of *Salmonella* in backyard chicken was moderate (16%) in Argentina (Xavier et al., 2011). However, a lower isolation rate was reported by (Jafari et al., 2007, Namata et al., 2009 and Leotta et al., 2010) who found 5.8, 6, and 3.5% as *Salmonella* prevalence in backyard chicken flock in Iran, Belgium, and Paraguay, respectively. In a study in backyard birds (RIR breed) in India (West Bengal), the isolation rate of *Salmonella* was 15%. *Salmonella* isolates were also obtained from feed (10%), drinking water (20%), and eggs (10%) of the studied backyard flocks. No *Salmonella* was detected from utensil swabs, litter, swab from the wall of the poultry house, dried manure under the house, and soil collected from all the studied agroclimatic zones. *Salmonella* isolation rate was significantly correlated ($P < 0.01$) with a higher-age group of the backyard birds (20–26 weeks) as compared to the middle- or lower-age group. Further, none of the *Salmonella* isolates possessed extended spectrum β lactamase (ESBL) genes probably due to a lack of antibiotic exposure (Samanta et al., 2014a). Transmission of antimicrobial-resistance genes into the commensal flora may take place in the intestinal tract of animals, including birds (Gustafson and Bowen, 1997). Specifically, the ESBL enzymes are increasingly expressed by many strains of bacteria with a potential for dissemination. These ESBLs diminish the activity of wide-spectrum antibiotics, creating major therapeutic difficulties in treatment of the patients (Samanta et al., 2015a).

2.1.5 Escherichia coli

E. coli are present as commensal microflora of the intestinal tract of mammals including poultry and their environment. Among several pathotypes, Avian pathogenic *E. coli* (APEC) are able to cause colibacillosis due to possession of specific virulence factors (Samanta, 2013). In California, *E. coli* were the most commonly diagnosed infectious diseases among backyard birds (Mete et al., 2013).

E. coli are also classified under several phylogenetic groups. The phylogenetic group B2 strains are commonly found in mammals and are often associated with extraintestinal infection in humans, pets, and Avian species. The group B1 strains are more commonly associated with ectotherms, birds, and environment (Blyton et al., 2015). Sometimes, *E. coli* present in Avian (APEC) and humans (uropathogenic *E. coli*, UPEC) share common virulence factors, such as *iucC*, *tsh*, *papC* (Rodriguez-Siek et al., 2005). In India, *E. coli* isolated from backyard flocks (RIR breed) did not possess the virulence genes (*iucC*, *tsh*, *papC*) associated with UPEC (Samanta et al., 2014b). Similarly, virulence gene (*papC*) was not detected in any of the *E. coli* isolates from free-range healthy layers in Australia (Obeng et al., 2012).

Further, none of the *E. coli* isolates from backyard flocks in India (West Bengal) was found to possess extended-spectrum β-lactamases (bla_{TEM}, bla_{SHV}, $bla_{CTX\text{-}M}$) or quinolone resistance gene (*qnrA*) due to a lack of antibiotic exposure (Samanta et al., 2014b). Thus, the studied backyard birds in India can be considered as safe food in relation to virulent and antibiotic resistant commensal bacteria. Similarly, no ESBL-producing *E. coli* were detected in backyard flocks in Finland (Pohjola et al., 2016; Miranda et al., 2008), which also reported lower levels of antibiotic resistance in *E. coli* isolates from organic poultry meat. In contrast, tetracycline resistance was most common in *E. coli* isolates from backyard poultry (25%) than in-care birds (15%) and wild birds (3%) in Australia due to the use of tetracycline for treatment of the birds (Blyton et al., 2015).

2.1.6 Fowlpox virus

Fowlpox virus belongs to the genus *Avipoxvirus* and family Poxviridae. It can infect the poultry throughout the world. Most of the infections in backyard birds are reported from Asia. In a study in India (West Bengal), fowlpox virus was detected in a backyard flock with pock lesions in comb, eyelid, beak, and wattle. Sequence analysis revealed the presence of nearly full-length reticuloendotheliosis provirus within the genome of fowlpox virus (Biswas et al., 2011a,b). A number of fowlpox outbreaks without reticuloendotheliosis virus have also been reported from backyard poultry at different regions of India and Iran (Dana et al., 2000; Das et al., 2013; Gholami-Ahangaran et al., 2014; Roy et al., 2013; Saha, 2003). Further study detected immunodominant B-cell and T-cell antigens in the fowlpox virus isolates from backyard birds, which will be useful for vaccine production (Roy et al., 2015).

2.1.7 Avian coronavirus

Some genotypes of Avian coronavirus (793/B, QX, IS/1494/06, IS/885/00, Q1) causing infectious bronchitis (IB) in chicken have been reported in recent decades. The Q1 strain of IBV was detected in naked-neck flocks in Italy coinfected with *E. coli*. This synergistic infection caused 4%–10% mortality (Toffan et al., 2013). Moreover, in Oman, 1.38% of the backyard birds possessed IB virus closely related to the virulent strains, such as 793/B, M41, D274, IS/1494/06, and IS/885/00 (Al-Shekaili et al., 2015). It seems that backyard poultry and free-ranging birds act as a center for IBV transmission currently (Promkuntod, 2015).

2.1.8 Campylobacter

In Canterbury, New Zealand, revealed the presence of *Campylobacter* spp. in 86% of the studied backyard chicken flocks (Anderson et al., 2012). *Campylobacter jejuni* alone, *Campylobacter coli* alone and both *C. jejuni* and *C. coli* were detected in 20 (57%), 2 (6%), and 8 (23%) of the flocks, respectively. PFGE analysis and comparison of the genotypes with the PulseNetAotearoa *Campylobacter* database showed the similarity of the isolates with the isolates from human and commercial chickens indicating the possibility of cross-transmission. In Finland, backyard chickens were also detected as a reservoir of *C. jejuni* strains (Pohjola et al., 2016).

2.1.9 Avian listeriosis

Clinical listeriosis is rare in birds. However, recently an outbreak of *Listeria monocytogenes* was observed in backyard flocks in Seattle (United States). Depression, lack of appetite, labored breathing, and increased mortality were noted in several affected birds. The pathologic changes in the internal organs of infected birds included severe myocarditis, pericarditis, pneumonia, hepatitis, and splenitis. No lesions were noted in the brain (Crespo et al., 2013). In Finland too, backyard chickens were observed to possess *L. monocytogenes*, although their role as a primary reservoir is questionable (Pohjola et al., 2016).

2.1.10 Other pathogens

In Europe, seroprevalence studies in backyard and fancy-breed poultry flocks revealed the presence of *Mycoplasma gallisepticum*, *Ornithobacterium rhinotracheale*, and Avian metapneumovirus antibodies (Haesendonck et al., 2014). In another study in Oman, backyard flocks were positive for Avian metapneumovirus subtype B (Al-Shekaili et al., 2015). *Pasteurella multocida* causing fowl cholera was detected in 7.6% backyard birds in Egypt. Most of the *P. multocida* isolates belonged to A:1 serotype (Mohamed et al., 2012).

2.2 Noninfectious Diseases

Among noninfectious conditions, fatty liver hemorrhagic syndrome (FLHS) and reproductive tract adenocarcinoma were the leading causes of mortality in backyard flocks in California (Mete et al., 2013). Necropsy findings in FLHS include abundant coelomic fat and an enlarged, tan to yellow, friable liver with hemorrhages. Another study revealed absence of hepatocellular lipidosis in 22% of the FLHS cases and mild hepatocellular lipidosis in 26% of the FLHS cases in the backyard birds (Trott et al., 2014).

2.3 Toxicosis

Lead toxicosis was detected in backyard flocks in California and the flaking paint from a wooden structure in the chicken coop was identified as the source of toxicosis. No clinical signs in the birds were detected. However, the birds were excreting the lead through the eggs. The edible portion of the eggs contained lead levels as high as 0.97 μg/g (Bautista et al., 2014).

2.4 Diseases of Urban Backyard Birds

In urban backyard flocks in the United States, ectoparasites, diarrhea, injuries, prolapsed vent, sour crop, and vices (feather pecking, cannibalism, piling, aggression) are most common menaces. Mortality due to diseases or vices is uncommon. The predation is the major cause of mortality in urban backyard flocks both in the United States and the United Kingdom (Elkhorabi et al., 2014; Karabozhilova et al., 2012). In Minnesota, lameness was the most commonly observed symptom followed by nasal or eye discharge, coughing, sneezing, and swollen sinuses in urban backyard flocks (Yendell et al., 2012).

3 Prevention and Treatment of Diseases

Vaccinations are an important tool for disease prevention in all poultry flocks throughout the world. The vaccines against NDV infection are available for decades, but in most of the countries they are sold in large vials of more than 100 doses, which are expensive for small-scale backyard farmers. The reconstituted vaccine should be used within a short period of time to avoid the loss of potency (Merck Animal Health, 2013). Further, in remote villages, accessibility of the vaccines, proper diluents, cold chain, and, moreover, qualified paraveterinarians are limited. In some countries, such as in Ethiopia, the vaccines are produced locally, which also creates challenges, such as irregular supply of specific pathogen-free (SPF) eggs, required for sustainable vaccine production (Sambo et al., 2015). Consequently, production and supply of vaccine is often hampered. Because of all these factors, conventional vaccination is not usually performed in most of the backyard flocks each year to prevent the outbreaks.

In the literature, very few examples are present regarding successful vaccination in backyard flocks. In Java (Indonesia), a large-scale mass vaccination was carried out to control outbreaks of HPAI in backyard flocks, and positive titer to H5 was detected in 20%–45% of poultry sampled in the mass vaccination area. In the HPAI-ND combined vaccination group, 12%–25% of the population had positive ND titers, compared to 5%–13% in the areas without ND vaccination (McLAWS et al., 2015). In another study in Indonesia, the results suggested that the HPAI-ND combined vaccination significantly reduced the incidence of HPAI in backyard poultry (Bett et al., 2005). Several types of inactivated H5N1 and H5N2 vaccines were also used in Egypt to control HPAI outbreaks (Abdelwhab and Hafez, 2011). However, use of live vaccine against HPAI is a controversial issue, and it is presumed that such vaccination against HPAI in China helped in the evolution of more virulent virus strain (Smith et al., 2006). In Pakistan, too, it is speculated that import of live poultry and extensive use of live vaccines can pose a huge risk for the emergence of new NDV strain (Munir et al., 2012). In most of the endemic countries, such as in India, vaccination is not practiced to control the HPAI infection in poultry. Culling or stamping out birds in a 3–5 km declared infected area is the official policy to control the outbreak in India (DADF, 2013). The metapopulation dynamic study of a poultry population in the United States demonstrated the effectiveness of culling in reducing the number of outbreaks in large poultry populations (Hosseini et al., 2013).

Besides conventional vaccines, a novel approach in the form of fast-dissolving tablets (FDT) against ND virus was also produced. The virus (LaSota strain) was freeze-dried into tablets containing a small number of doses, which is economically feasible for backyard farmers. The vaccine tablet can be diluted in water and administered either in drinking water of birds or by intraocular and/or intranasal route. The compact packaging of the FDTs will also provide cost savings in storing and distributing the vaccine in the cold chain (Lal et al., 2014).

Treatment of diseases in backyard flocks is also limited. The backyard poultry farmers in India (West Bengal) are reluctant to call for the assistance of local veterinarians or paraveterinarians due to lack of awareness, time, and motivation. In addition, doorstep services are also unavailable, especially in the remote villages (Debnath et al., 2011). The landless or marginal farmers also could not afford the treatment or vaccine costs (Indian Rupees 75 or US$ 1.15 per bird/year) (SAPPLPP, 2009). This is the probable reason the backyard birds reared in this part of India are not exposed to the antimicrobials and thus the commensal (*E. coli*, *Salmonella* spp.) present in the birds do not possess major antibiotic resistance genes (Samanta et al., 2015b). In Bangladesh, sometimes the farmers prefer to collect the medicines and suggestions from the local medicine shops. The farmers also avoid the government animal health centers due to lack of proper diagnosis and availability of poultry medicines (Sultana et al., 2012b). The reluctance of owners to seek veterinary attention was also noted even in developed countries, such as the United States (2.9% farmers use veterinary service), the United Kingdom, and Chile (Garber et al., 2007; Hamilton-West et al., 2012; Karabozhilova et al., 2012). The urban backyard farmers in the United States mostly use dewormers (coccidiostats) and antibiotics in larger flocks (<20) of birds (Elkhorabi et al., 2014). In Chile, the backyard birds were sometimes treated with the drugs approved for human use, which could be responsible for presence of drug residues in the poultry products (Greenlees, 2003). The Animals and Animal Products (Examination for Residues and Maximum Residue Limits) Regulations, 1997, control residues of medicines in food animals, including poultry, in European Union countries. These regulations divide medicinal substances into three categories: allowed, prohibited, and unlisted. Use of prohibited/unlisted medicines in poultry (commercial and backyard) is illegal (Table 14.1) (Whitehead and Roberts, 2014).

Occasionally, elderly farmers offered ethnoveterinary medicines, such as sour fruits, chili, and warm water to their backyard flocks (Sultana et al., 2012a). Similarly, in Ethiopia, tobacco leaf, "melia" plant, pepper, garlic, lemon juice, and table oil is administrated with drinking water to the sick birds (Sambo et al., 2015; Yemane et al., 2013). In Brazil, ash

Table 14.1: Prohibited medicines for food animals and poultry (European Union).

Sl no.	Prohibited Medicines
1	Chloramphenicol
2	Chloroform
3	Chlorpromazine
4	Colchicine
5	Dapsone
6	Dimetridazole
7	Metronidazole
8	Nitrofurans (including furazolidone)
9	Ronidazole

is applied on the body of backyard birds to prevent parasite infestation. In Nigeria, the ashes after burning of *Nicotiana rustica*, *N. tabacum*, or *Carica papaya* leaves are used. This is rubbed into the plumage to protect against parasitic infestation. Shea butter is used as a curative method against bird scabies. Palm oil is used especially against fleas and mites. Tobacco leaves (*Nicotiana tabacum*) provide protection for approximately 1 month against *Sarcoptes*, *Psoroptes*, and *Demodex* (Salifou et al., 2013). In Bangladesh, Indonesia and China, the sick birds are slaughtered and consumed when the treatment fails (Padmawatia and Nichterb, 2008; Sultana et al., 2012b; Zhang and Pan, 2008).

Addition of an indigenous homemade probiotic (Axone/Akhuni) in diet (at 5% w/w) significantly improved the growth rate, egg production, and egg weight of backyard poultry in India (*Vanraja* variety). Microbiological analysis of the probiotic (Axone) revealed the presence of *Bacillus coagulans*, a well-known beneficial bacterium (Singh and Singh, 2014).

4 Transmission Risk of Pathogens

4.1 Transmission Risk of Pathogens in Humans from Backyard Flocks

The zoonotic pathogens, such as HPAI are transmitted to humans from the backyard birds through direct or indirect contact. The direct contact takes place while walking through the flocks and handling sick poultry and while slaughtering poultry personally without appropriate protection (Burns et al., 2011; Liao et al., 2009). At the time of slaughter, the most commonly identified risk factors were direct contact with infected blood or other body fluids (Van Kerkhove et al., 2011). Associated risk factors related to environmental exposure include cleaning poultry areas, removal of feces, using poultry waste as fertilizer, inhalation, ingestion, and intranasal inoculation of contaminated water (Van Kerkhove et al., 2011). Indirect contact is more frequent and takes place when backyard farmers are exposed to apparently healthy poultry without any precautions (Rabinowitz et al., 2010) and when the farmers meet with each other (Burns et al., 2011). Backyard poultry acted as greater source of HPAI transmission than the commercial birds due to the absence of biosecurity measures. It is also estimated that average daily contact rate of humans was higher with the backyard flocks than with commercial poultry (0.0137 or 5 contacts per year) (Patyka et al., 2013). Rural people are at higher risk of HPAI transmission than their urban counterparts due to greater amount rearing of these backyard birds. Besides from being an essential component of rural livelihood, poultry rearing is also an important sector of the agricultural ecosystems. The droppings of chickens are used to feed aquatic animals and as soil fertilizers, which facilitates pathogen transmission (Liao et al., 2014). Moreover, Asian rural people prefer to take freshly slaughtered poultry than the packaged and processed meat. In a study in Southeast Asia, it was observed that almost all Vietnamese and more than half of the Thai people slaughtered the birds by themselves at home. This kind of practice also increases the possibility of disease transmission (Liao et al., 2014). Cock fighting (a traditional recreation in rural Asia) with backyard birds may also play a role in disease transmission. The owners transport their birds long distances to participate in bouts and sometimes they lick the wounds on their fighting cocks (Edmunds et al., 2013). More hazardous practices, such as keeping birds inside the bedroom, scavenging of birds around the places where food is cooked, using the same water source where villagers bath or wash their utensils for the birds' drinking were observed in Bangladesh (Sultana et al., 2012b).

The HPAI virus belonged to clade 2.2.2 and was prevalent in backyard and commercial poultry in India and Bangladesh before 2010 (WHO, 2012). During that period (2008), an HPAI outbreak in humans was detected, which was also followed by two subsequent human cases. In all these cases, the etiological virus belonged to clade 2.2.2 with other similar genetic characteristics indicating the cross-transmission from the poultry (Brooks et al., 2010). In Vietnam, most of the human exposure (96%) to HPAI occurred from the backyard poultry (Fielding et al., 2007). In Thailand, during 2007–10, 25 confirmed H5N1 cases in humans were detected of which 17 persons died (WHO, 2010). The history of direct contact to the backyard chickens and free-grazing ducks appeared to be related to H5N1 infections in humans in Thailand (Chantong and Kaneene, 2011). In China, a total of 46 H7N9 infections were identified in the Zhejiang province in humans during 2013. All the live poultry markets were closed and backyard poultry were slaughtered to control the outbreak in the locality (Gong et al., 2014). In Beijing (China), farmers who reared ducks in their backyards possessed antibody against Avian influenza, but they never vaccinated, indicating the means for possible transmission (Ma et al., 2012). Using logistic regression, it was shown that backyard poultry could act as a source of *Campylobacter jejuni* infection to children (El-Tras et al., 2015).

LPAI is also transmitted from poultry to humans causing influenza-like syndrome (CDC, 2008). Antibodies against H4 and H11 Avian influenza virus were detected in a small locality in Lebanon among the backyard farmers (Kayali et al., 2011). There is serologic evidence that waterfowl hunters, wildlife professionals, and veterinarians are at higher risk of infection with LPAI (Gill et al., 2006; Myers et al., 2007).

Urban backyard flocks also pose a major risk for transmission of zoonotic pathogens, such as *Salmonella* spp. in young and elderly persons handling the birds (Pollock et al., 2012). Centres for Disease Control and Prevention (CDC) had warned about handling of poultry by people below 5 years of age (CDC, 2009).

Other than transmission of zoonotic pathogens, eggs of the backyard birds are also detected to be contaminated with dioxins (Lin et al., 2012). During scavenging, the birds get access to the source of dioxins, such as soil, feeds, plants, insects, building materials containing fly ashes, debris, etc. (Solorzano-Ochoa et al., 2012). Dioxins enter the body through ingestion and mostly accumulate in the liver, ovarian follicles, and the adipose tissue (Piskorska-Pliszczynska et al., 2014).

4.2 Transmission Risk of Pathogens in Backyard Flocks from Other Birds

The vicious cycle of HPAI virus transmission from the reservoir ducks into the backyard flocks was detected. In South Asia, domestic ducks were the major risk factor for HPAI persistence and transmission into the backyard poultry (Gilbert and Pfeiffer, 2012). In Madagascar, the high density of ducks (palmipeds) and prevalent rice paddies were associated with AI infection in backyard birds (Andriamanivo et al., 2012). The water bodies and their banks or rice paddies are contaminated with the virus excreted by the reservoir ducks. The virus survives in the lower temperature of the water. The backyard flocks are exposed to the contaminated water and the virus is transmitted through oral route. So the presence of water bodies adjacent to the backyard farm is considered a major risk factor for the transmission of pathogens. Other than ducks, wild birds found around the water bodies, such as teals (*Anas chlorotis*), swans (*Cygnus atratus*), shags (*Phalocrocorax carbo*), seagull (*Larus Novaehollandiae Scopulinus*), pheasant (*Phasianus colchicus*), turkeys (*Meleagris gallopavo*), and hawks (*Circus approximans*) also play an important role in transmission of HPAI in backyard flocks (Zheng et al., 2010). Sparrows (*Passer domesticus*) and starlings (*Sturnus vulgaris*) most commonly visit the place where the backyard flocks are kept. Both sparrows and starlings are susceptible to experimental HPAI infection (Boon et al. 2007) and thus may act as a source of infection for the backyard birds. Moreover, in a metapopulation dynamics study, it was observed that movement of AI virus between commercial and backyard poultry may contribute to the maintenance of outbreaks in an area, but direction of the viral transmission cannot be predicted (Farnsworth et al., 2011).

In Bangladesh, the poultry purchased from the market are slaughtered at home and the remnants are offered to their backyard flocks. This malpractice is considered as the strongest risk factor for transmission of HPAI in backyard flocks in Bangladesh (Biswas et al., 2009). In Egypt, significant correlation exists between disposal of poultry carcass and feces in the environment and HPAI infection in poultry ($F = 15.7$, $P < 0.0001$) (Sheta et al., 2014). In Ethiopia, scavenging behavior of backyard chickens and chicken dealers were considered a major risk factor for infecting the backyard flocks. A number of farmers identified dogs bringing infected carcasses home to be an additional risk factor for transmission of infection (Sambo et al., 2015). Female backyard birds were found to be more susceptible to NDV infection than male chickens due to extensive roaming throughout the village with a greater possibility of exposure to infected birds (Molia et al., 2011).

5 Biosecurity Strategies for Backyard Poultry

Biosecurityis in practical terms a mindset or philosophythat must be developed by the producers to prevent the entry of disease into the flock. It is an approach with a focus on maintaining or improving the health status of the birds and preventing the introduction of new pathogens by assessing all the possible risks (Permin and Detmer, 2007). In rural backyard farming specially in developing countries, biosecurity measures are not practiced due to a lack of awareness and high cost of the measures (Samanta et al., 2015c). For example, the cost of a hen house in Cambodia (Southeast Asia) is US$ 25, whereas, the average monthly income of a Cambodian family is US$ 75 (Conan et al., 2013). A study conducted in a broiler farm in Finland detected 3.55 Euro cents (US$ 0.04) per bird as an average biosecurity cost (Siekkinen et al., 2012). In Bangladesh, although government circulated 10-point biosecurity measures to prevent AIV transmission, the backyard farmers ignored these recommendations because they were unable to identify the infection and measure the transmission risk. Most of the farmers considered the disease as fate or God's will or due to exposure to evil gas and air (Sultana et al., 2012b). After confirmation of human H5N1 infections in Anhui Province (China), the provincial government decreed that all backyard poultry must be kept in cages but the authority failed to implement the law (Kaufman, 2008). Similarly, poultry farmers of Indonesia (Java) and China (Haining) ignored the biosecurity practices due to lack of knowledge regarding zoonotic potentiality of Avian influenza (Padmawatia and Nichterb, 2008; Zhang and Pan, 2008).

In literatures, there are very few examples of the biosecurity practices being followed in the rural backyard farms in the developing countries. In Ethiopia, removal of manure and bedding from the chicken coops was occasionally performed to sell the objects directly as fertilizer. The materials used to build the chicken sheds, such as mud and cow dung made it difficult for sufficient cleaning with chemical disinfectants (Sambo et al., 2015). In Ghana, general biosecurity practices, such as hand washing after handling poultry, was low in the farmers (Odoom et al., 2012). In Bangladesh, the farmers who kept the birds in the sheds, cleaned the sheds every 2–4 days. The dried poultry feces and other debris were collected in a basket and directly used as fertilizer. The sick birds were mostly slaughtered for consumption. Hand washing with soap after slaughter, cleaning up the slaughter place in the yard with detergent was rarely practiced. The offals and visceras after slaughter were thrown into the nearest water bodies and bushes (Sultana et al., 2012b). Similarly in India (West Bengal), a low level of biosecurity awareness was observed among the backyard farmers, such as preparation of feed with boiled water (only 3% of the cohort), cleaning of feeding utensils and the drinking trough once in a month (90%), frequency of change of drinking water in the trough in 15 days interval (90%), frequency of change of litter in 15 days (90%), and storage of eggs at room temperature (93%). Majority of the farmers (60%) did not wash their hands before providing feed to the birds and before entry or exit of the poultry houses (Table 14.2) (Samanta et al., 2015c).

In developed countries, a moderate level of biosecurity awareness among the backyard farmers was observed probably due to higher education and socioeconomic conditions. In Chile, dead or sick backyard birds were neither consumed nor sold (Hamilton-West et al., 2012). In European Union countries, consumption of birds kept for the purpose

Table 14.2: Assessment of biosecurity practices by the backyard flock owners before and after adaptation of the recommended strategy in West Bengal, India.

Biosecurity Measures	Response Before Adaptation				Response After Adaptation			
Preparation of feed with boiled water (n = 30)	1[a] (3.33%)				4[a] (13.33%)			
Cleaning frequency of feeding utensils and drinking trough (n = 30)	Daily/weekly 0	15 days 3 (10%)	Monthly 27 (90%)	Any other 0	Daily 6 (20%)	15 days 9 (30%)	Monthly 15 (50%)	Any other 0
Frequency of change of drinking water in the trough (n = 30)	Daily/weekly 1[a] (3.33%)	15 days 27 (90%)	Monthly 2 (6.66%)	Any other 0	Daily 18[a] (60%)	15 days 10 (33.33%)	Monthly 2 (6.66%)	Any other 0
Frequency of change of litter (n = 30)	Daily/weekly 0	15 days 27 (90%)	Monthly 3 (10%)	Any other 0	Daily 18 (60%)	15 days 10 (33.33%)	Monthly 2 (6.66%)	Any other 0
Washing of hands before providing feed to the birds (n = 30)	Yes 12[b] (40%)		No 18 (60%)		Yes 17[b] (56.66%)	No 13 (43.33%)		
Washing of hands & feet before entry or exit of the poultry houses (n = 30)	Yes 12[b] (40%)		No 18 (60%)		Yes 17[b] (56.66%)	No 13 (43.33%)		
Scavenging during daytime (n = 30)	Near house 28 (93.33%)	Near paddy field 2 (6.66%)	Near broiler farm 0	Any other 0	Near house 28 (93.33%)	Near paddy field 2 (6.66%)	Near broiler farm 0	Any other 0
Presence of big tree near scavenging area (n = 30)	Yes 18 (60%)		No 12 (40%)		Yes 17 (56.66%)		No 13 (43.33%)	
Other birds observed in the flock premises (n = 30)	Duck 0	Pigeon 0	Crow 28 (93.33%)	Wild birds 2 (6.66%)	Duck 0	Pigeon 0	Crow 28 (93.33%)	Wild birds 2 (6.66%)
Travelling of farmers to animal gatherings (n = 30)	Poultry market 27 (90%)	Poultry show 0	Broiler farm 0	Other animal holdings 3 (10%)	Poultry market 27 (90%)	Poultry show 0	Broiler farm 0	Other animal holdings 3 (10%)

People involved in broiler farming entering the flock premises (n = 30)	Yes 2 (6.66%)		No 28 (93.33%)		Yes 1 (3.33%)	No 29 (96.66%)		
Disposal of carcass (n = 30)	Incineration 0	Garden burial 28 (93.33%)	Feed to flock 0	Human consumption 2 (6.66%)	Incineration 0	Garden burial 30 (100%)	Feed to flock 0	Human consumption 0
Washing of eggs (n = 30)	Yes 2[a] (6.66%)		No 28 (93.33%)		Yes 12[a] (40%)	No 18 (60%)		
Preservation of eggs (n = 30)	Room temperature 28 (93.33%)	4°C 2 (6.66%)		Any other 0	Room temperature 28 (93.33%)	4°C 2 (6.66%)	Any other 0	
Vaccination (n = 30)	Ranikhet disease 28 (93.33%)	Fowl pox 27 (90%)		Any other 0	Ranikhet disease 28 (93.33%)	Fowlpox 27 (90%)	Any other 0	
Treatment with antibiotic (n = 30)	Yes 0		No 30 (100%)		Yes 0	No 30 (100%)		

[a]Differs significantly at $P < 0.01$.

[b]Differs significantly at $P < 0.05$.

Source: From Samanta, I., Joardar, S.N., Ganguli, D., Das, P.K., Sarkar, U., 2015b. Evaluation of egg production after adoption of biosecurity strategies by backyard poultry farmers in West Bengal. Vet. World8, 177–182.

of showing or as pets is prohibited (Whitehead and Roberts, 2014). In New Zealand, poultry waste was composted prior to use as fertilizer on pastures or gardens to reduce the possibility of disease transmission (Zheng et al., 2010). In Canada (British Columbia), the biosecurity measures, such as limiting human visitors to the flock, isolation of new and sick birds, use of footbaths during entry or exit of the shed, changing clothes when returning home, designing pens to decrease risk of wild bird contact, and not sharing equipments were observed (Burns et al., 2011; Yendell et al., 2012). In the United States, the keepers of the backyard flocks followed similar kind of biosecurity measures, especially hand washing after handling the birds (Beam et al., 2013). However, majority of them did not use separate clothes to enter the coops and allowed visitors in the coop area. Feed and water of their birds were accessible to wild birds and rodents. The keepers were mostly unaware about the disease transmission possibility associated with the presence of wild birds or rodents (Elkhorabi et al., 2014). Lack of knowledge regarding the sources of infection and transmission pathways is still deficient among bird keepers, even in developed countries (Beam et al., 2013; Burns et al., 2011; Garber et al., 2007; Karabozhilova et al., 2012; Lockhart et al., 2010).

CDC played a major role by publishing educational documents on the risk of zoonotic pathogens from contact with live poultry, especially for inexperienced flock owners (CDC, 2013). The guideline is also framed for urban backyard poultry owners to reduce the risk of pathogen transmission. The guideline stressed limited flock size, composting of manure before using as fertilizer, prohibition of slaughter, required veterinary care to sick birds, and appropriate disposal of dead birds (Tobin et al., 2015).

The FAO had issued several guidelines for the farmers on how to increase biosecurity in backyard flocks, but a significant proportion of villagers continue their at-risk practices as observed in several countries (FAO, 2005, 2006). This discrepancy was explained by the fact that measures were often costly and may not be correlated with the economic benefits of the farmers (Aini, 2000). In Bangladesh, the biosecurity recommendation issued by the government to decrease the transmission of AI was not followed by the farmers because change in practices caused financial losses (Sultana et al., 2012b). In India (West Bengal), a cost-effective, agroclimatic zone-specific biosecurity strategy was developed for backyard farmers. The strategy stressed daily cleaning of the utensils with ash, offering potable drinking water to the birds, preparation of feed with boiled water, daily change of drinking water in the trough, sprinkling of detergent water left after washing of clothes in the scavenging area, disposal of carcasses by garden burial, washing of the eggs, storage of the eggs in cold temperature maintained by indigenous structures, and so forth. The strategy was moderately well adopted among the farmers due to its cost-effective nature and the ease of administration. Adoption of such strategies caused change in practices (Table 14.2) and as a consequence, the egg production level in the studied village increased (Samanta et al., 2015c).

6 Conclusions

The chapter elaborated the backyard farming including breeds reared, housing, feeding, with special emphasis on suggested biosecurity strategies and consequence of the adapted strategy. Other than chicken as the primary species, turkeys, geese, ducks, Muscovy ducks, quail, pigeons, and guinea fowl are reared by backyard farming throughout the world. The birds are kept by permanent confinement, free-range, and mixed confinement. In developing countries, the backyard poultry sector mostly suffers from two infectious diseases, such as AI and ND due to lack of biosecurity and proper vaccination. The zoonotic pathogens, such as HPAI are transmitted to human from the backyard birds through direct or indirect contact. In rural backyard farming, especially in developing countries, biosecurity measures are not practiced due to lack of awareness and high cost of the measures. In developed countries, a moderate level of biosecurity awareness among the backyard farmers was observed probably due to higher education and socioeconomic condition. The FAO had issued several guidelines for the farmers on how to increase biosecurity in backyard flocks but a significant proportion of villagers continue their at-risk practices as observed in several countries. In India (West Bengal), a cost-effective and agroclimatic zone-specific biosecurity strategy was developed for backyard farmers. The strategy stressed on daily cleaning of the utensils with ash, offering potable drinking water to the birds, preparation of feed with boiled water, daily change of drinking water in the trough, sprinkling of detergent water left after washing of clothes in the scavenging area, disposal of carcasses by garden burial, washing of the eggs, storage of the eggs in cold temperature maintained by indigenous structures, and so forth. The strategy was moderately well adopted among the farmers due to its cost-effective nature and ease of administration.

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