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HPAI PRO-POOR HPAI RISK REDUCTION

Qualitative Risk Assessment of HPAI H5N1 Transmission between Small-Scale Commercial Broiler Chicken Farms in Bogor, Indonesia

Syafrison Idris
Maria Fatima Palupi
Elly Sudiana
Fred Unger

Reviewed by:
S. Costard and D. Pfeiffer

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Preface

Since its re-emergence, highly pathogenic avian influenza (HPAI) H5N1 has attracted considerable public and media attention because the viruses involved have been shown to be capable of producing fatal disease in humans. While there is fear that the virus may mutate into a strain capable of sustained human-to-human transmission, the greatest impact to date has been on the highly diverse poultry industries in affected countries. In response to this, HPAI control measures have so far focused on implementing prevention and eradication measures in poultry populations, with more than 175 million birds culled in Southeast Asia alone.

Until now, significantly less emphasis has been placed on assessing the efficacy of risk reduction measures, including their effects on the livelihoods of smallholder farmers and their families. In order to improve local and global capacity for evidence-based decision making on the control of HPAI (and other diseases with epidemic potential), which inevitably has major social and economic impacts, the UK Department for International Development (DFID) has agreed to fund a collaborative, multidisciplinary HPAI research project for Southeast Asia and Africa.

The specific purpose of the project is to aid decision makers in developing evidence-based, pro-poor HPAI control measures at national and international levels. These control measures should not only be cost-effective and efficient in reducing disease risk, but also protect and enhance livelihoods, particularly those of smallholder producers in developing countries, who are and will remain the majority of livestock producers in these countries for some time to come.

Authors and reviewers

Syafrison Idris, Maria Fatima Palupi and Elly Sudiana work at the Directorate General of Livestock Services (DGLS), Jakarta, Indonesia; Fred Unger is Veterinary Epidemiologist and Scientist at International Livestock Research Institute (ILRI) posted in Bangkok, Thailand.

Solenne Costard works jointly for the Royal Veterinary College (RVC), London, United Kingdom and ILRI, Nairobi, Kenya; Dirk Pfeiffer is co-head of the Veterinary Epidemiology and Public Health Group at RVC, London, United Kingdom.

Disclaimer

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More information

For more information about the project please refer to www.hpai-research.net.

Abbreviations

CTS	Contractor Technical Services
DFID	Department for International Development
DGLS	Directorate General of Livestock Services
DLS	District Livestock Services
DOC	Day-old chicks
EFSA	European Food Safety Authority
EOE	Expert Opinion Elicitation
FAO	Food and Agriculture Organization of the United Nations
FTS	Feed Technical Services
GOPAN	Federation of Non-industrial Commercial Poultry Producer Organizations (*Gabungan Organisasi Peternakan Ayam Nasional)*
HPAI	Highly pathogenic avian influenza
HPAIV	Highly pathogenic avian influenza virus
IBD	Infectious bursal disease
IDP	Indonesian Dutch Partnership Program
IDP-CIVAS	Indonesian Dutch Partnership Program – Centre for Indonesia Veterinary Analytical Study
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
LBM	Live-bird market
NSWP	National Strategic Work Plan
OIE	World Organization for Animal Health (formerly *Office Internationale des Epizooties*)
OR	Operational Research Project
PDSR	Participatory Disease Surveillance and Response Project
PTS	Pharmaceuticals Technical Services
RVC	Royal Veterinary College

Glossary and definitions

With the exception of production sector categories all listed definition are based on the World Organization for Animal Health (OIE) Handbook on import risk analysis for animals and animal products (Murray et al. 2004).

Consequence assessment: The process of describing the relationship between specified exposures to a biological agent and the consequences of these exposures. A causal process must exist by which exposures produce adverse health or environmental consequences which may in turn lead to socio-economic consequences. The consequence assessment describes the consequences of a given exposure and estimates the probability of them occurring. Consequence in the context of this study determines the risk of transmission of HPAI H5N1 virus within flock and spread beyond the flock following the exposure of a small-scale commercial broiler chicken farm to the disease.

Exposure*:* The condition of being subjected to a source of risk.

Exposure assessment: The process of describing the biological pathway(s) necessary for exposure of animals and humans in the importing country to the hazard (in this case the pathogenic agent) released from a given risk source, and estimating the probability of the exposure(s) occurring, either qualitatively or quantitatively. Exposure assessment in the context of this study assesses biological pathways that will lead to the exposure of a small-scale commercial broiler chicken farm to HPAI H5N1 virus released by an infected small-scale commercial broiler chicken farm, and that this exposure results in the infection of at least one chicken on the farm.

Fomite*:* A fomite is any inanimate object or substance capable of absorbing, retaining, and transporting contagious or infectious organisms (from germs to parasites) from one individual to another.

Hazard: Any pathogenic agent that could produce adverse consequences. Hazard in the context of this study is a pathogenic agent Highly Pathogenic Avian Influenza Virus (HPAIV) H5N1.

Production sectors *(poultry)* (FAO, 2004): Poultry production sectors can be described according to production and marketing systems:

- Industrial integrated system with high-level biosecurity and birds/products marketed commercially (Sector 1)
- Commercial non-integrated poultry production system; moderate to high biosecurity; birds and products marketed commercially (Sector 2)
- Commercial poultry production system; minimum biosecurity; birds/products in live-bird markets (Sector 3)
- Village or backyard production --- no biosecurity, informal marketing system (Sector 4)

Qualitative risk assessment: An assessment where the likelihood of occurrence of the outcome or the magnitude of the consequence are expressed in qualitative terms such as high, medium, low or negligible.

Release assessment: The process of describing the biological pathway(s) necessary for an importation activity to “release” (that is, introduce) pathogenic agents into a particular environment, and estimating the probability, either qualitatively or quantitatively, of that complete process occurring. Release in the context of this study assesses all the biological pathways that will lead to the release of HPAIV H5N1 from an infected small-scale commercial broiler chicken farm.

Risk: The likelihood of the occurrence and the likely magnitude of the consequences of an adverse event to animal or human health in the importing country during a specified time period. Risk in the context of this study is likelihood of an H5N1 outbreak and the likely magnitude of the consequence of an outbreak to poultry in the exposed small-scale commercial broiler chicken farm during a year.

Risk estimation: The process of integrating the results from the release assessment, exposure assessment, and consequence assessment to produce overall measures of the risk(s) associated with the hazards identified at the outset.

Risk assessment: The evaluation of the likelihood and the biological and economic consequences of entry, establishment, or spread of a pathogenic agent within the territory of an importing country.

Uncertainty: The lack of precise knowledge of the input values which is due to measurement error or to lack of knowledge of the steps required, and the pathways from hazard to risk, when building the scenario being assessed.

Executive summary

As part of the DFID-funded Pro-Poor HPAI Risk Reduction Project, a qualitative risk assessment was conducted for risk questions agreed during a stakeholder workshop in November, 2008, related to transmission of HPAI H5N1 between small-scale commercial broiler farms in the District and Municipality of Bogor.

The principal risk questions were:

> **Risk question 1: Release assessment**: What is the risk of HPAIV H5N1 from an infected small-scale broiler farm?
>
> **Risk question 2: Exposure assessment:** What is the risk that another small-scale broiler farm gets exposed to HPAIV H5N1 released by the infected small-scale broiler farm, and that this exposure results in the infection of at least 1 chicken on the farm?
>
> **Risk question 3: Consequence/transmission assessment:** What would be the consequence of such infection (within herd spread and spread beyond the herd, economic consequence)?

Methodology

For the present qualitative risk assessment, the OIE framework was followed. With respect to the identified risk questions, the risk assessment team together with the workshop participants identified the risk pathways and data needs and sources for each step of the pathways.

Data for the parameters were obtained from available information (peer-reviewed and grey literature, results from studies conducted in West Java in recent years), expert opinion elicitation and interviews with key informants in the poultry sector. Expert opinion was collected through paper questionnaires distributed to the experts identified during the stakeholder workshop held at the beginning of the study.

To qualitatively estimate the risks associated with each pathway, the risk assessment team applied six probability categories, adapted from the 2006 European Food Safety Authority's (EFSA) HPAI risk assessment report: Negligible, Very Low, Low, Medium, High and Very High. The level of uncertainty was also indicated in each step of a pathway using the following three categories: Low, Medium and High. For each biological pathway, a risk estimate was obtained by combining risk categories according to a pre-defined combination matrix.

Result and discussion

The overall risk of transmission was assessed as low, and risk estimates for the different pathways range from negligible to low. The risk associated with movement of contaminated visitor and equipment exchange was assessed as the highest. The risk of transmission via free-ranging poultry and wild birds was assessed negligible to very low, while via other pathways was assessed as negligible. It is important to note that the risk was estimated low because of a conditional probability effect (risk of infection/prevalence of HPAI H5N1 in small-scale broiler farm when data were collected was low). However, there are many steps/mechanisms of transmission associated

with higher risk. It is highlighted that increasing prevalence of HPAI H5N1 in broiler farms will lead to increasing of risk of transmission.

All risk estimates, except the one considering transmission via manure, were associated with a high uncertainty because of the lack of data on both the poultry sector in Indonesia and the epidemiology of HPAIV H5N1 more generally.

Recommendations

Critical control points were identified, for which actions to be taken to reduce the risks of introduction, subsequent exposure of poultry populations and transmission of HPAIV H5N1 between small-scale broiler farms are suggested below:

Visitors

- Farmers should be introduced to biosecurity practices such as encouraging and enforcing visitors to use clean protective clothing and boots while handling birds, washing hands well before and after work, and not allowing any unauthorized visitors.
- Farmers should also make sure that there are footbaths, and that they provide adequate facilities to staff and visitors for cleaning and disinfection: sinks with soap/disinfectant, clean overalls and boots, etc.
- Pharmaceuticals Technical Services (PTS), Feed Technical Services (FTS) and Contractor Technical Services (CTS) should be trained on safe handling of poultry and provided with sufficient protective clothing to always be used within the farm.
- Farmers should be encouraged to harvest all broilers from a farm in a same day.

Equipment

- Risk could be lowered if all relevant equipment undergoes appropriate cleaning and disinfection every time after use. Since collectors seem to have little incentive to adopt such practices, they are less likely to implement proper cleaning and disinfection of transported cages. Cleaning and disinfection of transported cages should be done at the farm gate, before harvesting birds. The expense, however, may be imposed on the farmer. Farmers would need to be convinced that clean equipment is important to produce healthy poultry and that it is beneficial for them.
- Vaccinators and farmers should be trained on safe handling of vaccination equipment, which should always be cleaned and disinfected before and after being used.

Free range poultry and wild birds

- Disease could reduced by improving the construction of housing to further restrict access of free-range poultry, wild birds and farm bridge species to broilers.

Further observation

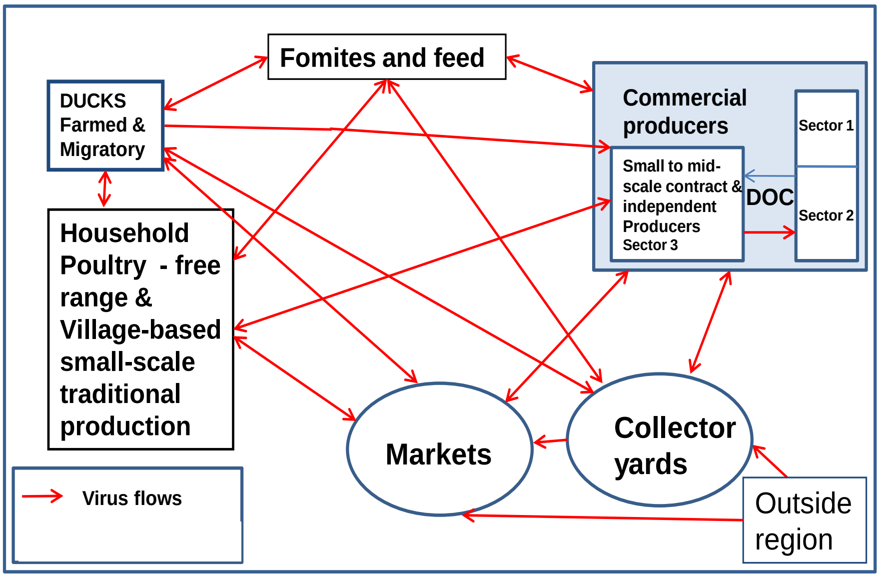
- Risk of disease spreading could be reduced by enhancing the compulsory reporting of contagious disease to veterinary authorities and by implementing containment measures such as bans on poultry sales and movements when disease is suspected. Veterinary authorities will need to provide sufficient compensation to encourage farmers to report any observed or suspected cases of contagious diseases.
- Improve detection and response capacities within veterinary authorities, particularly as they relate to small-scale commercial broiler farms.

1 Introduction

1.1 Context

Highly pathogenic avian influenza (HPAI) subtype H5N1 was first reported in Indonesia in 2004. Considered to be endemic in many parts of the country, it remains a large and complex problem affecting all poultry production sectors. The current hypothesis about maintenance of HPAI virus (**HPAIV**) infection among the poultry population in Indonesia is that a continuous circulation of HPAIV takes place involving all poultry sectors and market chains as an “infection cycle”. This hypothesis has been described by the Expert Team in the document “National Strategic Work Plan for the Progressive Control of HPAI in Animal 2009 – 2011” (NSWP) as described in Figure 1.

Figure 1: Infection cycle among poultry sectors and market chains in Indonesia (DGLS 2008).



The role of small-scale commercial (sector 3) and backyard (sector 4) poultry farms is considered to be very important in maintaining the circulation of HPAIV. Because of the absence of or minimal biosecurity measures applied in these sectors in Indonesia, they are likely to be exposed to HPAIV and to allow its spread, contributing to constant re-infection in these sectors and spread to others and creating the “infection cycle” of HPAI. In addition, many sector 3 poultry farms are surrounded by sector 4 farms, consequently both sectors influence each other in disease spread, including HPAI.

There is a need to improve biosecurity in sector 3 and 4 poultry farms. Approaches for targeting efforts better in terms of feasibility and concentrating limited resources are currently under discussion among stakeholders. Therefore, a better understanding of the mechanisms of virus introduction into farms and transmission of virus infection between sector 3 and 4 poultry farms is urgently needed to inform recommendations for targeting. One objective of the Pro-Poor HPAI Risk Reduction Project is to characterize HPAI risk and its impact on the poor, and during a stakeholder workshop convened in Bogor from 24th to 26th November 2008, agreed to design this activity to contribute to the targeting discussion by focusing on risk of disease spread among Sector 3 and 4 farms.

Sector 3 farms vary considerably in Indonesia and can house from 1,000 to 100,000 birds. Small-scale and large-scale farms are likely to have different structures and involve different marketing chains. Based on existing information on farm profiles (FAO 2008a), it was decided to restrict the risk assessment to the following farms: small-scale broiler farms with less than 5,000 birds and village chickens.

Consistent with priorities defined by the NSWP (DGLS 2008), it was decided to restrict the activity to a priority area targeted by the NSWP: West Java. The study area chosen for the Risk Assessment Activity is the District of Bogor and the City of Bogor, as this area has advantages such as: 1) previous studies in this area provide relevant information for the risk analysis; 2) the commercial poultry sector there has recently been profiled; 3) it is an important poultry production area supplying Jakarta consumers; and 4) the Risk Analysis Assessment Facilitator team and key informants representing small-scale broilers and village poultry farmers are located there.

Following discussions during the Bogor workshop, which involved a wide range of stakeholders – including government, non-governmental organizations, academia, industry, and technical service officers of contractor, pharmaceutical and feed companies – it was agreed that the risk assessment conducted under the Pro-Poor HPAI Risk Reduction Project should address the following important risk question:

In the District of Bogor and Municipality of Bogor, what is the risk of transmission of HPAIV infection:

- ***between small-scale broiler farms***
- ***between village chickens***
- ***between small-scale broiler farms and village chickens?***

However, due to resources constraints, it was decided to focus on one risk question only and to conduct a qualitative risk assessment of HPAI transmission between small-scale commercial broiler farms.

1.2 Approach

This risk assessment seeks to estimate the likelihood of transmission of HPAIV H5N1 between small-scale commercial broiler chicken farms, following the framework defined by the OIE (Murray et al. 2004), which can be summarised as assessing risk of release, exposure, consequences and deducing an overall risk estimation.

This risk assessment was conducted qualitatively since a quantitative approach would have required detailed epidemiological information currently not available and additional data collection beyond the scope of this project.

Risk categories

Within the qualitative risk assessment, probabilities are assessed and described textually on a scale from negligible (meaning that they cannot be differentiated from zero, and in practical terms can be ignored), through to very high adapted from the scale used by the EFSA for their assessment of HPAI risk (see Table 1).

They are based on the data presented by the Risk Assessment Team in this scientific report and are internally consistent across the different risk pathways and steps included in the risk assessment.

Table 1: Definition of probability categories used in this risk assessment (adapted from EFSA 2006)

Probability category	Interpretation
Negligible	Event is so rare that does not merit to be considered
Very low	Event is very rare but cannot be excluded
Low	Event is rare but does occur
Medium	Event occurs regularly
High	Event occurs very often
Very high	Even occurs almost at certainly

Combining parameters

To assess the overall probabilities of release and exposure, risk estimates for each parameter are combined. For each biological pathway, a risk estimate is obtained by combining parameter risk categories according to the combination matrix presented in Table 2.

Table 2: Risk categories combination matrix (adapted from Zepeda 1998)

Parameter 1 / Release risk category	Parameter 2 /Exposure risk category					
	Negligible	Very Low	Low	Medium	High	Very High
Very High	N	VL	L	M	H	VH
High	N	VL	L	M	H	H
Medium	N	VL	VL	L	M	M
Low	N	N	VL	VL	L	L
Very Low	N	N	VL	VL	VL	VL
Negligible	N	N	N	N	N	N

Input parameters

Data for the parameters were obtained from available information (peer-reviewed and grey literature; results from studies conducted in West Java in recent years), expert opinion elicitation (EOE) and interviews with key informants of the poultry sector.

Expert opinion was collected through paper questionnaires distributed to the experts identified during the stakeholder workshop held at the beginning of the study. Eight experts (3 from integrated poultry industries, 1 representative of poultry producer association, 2 officers from district veterinary services, and 2 international experts working on HPAI in the country) with extensive experience in the supervision of small-scale broiler farms or experience in poultry production were invited to participate in the EOE. The experts were asked to specify a most likely value, a minimum value, and a maximum value of each parameter. The experts were also asked to indicate how confident they were with their answers, using a scale from 1 to 5 (1 indicates no confidence at all, and 5 a high level of confidence in their answer). Experts were encouraged to use any knowledge or data available to inform their answers, but asked to use their personal judgment in the end and provide their best guess. The range of most likely values provided by the different experts for each probability estimate was used for the qualitative risk assessment. The questionnaire used for the EOE (in English and in Bahasa) is available from the authors upon request.

In-depth interviews were also conducted with selected informants and stakeholders of the poultry industry (small-scale commercial broiler chicken farmers, poultry association, government officer, (PTS), (FTS) and (CTS) to identify current practices in small-scale commercial broiler farms in Bogor.

Uncertainty

In addition to the risk estimate, the level of uncertainty associated with each parameter of the risk pathways is specified and considered when interpreting the data and the results. The uncertainty associated with data is categorised as presented in Table 3.

Table 3: Uncertainty categories (adapted from EFSA 2006).

Uncertainty category	Interpretation
Low	There are solid and complete data available; strong evidence is provided in multiple references; authors report similar conclusions
Medium	There are some but no complete data available; evidence is provided in small number of references; authors report conclusions that vary from one another
High	There are scarce or no data available; evidence is not provided in references but rather in unpublished reports or based on observations or personal communication; authors report conclusions that vary considerably between them

2 Risk question

The risk questions defined during the consultation with stakeholders at the Bogor workshop in November 2008 were formulated as specifically as possible to focus the efforts of the Risk Assessment Team. The final version agreed was as follows:

Release

What is the risk of release of HPAIV H5N1 from an infected small-scale broiler farm?

Exposure

What is the risk that another small-scale broiler farm gets exposed to HPAIV H5N1 released by the infected small-scale broiler farm, and that this exposure results in the infection of at least 1 chicken on the farm?

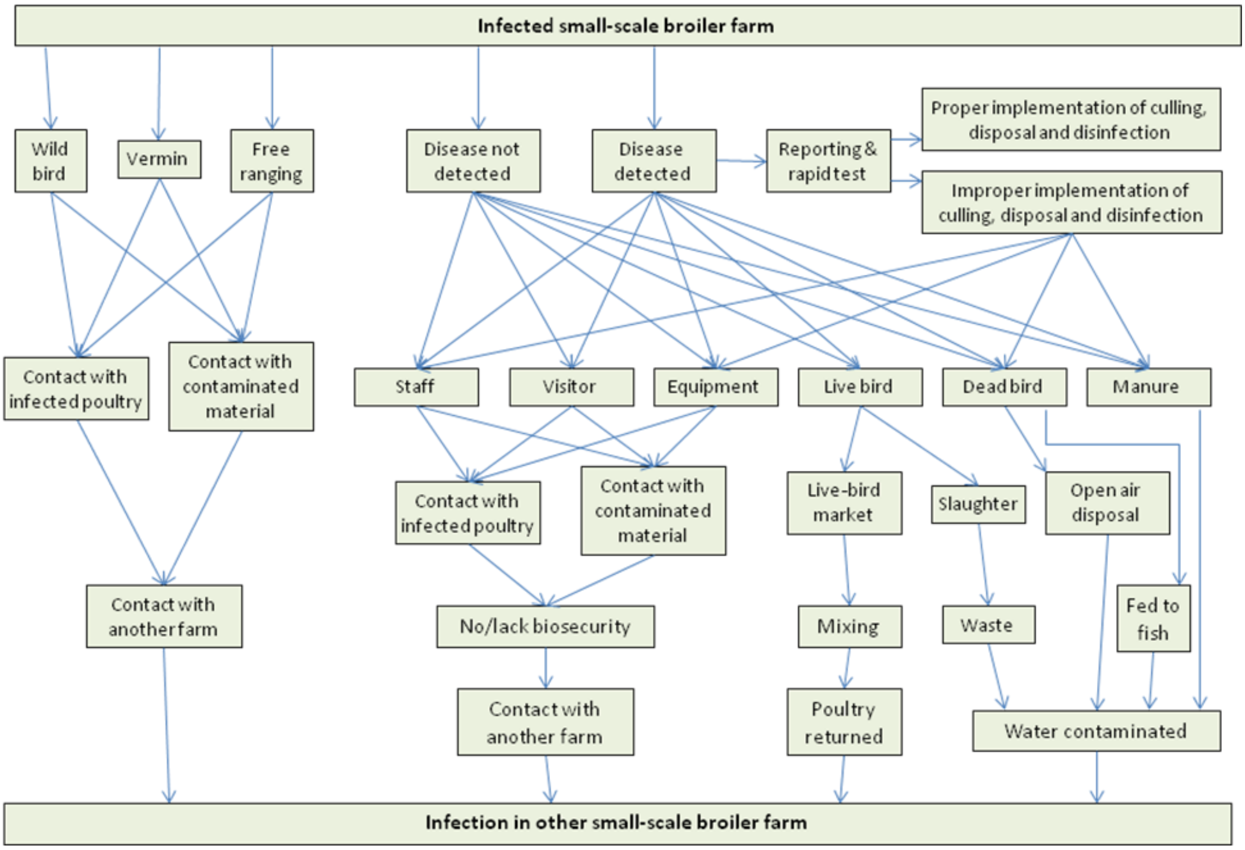
Consequences

What would be the consequences of such infection (within-flock spread and spread beyond the flock, economic consequences, etc.)?

3 Overview of risk pathways

The pathways of HPAIV transmission between small-scale broiler farms, corresponding to the risk question defined for Indonesia in Section 2, are described in Figure 2.

Figure 2: Risk pathways of transmission between small-scale broiler farms.



The risk pathways were formulated during discussions at the Bogor workshop in November 2008. The following pathways of transmission between small-scale broiler farms were identified:

- Live broilers, directly and via collecting yards, live-bird markets and slaughter points
- Farmers or staff
- Visitors
- Free-range poultry
- Wild birds
- Farm bridge species (vermin, dogs and cats)
- Dead broilers
- Manure
- Equipment

4 Risk assessment for release

4.1 Release pathway 1: through the live broiler market chain

Overview of information required for pathway 1

Step of risk pathway	Data needs	Data source
Probability of infection on small-scale broiler farm	Prevalence of infection in small-scale broiler population	EOE FAO (2008a)
Probability of farmer detecting the disease but not reporting and not implementing ban or culling Probability of not detecting the infection at least at an early stage	Detection at farm level Reporting compliance Ban or culling implementation	FAO (2008b) EOE
Probability of releasing infected live birds given farm is infected	Proportion of poultry infected Marketing practice	EOE FAO (2008b) Indonesian Dutch Partnership Program – Centre for Indonesia Veterinary Analytical Study (IDP-CIVAS: 2008)

Probability of infection on a small-scale broiler farm

We consider the flock to be an epidemiological unit because it is relevant to the broiler chicken production system and because control measures are implemented at flock level if an outbreak occurs.

Bogor has a large number of farms with higher than average flock size compared to the other districts the FAO studied in Western Java, and 35% of these farms have less than 5,000 birds. A large proportion of producers (40-60%) in Bogor operate within a partnership system as contracted farms (EOE: Maimun [CTS]; Payawal [CTS] and Muryanto [Federation of Non-industrial Commercial Poultry Producer Organizations: **GOPAN**]). On average, farm poultry populations are smaller for independent farms (FAO 2008a).

Most (90%) small-scale broiler farms in Bogor have experienced HPAI H5N1 in their flock since it was first reported in Indonesia. In an outbreak situation, 20% of farms are likely to be infected in Bogor. However, no outbreak had been reported at least for one year preceding our data collection in January 2009 (EOE: Maimun [CTS]).

A sudden demand for HPAI vaccine from broiler farms in a given area might be an indirect indicator of occurrence of the disease. However, so far, no marked demand for HPAI vaccine in Bogor has been reported and broiler farms are unlikely to vaccinate in Bogor at present (EOE: Fauzi [PTS]).

Interpretation: Results of the limited official HPAIV H5N1 surveillance within the broiler population and some indirect indicators suggest that HPAI H5N1 cases in Bogor are rare, but it is not possible to exclude that they occur. The probability of broiler farms being infected by HPAIV H5N1 is thus currently estimated as ***low (high uncertainty).***

The probability that farmers detect the disease but do not report and do not implement a ban or culling

Most of the respondents (77%) participating in an FAO poultry value chain study in Jakarta and its surrounding areas were able to identify the clinical symptoms of HPAI in poultry, particularly bruised and swollen wattles and combs, runny nose and eyes, and sudden death (FAO 2008b).

There is limited official disease surveillance within broiler farms (EOE: Herawati Kabupaten Bogor District Livestock Service [**DLS**]), therefore HPAI cases in broilers are considered to still be underestimated and underreported.

Small-scale broiler farmers are unlikely to report any suspected contagious diseases to official veterinary services (EOE: Herawati, Kabupaten [Bogor DLS]). It is common knowledge that broiler farms do receive technical advice from private veterinary service providers and may ask advice from these private veterinary services when HPAI is suspected in the farm, but not from any authority (EOE: Fauzi [PTS]).

In case of an HPAI outbreak, small-scale broiler farms are not likely (2%) to implement a proper ban on sales or movement of their poultry, or culling (EOE: Maimun [CTS]).

Interpretation: The probability of a farmer detecting the disease but not reporting and not implementing a ban or culling is ***very high (high uncertainty).***

Probability of releasing infected live birds given farm is infected

Most HPAI detections in small-scale broilers are based on clinical symptoms (see above the probability that farmers detect the disease but do not report and do not implement a ban or culling), therefore disease is unlikely to be detected during the incubation period.

Most broiler farms (75%) in the area studied by FAO in Western Java have poultry densities of 8-10 birds/m^2 (FAO 2008a). HPAIV is highly contagious, leading to conditions that facilitate rapid spread of a virus within a flock once it is established.

Almost all small-scale broiler farms (95-100%) sell their finished broilers to collectors or intermediaries, leaving only a small proportion of farms selling directly to collecting yards, live-bird markets (**LBM**) or slaughter houses (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN] and ILRI-Operational Research Project [**OR**]).

When HPAI is suspected, most (70-90%) farmers sell apparently healthy birds as quickly as possible to ordinary bird collectors, to save their capital (EOE: Maimun [CTS], ILRI-OR).

Sick birds are often sold for a cheaper price to a group of specific traders who specialise in buying sick birds (EOE: ILRI-OR).

According to a study conducted by IDP-CIVAS from July to December 2008, it was concluded that out of 136 broiler batches from Bogor which entered poultry collecting facilities in Jakarta, 1 was infected, but it is unclear whether the infection occurred at farm or along the market chain (IDP-CIVAS, 2008).

Interpretation: Given the information presented above, the probability of releasing infected live birds given the farm is infected is estimated ***very high (high uncertainty).***

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability that farmer detect the disease but does not report and does not implement a ban or culling	FAO (2008b) EOE	Very high	High
Probability of releasing infected live birds given farm is infected	EOE FAO (2008b) IDP-CIVAS (2008)	Very high	High

Overall risk estimate and conclusion for pathway 1

The overall risk estimate for the release via the marketing of live broilers was obtained by combining the three risk categories presented above, using the combination matrix in Table 2. The risk of release via pathway 1 was estimated as **low (high uncertainty)**, because the likelihood of a farm being infected was assessed to be low. In this pathway, under-reporting of contagious disease, improper implementation of bans and culling, and selling of birds in case of suspicion of disease are major critical points for the release of infected birds. Investigating the reasons and incentives for farmer behaviour in this respect would provide valuable information for developing efficient control measures.

4.2 Release pathway 2: through farmers and their employees

Overview of information required for pathway 2

Step of risk pathway	Data needs	Data source
Probability of infection on small-scale broiler farm	Prevalence of infection in small-scale broiler population	EOE FAO (2008a)
Probability of farmer/staff getting contaminated given the farm is infected	Proportion of poultry infected and of material contaminated Probability of infection not reported and ban not implemented Frequency of contact with poultry or contaminated material	EOE FAO (2008b)
Probability of staff leaving the farm contaminated	Biosecurity practices (clothes, foot bath, etc.)	EOE

Probability of farmer/staff being contaminated given farm infected

HPAIV is highly contagious, and the flock densities in broiler farms of Java (FAO, 2008a) provide conditions that facilitate the rapid spread of HPAIV within the flock once the disease is introduced. All excretions, secretions and feathers of infected birds are contaminated with HPAIV, so the bird's environment and material exposed to their secretions and excretion is very likely to be contaminated with HPAIV.

On average, small-scale broiler farms employ 1-2 staff or workers (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN]) who have many opportunities for contact with poultry during feeding, catching of birds, cleaning, etc. In addition, as explained previously, suspected outbreaks on farm are not reported and bans are not implemented. This, together with the fact that staff and workers are unlikely to take protective measures, increases the risk of contact with contaminated material.

Interpretation: The probability of the farmer/staff being contaminated in infected farms is estimated as ***very high (high uncertainty).***

Probability of farmers/ staffs leaving the farm contaminated

Answers from the EOE suggest that 50-60% of small-scale broiler farm owners ask their workers or staff to change their clothes before entering and leaving the farm (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN]). However, only 1% of farms provide a footbath (EOE: ILRI-OR) and adequate facilities for implementing these biosecurity measures. Moreover, an author observed at a number of small-scale broiler farms that these biosecurity measures, although recommended by owners, are not implemented by staff.

Interpretation: The probability of farmers leaving the farm contaminated is estimated to be ***high to very high (high uncertainty)*.**

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of staff getting contaminated given farm infected	EOE FAO (2008b)	Very High	High
Probability of staff leaving the farm contaminated	EOE	High to very high	High

Overall risk estimate and conclusion for pathway 2

The overall risk estimate for the release pathway 2, obtained using the combination matrix in Table 2, is ***low (high uncertainty).*** Both the likelihood of staff getting contaminated given the farm is infected and the likelihood of the farmer or staff leaving the farm contaminated are high. Owners should provide footbaths and adequate facilities to staff to ensure that they can apply biosecurity measures, and also investigate reasons why the biosecurity measures may not be implemented by farm staff.

4.3 Release pathway 3: through visitors

Overview of information required for pathway 3

Step of risk pathway	Data needs	Data source
Probability of infection on small-scale broiler farms	Prevalence of infection in small-scale broiler population	EOE FAO (2008a)
Probability of visitors entering small-scale broiler farm	Frequency of visitors allowed on the farm	EOE
Probability of visitor getting contaminated given farm is infected	Proportion of poultry infected and material contaminated Probability of infection not reported and ban not implemented Frequency of contact with poultry or contaminated material	EOE FAO (2008a)
Probability of visitor leaving the farm contaminated	Biosecurity practice for visitors	EOE FAO (2008a)

Probability of visitors entering the farm

Many opportunities for movement of people between farms exist in the broiler production system. Many visitors associated with poultry production—e.g. health controllers or supervisors from integrated companies, technical services officers and vaccinators representing veterinary drug companies, collectors and intermediaries, bird catchers and drivers—either work or have contact with poultry or with equipment or environments from broiler farms (EOE: Nugraha [PTS]).

The main types of visitors identified include:

<u>Technical services officer</u>: In terms of poultry health services, more than half (56%) of broiler producers reported receiving poultry health services from CTS, and almost one third (29%) from PTS (FAO, 2008a). Technical services officers frequently visit farms, e.g. up to 4 farm visits a day, and each farm could be visited more than once per batch (EOE: Nugraha [PTS]).

<u>Vaccinator</u>: Vaccination for IBD was carried out in most small-scale broiler farms at day 4 for a new batch, usually by vaccinators from the veterinary drug company supplying the vaccines (EOE: Nugraha [PTS]).

<u>Visitors associated with outputs such as broiler collectors and intermediaries, bird catchers, dead-bird collectors, manure collectors and truck drivers</u>: Small-scale broiler farms are most likely (95-100%) to sell their finished broilers to collectors and intermediaries. It is likely for collectors to employ bird catchers or drivers to assist broiler farmers in collecting birds. Collectors and associated staff frequently visit farms, and may visit 1-2 small-scale farms a day to collect broilers (EOE: Witrasari [FTS]).

<u>Other visitors supplying farms,</u> such as for delivery of feeds, are frequently allowed on the farms and usually come close to poultry sheds (EOE: Witrasari [FTS]).

Interpretation: The timing and frequency of visits appear to differ according to the type of visitors: technical services officers, vaccinators, bird collectors and associated staff visit small-scale broiler farms more often than farm suppliers. The overall probability of visitors entering the farm was estimated ***high to very high (high uncertainty)*.**

Probability of visitors getting contaminated given the farm is infected

The probability of visitors getting contaminated by HPAIV H5N1 varies depending on the proportion of poultry infected and material contaminated, the type of contacts (direct or indirect) and their frequency, and the use of protective measures.

As presented previously, the nature of HPAIV, the flock density and the absence of biosecurity measures or bans when disease is suspected favour the spread of infection within a farm and the contamination of the environment and equipment.

Visitors have opportunities for contact with poultry for several purposes, as described below.

Vaccinators get in contact with day-old chicks (**DOC**) rather than with growers (EOE: Nugraha [PTS]). If a farm is suspected with HPAI, technical services officers and vaccinators most likely stop entering the poultry sheds (EOE: Fauzi [PTS]).

A recent study showed that bird collectors have the most frequent contacts with poultry among all of the actors in the value chain, and their knowledge of bio-security practices is still very low (FAO 2008a).

Suppliers, such as visitors delivering feeds, are less likely to have contact with poultry (EOE: Witrasari [FTS]), but more so with equipment.

Interpretation: Technical services officers, vaccinators, collectors and associated staffs (drivers and bird catchers) have many opportunities for contact with birds and/or equipment. Therefore, the overall risk of visitors getting contaminated given the farm is infected is estimated as ***very high (high uncertainty)*.**

Probability of visitors leaving an infected small-scale broiler farm still contaminated

The probability of visitors leaving the farm contaminated depends on the implementation of disinfection or equivalent biosecurity measures to prevent the spread of the virus.

Small-scale broiler farms in the District and Municipality of Bogor are unlikely (1-10%) to ask visitors to use a footbath or change their clothes before leaving the farm (EOE: Payawal [CTS], Maimun [CTS] and Muryanto [GOPAN]). In addition, collector knowledge of bio-security practices is very low (FAO 2008a).

It is however interesting to note that, in areas where HPAI is suspected, technical services and vaccinators are most likely to apply stricter biosecurity when entering / leaving the farm (EOE: Maimun [CTS] and Fauzi [PTS]).

Interpretation: The probability of visitors leaving the farm still contaminated was estimated ***very high (medium uncertainty).***

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of visitors entering a small-scale broiler farm	EOE	High to Very high	High
Probability of visitor getting contaminated given farm infected	EOE FAO (2008a)	Very high	High uncertainty
Probability of visitor leaving the farm contaminated	EOE FAO (2008a)	Very high	Medium uncertainty

Overall risk estimate and conclusion for pathway 3

The overall risk estimate for the release via visitors, obtained using the combination matrix in Table 2, is ***low (high uncertainty).*** In this pathway, the bird collectors and associated staff are the visitors considered associated with the highest risk, and control efforts should include measures for these actors of the value chain. It is interesting to note that technical services and vaccinators are also associated with high risk given they may simply skip gates and an on-farm biosecurity procedure when they consider the farm is free of contagious diseases.

4.4 Release pathway 4: through free-range poultry

Overview of information required for pathway 4

Step of risk pathway	Data needs	Data source
Probability of infection on small-scale broiler farm	Prevalence of infection in small-scale broiler population	EOE FAO (2008a)
Probability of free-range poultry entering a small-scale broiler farm	Existence of free-range poultry in farm	EOE FAO (2008a)
Probability of free-range poultry getting contaminated/infected given it has entered an infected small-scale boiler farm	Frequency of contact	EOE
Probability of free-range poultry leaving broiler farm	Poultry habits Distance among farms	EOE

Probability of free-range poultry entering broiler farm

In the District and Municipality of Bogor, the proportion of households keeping village chickens vary from 20% in urban and peri-urban areas to 60-90% in rural areas (EOE: FAO-Participatory Disease Surveillance and Response Project [**PDSR**], ILRI-OR, Herawati [Kabupaten Bogor DLS] and Kota Bogor DLS). These are usually scattered across many households (EOE: Herawati [Kabupaten Bogor DLS]).

According to the FAO profiling study conducted, 14% of commercial poultry farms reported having non-commercial birds: local native chicken, ducks, etc. (FAO 2008a). Moreover, free-ranging poultry either reared by commercial farms or originating from surrounding farms can be found in most (75-100%) of small-scale broiler farms, and only few of the small-scale broiler farms (0-10%) have full fencing not allowing free-ranging poultry to enter the premises (EOE: Payawal [CTS], Maimun [CTS], ILRI-OR).

Interpretation: The probability of free-range poultry entering a small-scale broiler farm is estimated ***very high (medium uncertainty).***

Probability of free-ranging poultry getting contaminated or infected given it has entered an infected small-scale broiler farm

The probability of infection depends on, among others, the susceptibility of free-ranging birds to HPAI H5N1. Local native chicken, Muscovy duck, and other ducks and geese are usually free ranged in Bogor (EOE: Herawati, Kabupaten Bogor DLS) and all are susceptible to HPAI H5N1.

Free-ranging poultry can get infected or contaminated with HPAIV due to close proximity or direct contact with infected birds, contaminated respiratory secretions or faecal materials.

Interpretation: The probability of free-ranging poultry getting contaminated given it has entered an infected small-scale broiler farm is ***very high (high uncertainty).***

Probability of free-ranging poultry leaving the farm given farm is infected

The poultry farm density in Bogor is quite high, particularly in clustered farms, therefore farms are close to each others. As indicated previously, very few of the farms have fences preventing the movement of free-ranging poultry. Thus, free-ranging poultry are likely to wander between farms.

Interpretation: The probability of contaminated or infected free-ranging poultry leaving the farm was estimated ***high (high uncertainty).***

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of free-range poultry entering an infected small-scale broiler farm	EOE FAO (2008a)	Very high	Medium
Probability of free-range poultry getting contaminated/infected given it has entered an infected small-scale boiler farm	EOE	Very high	High
Probability of contaminated/ infected free-ranging poultry leaving the farm	EOE	High	High

Overall risk estimate and conclusion for pathway 4 (release of HPAIV H5N1 through free-ranging)

The overall risk estimate for release via free-ranging poultry, obtained using the combination matrix in Table 2, is ***low (high uncertainty)***. In this pathway, the risk is mainly due to both the presence of free-ranging poultry and the absence of adapted fencing in most small-scale broiler farms.

4.5 Release pathway 5: through wild birds

Overview of information required for pathway 5

Step of risk pathway	Data needs	Data source
Probability of infection on a small-scale broiler farm	Prevalence of infection in small-scale broiler population	EOE FAO (2008a)
Probability of wild birds entering a small-scale broiler farm	Frequency of wild birds observed on farm	EOE FAO (2007)
Probability of wild birds getting contaminated / infected given it has entered an infected small-scale boiler farm	Frequency of contact	EOE Dharmayanti and Indriani (2006)
Probability of contaminated/ infected wild bird leaving the farm	Wild bird habits Distance between farms	EOE

Probability of wild birds entering small-scale broiler farm

Bogor is a mountainous area and not on a migration route; migratory wild birds are not commonly observed close to commercial poultry farms (EOE: Herawati, [Kabupaten Bogor DLS]).

On most (80-100%) small-scale broiler farms, resident wild birds can be observed: mostly house sparrow (*Passer domesticus*) and also feral pigeon *(Columba livia)* (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN]). Sparrows and pigeons have broad and diverse habitat preferences, but all are birds that have adapted to exploit anthropogenic food sources. This results in numerous opportunities for close contact with domestic poultry, especially in open poultry farms where food is readily available (FAO 2007).

Interpretation: The likelihood of wild birds entering a small-scale broiler farm is estimated as ***very high (high uncertainty).***

Probability of a wild bird getting contaminated/infected given it has entered an infected small-scale boiler farm

The probability of infection depends on susceptibility of wild birds to HPAI H5N1, as well as the type and frequency of contacts with poultry on infected farms. Wild birds can get infected or contaminated with HPAIV in source farms due to close proximity or direct contact with contaminated respiratory secretions or faecal materials. There is limited information available on the susceptibility of resident wild bird species to HPAIV H5N1. Tree sparrows (*Passer montanus*) and feral pigeon were reported to be infected with HPAI H5N1 in virus-infected areas of Jakarta and Sukabumi in 2005 (Dharmayanti and Indriani 2006).

Interpretation: The likelihood of a wild bird getting contaminated or infected given it has entered an infected small-scale broiler farm was assessed as ***high (high uncertainty).***

Probability of contaminated/ infected wild bird leaving the farm

The poultry farm density in Bogor is quite high, and the general kind of broiler housing used cannot prevent wild birds from entering and/or leaving the farm.

Interpretation: The probability of a contaminated or infected wild bird leaving a farm was estimated to be ***very high (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of a wild bird entering small-scale broiler farm	EOE FAO (2007)	Very High	High
Probability of a wild bird getting contaminated given it has entered an infected small-scale boiler farm	EOE Dharmayanti and Indriani (2006)	High	High
Probability of a contaminated/ infected wild bird leaving the farm	EOE	Very high	High

Overall risk estimate and conclusion for pathway 5

The risk of release through wild birds was estimated ***low (high uncertainty)***. In this pathway, risk was due to the presence on farms of resident or non-migratory wild birds and the absence of wild bird-proof housing in most small-scale broiler farms. Control efforts could target more secure bird housing.

4.6 Release pathway 6: through farm bridge species

Overview of information required for pathway 6

Step of risk pathway	Data needs	Data source
Probability of infection on a small-scale broiler farm	Prevalence of infection in small-scale broiler population	EOE FAO (2008a)
Probability of a dog, cat, vermin, entering a small-scale broiler farm	Frequency of vermin observed on farm	EOE FAO (2008a)
Probability of vermin, a dog or cat getting contaminated or infected given farm is infected	Proportion of poultry infected and of material contaminated	EOE FAO (2008a)
	Frequency of contact	Thiry et al. (2007)
Probability of contaminated/infected bridge species leaving the farm	Animal habit Distance among farms	EOE

Probability of farm bridge species entering small-scale broiler farms

The environment surrounding poultry pens or houses on small-scale broiler farms was frequently reported as dirty or very dirty (FAO, 2008a), suggesting that poultry housing is suitable for rat nesting. In addition, poultry pens are attractive to rats because of the presence of poultry feed. Due to their small size, vermin can enter poultry sheds where feed is readily available. Small-scale broiler farmers are unlikely (less than 5%) to apply vermin control by using vermin traps or using rodenticide (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN], ILRI-OR). They only remove rat nests if observed.

Only few of the small-scale broiler farms (0-10%) have full fencing, thus cats and dogs can enter the farm ground. On most small-scale broiler farms, cats or dogs can be observed (EOE: Payawal [CTS], Maimun [CTS], ILRI-OR), either owned by the farmer or stray.

Interpretation: The probability of vermin entering small-scale broiler farms was estimated very high, while for dogs and cats it was estimated high. Therefore, the overall probability of farm bridge species entering small-scale farms was estimated ***very high (high uncertainty).***

Probability of farm bridge species getting contaminated or infected given the farm is infected.

Rats can get contaminated with HPAI virus via close contact with infected broilers, contaminated material on the farm, or dead birds.

A study carried out in Greater Jakarta described that most of the respondents reportedly dispose of dead birds directly in their surrounding environments without any special biosecurity treatment (FAO 2008a). Therefore, dogs on farms may have access to dead poultry and can get contaminated if feeding on them. According to farmers interviewed, cats are less likely to get in contact with dead poultry since they do not have the habit of eating carcasses.

Contact between birds and cats have occurred on different continents, where cats have been infected following the ingestion of infected chickens (Thiry et al. 2007). However, in Bogor, it was considered rare that cats would eat sick chickens and no farmer interviewed complained about cats and dogs entering poultry sheds or hunting/killing poultry.

Interpretation: Vermin have opportunities to get in contact with both infected poultry and contaminated material, while cats and dogs can get in contact with contaminated material or dead birds. The likelihood of vermin getting contaminated was assessed high, while for dogs and cats it was estimated as medium. Therefore, the overall likelihood of farm bridge species getting contaminated was estimated ***high (high uncertainty).***

Probability of contaminated/infected bridge species leaving the farm given farm is infected

The probability that vermin, dog and cat move between small-scale broiler farms depends on their habits, the distance between small-scale broiler farms and other conditions. The poultry farm density in Bogor is quite high. Rats are likely to stay on the farm as long as they have food, while cats and dogs are likely to wander between farms.

Interpretation: The likelihood of leaving the farm was estimated low for contaminated vermin, and medium for dogs and cats. Therefore, the overall likelihood of contaminated farm bridge species leaving the farm was estimated ***medium (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on a small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of bridge species entering a small-scale broiler farm	EOE FAO (2008a)	Very high	High
Probability of bridge species getting contaminated given a farm is infected	EOE FAO (2008a) Thiry et al. (2007)	High	High
Probability of bridge species leaving the farm contaminated given farm is infected	EOE	Medium	High

Overall risk estimate and conclusion for pathway 6

The overall risk estimate for the release HPAIV H5N1 through vermin, dogs and cats is ***very low (high uncertainty)***. In this pathway, the highest risk categories were associated with the absence of treatment against rats, the absence of appropriate fencing, and improper disposal of dead birds. Control measures should target the proper disposal of dead birds.

4.7 Release pathway 7: through dead broilers

Overview of information required for pathway 7

Step of risk pathway	Data needs	Data source
Probability of infection on a small-scale broiler farm	Prevalence of infection in small-scale broiler population	EOE FAO (2008a)
Probability of dead bird being infected/contaminated given farm is infected	Proportion of poultry infected Mortality rate due to HPAI infection Existence/titre of viruses in carcass	EOE EOE
Probability of releasing infected/contaminated dead birds given farm is infected	Detection, reporting of disease and implementation of a ban Disposal practice in small-scale broiler farms Dead bird trading	EOE FAO (2008b) EOE

Probability of a dead bird being infected/contaminated given farm is infected

The current mortality rate for HPAI reported in Bogor varies from 25% up to 90%, while morbidity is almost 100% (EOE: Nugroho [veterinarian working in veterinary practice]).

As discussed before, the nature of HPAIV and the farming systems facilitate the rapid spread of the infection once the disease is introduced. Dead birds from an infected farm are most likely infected or contaminated by the virus. HPAIV H5N1 can be present in chicken carcasses and feathers.

Interpretation: The probability that dead birds are infected given the farm is infected was estimated as ***very high (high uncertainty)***.

Probability of releasing infected/contaminated dead birds

As presented above, small-scale broiler farms are unlikely to report suspicions of HPAI and to implement a ban. Release of infected dead birds could occur via the disposal or trade of dead birds.

Disposal of dead birds:

Most of the respondents in the FAO value chain analysis study in Jakarta and surrounding areas reported disposing of dead birds directly in their surrounding environment without any special biosecurity treatment (FAO 2008b). This was confirmed by observations from Maimun (CTS) and ILRI-OR (EOE), who considered that only a minority of small-scale broiler farms burn and bury dead birds according to the regulations, while most (60-80%) farms dispose of dead birds without taking any biosecurity measure (e.g. throwing dead birds into a river or an open pit).

Out of 222 respondents from the same study, 48% handled dead birds correctly – by either burying them or burning them (FAO 2008b).

Trade of dead birds:

Dead birds are fed to catfish, so broiler farms sell dead birds to catfish farmers who collect them by bicycle, foot or motorcycle. People visiting markets may remove dead birds from the markets or from the disposal bins and take/sell to catfish farms. They usually put the birds in plastic bags and may also be transporting live birds purchased in the market. Broiler farms may also have catfish on site and directly dispose of the dead birds into the fish ponds (ILRI-OR, EOE 2009): around 2-30% of small-scale broiler farms use dead birds as feed for fish locally (EOE: Maimun [CTS], ILRI-OR).

There is also a trade of dead birds to small eateries. These are sold at a low price, and then small eateries sell poultry to consumer even though it is unethical as these chickens have not been slaughtered in the Halal (Islamic law) method.

Finally, there is also a trade of dead birds to dog owners (EOE: ILRI-OR).

In all cases, when HPAI is suspected, farms are unlikely (1-5%) to stop selling dead birds (EOE: Maimun [CTS], ILRI-OR).

Interpretation: The probability of a dead broiler being released through disposal or trading is ***very high (medium uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on a small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of a dead bird being infected/contaminated given farm infected	EOE	Very high	High
Probability of releasing infected/contaminated dead birds given farm is infected	FAO (2008b) EOE	Very high	Medium

Overall risk estimate and conclusion for pathway 7

The overall risk estimate for the release via dead birds, obtained using the combination matrix in Table 2, is ***low (high uncertainty).*** The absence of implementation of bans, the improper disposal of dead birds and the trade of dead birds are associated with higher risk of release.

4.8 Release pathway 8: through manure

Overview of information required for pathway 8

Step of risk pathway	Data needs	Data source
Probability of infection on a small-scale broiler farm	Prevalence of infection in the small-scale broiler population	EOE FAO (2008a)
Probability of manure being infected/contaminated given farm is infected	Proportion of poultry infected Viral shedding in faeces Survival of HPAIV in manure	EOE Seo and Webster (2001)
Probability of releasing infected/contaminated manure given farm is infected	Detection of disease and implementation of a ban Disposal practices in small-scale broiler farms Manure trading	EOE FAO (2008a)

Probability of manure contaminated given farm infected

Because of the nature of HPAIV and the farming systems in Java, the disease is very likely to quickly spread to all the flock once it is introduced on a farm. Moreover, research has shown that chickens shed H5N1 viruses in their faeces (Seo and Webster 2001), therefore manure in an HPAIV H5N1 infected farm will be contaminated by the virus.

Interpretation: The probability of manure being contaminated given a farm is infected is ***very high (low uncertainty).***

Probability of releasing contaminated manure given farm is infected

Most small-scale broiler farms do not implement a ban on sale of manure if suspected with HPAI (EOE: ILRI-OR). More than 80% of farms reported either bagging manure for disposal or using it as a fertilizer. More than 50% of the small-scale broiler farms are likely to sell the manure produced on farm, while less than 30% of them are likely use it for their own crops. A small proportion of smaller farms also use farm waste to feed fish (FAO 2008a).

Interpretation: The probability of releasing contaminated manure given a farm is infected is estimated as ***high (medium uncertainty).***

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on a small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of manure being contaminated given farm is infected	Seo and Webster (2001)	Very high	Low
Probability of releasing contaminated manure given farm is infected	FAO (2008a) EOE	High	Medium

Overall risk estimate and conclusion for pathway 8

The overall risk estimate for the release pathway 8 is ***low (medium uncertainty)***. In this pathway, the risk of releasing contaminated manure is mainly a result of the non-implementation of bans and the disposal of manure in the environment.

4.9 Release pathway 9: through equipment

Overview of information required for pathway 9

Step of risk pathway	Data needs	Data source
Probability of infection on a small-scale broiler farm	Prevalence of infection in the small-scale broiler population	EOE FAO (2008a)
Probability of equipment being contaminated given farm is infected	Proportion of poultry infected and of material contaminated Frequency of contact with infected bird Frequency of contact with infected poultry or contaminated material	Seo and Webster (2001) EOE FAO (2008a)
Probability of releasing contaminated equipment given farm is infected	Biosecurity practices (cleaning and disinfection)	EOE

Probability of equipment getting contaminated given farm is infected

Previous research has shown that all secretions, excretions and feathers of infected birds contain HPAIV (Seo and Webster 2001), therefore the equipment in HPAIV H5N1 infected farms is most likely contaminated by the virus. In addition, the absence of bans and other protective measures when HPAI is suspected in small-scale broiler farms increases the risk of contamination.

The different types of equipment identified as potential mechanical vectors for HPAI H5N1 are listed below.

Vehicles:

On most (90-100%) broiler farms, staff and visitor vehicles (e.g. motorbike, car or truck) are allowed (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN]).

Most traders in the FAO profiling study stated that vehicles usually visit more than one farm during each journey. This was common for input, feed and product transport vehicles (FAO 2008a).

Usually one truck can carry 3000 kg of finished live birds, collecting birds from one farm and delivering to collecting yards or LBM before moving to another farm (EOE: Muryanto [GOPAN] and Nugroho [veterinarian working in veterinary practice]).

Vaccination equipment:

Most small-scale farms vaccinate their birds against infectious bursal disease (IBD); the common method for IBD vaccination in Bogor is eye drops. In some circumstances, a small number of small-scale broiler farms may vaccinate their bird againts Newcastle disease using intra muscular vaccination and share the same vaccination equipment with other small-scale broiler farms (EOE: Nugroho [veterinarian working in veterinary practice], Nugraha [PTS], Fauzi [PTS]). Clothing (overalls, boots, gloves) was discussed under the section about visitors. For other vaccination equipment, the author has assumed that some biosecurity measures including cleaning and disinfection are being applied, which reduces the risk of contamination with HPAIV.

Trading related cages:

Most (95-100%) of the small-scale broiler farms sell their birds to bird collectors, and most use bird cages provided by the collectors/intermediaries to collect the birds (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN], ILRI-OR).

Interpretation: The probabilities of equipment being contaminated by HPAIV H5N1 depend on frequency of contact, whether equipment has direct or indirect contact with poultry, and whether protective measures are applied:

- The probability of a vehicle getting contaminated is ***high to very high (high uncertainty)***
- The probability of trading related cages/crates getting contaminated is ***very high (high uncertainty)***
- The probability of vaccination equipment getting contaminated is ***low (high uncertainty).***

Therefore, the overall probability of material getting contaminated is ***high to very high (high uncertainty)***.

Probability of releasing contaminated equipment given farm is infected

The probability of contaminated equipment leaving the farm depends on the implementation of biosecurity measures (for example, disinfection) to prevent the spread of the disease. Vaccinators are most likely to clean and disinfect vaccination equipment before leaving the farm (EOE: Fauzi [PTS]). Cleaning and disinfection of vehicles and cages before entering and/or leaving the farm is rarely applied (EOE: Payawal [CTS], Maimun [CTS], ILRI-OR).

Interpretation: The probability of releasing a contaminated vehicle given a farm is infected is very high (high uncertainty); the probability of releasing contaminated transported cages/crates given a farm is infected is very high (high uncertainty); the probability of releasing contaminated vaccination equipment given a farm is infected is very low (high uncertainty). Therefore, the overall probability of material getting contaminated is ***high to very high (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of infection on a small-scale broiler farm	EOE FAO (2008a)	Low	High
Probability of equipment being contaminated given farm is infected	EOE Seo and Webster (2001) FAO (2008a)	High to very high	High
Probability of releasing contaminated equipment given farm is infected	EOE	High to very high	High

Overall risk estimate and conclusion for pathway 9

In this pathway, the probability of release of contaminated material via vaccination equipment is associated with low risk categories, as experts consulted consider that vaccination equipment is properly cleaned and disinfected. On the contrary, because of the absence of biosecurity measures, the risk associated with vehicles is estimated high, and even higher with the transported cages and crates. The overall risk estimate for the release pathway was found to be ***low (high uncertainty)*** only because the initial probability of infection on the farm was considered low.

4.10 Overall risk estimate and conclusions for the risk of release

Summary of risk estimates for release

Risk Pathway	Probability and Uncertainty Estimate
1. Release of HPAIV H5N1 through live broilers	Low (high uncertainty)
2. Release of HPAIV H5N1 through farmers/staff	Low (high uncertainty)
3. Release of HPAIV H5N1 through visitors	Low (high uncertainty)
4. Release of HPAIV H5N1 through free-range poultry	Low (high uncertainty)
5. Release of HPAIV H5N1 through wild birds	Low (high uncertainty)
6. Release of HPAIV H5N1 through farm bridge species	Very low (high uncertainty)
7. Release of HPAIV H5N1 through dead broilers	Low (high uncertainty)
8. Release of HPAIV H5N1 through manure	Low (medium uncertainty)
9. Release of HPAIV H5N1 through equipment	Low (high uncertainty)

All of the risk estimates were found to be low (high uncertainty) due to the estimated low probability of infection of small-scale broiler farms. However, most of the consecutive steps of all the release pathways were associated with high risk.

All risk estimates are also associated with high uncertainty because risk was estimated using input parameters mainly based on expert opinion elicitation.

5 Risk assessment for exposure

5.1 Exposure pathway 1: Probability of infection of broilers in a small-scale commercial farm after exposure to an HPAI H5N1 infected live broiler

Probability of introduction of live bird

Step of risk pathway	Data needs	Data source
Sub-pathway Live-bird Market (LBM)		
Probability of live broilers being sent to LBM/collecting yards	Proportion of birds sent to LBM	Sudarman et al. (2010)
Probability of mixing of broilers with other birds on LBM/collecting yards	Practices in LBM	EOE
Probability that bird on LBM/ collecting yards gets infected/ contaminated given mixing with infected bird	Frequency of contacts between poultry from different sources + number of birds in LBM	EOE Kung et.al (2007) IDP-CIVAS (2007)
Probability of infected/contaminated broilers being returned from LBM/ collecting yards if unsold	Proportion of unsold birds returned	EOE
Probability that a small-scale farm gets infected given infected/ contaminated bird is returned from LBM/collecting yards	Infectiousness of contact	EOE
Sub-pathway slaughter place		
Probability of live broilers being sent for slaughtering	Proportion of birds sent for slaughter	Sudarman (2010)
Probability of waste being contaminated given infected birds are slaughtered	Virus shedding Slaughtering practices	 EOE
Probability that contaminated waste gets in contact with another small-scale broiler farm	Slaughter places waste management Proportion of farm using open air sources without treatment	EOE IDP-CIVAS (2007) EOE
Virus survival in water		Webster et al. (1978) Brown et al. (2007) Van Kerkhove (2009)
Probability small-scale farm gets infected following contact with contaminated waste from slaughtering place	Infectiousness of contact	EOE

Sub-pathway LBM

Probability of live broilers being sent to LBM

An LBM refers to retail places usually located in traditional markets.

A companion study on poultry value chains in Bogor (Sudarman et al. 2010) indicates that ready-to-slaughter broilers from contracted farms are either transported to processing plants (50% of total production) or sold to collectors (remaining 50%). In the case of independent farmers, the broilers are sold to slaughter houses (20% of total production) and slaughter points (10%), or to collectors (70%).

Collectors subsequently sell 23% of the broilers to LBM. Broilers are also sold on to other traders or to slaughterhouses (8% of total production), while the remaining 69% is exported to areas outside Bogor (*ibid*). Among the 23% of broilers sold to LBM, 3% is directly slaughtered at slaughter points within markets, and the remaining 20% is moved on to slaughter points located in residential areas of Bogor.

Interpretation: Given the information presented above, the probability of live broilers being sent to LBM in Bogor is estimated to be ***medium (medium uncertainty).***

Probability of mixing of broilers with other birds on LBM

Most LBM are supplied by diverse sources. Broilers are typically transported by truck using transport cages, with no direct contact between broilers from different sources before unloading. Once unloaded however, broilers from difference sources are commonly mixed in LBM.

Interpretation: The likelihood of broilers mixing in LBM was estimated as ***very high (high uncertainty).***

Probability that bird on LBM gets infected / contaminated given mixing with infected bird

Viral transfer from bird to bird is possible in an LBM situation. Infection of birds occurs by inhalation of aerosolized virus and by direct contact with virus in poultry faeces and other body excretes. Therefore, even when birds from different sources are kept in different cages in LBM, the dusty circulating air can contribute to the mechanical transfer of the virus particles, as suggested by Kung et al. (2007).

The presence of HPAI H5N1 in Jakarta poultry collecting yards was studied from April to June 2007, and included indigenous poultry originating from Bogor. It found 32 out of 39 (84%) poultry collecting facilities in the study were contaminated with HPAIV H5N1, and suggested that transmission of HPAIV to sentinel birds placed in the poultry collecting facilities had occurred (IDP-CIVAS 2007).

Interpretation: The likelihood that birds in LBM get infected or contaminated from mixing with infected birds is estimated as ***very high (high uncertainty)***, owing to the level of contamination of collecting yards and the possibility of transmission between broilers in such settings.

Probability of infected/contaminated broilers being returned from LBM if unsold

All experts consulted suggested that broilers from the market chain are very unlikely to return to source farms. Most batches delivered to buyers are based on delivery orders and are thus unlikely to be refused. For certain reasons such as health status, a broiler batch might be rejected on arrival at LBM; however, in such cases the collectors try to send the batch to another collecting facility, market or informal slaughter place which would accept it at a lower price (EOE: Maimun [CTS], ILRI-OR).

Interpretation: The likelihood of an infected or contaminated broiler being returned from LBM if unsold was estimated as ***negligible (high uncertainty)***.

Probability that a small-scale farm gets infected given infected/contaminated bird is returned from LBM

HPAIV is highly contagious and, as explained before, the conditions in broiler farms of Java (FAO 2008a) facilitate the rapid spread of HPAIV within the flock once the disease is introduced.

Interpretation: The likelihood that a small-scale broiler farm gets infected given an infected or contaminated bird is returned from LBM was estimated *as* ***very high (high uncertainty).***

Sub-pathway Slaughtering places

Probability of a live broiler being sent for slaughtering

Information on the destination of finished broilers was presented above.

In addition, the IDP study observed 40 collecting yards in Jakarta where all poultry was meant for human consumption. According to the data collected, birds from these collecting yards are usually slaughtered in private slaughtering facilities, which process 10-50 birds per day, or in LBM, from where processed meat is then transported to markets or other customers such as restaurants or wet markets (EOE: Mulyono [CIVAS]).

Interpretation: Given the information presented above, the likelihood of live broilers being sent for slaughtering in Bogor (58%) is estimated to be ***very high (medium uncertainty)***.

Probability of waste being contaminated given infected birds are slaughtered

Waste from an infected bird is most likely to be contaminated by the virus (HPAIV H5N1 is present in faeces, blood and feathers).

Interpretation: The likelihood that waste is contaminated given infected birds are slaughtered is estimated as ***very high (high uncertainty)***.

Probability contaminated waste gets in contact with other small-scale broiler farm

Most (80-95%) small-scale broiler farms obtain water from surface-water wells (EOE: Payawal [CTS], Maimun [CTS] and Muryanto [GOPAN]). However, the farms are unlikely to be exposed to waste from slaughtering activities as slaughterhouses/points in Bogor District and City are all far away from broiler farms (EOE: Herawati, [Kabupaten Bogor DLS]).

Small-scale broiler farms could also be exposed to waste from slaughtering activities through contaminated actors of the production chain or material, such as returning equipment (particularly transport cages). Cleaning and disinfection of this equipment is not applied effectively (IDP-CIVAS 2007), thus contamination by waste from LBM or slaughtering points cannot be excluded. However, contact with such returning equipment would only happen at the end of the production cycle, when finished broilers are being collected (see also the section on equipment).

Interpretation: The likelihood that contaminated waste gets in contact with other small-scale broiler farms either directly or through fomites (equipment) is estimated to be ***very low (high uncertainty).***

Virus survival in water

Avian influenza viruses can persist for extended periods of time in water. Results from studies on subtype H5N1 and other avian influenza subtypes in other parts of the world have shown that persistence of avian influenza viruses in water depends on temperature, pH and salinity. One study showed that avian influenza subtype H3N6 can persist for 4 days in lake water at 22^0 C (Webster et al. 1978). Another study (Brown et al. 2007) showed that HPAIV H5N1 in fresh water at 28^0 C takes 4-5 days to lose 90% of infectivity. Experimental evidence has also suggested that influenza A viruses are detectible in water for up to 6 days at 37°C (Van Kerkhove 2009). Therefore, HPAIV H5N1 contained in waste from slaughter places is likely to survive for a few days in water.

Interpretation: The probability that HPAIV survives in water is ***medium (high uncertainty).***

Probability that a small-scale farm gets infected following contact with contaminated waste or fomites from slaughtering place

Given the survival of HPAIV H5N1 in the water, birds can be exposed to HPAIV present in contaminated drinking water. Direct intranasal or conjunctive inoculation is a possible mode of infection, therefore drinking of contaminated water can result in infection of birds. An infectious dose of 10^4 CID/0.1 ml (DGLS 2007) is considered sufficient to cause infection. However, quantities of the virus in water might not reach an infectious dose due to dilution effect.

Birds can also be exposed to fomites. Under certain conditions with sufficient quantity of virus, infection of broilers in contact with fomites can occur.

Interpretation: The likelihood that a small-scale farm gets infected following contact with contaminated waste from a slaughtering place (water or fomites) is ***medium with high uncertainty.***

Summary

Step of pathway	Source	Risk Category	Uncertainty
Sub-pathway LBM			
Probability of live broilers being sent to LBM	Sudarman et al (2010)	Medium	Medium
Probability of mixing of broilers with other birds in LBM	EOE	Very high	High
Probability that bird in LBM gets infected or contaminated given mixing with infected bird	EOE Kung et al. 2007 IDP-CIVAS (2007)	Very high	High
Probability of infected or contaminated broilers being returned from LBM if unsold	EOE	Negligible	High
Probability small-scale farm gets infected given infected or contaminated bird is returned from LBM	EOE	Very high	High
Sub-pathway Slaughterhouse			
Probability of live broilers being sent for slaughtering	Sudarman et al. (2010) EOE	High	Medium
Probability of waste being contaminated given infected birds are slaughtered	EOE	Very high	High
Probability that contaminated waste gets in contact with another small-scale broiler farm	EOE IDP-CIVAS (2007) EOE	Very Low	High
Virus survival in water	Brown et al. (2007) Van Kerkhove (2009) Webster et al. (1978)	Medium	Medium
Probability that a small-scale farm gets infected following contact with contaminated waste from a slaughtering place	EOE	Medium	High

Overall risk estimate and conclusion for live bird pathway

The probability of small-scale broiler farms to become exposed to infected live broilers via the market chain depends on two sub-pathways: LBM and slaughtering places. The risk of exposure to HPAIV H5N1 for a broiler farm through live broilers returned from markets was assessed ***negligible (high uncertainty)***. The risk of exposure to and subsequent infection from HPAIV H5N1 for a broiler farm through introduced waste from slaughtering places was assessed as ***very low (high uncertainty)***. The overall risk estimate for the exposure pathway 5.1 was estimated ***very low (high uncertainty)***: for the LBM sub-pathway, this is because broilers are unlikely to be returned if unsold, and for the slaughter place sub-pathway, because there are few opportunities of effective contact with fomites or contaminated water.

5.2 Exposure pathway 2: probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from a contaminated farmer/staff

Overview of information required for pathway 2

Step of risk pathway	Data needs	Data source
Probability of farmer/staff entering another small-scale broiler farm	Proportion of multisite farms	EOE
	Proportion of staff working in more than 1 small-scale broiler farm	EOE
Probability of virus surviving on farmer/ staff hands/clothes	Virus survival	Alexander (2007)
	Biosecurity practice for staff	Bean et al. (1982) EOE
Probability of contact of broilers with farmer/staff	Frequency entering small-scale broiler farms	EOE
	Frequency of contact between farmer/staff and poultry	EOE
Probability that bird on another small-scale farm gets infected given contact with contaminated farmer/staff	Infectiousness of contact	EOE Alexander (2007) Power (2005)

Probability of contaminated farmers/ staffs entering another small-scale broiler farm

Farmers in Bogor are unlikely to have multisite small-scale broiler farms, and staff are unlikely to work in more than one small-scale broiler flock (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN], Kota Bogor DLS). However, a few farmers are occasionally asked by other farms to give help during vaccination or for collecting birds at times when more personnel than usual is needed (EOE: Nugroho [veterinarian working in poultry practice]). In these instances, a farmer can get contaminated if the other farm is infected. Farmers/staff also possibly get in contact with contaminated material (waste, contaminated water) from other small-scale broiler farms at LBM or at slaughtering places, or when visiting other farms – although the latter was considered a rare event.

Interpretation: Given the information presented above, the frequency of farmer/staff contact with other small-scale broiler farms and other contaminated places is very low, thus probability of contaminated farmer/staff entering a small-scale broiler farm is ***very low (high uncertainty).***

Probability that virus will have survived on farmer/staff hands and clothes

Fomites are considered to be one of the most important means for spread of avian influenza viruses, therefore farmers and staff with contaminated hands or clothes/boots/shoes can contribute to its spread (Alexander 2007). Influenza viruses can survive 24-48 hours on hard, non porous surfaces and less than 8-12 hours on cloth, paper and tissues (Bean et al. 1982).

As indicated in the release assessment, small-scale broiler farmers and staff in the District and Municipality of Bogor are unlikely to use footbaths or change their clothes before entering or leaving farms (EOE: Payawal [CTS], Maimun [CTS] and Muryanto [GOPAN]). If they visit other farms shortly after getting contaminated, then HPAIV H5N1 may survive on their hands, clothes or shoes.

Interpretation: The likelihood of virus surviving on contaminated farmers and staff is ***high (high uncertainty).***

Probability of contact of broilers with farmers/ staff

Farmers or staff can directly have contact with broilers for several purposes at all stages of the production cycle particularly for vaccination, bird separation and collecting birds. Indirect contacts also occur during feeding the bird.

Interpretation: Probability of contact of broilers with farmer/staff is ***very high (high uncertainty).***

Probability that contact with contaminated farmers/staff results in infection

The concentration of virus shed in poultry faeces is high. In a gram of infective faeces, the virus may be present at concentrations as high as 10^7 infectious particles, and may survive for more than 44 days (Alexander 2007). It is thus thought that a small amount of contaminated dust adhering to shoes or clothing is sufficient to transmit the virus (Power 2005).

People's hands, clothes or shoes can get soiled with faeces or secretions from infected animals, and then infect other poultry when visiting another farm. Viral transfer from contaminated staff to bird is possible by inhalation of aerosolized virus, or direct contact with virus in poultry faeces and other body excretes attached to shoes or clothes. Viral transfer from contaminated hands is also possible if they come in contact with birds' portal of entry for viral infection.

Interpretation: Probability that a bird on another small-scale broiler farm gets infected given contact with contaminated farmers or staff is ***high (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability contaminated farmers/ staff entering other small-scale broiler farm	EOE	Very low	High
Probability that virus survives on farmer/staff hand/clothes	Alexander (2007) Bean et al. (1992) EOE	High	High
Probability of contact of broilers with farmer/staff	EOE	Very high	High
Probability that bird on other small-scale farm gets infected given contact with contaminated farmer/staff	EOE Alexander (2007) Power (2005)	High	High

Overall risk estimate and conclusion for pathway farmer/staff

The risk of exposure to HPAIV H5N1 of a broiler farm through contaminated farmers or staff is ***very low (high uncertainty)***. This is due to the high risk of infection of poultry if they come in contact with contaminated hands, clothes or shoes, which could be reduced by implementing on-farm biosecurity measures.

5.3 Exposure pathway 3: probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from contaminated visitors

Overview of information required for pathway 3

Step of risk pathway	Data needs	Data source
Probability of visitors entering small-scale broiler farm once contaminated	Type of visitor Frequency of visits for each category of visitor	EOE EOE
Probability of virus surviving on visitor hands/clothes	Virus survival Biosecurity for visitor	FAO (2008b) EOE
Probability of contact of broilers with visitors	Frequency of contact	EOE
Probability that bird on a small-scale farm gets infected given contact with contaminated visitors	Infectiousness of contact	EOE

Probability of visitors entering a small-scale broiler farms

As small-scale farms in Bogor typically have only one shed, they implement an all-in all-out system. However, for some farms, the harvest might take 1 to 6 days due to operational or economic reasons. The number of production cycles per farm and per year is around six, and periods between cycles with empty sheds average 2 weeks (EOE: Nugraha [PTS], Nugroho and Darmawan [veterinarians working in poultry practices]).

Vaccinators visit some small-scale farms one time per cycle (EOE: Nugraha [PTS]), as indicated previously. Only a small number of small-scale broiler farms use intra muscular vaccination, which is sometimes carried out with the assistance of vaccinators from Vaccine Company. In this case, a vaccinator can cover 1-3 farms a day (EOE: Nugroho, [veterinarian working in poultry practice]).

Technical services (also called poultry health controllers) from the contractor frequently visit (once per week) small-scale contract farms and are usually allowed to enter the poultry shed. In independent farms, visits of technical service officers from pharmaceutical or feed companies are less frequent (1-2 times per batch) (EOE: Nugraha [PTS]). Besides regular control, technical services also come if contagious disease is reported in the area.

Collectors and associated staff typically visit small-scale farms at the end of a production cycle to collect ready-to-slaughter broilers (EOE: Nugraha [PTS]). Collectors will then access collecting yards, LBM, or slaughter places and are assumed more likely to be contaminated. This situation could potentially lead to the introduction of disease into a broiler farm, but only at harvest time, which is not considered a big risk for the farm. However, as described above, some farmers break up the harvest into more than one delivery (EOE: Nugroho, [veterinarian working in poultry practice]). In this case, collectors and associated staff coming from an infected farm can possibly infect the farm they partially harvested, and in particular the stock remaining in the farm. In addition, if the cleaning, disinfection and period with empty sheds are not implemented properly, infection of the next new batch can occur.

Interpretation: The likelihood of a visit from an agent coming from another small-scale farm appears to differ according to the type of visitors. Overall, this likelihood was estimated ***very high (high uncertainty)***; with the highest likelihood attributed to technical service officers.

Probability that virus will have survived on visitors

As detailed in section 5.2, people can greatly contribute to the spread of HPAIV H5N1. This is due to virus survival in the environment combined with lack of biosecurity measures. As a result, if contaminated visitors leaving an infected farm visit another farm in a relatively short time, it can potentially result in infection of the second farm.

Bird collector knowledge about biosecurity practices is still very low (FAO, 2008b), and they visit more than one farm a day. Thus, they can get contaminated in farms, collecting yards, LBM or slaughtering places, and then visit other broiler farms without carrying out appropriate cleaning and disinfection.

According to one expert consulted (EOE: Fauzi [PTS]), the technical services officers, animal health controllers and vaccinators are educated about HPAI disease transmission, so they are more likely to follow biosecurity. However, biosecurity measures for visitors are often considered costly, time-consuming or not easy to implement, so few preventive or control measures are actually implemented. In addition, according to the observations from another expert (EOE: Nugroho [veterinarian working in poultry practice]), the technical services and vaccinators seldom use disposable overalls and boots when visiting small-scale broiler farms, and rarely carry out cleaning and disinfection of their boots. As technical services officers visit up to 4 farms a day and vaccinators up to 2 farms at the beginning of the production cycle, they could get contaminated in one farm and then visit other broiler farms. Although technical service officers detecting a clinical disease in one farm would stop visits to other farms, there is still a possibility that they get contaminated at a very early stage of infection on the farm, when there are no or few clinical signs, and then carry on visits in other farms (EOE: Nugraha [PTS]).

Interpretation: According to the evidence presented above, the probability that HPAIV H5N1 survives on visitor clothes or boots when they visit another farm was estimated to be ***very high (high uncertainty).***

Probability that visitors have contact with broilers

Vaccinators, collectors and associated staff have contact with broilers (either DOC or ready-to-slaughter broilers) during farm visits. Technical service officers and animal health controllers, however, because they visit farms for monitoring purposes, are most likely to only do visual inspection of the flock without direct contact with birds.

Interpretation: The likelihood of contact between broilers and visitors differs according to the type of visitor: vaccinators, collectors and their associated staff have more opportunities of contact with broilers than technical service officers/animal health controller. Overall the probability that visitors have contact with broilers was estimated as ***very high (high uncertainty).***

Probability that birds on a small-scale farm get infected given contact with contaminated visitors

Information on probability of infection following contact with contaminated visitors was presented above.

Interpretation: The probability that broilers get infected following contact with a contaminated visitor is ***high (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of visitors entering a small-scale broiler farm	EOE EOE	Very high	High
Probability of virus surviving on visitor hands/clothes	FAO (2008b) EOE	Very high	High
Probability of contact of broilers with visitors	EOE	Very high	High
Probability that a bird on a small-scale farm gets infected given contact with contaminated visitors	EOE	High	High

Overall risk estimate and conclusion for pathway visitors

The risk for the exposure of HPAIV H5N1 to a broiler farm through contaminated visitors is ***high (high uncertainty)***. In this pathway, technical services are the visitors responsible for the highest risk categories, so control efforts should be strengthened for these actors. Bird collectors represent a lower risk as they intervene at the end of the production cycle. However, they still have an important role to spread virus along the value chain.

5.4 Exposure pathway 4: probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from infected/contaminated free-ranging poultry

Overview of information required for pathway 4

Step of risk pathway	Data needs	Data source
Probability of contaminated free-ranging poultry entering a small-scale broiler farm	Type of free-ranging poultry Frequency of free-ranging poultry observed in small-scale poultry farms	EOE EOE FAO (2008a)
Probability of contact of broilers with free-ranging poultry	Frequency of contact	EOE
Probability that a bird on a small-scale farm gets infected given contact with infected free-ranging poultry	Infectiousness of contact	EOE

Probability of infected free-ranging poultry entering a small-scale broiler farm

As described in the release assessment, free-range poultry are observed in many small-scale farms. However, direct access to poultry sheds is reduced by walls (in case of on-platform housing, 1-2 meters high). However, contact might happen because of close proximity.

Free-range poultry probably move between small-scale broiler farms, due to the high density of farms in Bogor District (FAO 2008a). The probability of movement is also affected by the phase of infection: before showing symptoms, poultry probably move between small-scale broiler farms, but not once the disease develops.

Interpretation: The probability of free-range poultry moving between/entering small-scale broiler farms if infected is rated as ***medium to high (high uncertainty)***.

Probability of contact with infected free-range poultry

Broilers are not very likely to be in direct contact with contaminated or infected free-ranging poultry since the housing walls limit access to the sheds. In addition, if infected, free-range poultry are even less likely to get in the sheds, or might stay away from other birds. However, indirect contacts with respiratory secretions or faecal materials, especially via contaminated equipment or staff, cannot be excluded, but was considered rare.

Interpretation: The probability of direct or indirect contact of broilers with infected/contaminated free-range poultry is ***low (high uncertainty)***.

Probability that broilers get infected following contact with infected or contaminated free-ranging poultry

Broilers can possibly get infected with HPAIV in infected farms, if they get in contact with contaminated respiratory secretions or faecal materials which contain a lot of virus, or even more if they get in close contact with infected free-range poultry.

Interpretation: The probability of broilers getting infected given contact with infected free-ranging poultry is ***very high (high uncertainty).***

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of free-ranging poultry entering a small-scale broiler farm	EOE FAO (2008a)	Medium to High	High
Probability of contact of broilers with free-ranging poultry	EOE	Low	High
Probability that a bird on a small-scale farm gets infected given contact with infected free-ranging poultry	EOE	Very high	High

Overall risk estimate and conclusion for pathway free-ranging poultry

The risk for the exposure of HPAIV H5N1 to a broiler farm through infected free-range poultry is ***very low to low (high uncertainty)***. In this pathway, risk is due to the existence of many free-ranging poultry and the absence of adapted fencing in most small-scale broiler farms.

5.5 Exposure pathway 5: probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from an infected/contaminated wild bird

Overview of information required for pathway 5

Step of risk pathway	Data needs	Data source
Probability of an infected/ contaminated wild bird entering another small-scale broiler farm	Type of wild bird	EOE
	Frequency of wild birds observed in small-scale poultry farm	EOE
Probability of contact between broilers and an infected/ contaminated wild bird	Frequency of contact	EOE
Probability that a bird on a small-scale farm gets infected given contact with an infected wild bird	Infectiousness of contact	EOE

Probability of infected wild bird entering a small-scale broiler farm

The probability of an infected wild bird moving between small-scale broiler farms is described in section 4.5 (release assessment).

This probability is also influenced by the phase of infection. At the beginning of infection, when infected wild birds do not have symptoms yet, they probably move between small-scale broiler farms, but this is unlikely once they develop symptoms.

Interpretation: The likelihood that infected wild birds move between small-scale broiler farms is considered ***medium to high (high uncertainty)***.

Probability of contact with infected wild bird

Poultry shed structures limit the access to other animals: only 40% are built over fish ponds, and 80% are fenced with bamboo. However, this still allows small wild birds (e.g. sparrows) to enter the sheds (e.g. via side walls, roof, and ventilation). For this reason, broilers can get in direct contact with contaminated or infected wild birds. In addition, it seems that some infected wild birds are asymptomatic carriers, and thus the likelihood of contact between wild birds and broilers might not be reduced because of clinical signs in infected wild birds. The frequency of direct contact with wild birds is relatively low (EOE: Nugroho [veterinarian working in poultry practice]). Instead, contacts with respiratory secretions or faecal materials are more likely to occur.

Interpretation: The probability of direct or indirect contact of broilers with an infected/ contaminated wild bird is ***low (high uncertainty)***.

Probability that broilers get infected following contact with an infected or contaminated wild bird

If broilers get in contact with wild birds, their contaminated respiratory secretions or faecal material, broilers can get infected with HPAIV.

Interpretation: The probability of a broiler getting infected given contact with an infected wild bird is ***very high (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of a wild bird entering a small-scale broiler farm	EOE	Medium to High	High
Probability of contact of broilers with a wild bird	EOE	Low	High
Probability that a broiler on a small-scale farm gets infected given contact with an infected wild bird	EOE	Very high	High

Overall estimate and conclusion for pathway wild bird

The risk for the exposure of a broiler farm to HPAIV H5N1 through infected wild birds is ***very low to low (high uncertainty)***. In this pathway, risk is due to the existence of many wild birds and the absence of adapted fencing in most small-scale broiler farms.

5.6 Exposure pathway 6: probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from a contaminated bridge species

Overview of information required for pathway 6

Step of risk pathway	Data needs	Data source
Probability of contaminated vermin, dog or cat entering another small-scale broiler farm	Frequency of vermin, dogs and cats observed in small-scale poultry farms	EOE
Probability of virus surviving in vermin, cats and dogs	Virus survival	Mahardika (2007) Burgos and Burgos (2007) Thiry et al. (2007) Marschall and Hartmann (2008) Beeler (2009)
Probability of contact of a broiler with vermin, dog or cat	Frequency of contact	EOE
Probability that a broiler on a small-scale farm gets infected given contact with contaminated vermin, dog or cat	Infectiousness	EOE

Probability of contaminated/infected farm bridge species entering a small-scale broiler farm

The different frequencies of movements between small-scale broiler farms for vermin, dogs and cats are described above in 4.6. Rats and cats are likely to stay on farm as long as they have food, while dogs are likely to wander between farms. Farm structures reduce the risk of cats and dogs entering poultry sheds. Vermin are more likely to enter poultry sheds than cats and dogs, but less likely to move between farms, unless adjacent.

Interpretation: Thus, the probability of contaminated farm bridge species entering small-scale broiler farms is ***low (high uncertainty)***.

Probability of virus surviving in farm bridge species

Studies have found that dogs and cats can carry the virus or have antibodies against HPAIV H5N1 (Mahardika 2007). After infection, cats and birds such as the vulture excrete the virus, which suggests that they could be a source of transmission (Burgos and Burgos 2007; Thiry et al. 2007; Marschall and Hartmann 2008; Beeler 2009). According to the literature review, cats and dogs can get infected and thus the virus might survive in their organism for some time. In their secretions and excretions, though, survival might be the same or lower than in bird excretions and secretions.

In addition to these considerations, HPAIV may survive on the hair of farm bridge species directly or in faeces for a specified time similar or shorter as what was described under 5.2, 5.8 and 5.9 (sections on virus survival).

Interpretation: The probability of virus surviving in bridge species is ***low (high uncertainty)***.

Probability of contact with a contaminated/infected farm bridge species

Chickens are unlikely to get in contact with cats and dogs (EOE: Nugroho [veterinarian working in poultry practice]). However, indirect contact cannot be excluded with vermin via contaminated feed, or with cats which are known to shed virus.

Interpretation: The probability of direct or indirect contact of a broiler with a contaminated bridge species is ***very low (high uncertainty)***.

Probability that broilers get infected following contact with an infected or contaminated bridge species

Broilers can possibly get infected with HPAIV following direct or indirect contact with contaminated or infected vermin, cats or dogs, or their excretions and secretions (Nugroho, veterinarian working in poultry practice). However, it may depend on virus load, temperature, humidity and the ability of the species to shed virus after infection.

Interpretation: The probability of a broiler getting infected given contact with a contaminated or infected bridge species is considered ***high (high uncertainty)***. The highest probability is given to vermin.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of contaminated vermin, dog and cat entering a small-scale broiler farm	EOE	Low	High
Probability of virus surviving in vermin, cat and dog	Mahardika (2007) Burgos and Burgos (2007) Thiry et al. (2007) Marschall and Hartmann (2008) Beeler (2009)	Low	Medium
Probability of contact of a broiler with vermin, dog or cat	EOE	Very low	High
Probability that a broiler on a small-scale farm gets infected given contact with contaminated vermin, dog or cat	EOE	High	High

Overall estimate and conclusion for bridge species

The overall risk for a broiler farm to be exposed to HPAI H5N1 through a farm bridge species was assessed as ***negligible (high uncertainty)***, mainly because of the structures preventing access to poultry sheds, and the relatively low frequency of movements between farms.

5.7 Exposure pathway 7: probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from dead broilers

Overview of information required for pathway 7

Step of risk pathway	Data needs	Data source
Probability of a contaminated or infected dead bird brought to another small-scale broiler farm	Frequency of entry	EOE
Probability of virus surviving in a dead bird	Virus survival	Senne et al. (1994) Van Kerkhove (2009) EFSA (2006) Yamamoto et al. (2008)
Probability of contact between broilers and a dead bird	Frequency of contact	EOE
Probability that a broiler on a small-scale farm gets infected given contact with an infected dead bird	Infectiousness	EOE

Probability of an infected dead bird being brought into a small-scale broiler farm

Dead birds in small-scale broiler farms are likely to be collected by farmers or specific collectors, travelling by bicycle, foot or motorcycle. People visiting markets may also collect dead birds from the markets or disposal bins and take or sell them to catfish farms (EOE: ILRI-OR).

Small-scale broiler farms are unlikely to buy dead birds from other small-scale broiler farms (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN], ILRI-OR). Inappropriately disposed dead birds can possibly contaminate neighbouring farms through water, but this is unlikely. People or equipment, or stray animals could also be responsible for transmission between farms if they get contaminated by infected carcasses, but this has been addressed in other sections.

Interpretation: The probability of an infected dead bird introduced to another small-scale broiler farm is ***very low (high uncertainty).***

Probability of virus surviving in a dead bird

Avian influenza type A viruses can survive in carcasses of infected birds for a varying period of time, depending on environmental conditions. In general, the period of infectivity increases with decreasing temperature (EFSA 2006). Experimental evidence has suggested that HPAIV H5N1 can survive in carcasses for several days at room temperature and longer in cooler (+4°C) temperatures (Van Kerkhove 2009). In addition, Senne et al. (1994) reported that HPAIV is inactivated if composting is applied at the end of the first 10 days.

It is important to note that feathers also constitute a possible source of infection as reported by Yamamoto et al. (2008): they found that 2 different HPAI virus (H5N1) genotypes can replicate in the feather epidermal cells of domestic ducks and geese.

Interpretation: Avian influenza type A viruses can survive in bird carcasses for a relatively long time, as described above. The probability that HPAIV has remained infective in a dead bird introduced into another farm was therefore considered ***very high (medium uncertainty).***

Probability of contact between broilers and infected dead birds

Contacts between poultry and infected dead birds from other farms are unlikely to occur since poultry are kept in closed sheds, and farmers put away dead birds found on or in the surroundings of their farms.

Interpretation: Small-scale broiler farms are unlikely to be in contact with dead birds from another farm, therefore the probability of a dead bird getting in contact with a broiler farm is assessed as ***negligible (high uncertainty)***.

Probability that bird on a small-scale farm gets infected given contact with a contaminated or infected dead bird

The amount of HPAIV present in broilers having recently died is considered to be sufficiently large to infect other broilers. That quantity will decrease considerably over time under tropical conditions.

Interpretation: If exposed to recently dead broilers, birds are likely to get infected, therefore the probability of infection following contact is assessed to be ***very high (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of a contaminated or infected dead bird entering a small-scale broiler farm	EOE	Very low	High
Probability of virus surviving in a dead bird	Senne et al. (1994) Van Kerkhove (2009) EFSA (2006) Yamamoto et al. (2008)	Very high	Medium
Probability of contact of broilers with a dead bird	EOE	Negligible	High
Probability that a broiler on a small-scale farm gets infected given contact with a contaminated or infected dead bird	EOE	Very high	High

Overall risk estimate and conclusion for pathway dead bird

The probability of a farm becoming exposed to HPAIV H5N1 infection through a dead bird from other small-scale broiler farms is ***negligible (high uncertainty)***, mainly because contacts between broilers and carcasses of infected birds from other farms are very unlikely.

5.8 Exposure pathway 8 : probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from contaminated manure

Overview of information required for pathway 8

Step of risk pathway	Data needs	Data source
Probability of manure being introduced into a small-scale broiler farm	Frequency of entry	EOE
Probability of virus surviving in manure	Virus survival	Lu et al. (2003) Fitchner (1987) Songserm et al. (2005)
	Manure treatment practice	EOE
Probability of contact of broilers with manure	Frequency of contact	EOE
Probability that a broiler on a small-scale farm gets infected given contact with contaminated manure	Infectiousness of contact	EOE

Probability of manure being brought to another small-scale broiler farm

Because each farm produces a large amount of manure, trucks collecting manure are unlikely to visit more than one farm a day. In addition, small-scale broiler farms are unlikely to buy manure or fertilizer from another small-scale broiler farm (EOE: Maimun [CTS], Muryanto [GOPAN], ILRI-OR).

Contamination can therefore only occur via equipment, people or stray animals, and has been addressed in the corresponding sections. In the case of neighbouring farms, contaminated manure may also be responsible for transmission of the disease if farm waste management is inappropriate.

Interpretation: Since the introduction of manure into other small-scale broiler farms is very unusual, the probability of manure being introduced into another small-scale broiler farm is ***very low (high uncertainty)***. Other relevant mechanisms of transmission (people, equipment, animals) have been addressed in other sections of this report.

Probability of virus surviving in manure

Avian influenza type A viruses can survive in chicken manure for relatively long periods. The variability in survival in manure reported by different researchers is influenced by factors such as temperature and pH. Lu et al. (2003) reported that H7N2 avian influenza virus can survive in manure at a temperature of 37°C for 14 days with infectivity retained, and Fitchner (1987) suggested that avian influenza H5N2 virus survives and retains infectivity in chicken manure at ambient temperature for up to 105 days. However, it is also reported that HPAIV is very rapidly inactivated by direct solar radiation (Songserm et al. 2005), or when manure is used for composting or is treated.

In Bogor, more than 80% of small-scale broiler farms collect manure immediately after harvest. The manure is then likely to be sold without being treated. A small proportion of smaller farms also use farm waste to feed fish (FAO, 2008a).

Interpretation: Avian influenza type A viruses can survive in chicken manure for relatively long periods, especially if manure is not treated or exposed to sunlight before being sold. The probability of virus surviving in chicken manure was therefore assessed as ***very high (medium uncertainty)***.

Probability of contact of a broiler with manure once introduced from another farm

In the case of neighbouring farms, broilers could possibly get in contact with manure from those farms if their waste management is inappropriate. However, it is unlikely to occur since poultry are kept in closed sheds. In addition, since manure has an economic value, farmers are most likely to collect and sell it.

Interpretation: The probability that broilers get in contact with contaminated manure introduced into the farm was assessed to be ***negligible (high uncertainty)***.

Probability that a broiler on a small-scale farm gets infected given contact with contaminated manure

Assuming that HPAIV has survived in contaminated manure, then a bird is very likely to be infected if it gets in contact with manure, even in a small amount.

Interpretation: The likelihood of becoming infected following contact with contaminated manure is ***very high (high uncertainty)***.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of manure entering a small-scale broiler farm	EOE	Very Low	High
Probability of virus surviving in manure	Lu et al. (2003) Fitchner (1987) Songserm et al. (2005) EOE	Very high	Medium
Probability of contact of broilers with manure	EOE	Negligible	High
Probability that a broiler on a small-scale farm gets infected given contact with contaminated manure	EOE	Very high	High

Overall risk estimate and conclusion for pathway manure

The probability of a farm being exposed to HPAIV H5N1 infection through manure from another small-scale broiler farm is ***negligible (high uncertainty)***. This conclusion is based on the observation that manure is unlikely to be introduced to another small-scale broiler farm, and even less likely to get in contact with broilers on that farm.

5.9 Exposure pathway 9: probability of infection of broilers in a small-scale commercial farm after exposure to HPAI H5N1 from contaminated equipment

Overview of information required for pathway 9

Step of risk pathway	Data needs	Data source
Probability of contaminated equipment being introduced into another small-scale broiler farm	Type of equipment Frequency of entering	EOE
Probability of virus surviving in equipment	Biosecurity for equipment Virus survival	EOE Bean et al. (1982)
Probability of contact of broilers with equipment	Frequency of contact	EOE
Probability that a broiler on a small-scale farm gets infected given contact with contaminated equipment	Infectiousness of contact	EOE

Probability of contaminated equipment entering a small-scale broiler farm

During a broiler production cycle, small-scale broiler farms are visited by various types of visitors, with accompanying vehicles and equipment. Vehicles supplying DOC, feeds or drugs are allowed onto the farm at the beginning of the production cycle. Technical service vehicles are allowed on farms 1-4 times during the entire growing period, while vehicles from bird and manure collectors enter farms at the end of a batch. It is likely that these vehicles and corresponding equipment enter more than one farm a day. For feed and drug suppliers or technical service officers, there are no direct contacts with birds, thus vehicles constitute the main type of "contaminated equipment" which can be introduced into a farm.

Most (95-100%) of the small-scale broiler farms sell their birds to collectors who are most likely to visit more than one small-scale broiler flock a day. Vehicles and cages used to collect the birds are generally used across different farms (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN], ILRI-OR). Vehicles and cages can get contaminated in farms, collecting yards, LBM and slaughtering places, and then be introduced onto other small-scale broiler farms without appropriate cleaning and disinfection. In Bogor, some small-scale broiler farms are located in remote areas, or don't have a parking area. In these instances, trucks are usually parked at distance (e.g. 30 meters) from poultry sheds. However, transport cages are always brought into the poultry shed to collect birds. Birds—both broilers being sold and broilers being held for a few days more—can have contact with the cages, and dirty cages can contaminate the shed's ground (EOE: Nugroho [veterinarian working in veterinary practice]).

Small-scale broiler farms using vaccinators have an increased risk of introduction of contaminated vaccination equipment compared to farms which carry out vaccination on their own. This is because equipment used by vaccinators can be contaminated during previous visits to other farms if cleaning and disinfection is not carried out properly.

Interpretation: The probability of contaminated vehicles or equipment being brought to another small-scale broiler farm is ***very high (high uncertainty).***

Probability of virus on equipment has survived

Contamination of equipment happens mainly via faeces, respiratory excretions as well as feathers and dust. As discussed previously, an avian influenza virus can survive outside the host for certain periods of time depending on the environmental conditions. Both influenza A & B viruses survived for 24-48 hours on hard, nonporous surfaces such as a stainless steel and plastic, but the viruses survived for less than 8-12 hours on cloth, paper, and tissues (Bean et al. 1982). Survival in faeces is usually longer, especially under favourable conditions of humidity and temperature.

Vehicles and cages used to harvest broilers are usually owned by collectors or traders. They get in contact with the broiler farms at the end of a production cycle, and are typically used in several farms over a short period (more than 1 farm visited per day).

Faeces and respiratory discharge from HPAI infected flocks can contaminate transport cages, which are unlikely to be cleaned and disinfected properly between deliveries (at best, they are washed with water if very dirty) (EOE: Payawal [CTS], Maimun [CTS], Muryanto [GOPAN], ILRI-OR).

Interpretation: Considering the lack of cleaning and disinfection of equipment such as transport cages, and the short time between visits to different small-scale broiler farms, the probability of HPAIV H5N1 having survived on equipment which get in contact with broilers is ***very high (high uncertainty)***.

Probability of contact of broilers with equipment

The information provided above indicates that broilers are likely to have contact with equipment from vaccinators and collectors. However, they are unlikely to get in contact with vehicles, as the broilers are kept in closed sheds. It is however possible that contaminated material from vehicles (faeces, dirty packages, etc.) contaminates equipment or people from the farm, which in turn get in contact with broilers.

Interpretation: The probability of contaminated equipment getting in contact with poultry from other farms is ***high (high uncertainty)***.

Probability that bird gets infected following contact with contaminated equipment

The amount of HPAIV in contaminated poultry transport cages is expected to be sufficient to infect other broilers considering the virus load in faeces from infected birds, the short time between visits to different farms, and the inappropriate cleaning and disinfection of equipment.

In the case of vehicles and cages associated with broiler harvest, contacts happen at the end of a production cycle. Therefore, although the infection of poultry (ready for sale/slaughter) may well happen, infected animals are very likely to have left the farms when they become infectious. Hence, their potential for disease spread is more likely to be via subsequent contamination of other actors, equipment or birds in LBM, collecting yards and slaughter places, or at any point along the market chain. However, if cleaning and disinfection are not carried out properly after the broiler harvest, and the time with empty sheds is not respected, contaminated material might still be present on the farm when a new batch is introduced, resulting in its infection. Although this cannot be excluded, it is thought not to be a common situation.

Some farmers may spread the delivery batch over more than one day and some broilers are held on the farm for several days. Under these circumstances, these broilers may get infected from contaminated equipment and may even develop symptoms before they are sold (EOE: Darmawan and Nugroho [veterinarians working in poultry practice]).

In the case of vaccination equipment, if the contaminated material having contact with birds contains enough virus particles, it will result in infection of birds at an earlier stage of the production cycle.

Interpretation: The probability of a bird getting infected given contact with contaminated equipment was estimated to be ***very high (high uncertainty)***. In this pathway, equipment from collectors are associated with the highest risk categories, because they are used across different farms over short periods of time, get in close contacts with birds, and are not cleaned and disinfected appropriately.

Summary

Step of pathway	Source	Risk Category	Uncertainty
Probability of equipment entering a small-scale broiler farm	EOE	Very high	High
Probability of virus surviving in equipment	EOE Bean et al. (1982)	Very high	High
Probability of contact of broilers with equipment	EOE	High	High
Probability that a broiler on a small-scale farm gets infected given contact with contaminated equipment	EOE	Very high	High

Overall risk estimate and conclusion for pathway equipment

The risk of poultry within a farm becoming exposed to HPAIV H5N1 infection via equipment was assessed as ***high (high uncertainty)***. In this pathway, equipment from collectors is associated with the highest risk categories. When the broiler harvest is done over more than a day, it increases the probability that some infected birds remain on farm long enough to develop symptoms and further spread the infection.

Summary of Exposure Assessment

Risk Pathway	Probability and Uncertainty Estimate
1. Exposure of HPAI H5N1 through live broiler	Very low (High uncertainty)
2. Exposure of HPAI H5N1 through farmer/staff	Very low (High uncertainty)
3. Exposure of HPAI H5N1 through visitors	High (High uncertainty)
4. Exposure of HPAI H5N1 through free-range poultry	Very low to low (High uncertainty)
5. Exposure of HPAI H5N1 through a wild bird	Very low to low (High uncertainty)
6. Exposure of HPAI H5N1 through bridge species	Negligible (High uncertainty)
7. Exposure of HPAI H5N1 through a dead broiler	Negligible (High uncertainty)
8. Exposure of HPAI H5N1 through manure	Negligible (High uncertainty)
9. Exposure of HPAI H5N1 through equipment	High (High uncertainty)

The exposure pathways associated with the ***highest risk*** estimates in this study are: visitors and equipment (***high with high uncertainty***). Free-range poultry and wild birds were assessed as ***very low to low*** (***high uncertainty***) followed by live broilers and farmer/staff (***very low with high uncertainty***). Exposure via farm bridge species, dead broiler and manure was assessed to be ***negligible***.

6 Consequence assessment

When an HPAI outbreak occurs in a small-scale broiler farm, the disease spreads rapidly within the flock. According to government regulations, the affected flock is subject to immediate targeted culling and disposal to stop the disease spread. However, partly due to inadequate compensation, farmers are not likely to report the suspected HPAI cases to the veterinary authorities. Instead, farmers usually sell birds immediately to the usual market chain, so as to avoid further financial losses. Because of under-reporting, the restriction of poultry movement and contaminated materials cannot be enforced properly. As a consequence, HPAIV H5N1 can spread beyond the farm and to the market chain via certain pathways described in the release and exposure assessments.

Small-scale commercial broiler farms produce 5 or 6 batches per year. According to farmers' experience, HPAI outbreaks are most likely to occur at the end of a production cycle. This is partially explained by the increased risk posed by bird collectors or traders and associated transport cages at harvest time. In this case, the birds may not develop disease while on the farm, but still help maintain the virus circulating in the environment, particularly in LBM and collecting yards, as suggested by the IDP study (IDP-CIVAS 2007). If HPAI is suspected on the farm at an earlier stage, it is still possible for farmers to sell the batch of broilers, as there is a market for prematurely harvested birds in Bogor City and District.

Although they may not report suspicion of an outbreak to veterinary authorities, farmers are likely to ask for advice from technical services and to implement stricter cleaning and disinfection and extended resting time. This way, the impact of the outbreak on the affected farm is limited. Farmers are then likely to introduce a new batch.

In terms of financial impact, farmers suffer direct losses if the broilers develop symptoms and the mortality is higher than usual, or if they have to sell their chickens at a lower price. They also incur additional costs to implement a stricter cleaning and disinfection and extended resting period after selling the affected batch. For contracted farms, these losses are typically less serious than for independent farm owners. Indeed, the agreement for contracted farms usually stipulates that costs are shared between farmers and contactors. According to one respondent, after experiencing an outbreak, an independent farm may possibly opt to become a contracted farm as their losses were too severe to maintain independency.

The biological and economic consequences of the introduction of HPAI into a small-scale commercial broiler farm were generally considered moderate for the affected farm. However, such an outbreak can be a source of infection for other farms and help maintain HPAIV circulating in the poultry sector. Therefore, the consequence for the poultry sector in general was considered high.

7 Conclusion and recommendations

Table 4 shows the risk estimates obtained for the release and exposure assessments of all risk pathways involved in the transmission of HPAIV H5N1 between small-scale broiler farms in Bogor District and City, as well as the overall risk estimate derived by combining the release and exposure estimates. The overall risk of transmission was assessed as low, and risk estimates for the different pathways range from negligible to low. The risk associated with movement of contaminated visitors and equipment exchange was assessed as the highest. The risk of transmission via free-ranging poultry and wild birds was assessed as negligible to very low, while all other pathways were assessed as negligible. All risk estimates, except the one considering transmission via manure, were associated with a high uncertainty because of the lack of data on both the poultry sector in Indonesia and the epidemiology of HPAIV H5N1 more generally.

Table 4: Overall risk estimates for the transmission of HPAIV between small-scale broiler farms in Bogor District and City.

Pathways	Release		Exposure		Overall Risk	
	Risk	Uncertainty	Risk	Uncertainty	Risk	Uncertainty
Live Broiler	Low	High	Very Low	High	Negligible	High
Farmer/Staff	Low	High	Very Low	High	Negligible	High
Visitors	Low	High	High	High	Low	High
Free-range Poultry	Low	High	Very Low to Low	High	Negligible to Very Low	High
Wild Birds	Low	High	Very Low to Low	High	Negligible to Very Low	High
Farm Bridge species	Very Low	High	Negligible	High	Negligible	High
Dead Poultry	Low	High	Negligible	High	Negligible	High
Manure	Low	Medium	Negligible	High	Negligible	Medium
Equipment	Low	High	High	High	Low	High

In this study we found the following practices associated with non-negligible risk of transmission:

Visitors (low, high uncertainty)

- The movement of visitors between small-scale broiler farms is recognized as a higher risk pathway. In fact, most bird collectors (for trading purposes) move to collect poultry between different farms within less than 24 hours. Such a practice carries very high risk of contamination from the biosecurity point of view. In addition, animal health workers (PTS, FTS, CTS) do not always use protective clothing when visiting a farm.

- Farmers should be introduced to biosecurity practices such as encouraging and enforcing visitors to use clean protective clothing and boots while handling birds, washing hands before and after work and not allowing any unauthorized visitors on premises.

- Farmers should also make sure that there are footbaths at the farm entrance, and that they provide adequate facilities to staff and visitors for cleaning and disinfection: sinks with soap/disinfectant, clean overalls and boots, regular refilling of footbath with disinfectant, etc.

- PTS, FTS and CTS should be trained on safe handling of poultry and provided with sufficient protective clothing to be used systematically during farm visits.

Equipment (low, high uncertainty)

- Equipment represent a high risk of transmission of HPAIV H5N1 between small-scale broiler farms in Bogor. Indeed, equipment is being used across different farms and into the market chain (collecting yards, LBM, slaughtering places) without appropriate cleaning and disinfection.

- The risk could be reduced if all such equipment undergo appropriate cleaning and disinfection every time after use. Since collectors seem to have little incentive to adopt such practices, they are less likely to implement proper cleaning and disinfection of transported cages. Cleaning and disinfection of transported cages should be done at the farm gate, before harvesting birds. The expense, however, would then be imposed on the farmer. Farmers would need to be convinced that clean equipment is important to produce healthy poultry and that it is beneficial for them.

- Vaccinators and farmers should be trained on safe handling of vaccination equipment, which should always be cleaned and disinfected before and after being used.

Spreading the delivery batch over more than one day is a high-risk mechanism for transmission of HPAIV H5N1. This practice facilitates contact between contaminated visitors (collectors and associated staff) and transported cages and broilers that will remain on farms. Farmers should be encouraged to harvest all broilers in the same day.

Free-range poultry and wild birds (negligible to very low, high uncertainty)

- In these pathways, HPAI risk is largely due to the existence of many free-ranging poultry and wild bird species. The current fencing measures applied may only reduce the contact with free-ranging poultry, big wild birds such as vultures, and farm bridge species in most small-scale broiler farms. However, small wild birds (e.g. sparrows) may still have access to pens, and get in contact with broilers due to the type of construction of the poultry housing (e.g. side wall, roof, and ventilation). Disease could therefore be reduced by improving the construction of housing to further restrict access of these animals to the pens.

Further observation

- Under-reporting of contagious disease is a critical factor associated with high risk of release of HPAIV from infected broiler farms. The main reason farmers didn’t report cases or disease suspicious to veterinary authorities was because they feared the authorities would cull their birds without proper compensation (difficulties: implementation left with district authorities and insufficient funding at various levels).

- On the other hand, the lack of active surveillance in the commercial poultry sector failed to detect cases of HPAI in small-scale commercial broiler farms. The main constraints to implementing surveillance and control measures included limited resources and initial prioritization of backyards in the PDSR.

- As a consequence of under reporting and lack of active surveillance, containment measures (including culling and bans on selling infected birds, dead birds and manure) were unable to be implemented to avoid release of HPAIV from affected premises. In addition, the control of outbreaks by stamping-out, cleaning and disinfection generally rely on voluntary compliance (according to the Standard Operating Procedures).

  In this context, the options for actions in order to reduce the risks of transmission between small-scale commercial broiler farms include the following:

- The risk of disease spreading could be reduced by enhancing the compulsory reporting of contagious disease to veterinary authorities and by implementing containment measures such as bans on poultry sales and movements when disease is suspected. Veterinary authorities will need to provide sufficient compensation to encourage farmers to report any observed or suspected cases of contagious diseases, and communicate on the risk of further spread of the disease and impact on production if suspicions are not reported.

- Improve detection and response capacities within veterinary authorities, particularly as they relate to small-scale commercial broiler farms.

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Annex 1: Experts consulted (Expert Opinion Elicitation [EOE] and in-depth interview)

Darmawan , Charolus Baso (veterinarian working in poultry practice)

FAO-PDSR (expert within FAO-PDSR)

Fauzi, Rama Syahti Prima (veterinarian working as pharmaceutical technical service)

Herawati, Titik (Kabupaten Bogor District Livestock Services)

ILRI-OR (a group of experts within ILRI-OR)

Maimun (veterinarian working as contractor technical services)

Mulyono, Albert Teguh (CIVAS)

Muryanto, Saptono Adi (veterinarian working at GOPAN, non industrial commercial poultry producer association)

Nugraha, Candra Tri (pharmaceutical technical service)

Nugroho, Tatan Aji (veterinarian working in poultry practice)

Payawal, Randy (veterinarian working at Sierad Produce, an integrated poultry company)

Witrasari, Wenda (veterinarian working as feed technical service)

Kota Bogor District Livestock Services (expert within Kota Bogor DLS)