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Expected utility of voluntary vaccination in the middle of an emergent Bluetongue virus serotype 8 epidemic: A decision analysis parameterized for Dutch circumstances

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ABSTRACT

In order to put a halt to the Bluetongue virus serotype 8 (BTV-8) epidemic in 2008, the European Commission promoted vaccination at a transnational level as a new measure to combat BTV-8. Most European member states opted for a mandatory vaccination campaign, whereas the Netherlands, amongst others, opted for a voluntary campaign. For the latter to be effective, the farmer's willingness to vaccinate should be high enough to reach satisfactory vaccination coverage to stop the spread of the disease. This study looked at a farmer's expected utility of vaccination, which is expected to have a positive impact on the willingness to vaccinate.

Decision analysis was used to structure the vaccination decision problem into decisions, events and payoffs, and to define the relationships among these elements. Two scenarios were formulated to distinguish farmers' mindsets, based on differences in dairy heifer management. For each of the scenarios, a decision tree was run for two years to study vaccination behaviour over time. The analysis was done based on the expected utility criterion. This allows to account for the effect of a farmer's risk preference on the vaccination decision. Probabilities were estimated by experts, payoffs were based on an earlier published study.

According to the results of the simulation, the farmer decided initially to vaccinate against BTV-8 as the net expected utility of vaccination was positive. Re-vaccination was uncertain due to less expected costs of a continued outbreak. A risk averse farmer in this respect is more likely to re-vaccinate. When heifers were retained for export on the farm, the net expected utility of vaccination was found to be generally larger and thus was re-vaccination more likely to happen.

For future animal health programmes that rely on a voluntary approach, results show that the provision of financial incentives can be adjusted to the farmers' willingness to vaccinate over time. Important in this respect are the decision moment and the characteristics of the disease. Farmers' perceptions of the disease risk and about the efficacy of available control options cannot be neglected.

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1. Introduction

Introduction of a vector-borne disease can have large socio-economic consequences, in terms of production, policy and trade (Burrell, 2002). Bluetongue virus serotype 8 (BTV-8) appeared in north-western Europe in August 2006, where this serotype was previously unknown to the EU. This specific serotype affected also cattle with clinical disease, whereas symptoms of other serotypes usually were seen in sheep (Elbers et al., 2008a).

In response to this outbreak, the Dutch government started to put reactive measures into place based on EU Directive 2000/75/EC. The Directive stipulated the disease should be combatted and eradicated using control, monitoring, surveillance and restrictions on movements of susceptible animal species (European Council, 2000, 2007). In detail, measures entailed diagnostics, mandatory indoor housing of ruminants, medical treatment of animals, treatment of stables and vehicles for animal transport with insecticides, extra testing of animals for export and movement restrictions (Velthuis et al., 2010). Nevertheless, many new outbreaks were reported after July 2007. This indicated that BTV-8 had survived successfully the winter of 2006, despite hopes that the cold seasonal temperatures would have constrained the outbreak (Wilson and Mellor, 2009). In order to put a halt to the BTV-8 epidemic, the EU Commission promoted a vaccination campaign at transnational level to be started in the spring of 2008. It was expected that the virus would be manageable by an effective use of vaccination (Wilson and Mellor, 2008). Furthermore the Commission decided to provide financial incentives 'to prevent the spread of the disease as rapidly as possible' (European Council, 2008). Member states like Belgium and Germany opted for a mandatory vaccination campaign. Other member states, such as the United Kingdom (UK) and the Netherlands, decided to offer their farmers a voluntary vaccination programme with provision of financial incentives. In the Netherlands, bad experiences of cattle farmers with a past mandatory vaccination campaign against Infectious Bovine Rhinotracheitis, when a batch of vaccines was contaminated, were amongst the reasons to adopt a voluntary programme (Elbers et al., 2010). The main reasons to adopt a voluntary programme in the UK were to minimize the regulatory burden on the industry and avoid a costly system of enforcement to check compliance (Anon., 2008).

The financial consequences in the Netherlands until the year in which the vaccination programme took place were estimated to be €32.4 million in 2006, mainly because of indirect costs of control and diagnosis. In the subsequent year, the costs were estimated at €170 million Euros, primarily as a result of direct costs of the disease (Velthuis et al., 2010).

The effectiveness of the vaccination programmes within each member state are not known for all EU countries. For the Netherlands a vaccination coverage of 70–80% was reached in 2008 (Elbers et al., 2010) and new infections in the subsequent years were not reported.

Before and during a voluntary vaccination campaign, it was unclear whether the costs and responsibility sharing with the farmer community led to a successful uptake, and what the effect of providing financial incentives would be. In the UK, some veterinary experts discussed the responsibility of the government in the control of diseases such as Bluetongue (e.g. Brownlie, 2008; Orpin, 2008). The central element of discussion was the trade-off between effectiveness and efficiency, between a guaranteed high vaccination coverage for eradication with higher government spending on enforcement (mandatory) and on the other hand a vaccination campaign with less certainty about the resulting coverage, but more efficient and fast distribution of vaccines and less public spending (voluntary). For the latter, the farmer's willingness to vaccinate had to be high in order to reach a coverage that eradicated BTV-8, which is the leading goal (European Council, 2000). The coverage aimed for to prevent between herd-transmission was 80 percent (Velthuis et al., 2011).

In the field economics of animal health, only a few studies looked specifically at voluntary participation in animal health programmes. The voluntary participation in pre-outbreak animal disease insurances was studied with special attention to the risk attitude and/or risk perception of farmers (Ogurtsov et al., 2009; Niemi and Heikkilä, 2011). For vaccination – that might be considered as insurance before, during or after an epidemic – the collective effectiveness of a voluntary campaign was studied for a theoretical endemic disease comparable to Bovine Viral Diarrhoea (Rat-Aspert and Fourichon, 2010). In these studies, the characteristics of the disease and the decision moment differed. These factors were considered to be important decision variables when modelling the vaccination behaviour, just as the risk attitude of farmers.

This study contributes to the existing literature by providing a decision model that can be used as a basic framework to assess a farmer's expected utility of an intervention to control disease, such as vaccination. Furthermore, with this decision model we simulated the farmer's expected utility of (voluntary) vaccination in the middle of an emergent BTV-8 epidemic, to study determinants of the willingness to vaccinate, which is expected to increase with the expected utility of vaccination. The results of this study can be used to evaluate the effectiveness of policy instruments, e.g. provision of financial incentives that encourage a successful uptake of voluntary vaccination.

2. Materials and methods

This study used decision analysis, utilizing a decision tree, to simulate the farmer's decision to vaccinate against BTV-8 as part of the public voluntary vaccination programme. Decision analysis is a prescriptive model of choice based on logical derivations from some axioms ruling how a Decision Maker (DM) would act in making risky decisions. Risk is defined here as uncertain consequences (Hardaker et al., 2004). The corresponding axioms that allow to derive a DM's expected utility in a consistent way is, for example described by Clemen and Reilly (1999). In this study the farmer has been conceptualized as a rational economic DM that maximizes expected utility (see Seegers et al., 1994; Hardaker et al., 2004).

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