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Avian influenza transmission risks: Analysis of biosecurity measures and contact structure in Dutch poultry farming

A. Ssematimba[a,b,*], T.J. Hagenaars[a], J.J. de Wit[c], F. Ruiterkamp[c], T.H. Fabri[c], J.A. Stegeman[d], M.C.M. de Jong[b]

[a] Department of Epidemiology, Crisis Organization and Diagnostics, Central Veterinary Institute (CVI) Part of Wageningen University and Research Centre, P.O. Box 65, 8200 AB Lelystad, The Netherlands
[b] Quantitative Veterinary Epidemiology, Department of Animal Sciences, Wageningen University, P.O. Box 338, 6700 AH Wageningen, The Netherlands
[c] Animal Health Service (AHS), P.O. Box 9, 7400 AA Deventer, The Netherlands
[d] Department of Farm Animal Health, Faculty of Veterinary Medicine, Utrecht University, Yalelaan 7, 3584 CL Utrecht, The Netherlands

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ABSTRACT

In the 2003 epidemic of highly pathogenic avian influenza in Dutch poultry, between-farm virus transmission continued for considerable time despite control measures. Gaining more insight into the mechanisms of this spread is necessary for the possible development of better control strategies. We carried out an in-depth interview study aiming to systematically explore all the poultry production activities to identify the activities that could potentially be related to virus introduction and transmission. One of the between-farm contact risks that were identified is the movement of birds between farms during thinning with violations of on-farm biosecurity protocols. In addition, several other risky management practices, risky visitor behaviours and biosecurity breaches were identified. They include human and fomite contacts that occurred without observing biosecurity protocols, poor waste management practices, presence of other animal species on poultry farms, and poor biosecurity against risks from farm neighbourhood activities. Among the detailed practices identified, taking cell phones and jewellery into poultry houses, not observing shower-in protocols and the exchange of unclean farm equipment were common. Also, sometimes certain protocols or biosecurity facilities were lacking. We also asked the interviewed farmers about their perception of transmission risks and found that they had divergent opinions about the visitor- and neighbourhood-associated risks. We performed a qualitative assessment of contact risks (as transmission pathways) based on contact type, corresponding biosecurity practices, and contact frequency. This assessment suggests that the most risky contact types are bird movements during thinning and restocking, most human movements accessing poultry houses and proximity to other poultry farms. The overall risk posed by persons and equipment accessing storage rooms and the premises-only contacts was considered to be medium. Most of the exposure risks are considered to be similar for layer and broiler farms. Our results, including those on farmer opinions, are relevant for the communication with farmers and poultry-related businesses about practices and risks. We conclude by providing recommendations for improvement of control strategies.

* Corresponding author at: Department of Epidemiology, Crisis Organization and Diagnostics, Central Veterinary Institute (CVI) Part of Wageningen University and Research Centre, P.O. Box 65, 8200 AB Lelystad, The Netherlands. Tel.: +31 320238852; fax: +31 320238961.
E-mail address: amos.ssematimba@wur.nl (A. Ssematimba).

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1. Introduction

The poultry industry makes a significant contribution to the Dutch national economy. For example, in 2011, the average broiler population was more than 45 million birds, the laying hen population was close to 33 million birds and close to 900,000 tonnes of poultry meat and close to 10 billion eggs and egg products were exported (PVE, 2012). The profitability of this industry was severely affected by the occurrence in 2003 of an H7N7 highly pathogenic avian influenza (HPAI) virus epidemic. In addition, this epidemic presented a risk to human health, both through transmission of the circulating virus to humans and through its assumed potential to seed the development of a new pandemic influenza strain (Koopmans et al., 2004). The epidemic comprised 255 outbreak farms, 30 million birds were culled (Stegeman et al., 2004) and 89 people were infected, one of whom died (Koopmans et al., 2004). The direct costs as a result of bird deaths and depopulation amounted to €250 million, while indirect costs due to the epidemic were much higher (Tacken et al., 2003; Meuwissen et al., 2006).

Although, after diagnosis of the first cases of the epidemic, movement bans and other control measures were put in place, a continued spread of the virus was observed. In spite of the culling of contiguous flocks, i.e., flocks that were in the neighbourhood of the outbreaks or that had had contact with an infected farm, this spread continued for weeks in particular in the high poultry density areas (Stegeman et al., 2004). The transmission pattern during the epidemic indicates the presence of (untraced) indirect transmission routes or mechanisms that are not controlled by the European Commission's strategies. Hence in order to possibly improve control strategies, a better understanding of indirect transmission mechanisms is needed.

AI viruses may be introduced into poultry from reservoirs such as aquatic wild birds (Webster et al., 1992; Alexander, 2000, 2007; de Jong et al., 2009) but the mechanisms of their subsequent spread are partially unclear. Transmission of the virus through movements of humans (visitors, servicemen and farm personnel), vectors (wild birds, rodents, insects), air- (and dust-) related routes and other fomites (e.g., delivery trucks, visitors' clothes and farm equipment) have all been hypothesized (Halvorson et al., 1980; Webster et al., 1992; Sawabe et al., 2006; Sievert et al., 2006; Ssematimba et al., 2012a,b).

It is therefore hypothesized that the risk of introducing the virus to a farm is determined by the farm's neighbourhood characteristics, contact structure and its biosecurity practices. On the one hand, neighbourhood characteristics include factors such as the presence of water bodies (accessed by wild birds), the density of poultry farms (together with the number and type of birds on these farms) and poultry-related businesses and the road network. The use of manure in the farm's vicinity is also deemed to be risky (Alexander, 2000, 2007; Swayne and Suarez, 2000; Thomas et al., 2005). On the other hand, contact structure risk factors include the nature and frequency of farm visits. Therefore, a detailed analysis of the contact structure, including neighbourhood risks, and biosecurity practices across different types of poultry farms and poultry-related businesses could help the improvement of intervention strategies, biosecurity protocols and adherence to these, as well as contact tracing protocols. Farmers' perception of visitor- and neighbourhood-associated risks of virus spread is also important due to its relevance to adherence with biosecurity protocols, to contact tracing and to communicating advice to them.

The between-farm virus transmission risks may be split into two categories namely, introduction and onward-spread risks. The former entail the target farm's exposure through incoming contacts (human and fomite), through inputs such as feed and egg trays and through neighbourhood-related risks such as air-borne contamination. The latter can be through farm outputs (waste and non-waste), outgoing contacts (human and fomite) and contamination of the neighbourhood (e.g., through emissions from the farm). Therefore, we systematically analysed all day-to-day farm activities involving people and/or materials and/or equipment going in or out of the farm.

Through questionnaire-guided in-depth interviews, we sought information directly from the farmers and the poultry-related businesses. These interviews were aimed at gathering first-hand information about all the visits and processes involved and the accompanying biosecurity practices throughout the production round and across all poultry husbandry types. Other aspects of interest were the details about the farm's neighbourhood which are important in relation to indirect transmission risks. In the interviews, we aimed to learn more about possible risks in practice corresponding to the indirect contact types that are commonly hypothesized and/or that can be found in the tracing reports of the H7N7 epidemic in 2003 and any further possible indirect contact types, in particular those that could provide a pathway for the untraced outbreaks (or 'neighbourhood infections').

Based on the gathered information, we generated a list of contact types that could serve as avian influenza (AI) transmission pathways. For these contact types, we then performed a qualitative risk assessment based on contact type, their corresponding biosecurity practices and contact frequency to ascertain which mechanisms are the most important to target during prevention and control.

2. Materials and methods

2.1. Study population

A cross-sectional study was performed with the aim of obtaining information on the types and frequency of the various day-to-day farm contacts and activities that can guide the determination of potential pathways of AI spread between poultry farms. The study involved 42 farmers and 18 poultry-related business representatives distributed all over The Netherlands. The stratum-specific sample sizes for the farms/firms to be interviewed were determined based on the underlying goal of making sure that all relevant types in the poultry chains were included. By sampling more farms from those strata representing a higher population proportion an attempt was being made to capture any between-farm variation in biosecurity practices present.