

## Chapter 24

### Modelling performance of monitoring systems for Avian Influenza

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#### 1. Introduction

As for most highly contagious diseases, also for Avian Influenza (AI) monitoring systems are in place in most member states of the European Union (EU). The main purpose of these monitoring systems is to detect the presence of AI virus as soon as possible. After detection, AI control can be started aiming at a rapid eradication of the disease. Following Longworth and Saatkamp (2008, chapter 28 of this report), the main aim of such monitoring systems is to reduce the High Risk Period (HRP) of AI as much as possible, which results in the least unfavorable starting situation for disease eradication in terms of number of infected farms at the time of first detection (i.e. start of eradication).

Monitoring systems can include various measures, e.g. syndrome surveillance by the farmer, diagnosis by (regular checks by) veterinarians, regular inspection and blood sampling. All these different measures have their own features in terms of frequency, reliability, time consumption and costs. Hence, the performance of a monitoring system is the overall result of these combined measures. Performance of monitoring systems is influenced also by other factors, such as the characteristics of the disease (e.g. speed of spread and establishment of symptoms), alertness of the people involved, and the structure of the production and veterinary infrastructure.

The aim of this study was to develop a framework for quantitative analysis of performance of AI monitoring, and to find out which factors particularly influence this performance.

#### 2. Material and methods

As a starting point for research HPAI in broilers in The Netherlands was chosen. Nevertheless, the methodology developed is flexible and generic, i.e. applicable to other conditions as well.

##### 2.1. Framework

The basis for AI monitoring in The Netherlands is syndrome surveillance at the level of individual poultry flocks. In case a farmer has suspicion, other actions will follow. In Figure 1, the basic layout of this monitoring system is presented (which was the basic framework for subsequent simulation model design). Syndrome surveillance can be done by the farmer through clinical suspicion and/or increased mortality, or by e.g. the observation of reduced feed intake. This first suspicion can trigger two types of action by the farmer: (1) an additional clinical inspection by specialists of the Food Safety Authority (FSA), or (2) a differential diagnosis by a veterinarian. In case of the latter, three possible courses of action are possible: (1) an additional clinical inspection by FSA experts, (2) taking of swabs to be analyzed by the reference laboratory or (3) post mortem investigation by the Animal Health Service (AHS). All these three actions will result (in case of positive suspicion) by final diagnosis in the reference lab. The various 'routes' from syndrome surveillance to reference lab are dependant on the alertness and risk perception of the people involved. Moreover, different routes have different time use and costs, i.e. they can influence the overall monitoring performance.

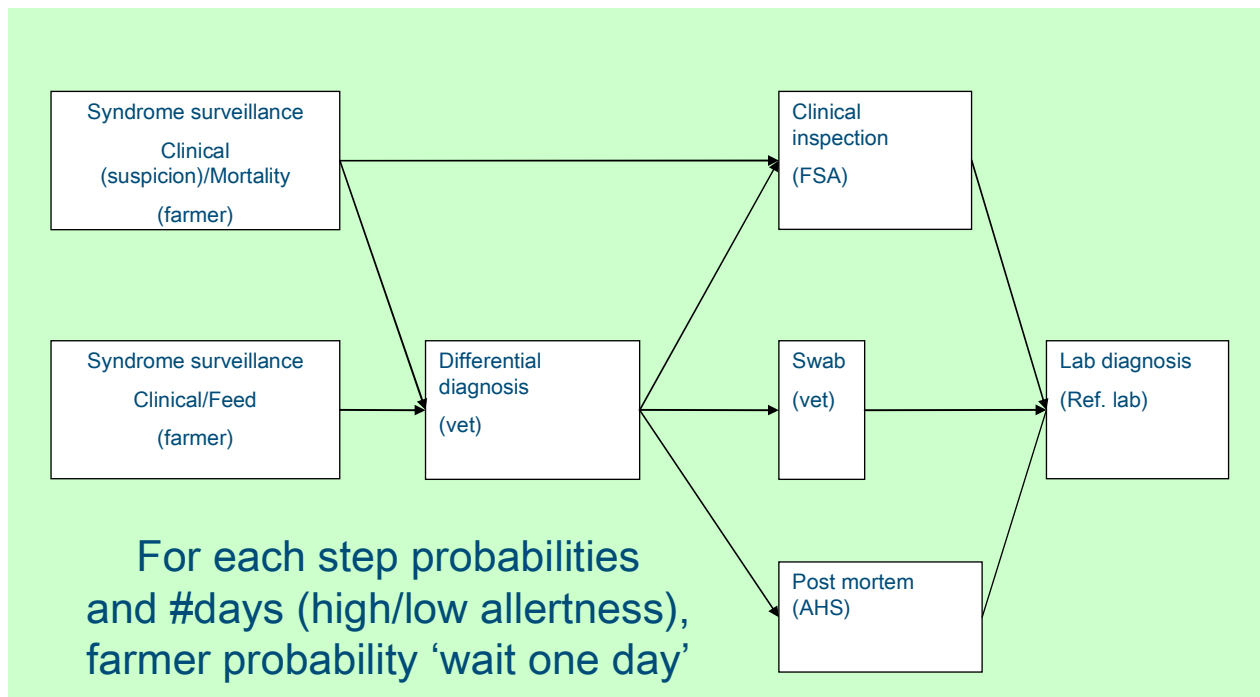


Figure 1. Framework of the simulation model.

## 2.2. Model design

Based on the framework presented in 2.1., a quantitative simulation model was designed in Excel/@Risk. This stochastic model enabled simulation of various set-ups of the monitoring systems, and can account for the stochastic nature of the monitoring.

The model starts with the introduction of HPAI in one specific broiler farm. This introduction is followed by (1) within-flock transmission and (2) between-flock transmission. The former will affect various relevant parameters such as clinical symptoms, feed and water intake and mortality. The latter will affect the number of farms infected with HPAI. At a certain moment, on one farm first suspicion of HPAI will take place. This can be the index farm, but not necessarily. This suspicion is followed by confirmation by the reference lab. The output of the model consists of two performance parameters of the monitoring: (1) the time between first introduction and detection, and (2) the number of infected farms at the moment of detection. Within-flock and between-flock transmission was simulated using the results of Stegeman et al. (2004), Bos et al. (2008) and Bos et al. (2007), chapters 12, 15 and 16 of this report respectively.

Syndrome surveillance by the farmer was modeled according Table 1. Three types of measures can be taken by the farmer: syndrome surveillance with regard to (1) diseased birds, (2) reduced intake of feed and water and reduced egg production, and (3) increased mortality. For each of these measures, the main features are presented in Table 1.

Within the model, two levels of alertness are possible, which reflect the general alertness in the chain or population (note: not the alertness of the individual farmer): low and high. The former is valid for a routine situation, the latter for a situation where HPAI occurs in e.g. a surrounding country or important trade partner.

Table 1. Syndrome surveillance by the farmer.

Measure	Sample type	Performed by	Frequency	Remarks
Syndrome surveillance – diseased birds	Number of diseased birds in poultry house	Farmer	Daily	Increased morbidity → consult vet
Syndrome surveillance – feed, water, eggs	- feed intake - water intake - egg production	Farmer	Daily	Two days in a row ≥5% drop in feed/water/egg → consult vet
Syndrome surveillance – mortality	Number of dead birds in poultry house	Farmer	Daily	Two days in a row ≥0,5% mortality <sup>3)</sup> → notification

In order for a farmer to take action, the specific parameters (e.g. feed intake or mortality) have to pass a certain threshold, which is the result of the course of the within-farm outbreak.

Within the model, the following thresholds are used:

- Mortality threshold: 0.5%;
- Feed threshold: 5.0%;
- Low% Clinical threshold: 2.5% (experimenting 0-5%);
- High% Clinical threshold: 10.0% (experimenting 5-20%).

Furthermore, the following hierarchy among the different thresholds is kept: High% Clinical > Mortality > Feed > Low% Clinical threshold (read ‘>’ as dominates over...).

The probability that a farmer takes action is presented in Table 2.

Table 2. Probability of actions taken by the farmer.

	LOW		HIGH	
	yes	no	yes	no
High% Clinical	0.80	0.20	0.95	0.05
Mortality	0.70	0.30	0.80	0.20
Feed	0.70	0.30	0.80	0.20
Low% Clinical	0.50	0.50	0.80	0.20

As stated, various routes can be taken for subsequent action. The route that is chosen depends on the threshold that is exceeded, when Feed and Low% Clinical are exceeded route 1 is excluded (which makes 14 scenarios in total). The scenario that is chosen depends on its probability, which in turn is dependent on the alertness level, as presented in Table 3.

Each scenario contains different steps that will take some time (in hrs). The duration is stochastic, following a triangular distribution with the min, most likely and max number of hours depending on the alertness level. The duration of the FSA is that short that there is no flexibility possible (the FSA team has to respond within 3 hrs.) Therefore, it is not stochastic. In Table 4, the duration of the various scenarios is presented.

Table 3. Probability of the various routes followed after suspicion by the farmer.

**Probabilities of the scenarios:**

	Scenario	warn vet	warn fsa	swab	ahs_pm	vet_warn_fsa	Probability Scenario
High% clinical	1		1				0.050
	2	1		1			0.000
	3	1			1		0.000
	4	1				1	0.950
							1.000 (SUM)
mortality	5		1				0.025
	6	1		1			0.125
	7	1			1		0.050
	8	1				1	0.800
							1.000 (SUM)
feed	9	1		1			0.100
	10	1			1		0.100
	11	1				1	0.800
							1.000 (SUM)
Low% clinical	12	1		1			0.100
	13	1			1		0.100
	14	1				1	0.800
							1.000 (SUM)

Table 4. The duration of the various scenarios.

**Duration scenarios (in hours):**

Scenario	Vet	FSA			AHS_PM			CVI (incl transport)					
		Min	Most likely	Max	Min	Most likely	Max	Min	Most likely	Max			
High% clinical	1	na	na	na	1	2	3	na	na	na	7	12	24
	2	1	8	24	na	na	na	na	na	na	12	24	48
	3	1	8	24	na	na	na	6	12	24	12	24	48
	4	1	8	24	1	2	3	na	na	na	7	12	24
Mortality	5	na	na	na	1	2	3	na	na	na	7	12	24
	6	1	8	24	na	na	na	na	na	na	12	24	48
	7	1	8	24	na	na	na	6	12	24	12	24	48
	8	1	8	24	1	2	3	na	na	na	7	12	24
Feed	9	1	8	24	na	na	na	na	na	na	12	24	48
	10	1	8	24	na	na	na	6	16	36	12	24	48
	11	1	8	24	1	2	3	na	na	na	7	12	24
Low% clinical	12	1	8	24	na	na	na	na	na	na	12	24	48
	13	1	8	24	na	na	na	6	16	36	12	24	48
	14	1	8	24	1	2	3	na	na	na	7	12	24

### 3. Results and conclusions

The modeling approach is not yet fully finalized, therefore only preliminary results will be presented here.

In Figure 2, the course of the AI outbreak in the index farm is presented in terms of susceptible (S), infected but not yet infectious (E), infectious (I) and removed (R) animals. As can be seen, a very rapid within-farm spread of AI occurs, resulting in no susceptible animals left around day 14 post introduction.

In Figure 3, the simulated infections of secondary farms is presented. As can be seen, after approximately 2 weeks following first introduction, quite some spread has already occurred resulting in an increasing number of secondary farm infections.

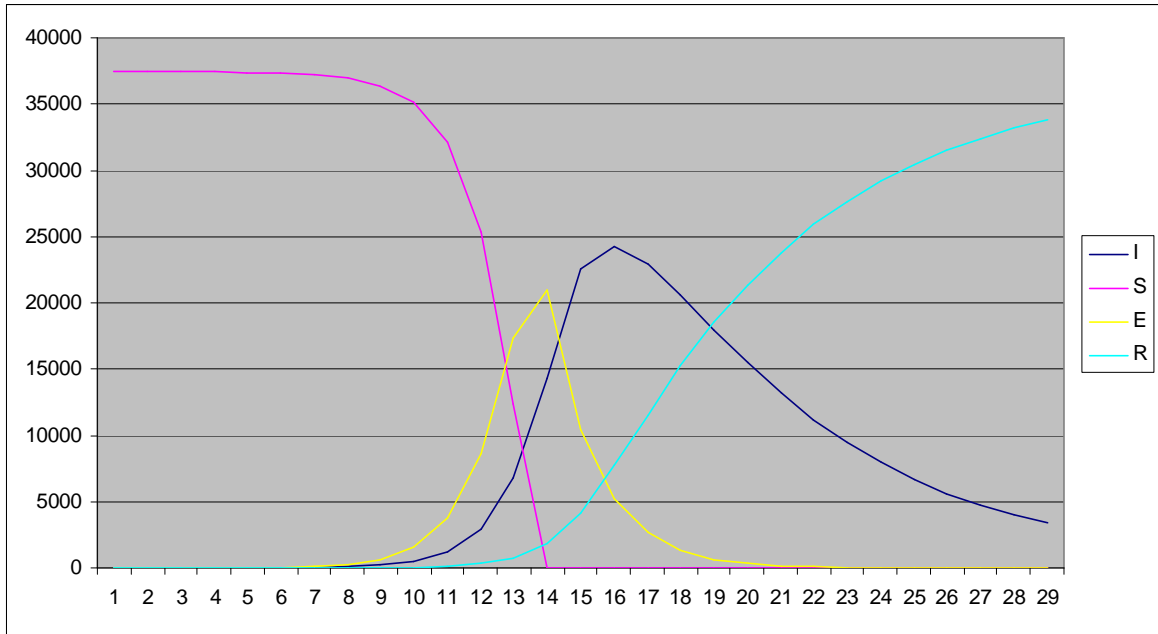


Figure 2. Infection pattern of AI on the index farm.

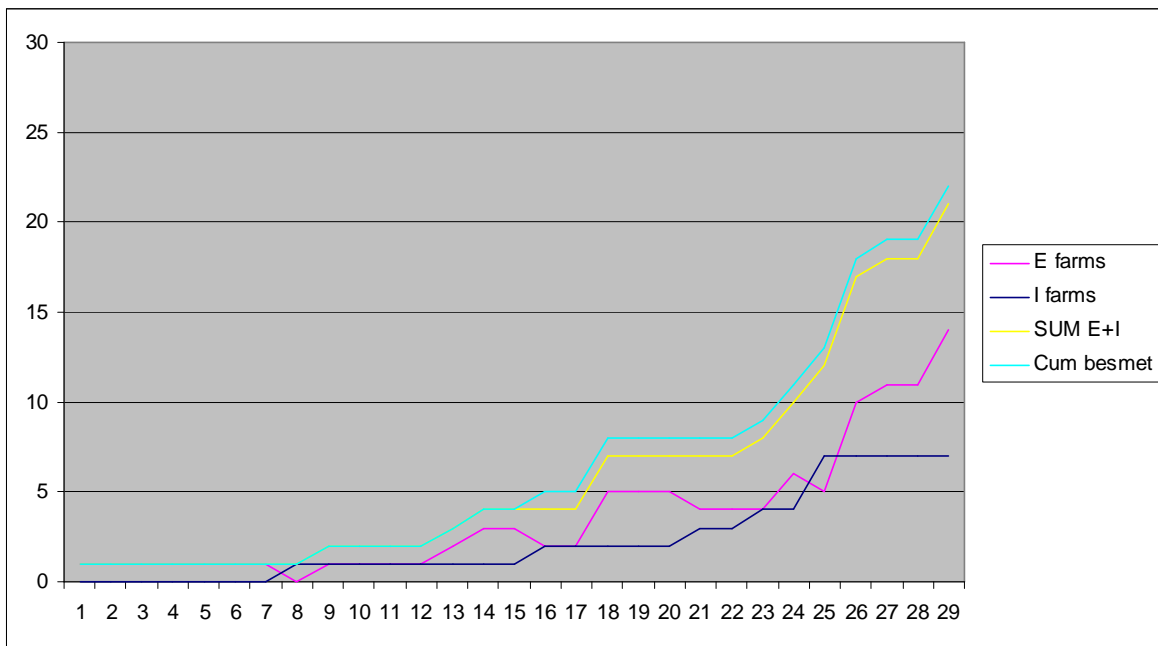


Figure 3. Infection of secondary farms.

In Figures 4 and 5, preliminary results of the main output parameters is presented for the default situation. On average, it took approximately 13 days after first introduction to notify HPAI (be it in the index farm or in another farm). The range was between 9 and 17 days. At this moment of first detection, on average 2.7 farms were infected, with a range of 1 to 8 (Figure 5).

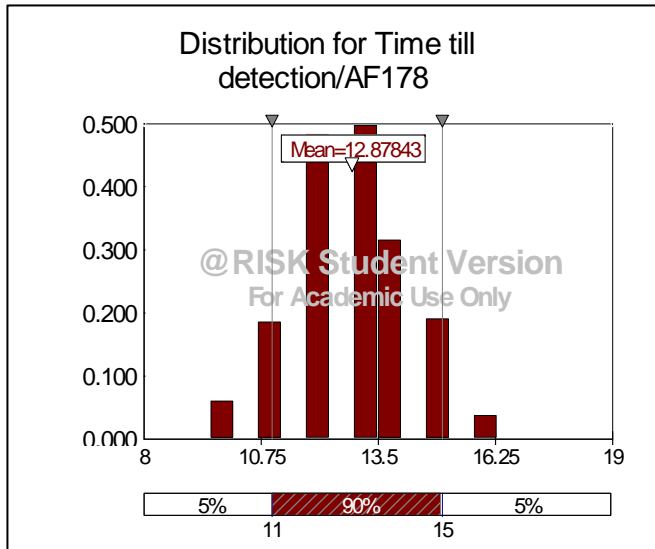


Figure 4. Distribution of the time until first detection of HPAI.

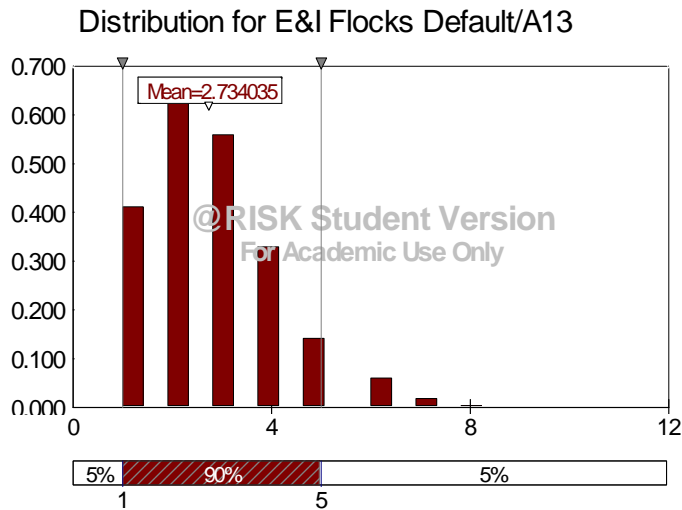


Figure 4. Distribution of the number of HPAI infected flocks at the moment of first detection of HPAI.

These results indicate, that in the current version of the model both within- and between-flock transmission occurs very rapidly, leaving little space for improvement of monitoring. Further research is underway to (1) refine the current model, and (2) to include other monitoring scenarios and HPAI spread conditions.