# ECONOMIC EVALUATION OF STRATEGIES TO CONTROL HIGH PATHOGENIC AVIAN INFLUENZA IN BELGIUM

**Y. Vandendriessche[1], X. Gellynck[1], H. Saatkamp[3], J. Dewulf[2], S. Van Steenwinkel[2], B. Vermeire[1], J. Viaene[1]**

*[1]Department Agricultural Economics, Ghent University, Belgium*
*[2]Department of Obstetrics, reproduction and herd health, Ghent University, Belgium*
*[3]Business Economics, Wageningen University, The Netherlands*
*e-mail: Jacques.Viaene@UGent.be*

**Abstract**

*High Pathogenic Avian Influenza (HPAI) may pose a major threat for the Belgium poultry sector, as an outbreak of HPAI results in tremendous economic losses. This paper aims to evaluate different strategies to control HPAI, in order to reduce the economic damage caused by an eventual future outbreak. The economic evaluation is based on the output of an epidemiological model called InterSpread PLUS, a SPPS module enabled to transfer directly the epidemiological output into economic data related to the losses at farm level. In a first stage the risks for the Belgium poultry sector are assessed. The actual risks are dependent of the intensive character of poultry farming in Belgium, the large amount of (international) transport movements of living poultry, the presence of sensitive nature areas and the border with the Netherlands where the poultry density is even larger. In a second stage, possible intervention scenarios are evaluated. Three scenarios are worked out: one stamping out scenario, corresponding with the current regulation and two emergency vaccination scenarios. The two vaccination scenarios have a different vaccination radius. In a last stage an economic analysis of the three scenarios is made. Results suggest that from an economic point of view, stamping-out is a better option at farm level then emergency vaccination within the current context. In addition to the losses at farm level, the evaluation of the losses at market level is the subject of further research.*

**Key words**: High Pathogenic Avian Influenza, poultry farming, vaccination, stamping-out, economic evaluation

## INTRODUCTION

For some years HPAI has been an important threat to the poultry farming in Europe [6]. Avian Influenza is a member of the type A influenza viruses which can infect a wide range of birds like wild ducks, chickens, turkeys, geese but also mammals like pigs, horses, mink and seals [25]. There is moreover a concern that the H5N1 virus could mutate into a form that can be passed from human to human, which would pose a significant risk to a global pandemic [11]. Since the discovery of the virus in 1955, outbreaks with HPAI occurred throughout the world. In the European Union (EU-27) these outbreaks were situated in Italy (H5N2 and H7N1) and in 2003 in the Netherlands, Belgium and Germany [4]. In 2007, also cases have been observed in the United Kingdom, Germany, France, Denmark, Sweden and Czech Republic. In 2005 several nidi of infection were detected outside Europe, initially in Asia but later also in the Middle East and Africa [10]. In literature researchers indicate that the number of outbreaks of HPAI has increased during the last 15 years [16].

During the last decade this disease has affected over 200 million birds. Several of these outbreaks such as those in Italy in 1999–2000, the Netherlands in 2003, Canada in 2004 and throughout Asia during 2003–2006 have lead to devastating financial consequences for the poultry industry. In some countries the effects have escalated to a level where the impact was felt by the overall national economy [7]. In 2003 an outbreak of HPAI occurred in Belgium, in sum approximately 2.3 million birds were eradicated at different poultry farms. In total the passage of HPAI in Belgium caused about 30 millions Euro direct costs. Those consisted mostly of the eradication costs and the compensations for the affected farms. The total economic damage is valued on more than the double. By transport prohibition the hatcheries could not deliver their hatchery eggs and day-old chicks. As a result no other possibility remained then destroy them. For lack of supply also the slaughterhouses fell empty and the production of feed suppliers decreased with half [28].

The aim is to compare three control strategies, respectively stamping-out, emergency vaccination and a combined stamping-out and vaccination strategy, based on simulated epidemics by the spatial transition model Interspread Plus [23] and [24]. In its scenario-research concerning the effectiveness of vaccination against classical swine fever (CSF) and impact of it on the sale of the products, Meuwissen et al. [16] distinguish three groups of damage: direct costs, consequential losses and market damage for the rest of the country. Within this research, the modeling of economic effects is limited to the direct costs and consequential losses for affected farms. Preventive vaccination is not investigated because this strategy causes a negative economic impact. When preventive vaccination is applied in a European country, a direct export prohibition is imposed for living poultry. According to Capua & Maragnon [5] export-restrictions pose the biggest share of economic losses during an outbreak of AI. From an economic point of view the application of preventive vaccination of birds in zoos, can be considered as an appropriate measure. Because these birds will never enter the food chain. The directive 2005/744/EC of the European Commission allows vaccinating birds in zoos under very strict rules. Philippa et al. [20] considered this after research as a positive measure against the distribution of the AI virus.

**THREATS DUE TO AVIAN INFLUENZA**

The production of poultry and eggs is concentrated in the northern part of Belgium, in the region of Flanders. Both the poultry meat and egg sector are characterized by (1) a decreasing number of holdings, (2) increasing size of holdings and (3) export-oriented structure. Belgium is net exporter for hatchery eggs, consumption eggs, day-old chicks and poultry meat. The export is principally directed towards member states of the European Union, but third countries are traditionally important customers for specific products. In the poultry meat chain, day-old broiler chicks produced in the hatcheries go to broiler farms. In the egg chain, day-old layer chicks produced in the hatcheries go to rearing farms, after about 18 weeks the pullets are transferred to laying farms

Avian Influenza is an infectious disease which is counted to the category of production risks. These are risks that originate directly from the production process and are related to the product itself [1]. An outbreak of Avian Influenza leads on the one hand to costs for eradication of companies (direct costs) and on the other hand to costs which are caused by a period of obligatory vacancy (consequential losses). In addition to the direct impact, there are large effects on consumption as many consumers reduce poultry consumption because of the negative publicity and fears of contracting disease [11]. This consumption reduction in combination with a decrease of export is considered to be the market effects.

Both in the layer and the broiler farms, the degree of risk is determined by the location of the company, the duration of the outbreak and the size of the farm [1]. The chance of introduction in a region is more or less proportional with the number of companies or the number of animals in a region (density). Specifically for Belgium where poultry farming is already intensive, the border with the Netherlands where the poultry density is even larger, causes an extra risk. Also the structure of the poultry sector is determinative for the level of risk. The Belgian poultry production is coupled with a large number of transport movements of living bird, hatchery eggs and bird products. The international character of the Belgian poultry sector, leads to extra (cross-border) transport movements [30].

Belgium has areas with substantial waterways and is located on migratory flyways. Some poultry farms are located close to bodies of water where migratory birds may gather, and some in areas with a high number of migratory birds. This presence of sensitive nature areas raises the risk for the introduction of the AI virus. Migratory birds and waterfowl are thought to be the reservoir for influenza A viruses in nature [17] and [32]. Influenza viruses occur relatively often by wild birds, especially with water birds. Generally the contaminated birds do not become sick, but they can transfer the virus to other birds. Some types can lead to HPAI at poultry farm level. Another risk factor is the presence of turkeys in the neighborhood of the company, which raises the risk for infection, because these birds are much more sensitive for infection [17].

## MATERIAL AND METHODS
## CONTROL STRATEGIES

Before the EU basic principle for the control of epidemic diseases like HPAI, and others, was the eradication of infected herds and non-vaccination. This strategy aimed at keeping or recovering the highest sanitary status of “free from disease without vaccination” in the shortest possible time [5]. In 2005 the European Union enacted a new council directive on Community measures for the control of Avian Influenza [9]. The biggest change compared to the previous directive [8] is, that Member States can use preventive vaccination and emergency vaccination as a strategy to control AI. Vaccination can only take place after national authorities completed a risk analysis, in which the need has been showed sufficiently in a vaccination plan. The national authorities must indicate which measures are established and how they will monitor the vaccinated birds. Ultimately the plan indicates what has to be considered by the European Commission in the event of a decision to vaccinate against AI.

Recent epidemics with HPAI in densely populated livestock areas have illustrated that the eradication and non-vaccination strategy needs to be combined with large-scale pre-emptive slaughtering to be effective. The aim of these pre-emptive slaughtering is on the one hand to reduce the number of susceptible animals and on the other hand to eliminate sources of infection in a very early stage. But this pre-emptive culling becomes more socio-ethically undesirable. The use of vaccination instead of large-scale pre-emptive culling can hereby offer a solution. The expected advantages of a vaccination policy are two-fold. Firstly vaccination reduces susceptibility to infection, a higher dose of virus is necessary for establishing an infection in vaccinated birds. Secondly there is a significant reduction in the amount of virus shed by infected birds, thus less virus to contaminate the environment reducing the risk of spread to other avian species and reducing the occupational risk faced by poultry workers [3].

During the HPAI epidemic in the Netherlands in 2003, 255 herds became infected. Besides these infected herds, also 17.584 neighboring and contact herds were depopulated. Of these, 16.490 were hobby farms. In total over 30 million birds were killed and destroyed [14]. During the same epidemic in Belgium, 147 professional herds (4,5 million birds) and 189 hobby herds were depopulated. In both countries only a minority of the killed animals originated from the infected herds. However it should be mentioned that not every entry of the virus into a susceptible population results in a dramatic epidemic. Recent outbreaks of HPAI in commercially raised poultry in France, Denmark and Sweden have clearly demonstrated that these could be efficiently controlled without devastating consequences. In the following part, three scenarios to control HPAI are worked out.

**Non vaccination or stamping-out scenario**

This is the basic strategy, which has been applied for example at the suppression of HPAI in Belgium and the Netherlands in 2003, where all infected and contact holdings are eradicated. Starting from the EU regulation, this strategy is supplemented with a pre-emptive culling within a 3 km radius around any detected farm. Also the disposal of carcasses and eggs at the affected holdings is obliged. Following the eradication, the equipment likely to be contaminated and any vehicles used for transportation to or from the holding must be thoroughly cleansed and disinfected. No poultry may be reintroduced into the holding for at least 21 days after the cleansing and disinfection operation is completed [9]. The movement and transport of birds, eggs, poultry meat and carcasses is banned within or through the protection zone (3 kilometers around the holding), except for transit by major highways or railways. These measures must be applied for at least 21 days after culling and destruction of the birds and the preliminary cleansing and disinfection of the holdings on which the outbreak occurred. After this time, the protection zone will become part of the wider surveillance zone (10 kilometers around the holding). Within the surveillance zone similar restrictions to those in the protection zone must be applied. The measures must be applied for minimum 30 days following the cleansing and disinfection operation [9].

**Emergency vaccination scenario**

In theory, emergency vaccination is able just as pre-emptive eradication, to reduce the infection pressure in an infected region by reducing the number of susceptible animals and eliminating sources of infection in a very early stage [10]. To be as efficient as pre-emptive eradication, a vaccine is needed that is able to prevent the horizontal virus transmission already shortly after vaccination. Vaccination strategies are also accompanied by the eradication of the poultry at infected and contact holdings. The vaccination zone is defined as a radial zone with a radius of 3 km around each detected farm. Not all types of poultry are qualified for vaccination [7]. Vaccination of broiler type chickens that are slaughtered within 7 – 8 weeks is discouraged in principle, as there is no sufficient time to develop adequate immunity following a primer and booster vaccination [3].

A vaccination strategy must also include; monitoring the evolution of infection (DIVA approach), early detection of any possible outbreaks, restriction and eradication measures and enforcement of adequate bio security [7]. Previous experiences have indicated that, in order to succeed in controlling an infection, vaccination programs must be part of a wider territorial strategy [7]. Before emergency vaccination can be carried out, a risk assessment must show that there is a significant and immediate threat of AI spreading to the poultry and birds concerned, from another infected area. Therefore a Member State must submit a detailed vaccination plan to the European Commission. This vaccination plan must include intensive surveillance measures on vaccinated poultry, in line with the "DIVA" strategy. This means that regular swabs must be taken for testing from vaccinated poultry to ensure that they have not become infected with the AI virus [13]. Member States using vaccination as a preventive measure must also carry out blood tests that allow the differentiation between vaccinated and infected poultry [9]. If there is an outbreak of HPAI in vaccinated poultry, Member States must apply the same eradication and control measures as are carried out when there is an outbreak in unvaccinated poultry.

**Combined stamping-out and vaccination scenario**

This scenario is a combination of the previous two scenarios. The stamping-out radius will decrease to 1km around every infected farm, but the vaccination radius (3km), will remain the same. All characteristics related to stamping-out as well as vaccination, will also be applied in this scenario.

## CONVERSION AND COST MODULE

The input for the economic model is generated by the spatial transition model Interspread Plus. It is a form of state transmission model. The model starts with a farm-file, providing details related to farm size, farm type, number of contacts and the geographical location. Spatial modeling allows evaluating infection spread using real farm data. Parameters to spread or control infection in Interspread Plus can be declared as point estimates, defined distributions, or look-up tables with empirical values [22].

The model is stochastic, and therefore the uncertainty and variation in the different underlying processes is represented by random sampling from the specified probability distributions. Previously Interspread Plus has been used to model outbreaks of foot and mouth disease in the Republic of Korea [33], and classical swine fever in Denmark [2] and Belgium [19]. In order to simulate the direct costs and consequential losses for the Belgian poultry industry as a whole, in a first stage the epidemiological output for each control strategy was transformed into economic parameters, by using a SPSS model (Figure 1). The scenarios are compared according to the 5th, 50th and 95th percentiles of 20 simulated outbreaks.

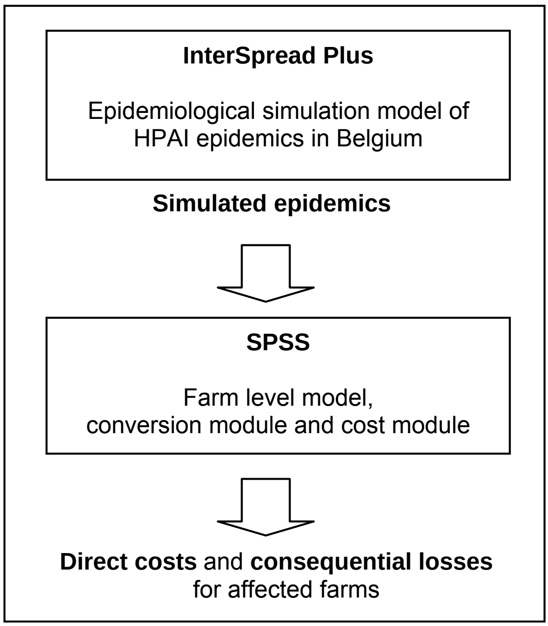


Figure 1: Framework for calculating the direct costs and consequential losses.

**Direct costs**

The following direct costs can be associated with the control of an outbreak of HPAI: fixed costs (monitoring or compliance with control measures and costs for crisis centre), compensation costs (for depopulated farms) and organizational costs (depopulation, tracing, screening, vaccination and monitoring). Fixed costs associated with running the crisis centre and monitoring compliance with movement restrictions are not calculated, however these are assumed to remain the same across scenarios [15]. The compensation and organizational costs will be passed on.

The compensation cost per bird for (preventive) eradicated poultry is based on the value tables, which are annually set up by VEPEK (Association for poultry, eggs and rabbits in Belgium) [30]. The compensation provides incentives for farmers to report outbreaks when flock culling is necessary [11]. These values are presented in the table below (Table 1), they are presented as averages over all ages in the production cycle [12], [18] and [21]. The reason for that, is the fact that the program Interspread Plus is not able to indicate in which faze of the production cycle, the farms are (preventive) eradicated.

Table 1: Compensation values for eradicated poultry per bird type

| | Broiler chickens | Turkeys | Inside layers | Outside layers | Ready-to-lay layers | Ready-to-lay breeders | Breeders (parent stock) |
|---|---|---|---|---|---|---|---|
| Value (€/bird) | 1.03 | 10.00 | 2.39 | 2.65 | 1.94 | 6.37 | 7.64 |

Organizational costs are calculated for depopulation, vaccination, screening and monitoring of vaccination efficacy and disease spread in vaccination zones. Per unit costs associated with depopulation, is calculated based on the current contracts of FASFC (Federal agency for the safety of the food chain) with the different companies. The costs for screening are based on historical costs during the 2003 HPAI epidemic [29]. The costs for vaccination are based on previous research concerning vaccination against HPAI [31]. The per unit costs are presented in table 2.

Table 2: Organizational per unit cost parameters used in the calculation of direct costs

| Direct costs eradication | Unit | Value | Direct costs vaccination | Unit | Value |
|---|---|---|---|---|---|
| Taxation | €/farm | 50 .00 | Vaccination | €/dose | 0.05 |
| Culling | €/bird | 2.10 | Labor costs for application | €/bird | 0.12 |
| Transport and destruction | €/bird | 1.50 | Other materials | €/farm | 250.00 |
| Cleaning and disinfection | €/farm | 350.00 | Vaccination total | €/bird | 0.17 |
| Depopulation total | €/bird | 3.60 | | €/farm | 250.00 |
| | €/farm | 400.00 | Monitoring vaccination | €/farm | 464.80 |
| Screening | €/farm | 520.00 | Surveillance in vaccination zone | €/farm | 357.10 |

**CONSEQUENTIAL LOSSES**

The consequential losses are associated with idle production factors and problems with egg delivery. The consequential losses are calculated for three types of affected farms, the depopulated farms, farms in the surveillance zone (10 km zone around every detected farm) and finally farms which face welfare problems due to delivery problems. Empty farms arise either through control measures such as depopulation or because of controlled marketing and restrictions on restocking. The consequential damage is formulated as losses per day the farm is empty, because of restrictions on restocking [15]. The losses are calculated as the loss per animal per day. The amount is based on the average income level per year in Belgium as base for taxing for the professional poultry farmers in the years 2006, 2007 and 2008, in combination with the annual depreciations of the investments. The loss per bird per day used to calculate the consequential losses is shown in table 3.

Because it is assumed that once a farm is depopulated it remains depopulated until the end of the epidemic, these farms face losses associated with idle production factors. The farms located in zones where movement restrictions apply (farms in the surveillance zone), experience consequential losses associated with supply and delivery problems. Consequential losses for farms under movement restrictions include on the one hand the losses for layer and breeder farms associated with being unable to deliver eggs for their initial purpose, but at a lower price for industrial use, on the other hand broiler farms which face costs associated with a reduction in price for delivered poultry at the end of the movement restrictions. The losses for hatcheries inside a surveillance zone are calculated separately. If the duration of an outbreak is long, some farms with short production cycles will face welfare problems (broiler chickens and reared layers and parent stock) if they are unable to deliver poultry. Farms with welfare problems in movement restriction zones are assumed to deliver poultry to slaughter under strict hygiene conditions and thereafter are not allowed to restock. It is assumed that all the farms are situated halfway through the production cycle at all times, and farms which become empty remain empty until the end of the outbreak.

Table 3: Per bird per day loss parameters used in the calculation of consequential losses for farms which are either depopulated (empty) or located within a movement restriction zone

| | Daily loss per bird per day | Losses associated with egg delivery |
|---|---|---|
| | eurocent/bird/day | eurocent/bird/day |
| Broiler chickens | 0,495 | |
| Ducks | 0,561 | |
| Turkeys | 1,482 | |
| Inside layers | 0,851 | 3,24 |
| Outside layers | 1,419 | 5,385 |
| Ready-to-lay layers | 0,746 | |
| Breeders | 1,539 | 10,155 |

## RESULTS AND DISCUSSION

The outcome of the epidemiological and economical evaluation are reported in terms of key indicators, including the number of farms depopulated, the number of farms detected, the number of farms infected, the number of farms vaccinated, number of farms in the surveillance zone and the length of the outbreak. Finally the total direct costs and consequential losses are presented, which results into a total cost on farm level. For each indicator the 5$^{th}$, 50$^{th}$ and 95$^{th}$ percentiles of simulation results for 20 iterations are presented.

### ECONOMIC EVALUATION: STAMPING-OUT

This scenario gives the best results (table 4) regarding to epidemiological parameters. When the 50 percentile is compared over the 3 scenarios, it is clear that this scenario results in the shortest length of outbreak, least infected farms and least farms in the surveillance zone. From an economical point of view this is the worst scenario for both the 5, 50 and 95 percentile, because the overall cost at farm level is the highest. Nevertheless, it is very important to mention that these epidemiological parameters like length of outbreak and number of farms in surveillance zone, will become very important for the calculation of the market effects. Previous research has indicated that these market effects can reach for higher amounts in comparison to losses at farm level [26]. Stamping-out can be considered generally as a rather expensive option but also as a very effective option. Due to the effectiveness, stamping-out will limit the export restrictions which will be of great benefit for the market damage [5]. The calculation of market damage will be the subject of further research, which will lead to a full appraisal of the three scenarios.

Table 4: Results for the stamping-out scenario

| **Percentiles** | **5** | **50** | **95** |
|---|---|---|---|
| Number of farms depopulated | 20 | 43 | 156 |
| Number of farms detected | 3 | 12 | 63 |
| Number of farms infected | 4 | 16 | 71 |
| Number of farms vaccinated | 0 | 0 | 0 |
| Number of farms in the surveillance zone | 77 | 162 | 612 |
| Length of outbreak (days) | 52 | 72 | 136 |
| Total direct cost | 3.833.290 | 7.072.459 | 21.855.291 |
| Total consequential losses | 2.003.917 | 4.477.308 | 17.946.269 |
| **Total cost on farm level** | **5.837.207** | **11.549.767** | **39.801.560** |

## ECONOMIC EVALUATION: VACCINATION

This scenario scores the worst on epidemiological parameters (table 5), because the length of the outbreak is the highest, this parameter is considered as the most important epidemiological parameter. From an economical point of view, this scenario scores rather good. It scores a lot better than scenario 1 and the total cost is a bit higher but comparable to scenario 3. Despite of the epidemiological parameters, this scenario scores very good on socio-ethical parameters related to animal welfare, because only a limited number of animals are depopulated. Hereby it should be mentioned that in previous research, it was found that vaccination led to for higher losses related to market effects [16]. Especially caused by export restrictions of live poultry [9]. It is also assumed that third countries will close their borders for poultry products during de vaccination period. Additionally it is expected that even European countries will (partially) close their borders for poultry products. These export problems in combination with a demand chock may possibly have a much bigger impact on the overall costs than the benefits on farm level.

Table 5: Results for the vaccination scenario

| **Percentiles** | **5** | **50** | **95** |
|---|---|---|---|
| Number of farms depopulated | 4 | 21 | 65 |
| Number of farms detected | 4 | 21 | 65 |
| Number of farms infected | 4 | 21 | 65 |
| Number of farms vaccinated | 7 | 21 | 63 |
| Number of farms in the surveillance zone | 77 | 203 | 684 |
| Length of outbreak (days) | 53 | 84 | 154 |
| Total direct cost | 380.051 | 3.830.948 | 10.289.117 |
| Total consequential losses | 2.353.126 | 7.611.991 | 18.914.914 |
| **Total cost on farm level** | **2.733.177** | **11.442.939** | **29.204.031** |

## ECONOMIC EVALUATION: COMBINATION OF STAMPING-OUT AND VACCINATION

This scenario can be considered as the best overall scenario at farm level (table 6). The epidemiological parameters are comparable to scenario 1, and are a lot better than scenario 2. The direct cost is higher in comparison to scenario 2 and the consequential losses are higher than scenario

1 but the overall total cost is the most interesting. Because of the limited number of depopulated animals, this scenario can also be considered as a rather ethical scenario regarding animal welfare. Also here it should be mentioned that the use of vaccination can have imported consequences related to market effects.

Table 6: Results for the combined stamping-out and vaccination scenario

| **Percentiles** | **5** | **50** | **95** |
|---|---|---|---|
| Number of farms depopulated | 4 | 22 | 70 |
| Number of farms detected | 3 | 14 | 56 |
| Number of farms infected | 4 | 16 | 64 |
| Number of farms vaccinated | 7 | 17 | 48 |
| Number of farms in the surveillance zone | 77 | 175 | 638 |
| Length of outbreak (days) | 52 | 75 | 102 |
| Total direct cost | 379.690 | 4.026.829 | 9.362.919 |
| Total consequential losses | 2.347.219 | 5.855.818 | 15.889.631 |
| **Total cost on farm level** | **2.726.909** | **9.882.646** | **25.252.550** |

## CONCLUSION

The simulation results show that the different scenarios result in a very differing outcome as well for the epidemiological output as the economic output. The economical output is split up into direct costs and consequential losses. Here, important discrepancies arise from the different scenarios. Vaccination, on the one hand, limits the direct costs due to the fact that vaccination is a cheaper option than depopulation, while on the other hand the consequential losses are higher. The consequential losses for vaccination are higher because the average length of an outbreak is longer, which leads to a longer period with idle production factors. To limit the length of a vaccination scenario, the combination with al limited pre-emptive culling (1km) can be considered. From both an epidemiological and economical perspective this combination of vaccination and pre-emptive culling seems to be an attractive strategy. However, given the fact that the losses on farm level are only a part of the total damage during an outbreak, further research will investigate the third scenario in terms of total economic impact, taking in consideration losses on farm level as well as market effects. This will enable us to draw conclusions about what is the best scenario to implement during an outbreak Nevertheless, some important parameters are yet generated by both models, regarding epidemiological and economical parameters. These parameters will also be used in the evaluation of the total cost including the market effects. The parameters such as number of farms in the surveillance zone and length of the outbreak, will be very determining for the overall total cost.

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## REFERENCES

[1] Baltussen W., Horne P., Van Hennen W., Wisman J., Asseldonk M. (2007): Risicobarometer voor de pluimveehouderij. LEI, Den Haag.

[2] Boklund A., Goldbach S., Uttenthal A., Alban L. (2008): Simulating the spread of classical swine fever virus between a hypothetical wild-boar population and domestic pig herds in Denmark. Preventive Veterinary Medicine 85(3-4), 187-206.

[3] Breytenbach J. (2005): Guidelines for the Administration of Nobilis Influenza H5 Vaccine as Part of an Avian Influenza Control Strategy, Intervet International, The Netherlands.

[4] Capua I., Maragnon S., Dalla Pozza M., Santucci U. (2000): Vaccination for avian influenza in Italy. veterinary record , Vol 147, 751-751.

[5] Capua I., Maragnon S. (2003): The use of vaccination as an option for the control of Avian

influenza. 71st General Session International Committee. World organisation for animal health, Paris, 18-23 May 2003, Office international des épizooties (OIE), Paris.
[6] Capua I., Maragnon S. (2006): Control and prevention of avian influenza in an evolving scenario. Vaccine, Vol 24, 391-397.
[7] Capua I., Maragnon S. (2007): The use of vaccination to combat multiple introductions of Notifiable Avian Influenza viruses of H5 an H7 subtypes between 2000 and 2006 in Italy. Vaccine, Vol 25, 4987-4995.
[8] Council Directive 92/40/EEC of 20 December 1992 on Community measures for the control of avian influenza. Official Journal of the European Union.
[9] Council Directive 2005/94/EC of 20 December 2005 on Community measures for the control of avian influenza and repealing Directive 92/40/EEC. Official Journal of the European Union.
[10] Dewulf J., Koenen F., De Clerq K., Van Den Berg T., Ribbens S., De Kruif A. (2005): Uitbraken en bestrijding van klassieke varkenspest, mond- en klauwzeer, en hoogpathogene Aviaire Influenza in de Europese Unie. Vlaams Diergeneeskundig Tijdschrift 74, 103-116.
[11] Djunaidi H., Djunaidi A. (2007): Economic impacts of Avian Influenza on world poultry trade and the U.S. poultry industry: A spatial equilibrium analysis. The journal of agricultural and applied economics, 39.2: 131-323.
[12] EUROSTAT (2009): Intra- and Extra – EU trade data, Issue number 3/2009. European Communities, ISSN 1017-6594.
[13] Ivanov Y. (2007): Avian Influenza vaccines and vaccination policy. International Avian Influenza Congress, Turkey.
[14] Ladommada A. (2004): Avian Influenza- The European experience. FAO/OIE regional meeting. Bangkok, 30 may 2004, (AI is difficult to control, even in Europe).
[15] Longworth N., Mourits M., Saatkamp H. (2009): An epidemiological an economic analysis of control strategies for HPAI outbreaks in the Netherlands. Article in progress.
[16] Meuwissen M., Mourits M., Huirne R. (2004): Scenario-onderzoek effectiviteit vaccinatie en impact op afzetproducten. Wageningen Universiteit, IRMA, 31 p.
[17] Murphy B., Webster R. (1996): Orthomyxoviruses. In: Fields B N, Knipe D M, Howley P M, Chanock R M, Melnick J L, Monath T P, Roizman B, editors. Fields Virology. 3rd ed. Philadelphia, Pa: Lippincott-Raven Publishers, pp. 1397–1445.
[18] NIS (2009): Land- en tuinbouwtelling op 15 mei.
[19] Ribbens S. (2009): Evaluating infection spread in Belgian pig herds using classical swine fever as a model. PhD Thesis.
[20] Philippa J., Baas C., Beyer W., Bestebroer T., Fouchier R., Smith D., Shaftenaar W., Osterhaus A. (2007): Vaccination against highly pathogenic avian influenza H5N1 virus in zoos using an adjuvanted inactivated H5N2 vaccine. Institute of Virology, Rotterdam, Nederland.
[21] SANITEL (2009): Pluimveestatistieken. FAVV
[22] Sanson R., Stevenson M., Mackereth G., Moles-Benfell, N. (2006): The development of an InterSpread Plus parameter set to simulate of FMD in New Zealand. In: J. McKenzie, Editor, Proceedings of the 11th International Symposium on Veterinary Epidemiology and Economics Cairns, p. 682.
[23] Stern M. (2003): InterSpread Plus: User guide. Massey University. Palmerston North, New Zealand.
[24] Stevenson M., Sanson R., Stern M., O'Leary B, Mackereth G., Sujau M., Moles-Benfell N., Morris R. (2006): InterSpread Plus: a spatial and stochastic simulation model of disease in animal populations.
[25] Swaneyne D., Suarez D. (2000): Highly pathogenic avian influenza. Revue scientifique et technique 19, 463-482.
[26] Tacken G., Van Leeuwen M., Koole B., Van Horne P., Wisman J., Tabeau A., Betgen M., Van Der Walle K., Saatkamp H. (2003): Economische gevolgen van vaccinatie ter bestrijding en bij herbevolking van geruimde gebieden, Bijlage 1 bij VVA03 2553, LEI, Den Haag.
[27] Tumpey T, Kapczynsky D, Swayne D. (2004): Comparative susceptibility of chickens and turkeys to Avian Influenza A H7N2 virus infection and protective efficacy of a commercial Avian Influenza H7N2 virus vaccine. Avian Dis. 48, 167–17.
[28] Van Thuyne D. (2006): De kippenboer verliest zijn pluimen, Trends.
[29] VEPEK (2003): Kosten-batenanalyse vaccinatie Aviaire Influenza Scenario-ontwikkeling.
[30] Viaene J., Verheecke W. (2009): Overzicht van de Belgische pluimvee-en konijenhouderij in 2008, VEPEK.
[31] Viaene J., Verstrynghe B. (2003): Economische schade Aviaire Influenza in België, VEPEK.
[32] Webster R., Bean W., Gorman O., Chambers T., KawaokaY. (1992): Evolution and ecology of influenza A viruses, Microbiol Mol Biol Rev, 56(1), 152-179.
[33] Yoon H., Wee S., Stevenson M., O'Leary B., Morris R., Hwang I., Park C., Stern M. (2006): Simulation analyses to evaluate alternative control strategies for the 2002 foot-and-mouth disease outbreak in the Republic of Korea. Preventive Veterinary Medicine 74: 212-225.