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STRATEGIES TO CONTROL HIGH PATHOGENIC AVIAN INFLUENZA (HPAI) IN THE BELGIAN POULTRY SECTOR

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Invited paper

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. In order to reduce the economic damage for an outbreak, different strategies to control HPAI are evaluated. In a first stage the structure of the Belgium poultry sector is described and risks are analysed. The actual risks are dependent of the intensive character of poultry farming in Belgium, the large number of 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 the possible intervention strategies are evaluated. Starting from the current regulation, two strategies are worked out: stamping out and emergency vaccination. The success of emergency vaccination is associated with the correct identification of compartments at risk, prompt deployment of emergency vaccines, rapid enforcement of appropriate complementary control measures and also the level of being ready. In a third stage an economic analysis of control strategies for HPAI outbreaks is made. Results suggest that from an economic point of view, stamping-out is at farm level a better option then emergency vaccination within the current context.

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 (*Capua and Marangon, 2006)*. 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 in mammals like pigs, horses, mink and seals (*Swayne and Suarez, 2000)*. There is also 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 (*Djunaidi and Djunaid, 2007)*. 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) (*Capua et al., 2000)* and in 2003 in the Netherlands, Belgium and Germany. In 2007, also cases have been observed in the United Kingdom, Germany, France, Denmark, Sweden and Czech Republic. In 2005, outside Europe there have been detected several nidi of infection, initially in Asia but later also in the Middle East and Africa (*Dewulf et al., 2005)*. In literature it is described by some research workers that the number of outbreaks of HPAI has increased the last 15 years (*Meuwissen 2004)*. LPAI variants on the other hand occur more frequent.

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 (*OIE, 2003)*. In 2005 the European Union enacted a new council directive on Community measures for the control of Avian Influenza *(2005/94/EC)*. The largest change in comparison with the previous directive *(92/40/EEC)* is the fact that on basis of the present directive, 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 which would have 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 this eradication and non-vaccination strategy needs to be combined with huge 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. During the HPAI epidemic in the Netherlands in 2003, 255 herds became infected. Besides these infected herds, also 17.584 neighbouring and contact herds were depopulated. Of these 16.490 were hobby farms. In total over 30 million birds were killed and destroyed (*Laddomada, 2004)*. During the same epidemic 147 professional herds (4,5 million birds) and 189 hobby herds were depopulated in Belgium. In both countries only a minority of the killed animals originated from the infected herds. On the other hand 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.

Including estimations of the ongoing Asian H5N1 epidemic, in 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 (*Capua and Marangon, 2007)*. 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., 2004)* distinguish three groups of damage: direct costs, consequential losses and market damage for the rest of the country. 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 existed mainly from 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 of that no other possibility remained then destroy them. For lack of supply also the slaughterhouses fell empty and feed suppliers saw their production decrease with half (*Van Thuyne, 2006)*.

The aim is to compare two control strategies, respectively stamping-out and emergency vaccination, based on simulated epidemics by the spatial transition model Interspread Plus *(Stern, 2003; Stevenson et al., 2006)*. Within this research, the modeling of economic effects is limited to the direct costs and consequential losses for affected farms. In further research also the market effects will be considered, in order to be able to calculate the total cost of an outbreak. Here we will not consider preventive vaccination, 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 and Marangon, 2003)* 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., (2007)* considered this after research as a positive measure against the distribution of the AI virus.

Belgian poultry sector

Structure

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 characterised by (1) reduction in 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 (e.g. chicken legs). Belgium has 134 parent stock farms with a capacity of 2.1 million parent breeding bird places (*Sanitel, 2009)*. In Flanders 92 % of the parent stock farms and their capacity are aimed at broiler production, the other 8 % are intended for production of laying hens (*Vepek, 2009)*. Together these parent stocks provide 338 million hatchery eggs per year. Almost 99 million of the hatchery eggs are exported and 64 million hatchery eggs are imported (*Eurostat, 2009)*. This results in the incubation of 303 million eggs per year (*NIS, 2009)* in one of the 20 hatcheries in Belgium (*Vepek, 2009)*.

In the poultry meat chain, day-old broiler chicks produced in the hatcheries go to broiler farms. In Belgium there are 1.005 broiler farms with a capacity of 27 million broiler places (*Sanitel, 2009)*, which have a brute production of 289.000 ton carcass weight per year (*NIS, 2009)*. Over 62 % of the broiler farms and almost 82 % of their capacity are concentrated in Flanders, especially West-Flanders (27 % of the capacity) and Antwerp (24 % of the capacity) (*Sanitel, 2009)*. Part of the broilers is exported (12.000 ton carcass weight), but more broilers (184.000 ton carcass weight) are imported. This means that the Belgian slaughterhouses produce 461.000 ton carcass weight of poultry meat each year, of which about 84 % is exported. With an import of 99.000 ton carcass weight this leaves 173.000 ton carcass weight per year or 16,61 kg per head per year for human consumption (*NIS, 2009)*. Twelve of the largest slaughterhouses account for 88 % of the poultry meat production (*Vepek, 2009)*.

In the egg chain, day-old layer chicks produced in the hatcheries go to rearing farms. In Belgium there are 103 rearing farms with a capacity of 3.2 million pullet places. After 18 weeks the pullets are transferred to one of the 383 laying farms. Belgium has a capacity of 11 million hen places (*Sanitel, 2009)*, of which 1 % organic, 5 % free range, 7 % barn and 87 % cage (*Vepek, 2009)*. Equivalent to the broiler production, also the laying farms (85 %) and their capacity (86 %) are concentrated in Flanders, with 33 % of the capacity in West-Flanders and 27 % in Antwerp (*Sanitel, 2009)*. Belgium produces 3.294 million eggs per year. The export of 951 million consumption eggs and 786 million processed eggs, together with the import of 538 million consumption eggs and 537 million processed eggs makes Belgium a net exporter in both eggs and their products. In Belgium there are 2.632 million eggs per year available, 297 million for industrial use and 2.335 million for human consumption (or 224 eggs per head per year) (*NIS, 2009)*.

Threats due to Avian Influenza

Avian Influenza is an infectious disease which is counted to the category of production risks. These are risks that directly originate from the production process and are related to the product itself (*Baltussen et al., 2007)*. An outbreak of Avian Influenza leads on the one hand to costs for eradication of companies (direct damage) and on the other side to costs which go paired with a period of obligatory vacancy (consequential damage). 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 (*Djunaidi and Djunaidi, 2007)*. 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 (*Baltussen et al., 2007).* 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, cause an extra risk. Also the structure of the poultry sector is determinative for the level of risk. The Belgian poultry production goes paired 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.

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. The 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 *(Murphy et al., 1992; Webster et al., 1996*). Influenza viruses occur relatively much 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. Also the presence of turkeys in the neighbourhood of the company raises the risk for infection, because they are more sensitive for infection (*Tumpey et al., 2004).*

Control strategies

Non vaccination

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 can be supplemented with a pre-emptive culling within a 1 up to 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 *(Directive 2005/94/EC)*. 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 *(Directive 2005/94/EC)*.

Emergency vaccination

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 (*Dewulf et al., 2004)*. 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. All vaccination strategies include the eradication of the poultry at infected and contact holdings. The vaccination zone is defined as a radial zone with a radius of 1 up to 5 km around each detected farm. Not all types of poultry are qualified for vaccination (*Capua and Marangon, 2007),* broilers for example are not suitable for vaccination because of their short lifetime.

A vaccination strategy must also include monitoring the evolution of infection (DIVA approach), early detection of any possible outbreaks, and enforcement of adequate biosecurity, restriction and eradication measures (*Capua and Marangon, 2007)*. Previous experiences have indicated that in order to succeed ultimately in controlling an infection, vaccination programs must be part of a wider territorial strategy (*Capua and Marangon, 2007)*. 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 (*Ivanov, 2007)*. Member States using vaccination as a preventive measure must also carry out blood tests that allow the differentiation between vaccinated and infected poultry *(Directive 2005/94/EC)*. If there is 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 (non vaccination).

Economic comparison of control strategies

Materials and Methods

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 modelling allows the user to evaluate 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 (*Sanson et al., 2006)*. The model is stochastic, and so the uncertainty and variation in the different underlying processes is represented by random sampling from the specified probability distributions. Before Interspread Plus has been used to model outbreaks of foot and mouth disease in the Republic of Korea (*Yoon et al., 2006)*, and classical swine fever in Denmark (*Boklund et al., 2008)* and Belgium (*Ribbens, 2009)*. In order to simulate the direct costs and consequential losses for the Belgian poultry industry as a whole, we first transformed the epidemiological data for each control strategy into economic parameters, by using a SPSS model.

Direct costs

Direct costs refer to the compensation for culled birds and the organisation costs of control measures (*Longworth et al., 2009)*. Compensation for culled poultry flocks is calculated per culled bird. The value of culled birds is based on value tables prepared by *Vepek*, which are annually updated. Values are calculated as averages over all ages, since the stage in the production cycle is unknown for individual farms. The per unit compensation values used in the calculations are presented in Table 1.

Table 1. Compensation values for slaughtered poultry used in the calculation of direct costs

	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

Organisational costs are calculated for depopulation, screening, monitoring of vaccine efficacy and surveillance of disease spread in vaccinated flocks. 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 (*Longworth et al., 2009).* Per unit costs associated with depopulation and screening are calculated based on the current contracts of FASFC (Federal agency for the safety of the food chain) with the different companies. The costs for depopulation and screening are based on historical costs during the 2003 HPAI epidemic (*Vepek 2003).* The costs for vaccination are based on (*Vepek, 2003).* The per unit costs used are presented in Table 2.

Table 2. Organisational per unit cost parameters used in the calculation of direct costs

Direct costs eradication	Unit	Value	Direct costs vaccination	Unit	Value
			Vaccination	€/dose	0.05
			Labour costs for application	€/bird	0.06
Depopulation total	€/bird	3.6	Vaccination total	€/bird	0.11
			Monitoring vaccination	€/farm	464.8
Screening	€/farm	541.33	Surveillance in vaccination zone	€/farm	357.1

Consequential losses

The calculation of the consequential losses is based on the average income level per year in Belgium as base for taxing. Consequential losses are calculated on an individual farm basis for affected farms, which in this study corresponds to farms which were either detected or located inside a movement restriction zone (MRZ). The MRZ is equivalent to the surveillance zone (a radius of 10 km around each detected farm). Within this zone, at any time farms can either be empty or in operation. 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 (*Longworth et al., 2009).* It is assumed that farms are situated halfway through the production cycle at all times, and farms which become empty remain empty until the end of the outbreak. The loss per bird per day used to calculate the consequential losses is shown in Table 3.

Table 3. Per 1000 birds 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 1000 birds per day (Euro)
Broiler chickens	3.42
Turkeys	9.34
Layers	3.93
Ready-to-lay layers	5.36
Breeders	16.79

Results and Discussion

For the economic evaluation of the two scenarios, the simulations are based on the outbreak of HPAI in Belgium in 2003. In a first step the stamping-out strategy is considered, in this way an imitation of the real outbreak of 2003 is tried to be made. In a following step, the case is calculated if there has been chosen for emergency vaccination during the outbreak in 2003. Because of the fact that vaccination was never used before in Belgium, some assumptions are made:

- Ring vaccination with a 10 km radius around every infected farm
- Time to immunity is 3 weeks
- Only one application of the vaccine per bird is necessary
- Broilers are not vaccinated
- The first two weeks, the vaccination capacity is limited

Table 4. presents the outcome of the epidemic and economic calculations. The number of affected farms is calculated by the spatial transition model Interspread Plus. In a second stage, the economic consequences are calculated with a SPSS module in order to become a total cost on farm level.

Table 4. Results for the stamping-out and the emergency vaccination strategies

Strategy	Stamping-out	Emergency vaccination
No. of farms Detected infected	8	16
No. of farms Depopulated	37	59
No. of farms Vaccinated	-	13
No. of farms in MRZ	157	170
Duration (Days)	96	89
Direct costs (€)	4.582.316	8.398.913
Consequential losses (€)	1.507.176	1.102.667
Total (million €)	6.089.492	9.501.580

The results clearly indicate that in this specific situation (outbreak of 2003 in Belgium), stamping-out is a better strategy then vaccination. The difference between the two strategies results in a higher direct damage at poultry farm level for emergency vaccination of 3.4 million Euro in comparison with stamping-out. Probably the main raison for the result, is the fact that the broiler chickens are not vaccinated, in this way the broilers remain a possible threat to spread the AI virus. Also the fact that the share of broiler farms in Belgium is more then 60 % of all poultry farms, may explain this results. This can also declare the fact that the total number of depopulated farms for the vaccination strategy is much higher. The positive aspect of emergency vaccination, is the fact that the duration of the total outbreak is 7 days less, which probably can be explained by the fact that there are less susceptible birds in the neighbourhood of the affected farms. The economical benefits involved with a shorter duration, are related to lower consequential losses.

Table 4. indicates also that the direct costs are clearly higher then the consequential losses. This is can be declared by the fact that the consequential damage is based on the average income. The last three years, poultry farming was not the most profitable agricultural sector. We also underestimate the consequential losses by not taking in account fixed costs like depreciations and running assurances.

Conclusion

For the conclusions it must be indicated, that the results are limited to one very specific situation. Later on in this research it's the intention to generate the same data, but with more iterations. In this way, it will be possible to make conclusions who are well-founded from a statistical point of view. Nevertheless with these preliminary results we can conclude that vaccination will not always be an option. Especially because of the fact that the market damage is not yet considered. Previous research indicated already that the market damage for vaccination is significantly higher (*Tacken et al., 2003),* in comparison with stamping-out. So one can assume that if the market damage is included, the economical discrepancies between the two scenario's will even become larger. As a final conclusion we can assume that within the current context, vaccination is not yet an interesting economic option. Hereby we must remark that in the future, a better vaccine who is easier to apply, can be developed. In this case vaccination can become an option in specific situations.

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Strategije za kontrolu visoko patogenog ptičijeg gripa (HPAI) u živinarskom sektoru u Belgiji

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Rezime

Visoko patogeni ptičiji grip (High Pathogenic Avian Influenza - HPAI) može predstavljati veliku opasnost i pretnju za sektor živinarstva u Belgiji, jer pojava HPAI rezultira u velikim ekonomskim gubicima. U cilju ublažavanja ekonomske štete do koje može doći zbog izbijanja ove bolesti razmatraju se različite strategije za kontrolu HPAI. U prvoj fazi se opisuje struktura ovog proizvodnog sektora u Belgiji, i analiziraju se rizici. Objektivni rizici zavise od intenziteta živinarske proizvodnje u Belgiji, transporta živih ptica, postojanja posebno osetljivih prirodnih regiona, kao i graničnih područja sa Holandijom gde je gustina, odnosno broj živine još veći. U drugoj fazi, ocenjuju se potencijalne interventne strategije. Počev od postojećih propisa, razvijene su dve strategije: iskorenjivanje bolesti i hitna vakcinacija. Uspeh hitne vakcinacije uključuje preciznu identifikaciju delova koji su rizični, blagovremenu upotrebu vakcina, brzu primenu adekvatnih komplementarnih kontrolnih mera i nivo spremnosti. U trećoj fazi radi se ekonomska analiza kontrolnih strategija za pojavu HPAI. Rezultati ukazuju da, sa ekonomskog stanovišta, iskorenjivanje na nivou farme je bolja opcija nego hitna vakcinacija u okviru postojećeg konteksta.

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