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Review on Biosecurity in Extensive Poultry Production in Developing Countries with Respect to Highly Pathogenic Avian Influenza

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Abstract The poultry sectors have been severely affected by outbreaks of avian influenza in the past years. In particular, extensive poultry were considered to be the main problem with respect to controlling the disease. However, the epidemiology of avian flu shows that all poultry sectors and relative activities are culpable. For better control of this flu, it seems that more strict control measures must be undertaken. During the outbreaks, the biosecurity measures implemented concerned mainly the stamping out, movement control and sometime, banning outdoor poultry keeping. The implementation of these measures challenged with the realities of some developing countries in general, and Africa in particular. Furthermore some of the measures were found to generate livelihood and food security problems in developing countries as well as social-ethical issues in the developed world. Vaccination was proven to decrease the occurrence of outbreaks in chickens as well as the transmission of the virus to humans, and could therefore be the most suitable control strategy for developing countries.

Keywords: *biosecurity avian flu, extensive poultry system*

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1. Introduction

Livestock account for approximately 40% of the global value of agriculture output and is estimated to support the livelihoods and food security of about a billion people [1]. Besides this, the livestock sector is truly global, involving consumers, traders and labourers worldwide [2]. Likewise, several of the infectious livestock-diseases may occur in the developing as well as in the developed world. Notably, this is also true for zoonotic diseases. In developing countries livestock are particularly vulnerable to diseases due to factors such as presence of a wide range of disease-causing agents and lack of knowledge about their control as well as limited access to animal health and production services [3,4,5]. In poultry farming, a practice favoured by resource poor farmers [6], diseases are the major causes of mortality and production loss in smallholdings [7]. Generally, poor animal health hits livelihoods harder in poor countries, as there is often a larger proportion of the population depending on livestock in these countries. At the same time, the emergence of infectious diseases in livestock, including zoonoses, may be a severe threat to livestock and public health globally. To stop the spread of infectious agents from infected to susceptible animals or prevent the introduction of infected animals into a herd, region, or country in which the infection has not yet occurred are the cornerstones of biosecurity [8]. Biosecurity also includes the exclusion, eradication, and effective management of risks posed by diseases to the economy, environment and human health [9]. The biomedical concepts of disease prevention and biosecurity applied to industrially raised poultry should not differ from those applied to smallholder farms. However, in certain circumstances the concepts appear to be inapplicable for social and economic reasons. This is often the case in smallholder's farms in developing countries. In practice, the implementation of biosecurity measures needs to consider the pathogenic agents involved and the production practices of the farming system at risk. In the context of avian flu for instance, the more complex the production and marketing chain, the harder it seems to be to control and eradicate the disease [10]. Biosecurity measures have been developed mostly for large scale commercial poultry production. In smallholder backyard and free ranging poultry systems in general, there are only a limited number of scientific publications related to poultry health, and few scientific studies deal with the implementation of biosecurity.

The objective of this work was to analyse the biosecurity measures that have been implemented during outbreaks of Highly Pathogenic Avian Influenza (HPAI) in developing countries in general, and in Africa in particular.

2. Methodology

To prepare this synthesis article, both quantitative and qualitative information which were basically based on secondary sources were used. Desk research was done by analysing data from journal articles, workshop and seminar papers. During the outbreaks of avian influenza in the past, the implementation of some of the biosecurity measures challenged with the realities of some developing countries in general, and Africa in particular. In this paper, we discussed about these biosecurity measures and presented the most suitable control strategy for developing countries.

3. Small Scale Poultry

In developing countries the greater part of animal production is ensured by smallholder farmers [11,12]. Poultry farming is an important part of the daily life of the rural population, especially for rural farmers, who raise local poultry for several purposes, such as to supply meat and eggs and generate income [13]. Chickens are also commonly used in Africa for gifts and sacrifices in social rites [14,15]. The poultry business can be characterized by two main production systems:

The family poultry system, which is widespread in rural, urban and peri-urban areas, is practiced mainly by resource-poor people and is based on indigenous breeds with poor production performances. These breeds are characterized by a genetic diversity allowing them to adapt to harsh environmental conditions as well as to resist to diseases [16]. Indeed, it was proven that increasing genetic diversity increases also the time elapsed for a pathogen agent to reach the peak of a major epidemic [17]. Family poultry system is a free-range production system in which birds of different species and from multiple households often mingle to scavenge together in order to find most of their feed constituted mainly by materials from the environment and household leftovers [15,18,19,20,21]. The system requires minimal investment to maintain [22] and therefore is important and widely distributed among smallholder farms. It has been estimated that 70% of poultry population in Africa is found in family production systems [12].

The mid-size commercial poultry system is practiced in peri-urban areas, with imported highly selected birds reared under relatively intensive conditions for eggs or meat production [23,24]. These production units in peri-urban areas belong generally to wealthy entrepreneurs living in the cities.

Poultry appear to be a class of small livestock that resource-poor people can afford, including disadvantaged social groups such as women and the landless, and therefore is one of the most important sustainable sources of income and capital accumulation available to the poor [25,26,27]. Moreover, small scale rural poultry is an excellent tool in poverty alleviation as well as promoting gender issues, due to their quick turnover and low investment requirement [28].

However, small scale poultry production is still facing constraints. Indeed, the lack of basic disease control measures associated with poor nutrition and housing management contribute to lower the productivity of smallholder poultry compared with large scale commercial poultry production [29,30,31]. In developing countries, there is a general agreement that the major direct and indirect constraint to the expansion of chicken production by village farmers is the viral Newcastle disease [32,33]. Apart from the control of this disease, little work has been done related to diseases. In the recent years the extensive poultry production has been severely affected by the avian influenza epizootic.

4. Overview of Avian Influenza Epidemiology

There are many controversies about the source of the AI virus. All known influenza A virus subtypes have been detected in wild birds and poultry [34,35,36]. Aquatic birds (ducks, geese, swans, gulls, terns) and shorebirds are considered to constitute the major natural reservoir for avian influenza [37,38]. It appears that all poultry sectors, wild birds, human movement, equipments and live bird markets are all culpable for the spread of the infection [39,40] (Figure 1).

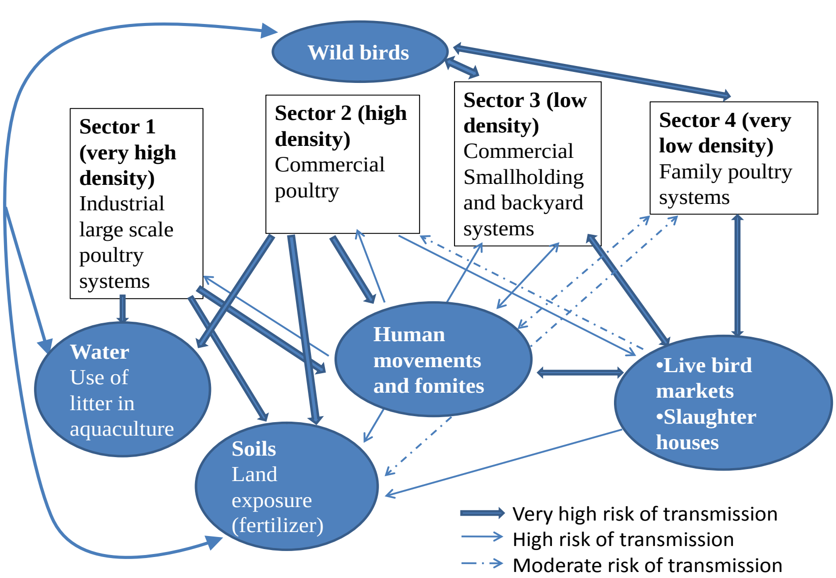

Figure 1. Epidemiology of avian influenza in different poultry farming sectors (Sources: Analysed data from different authors [8,39,40,41,42,43])

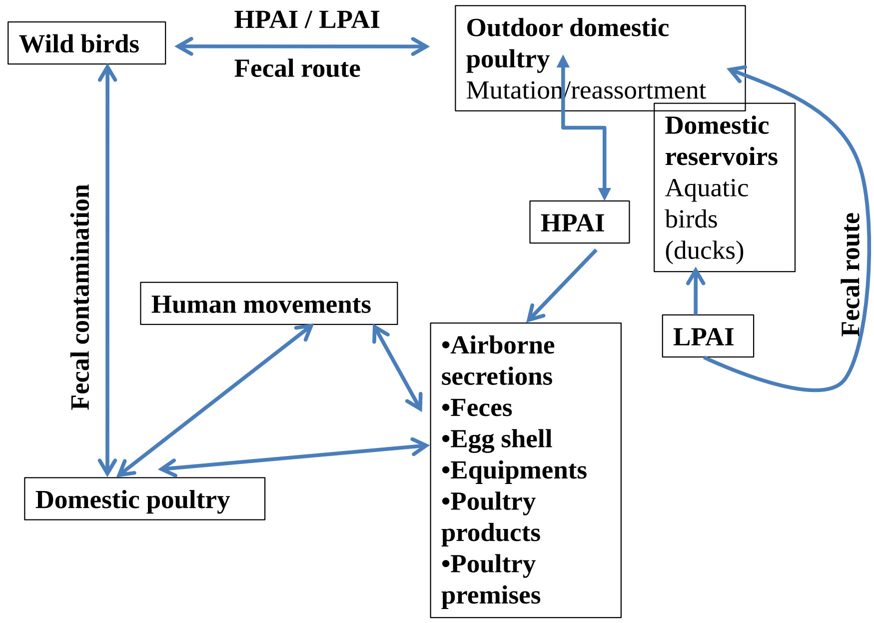

Figure 2. Transmission routes of avian influenza (Sources: Analysed data from authors [37,38,39,45,48])

The clinical manifestations in birds are variable; the most common characteristic is respiratory signs or rapid death [44], chickens and turkeys being the most sensitive [42]. The virus is excreted from infected birds through faeces and secretions from the nose, mouth, and eyes. The AI is spread primarily by direct contact between healthy and infected birds and by indirect contact with contaminated equipment and materials. Wild aquatic birds are the primary natural reservoir for the low pathogenic avian influenza (LPAI) viruses and often introduce LPAI into domestic flocks raised in backyard or in free-ranging systems through faecal contamination [45]. Within a poultry house, transfer of the highly pathogenic avian influenza (HPAI) virus between birds can also occur via airborne secretions. The spread of avian influenza between poultry premises often follows the movement of infected people and equipment. AI also can be found on the outer surfaces of egg shells, movement of eggs is therefore a potential means of AI transmission. Further, the amounts of viruses present in the environment influence the probability of transmission to new hosts [46] (Figure 2). Increased occurrence of HPAI was recorded, especially in South East Asia where the disease seems to have become endemic and its eradication has not yet been achieved. This allowed its spread to other continents both by poultry trade and possibly by migratory birds. The H5N1 HPAI has spread from Asia to Russia to Europe and to Africa [47].

The Influenza A virus of avian origin has been implicated in outbreaks of influenza in other hosts [49,50]. The viruses are variable genetically and new strains can be developed easily through mutations and reassortments [51]. Most human infections with HPAI H5N1 have occurred after exposure [52] to infected poultry, such as in live bird markets [39] or in the poultry industries, rather than to wild birds [53]. The ability of HPAI H5N1 to infect a variety of cell types means that humans can be infected through the faecal-oral as well as the respiratory routes. Ingestion of undercooked or raw poultry products has therefore been suggested as a possible route of transmission [54].

Finally, it was proposed that a vast influenza virus gene pool for future epidemics in other animal species, including human pandemics, exists in avian species [36], this view raises the issue about the biosecurity in avian production also for the improved safety of human and other animals.

5. Avian Influenza and Biosecurity

Most biosecurity measures are developed for large-scale commercial poultry production systems. In 1992 the European Union adopted a non-vaccination policy for the control of certain infectious livestock-diseases based on the stamping-out principle [55]. That control strategy includes movement restrictions followed by the culling of all infected and healthy but susceptible animals near the source (s) of the infection. The main idea behind this non-vaccination policy was to facilitate free market trade of animal products between countries who adopt the same policy. Furthermore, economic analysis in Europe showed a higher efficiency of controlling an epidemic by this way compared with preventive vaccination [56]. Therefore, during the epizooty of avian influenza in Asia, Europe and Africa, millions of poultry were culled in order to stop the spread of the disease [47]. However, despite the enforcement of massive depopulation measures, it seems that in some areas influenza viruses may persist undetected in domestic reservoirs or potentially in wild birds and can re-emerge after repopulation of the same area. Obviously, this implies that frequent incursion of AI viruses in densily poultry population areas compromise poultry production in these areas [51]. Furthermore, controlling disease outbreaks by only stamping out and culling policy was found to generate social-ethical and animal welfare problems in the EU [57,58] as well as livelihood and food security problems in developing countries [12,59,60]. This highlights the necessity to balance this control strategy against the trading advantages of rapid eradication and the possible advantages of alternative control strategy. Such an alternative strategy is to combine stamping out and pre-emptive culling with other biosecurity measures such as vaccination [61]. This can allow the rapid eradication of the disease at acceptable cost for both the producers and the public in a high-risk area, as was seen in the control of H5N1 HPAI in Hong Kong [62]. The successful Hong Kong experience, compared with the other infected countries, on the control of H5N1 demonstrated that different approaches to control can be effective. It also gave information on the extent of the measures required to ensure freedom from infection in a high-risk area, and it clearly highlighted that there is no “one size fits all”.

Family poultry farms are widespread in the developing world (backyard and free-ranging system in Africa and Asia) and do also exist in the developed world. In the context of controlling avian influenza, a rapid detection in farms is crucial. This might however be difficult in Asian and African small scale poultry farms. The reasons are multiples, but one can cite the lack of awareness of disease occurrence and definitely the tendency to neglect mild primary signs of disease. In developing countries in general poultry easily come in close contact with wild birds, and basic biosecurity measures still need to be strengthened. Consequently, outdoor poultry were indexed to be the main problem in controlling the spread of AI [42]. However, given the genetic diversity in these birds which may slow down the spread of the virus this assumption can be challenged. Indeed, in some developing countries such as Burkina Faso, Niger, and Côte d’Ivoire, outbreaks localized to some free-ranging poultry systems did not show further expansion and no human cases has been recorded (Table 1) [63]. Likewise, it was reported that in Malaysia, the mortality rate from HPAI among village chickens was only 5% (Press Release from GRAIN in 2006), implying that the virus might have a hard time spreading among small scale poultry farms.

Despite the culling of hundreds of millions of poultry and the application of increasingly strict biosecurity measures, such as bans on outdoor poultry keeping, movement control of poultry and poultry products, these control methods seem not to have been completely successful and HPAI H5N1 outbreaks continue to be reported. Therefore, some countries (Hong Kong, Vietnam, China, etc.) decided to adopt a culling plus vaccination combined strategy to fight the avian influenza [62].

Most vaccine studies involving the protection of birds against both LPAI and HPAI viruses have been performed in chickens, and to a lesser extent in turkey and ducks [61,64,65,66]. According to authors [67] and [45], a vaccination can be used in three different ways as part of an AI control strategy: 1) prophylactic or preventive vaccination, 2) emergency (at outbreak) vaccination and 3) endemic (routine) vaccination. If properly administered the vaccination against AI seems to, increases the resistance to virus exposure, reduces virus shedding levels and reduces the risk of transmission [47]. Even though this contributes to controlling the disease, viral circulation may still occur in a clinically healthy vaccinated population, and this may lead to an endemic situation. To minimize this risk, a system for DIVA differentiating infected from vaccinated animals (DIVA) was elaborated to enable the detection of field exposure in a vaccinated population. This system has been successfully used in the eradication of the disease without involving mass culling of birds [51]. The principle of this DIVA system is to use a vaccine containing a virus of the same haemagglutinin (H) subtype but a different neuraminidase (N) from the prevailing field virus. Vaccinated and field-exposed birds will be then differentiated using a serological test to detect specific anti-N antibodies. However, the DIVA strategy seem to be of limited use if a new field virus emerges that has a different N antigen to the existing field virus or if subtypes with different N or H antigens are already circulating in the field [68].

Following the multiples outbreaks of AI in many farm flocks in more than 20 provinces of China, the Chinese government decided to use a culling plus vaccination combined strategy to control the infection [69]. This strategy in China had increased the protection of poultry from H5N1 virus infection, had reduced the virus load in the environment and had prevented the virus transmission from poultry to humans.

After many outbreaks of HPAI in smallholder poultry farms in Vietnam a study was conducted to evaluate the effect of vaccination on the occurrence of AI in different management systems [70]. Regardless of farming system, it was concluded that at least 2 vaccinations per year, in combination with good feeding management, reduction of visitors to the farms, avoiding scavenging together with ducks from other farms as well as keeping ducks with chickens in the same farm, were necessary to reduce the risk of an outbreak.

Collectively the experiences in China and Vietnam supported the use of vaccination in poultry as a way to reduce the transmission of the virus from poultry to humans.

6. Avian Influenza and the Biosecurity Measures Implemented in Outdoor Poultry Systems in Africa and Asia

The primary introduction of the HP H5N1 virus in Africa occurred in Nigeria in February 2006 and in total 11 African countries were affected [71,72] as presented in Table 1 and Figure 3.

Table 1. Situation of H5N1 in Africa

Countries affected in Africa	Poultry sector concerned	Human cases
Egypt	Commercial and village farms	94
Nigeria	Commercial farms	1
Djibouti	Commercial farms	1
Soudan	Commercial farms	0
Benin	Commercial farms	0
Togo	Commercial farms	0
Ghana	Commercial and village farms	0
Burkina Faso	Village farms	0
Cameroun	Village farms	0
Côte d’Ivoire	Village farms	0
Niger	Village farms	0

Source: [63,72].

Figure 3. African countries that have been infected by avian influenza (Source: [63,72])

The origin of the disease remained unknown. This was because of the difficulty to control the movements of poultry and poultry products which in turn was due to poor epidemiologic means, as reported by many studies in the continent [3,5]. In Niger, for instance, it took a month from the discovery of the outbreak of avian flu to start the culling of poultry in all infected areas [73]. In addition, the lack of awareness among farmers was a big challenge. The trade and other poultry movements between countries seem to have played a major role in the transmission of the disease. The role of migratory wild birds in the disease transmission was not proven, despite the multiple studies in the main gathering places of migratory birds [63]. Only one case of HPAI was found in a wild duck in Cameroun. Following the outbreak, biosecurity measures as described above were implemented in affected as well as in unaffected areas of infected countries:

In areas which were not affected, the measures concerned the ban on import of poultry or poultry products, movement control of live birds, the establishment of early warning systems and the re-evaluation of diseases prevention strategies. In affected areas, the main biosecurity measures implemented by the authorities was the stamping out and at large the internationally recommended disease control principles according to the Terrestrial Animal Code [74] (Table 2). In addition, vaccination was applied in the commercial poultry sector in Cote d'Ivoire and Egypt [71,75], education campaigns and socio-economic management of eradication have also been undertaken. However, the implementation of these measures was challenged with some realities of developing countries.

Table 2. The basic principles of avian influenza prevention and control

Prevention goal	Methods used
Early detection	Surveillance of the flock
Rapid response	Killing infected and susceptible animals
Stop infection spreading	• Avoiding possible contact with wildlife (ban on outdoor poultry keeping during high risk period). • Movement control of poultry/products • Cleaning • Disinfection • Vaccination

Source: [41,76]

For example in Burkina Faso the authorities required the villagers to prevent their birds from roaming freely by keeping them confined [24]. However, smallholders were not capable of respecting these instructions because of their limited resources to feed birds in confinement. In Nigeria it was reported that some poor poultry owners were hiding their birds from official culling teams as compensation was found to be inadequate, in addition to the fact that it did not compensate for future loss of earnings. Some villagers were also arrested for eating killed birds retrieved from disposal pits [73]. Similarly, in rural Africa, as was shown by author [77], traditionally, households slaughter and consume birds when signs of illness appear in backyard flocks, and this practice is difficult to change. In rural areas, surveillance for avian diseases is non-existent, nutrition of the birds is poor and high mortality is common, increasing the likelihood that outbreaks of H5N1 will be missed. Given such situation, poultry health programs will increase their odds of success by involving local leaders and by addressing the current challenges facing the farmers, [15].

In Asia measures against avian influenza included market closures and bans on outdoor poultry keeping [62]. A comparison study between Thailand and Vietnam shows the difference in poverty risk between the two countries, following the implementation of these bans. In Thailand, where the poor smallholders are responsible for less than 25 % of the poultry production and marketing, the poverty risk was lower compared to Vietnam, where poor smallholders account for about 2/3 of the production and 50% of the direct marketing [60]. Similarly, the effect of avian flu infection and eradication on household income losses was estimated in Ghana by computer models (Pro-poor HPAI Risk Reduction). It was found that infection and eradication would generate a total of 46% losses in overall income from poultry. The population group that would be most strongly affected was found to be the poorest households. Therefore, if the poor are highly represented in a country's poultry production, any national strategy for intervention in the poultry sector should consider carefully the welfare of the poor farmers. In West Africa in general, not only the poor farmers will suffer economically, but also other parts of the society, since only the indigenous chicken breeds are used in several rituals and sacrifices.

Because of the actual and potential human health implications related to HPAI infection, international human and animal health organisations as well as scientific community consider HPAI as a major threat to public health [53,76]. Nevertheless, to reduce HPAI risks to humans without any adverse effect on the poor or the whole society, the policy maker will need more effective means to identify local outbreaks and contain them. Indeed local communities are sometimes well aware of local outbreaks and infections but the reporting processes are strangled by lack of incentive [60]. A study in Vietnam [59] showed that inadequate reporting and reaction to the disease might have led to a future endemic situation in smallholder systems, and this highlighted the incentive need.

7. Conclusion

The establishment of efficient biosecurity measure in developing countries with respect to avian influenza should consider the resources available to combat the disease. Measures based on non-vaccination, culling and bans on outdoor poultry keeping seem to have been set up mainly to meet global market requirements. However, several resources poor nations, in particular Sub-Saharan countries often have no or few animal products to export due to low quality feed resources and management, the occurrence of animal diseases, and lack of technology to meet global market requirements. Further, these policies have been found to generate social-ethical problems in the developed world as well as livelihood and food security issues in the developing world. Considering that it is likely that the HPAI virus evolves slowly in low density extensive chicken systems, as well as in migratory birds, and therefore is likely to kill them instead of being spread highly in the environment and subsequently to humans, the stamping out method could indeed be challenged. It is therefore suggested that AI prevention measures in Africa should be part of an integrated programme dealing with the common problems faced by the farmer such as Newcastle disease and other diseases, in addition to feeding problems. In such a programme, culling should be replaced by vaccination in the biosecurity measures.

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