

Economic aspects of C-strain vaccination to control Classical Swine Fever epidemics



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Summary

S.1 Key outcomes

This research is focused on economic differences of emergency vaccination in case of an outbreak of Classical Swine Fever (CSF) in a densely populated livestock area in the Netherlands. It compares the effect of a vaccination to live strategy in which a C-strain vaccine is used with the effects of a E2 subunit vaccine. The last vaccine is the preferred vaccine in the current contingency plans.

From an economic perspective based on this research the following can be concluded with respect to vaccination radius and vaccination strategies:

- Vaccination in a 2 km radius around infected farms is the preferred strategy compared to 1 or 3 km;
- C-strain use results in slightly smaller economic effects compared to C2 subunit vaccine in case:
 - Products of C-strain vaccinated animals do not need an additional heat treatment;
 - Of the vaccinated animals only 1 animal per pen of 10 animals has to be tested with PCR;
 - Export markets accept non-vaccinated products from an area/country in which with C-strain vaccination has been used as a vaccination to live strategy.

At present the small economic advantage in the optimal situation of vaccination with C-strain compared does not outweigh these constraints and uncertainties.

Table S.1 summarises the main economic findings.

Table S.1 Costs of the different control strategies in case of an outbreak of CSF in a DPLA in the Netherlands (in million € per outbreak)									
	Control			Farmers			Total		
	Percentile			Percentile			Percentile		
	Mean	0.05	0.95	Mean	0.05	0.95	Mean	0.05	0.95
vacE2_1km	35.63	12.13	74.10	12.77	2.57	29.80	48.40	15.40	103.82
vacE2_2km	27.59	11.18	50.33	17.64	4.93	35.36	45.23	16.56	84.85
vacE2_3km	25.02	11.05	44.68	23.12	7.65	44.60	48.15	19.66	87.85
vacC_1km*	32.40	11.91	62.05	10.99	2.63	25.16	43.40	14.70	85.90
vacC_2km*	26.75	11.43	48.32	15.93	4.44	31.03	42.68	16.73	77.96
vacC_3km*	25.21	11.14	42.20	21.03	6.90	39.14	46.24	19.31	80.07
vacC_1kmcul*	75.97	21.73	158.68	9.84	1.65	26.88	85.81	23.76	184.88
vacC_2kmcul*	108.15	34.20	204.48	11.80	2.32	28.51	119.95	36.76	231.53
vacC_3kmcul*	140.58	50.76	256.40	14.20	3.19	32.71	154.78	53.64	287.59

S.2 Method

In the calculations only those costs are include that are expected to be influenced by the vaccination strategy. These costs and the values used in the calculations can be found in Table 2.2.

Not included were enforcement costs and export losses.

Samenvatting

S.1 Belangrijkste uitkomsten

In dit onderzoek zijn de verschillen in economische effecten van noodvaccinatie bij een uitbraak van Klassieke Varkenspest (KVP) in een veedichtgebied in Nederland onderzocht. Hierbij is een levend vaccin gebaseerd op de C-stam vergeleken met het vaccin dat op het moment als voorkeurvaccin genoemd wordt in de bestrijdingsdraaiboeken (het E2 subunit vaccin).

De resultaten laten zien dat bij toepassing van een 'vaccination-to-live'-strategie:¹

- Bij een vaccinatiecirkel van 2 km rond geïnfecteerde bedrijven is de schade lager dan bij vaccinatie in een cirkel van 1 km of 3 km voor zowel C-stam als E2 subunit vaccin
- Er zijn geringe verschillen tussen de vaccinatiestrategie met C-stam of met E2 subunit vaccin. Dit geringe verschil in het voordeel van C-stam geldt alleen als er aan een aantal belangrijke voorwaarden rond de afzet van producten van gevaccineerde producten is voldaan. Deze randvoorwaarden zijn:
 - Aanvullende hittebehandeling van producten is niet vereist (de huidige regelgeving maakt op het ogenblik deze hittebehandeling wel noodzakelijk);
 - Er hoeft tijdens de eindscreening van de gevaccineerde dieren maar 1 dier per hok van 10 dieren onderzocht te worden met de relatieve dure PCR-techniek;
 - Afnemers in het buitenland accepteren (producten van) niet-gevaccineerde dieren uit een regio/land waar met C-stam gevaccineerd wordt.

Op het ogenblik is het onzeker of de beperkte economische voordelen opwegen tegen de vele onzekerheden en beperkingen die met de introductie van het C-stam vaccin gepaard gaan.

In tabel S1 zijn de belangrijkste resultaten van de berekeningen samengevat.

Tabel S.1 Kosten van de verschillende controlestrategieën in het geval van een uitbraak van KVP in een varkensdicht gebied in Nederland (in miljoen € per uitbraak)									
	Controle kosten			Kosten veehouders			Totaal		
	Mediaan	Percentiel		Mediaan	Percentiel		Mediaan	Percentiel	
		0,05	0,95		0,05	0,95		0,05	0,95
vacE2_1km	35,63	12,13	74,10	12,77	2,57	29,80	48,40	15,40	103,82
vacE2_2km	27,59	11,18	50,33	17,64	4,93	35,36	45,23	16,56	84,85
vacE2_3km	25,02	11,05	44,68	23,12	7,65	44,60	48,15	19,66	87,85
vacC_1km*	32,40	11,91	62,05	10,99	2,63	25,16	43,40	14,70	85,90
vacC_2km*	26,75	11,43	48,32	15,93	4,44	31,03	42,68	16,73	77,96
vacC_3km*	25,21	11,14	42,20	21,03	6,90	39,14	46,24	19,31	80,07
vacC_1kmcu*	75,97	21,73	158,68	9,84	1,65	26,88	85,81	23,76	184,88
vacC_2kmcu*	108,15	34,20	204,48	11,80	2,32	28,51	119,95	36,76	231,53
vacC_3kmcu*	140,58	50,76	256,40	14,20	3,19	32,71	154,78	53,64	287,59

S.2 Methode

Bij de berekeningen zijn alleen de kosten die mogelijk verschillen tussen de onderzochte strategieën meegenomen (zie tabel 3). In deze berekeningen zijn niet meegenomen de handhavingskosten en de gederfde exportinkomsten.

¹ De gevaccineerde dieren worden pas geslacht op het einde van hun normale productiecycclus en hun producten worden gekanaliseerd binnen Nederland afgezet.

1 Setting the scene

1.1 Introduction

Epidemic livestock diseases, for example Classical Swine Fever (CSF), present a threat to the productivity of the livestock sector and can have substantial effects on national economies. Therefore a rapid detection and eradication is of utmost importance. In case of an outbreak of CSF the Competent Authorities in Europe apply control measures to eliminate the infection from its territory and to avoid spread to other member states (MSs).

Given the importance of these epidemic livestock disease for MSs and EU economy the EU agreed upon a minimal set of measures to be applied in case of an outbreak (Council Directive 2001/89/EC). Especially in MSs with a large, concentrated and intensive livestock sector the EU minimum measures do not lead to a swift and efficient containment of the epidemic and additional measures need to be applied. These measures can consist of preventive culling in a circle around infected farms, application of movement restrictions and/or vaccination in an area around infected farms. These specific additional control measures can only be applied after approval by the EU commission.

To avoid large-scale culling of healthy animals in future outbreaks of CSF the Dutch Government intends to use a 'vaccination-to-live' strategy. To be able to quickly respond in case of an outbreak vaccine stocks need to be available. For this arrangements need to be made with potential vaccine suppliers regarding type of vaccine and amount of vaccine needed.

At the moment, for emergency vaccination against CSF, 2 types of vaccines could be considered to be used to control an outbreak of CSF: E2 subunit vaccine and C-strain vaccine.

For E2 subunit vaccine diagnostic ELISA-tests can distinguish vaccinated from infected animals. However, there is some uncertainty whether the future availability of the E2 Elisa test can be ensured.

An alternative for the E2 subunit vaccine could be a vaccine based on the C-strain. A problem with C strain is that with serological tests it is not possible to distinguish vaccinated from infected animals. To investigate the presence of viral material a PCR has to be used.

In an accompanying study (Backer et al., 2013) the epidemiological effects of control strategies in which either E2 subunit vaccine or C strain were used in CSF epidemics were reported. The objective of this research is to compare differences in economic effects of control measures between intervention with vaccination with a E2 subunit vaccine or a vaccine based on the C-strain.

Control measures are associated with costs (see Text box 1). Detection and culling of infected farms, preventive culling of high risk farms, movement restrictions to prevent further spread of infection, vaccination as well as other additional preventive measures are accompanied with substantial costs for government as well as the livestock production chain. Besides these direct costs, there are revenues forgone (losses) related to export bans and (temporary) loss of export markets within and outside the EU. The largest part of these export losses are related to the fact of an outbreak of CSF and depend only for a small part on how the outbreak is controlled. For exporting MSs like the Netherlands, Belgium and Denmark these export losses may even be larger than the direct losses of an outbreak.

Text box 1 Economic effects of an outbreak of CSF

When evaluating the economic losses related to an epidemic of a contagious disease, different components can be distinguished:

- *Direct costs related to the control of the epidemic*
These include the costs for the infrastructure for the control of the epidemic, the costs associated with culling and destroying of infected and contact animals, the costs associated with destruction of feed on detected farms, and the compensation and vaccination costs.
- *Costs related to trade restrictions*
Due to an epidemic the national and international market access for animals of susceptible species and their products is restricted. An epidemic of CSF will result in trade restrictions that are mostly related to the epidemic per se and do not depend on the specific characteristics of the control strategy chosen. After the last outbreak it takes time until all the restrictions in trade are lifted and the situation from before the epidemic is restored.
- *Ripple effects*
The effects from outbreaks of CSF that are felt upstream and downstream along the livestock value chain: breeding, feed production, input supply, slaughter, processing, final sale and consumption.
- *Spill-over effects*
The effects from outbreaks of CSF that are felt in other sectors like tourism. Since other than typical agricultural production is becoming more important for the rural economy these spill-over effects are likely to become a large part of the total epidemic costs.

The duration of the trade restrictions has a large effect on the economic consequences for an infected country. For a country like the Netherlands, which depends to a large extent on export of pigs and pig meat, the duration of trade restriction within and outside the EU from infected areas determine for a large part the economic effects. However these effects are to a large part determined by the fact of an outbreak and for a smaller part on the way the outbreak is controlled.

1.2 Objective of the research

The objective of this research was to get an insight into the economic aspects of application of vaccination with vaccines based on C strain compared with vaccines based on E2 subunit vaccine in the control of an outbreak of CSF in a densely populated livestock area (DPLA) in the Netherlands.

The results of this economic study are presented below. These results can support the policy makers to make an informed decision on the choice of vaccine type.

2 Material and Methods

2.1 Epidemiological data

Control strategies

The epidemiological data as presented in the epidemiological section of the report were used as input for the economic calculations (Backer et al., 2013). In total 8 strategies were analysed and the main epidemiological findings are summarised in Table 2.1. Table 2.2 gives an overview of the measures applied in the different control strategies.

Table 2.1 Summary of main epidemiological outcomes a)								
control strategy	Duration (days) b)		Number of detected farms		Number of pre-emptively culled farms		Number of vaccinated farms	
EU	202	(65-475)	40	(10-128)	0	(0-0)	0	(0-0)
cul_1km	93	(35-199)	13	(5-27)	79	(26-173)	0	(0-0)
vacE2_1km	136	(45-310)	19	(6-52)	8	(2-20)	98	(20-254)
vacE2_2km	113	(37-236)	14	(5-32)	8	(2-20)	191	(56-414)
vacE2_3km	104	(34-203)	12	(5-26)	8	(2-20)	278	(95-588)
vacC_1km	125	(42-264)	16	(5-41)	8	(2-20)	88	(19-223)
vacC_2km	101	(36-208)	12	(5-27)	8	(2-20)	175	(51-379)
vacC_3km	91	(31-185)	10	(4-22)	8	(2-20)	260	(83-515)

a) Effectiveness of control strategies for default HRP: epidemic duration, number of detected, pre-emptively culled and vaccinated farms per epidemic; median values and (5-95%) interval between brackets; b) Duration of the epidemic is defined as the time between the first and the last detection.

The benchmark strategies

EU: The EU demands a minimal control strategy, as required by Council Directive 2001/89/EC. All animals on infected detected farms are culled, transport is regulated in protection and surveillance zones, and dangerous contacts are actively screened and traced.

The measures of the EU strategy are always applied; on top of this additional measures are taken in the following control strategies:

- *cul1*
Additional pre-emptive depopulation in a 1-km radius around infected premises is a much used strategy within the EU in a DPLA.
- *vacE2_Xkm*
Emergency vaccination of finishing pigs and piglets in X (1, 2 or 3) km around infected premises instead of preventive culling. Sows are excluded from vaccination to minimise the risk of persistently infected piglets being undetected. The vaccine strain used is the E2 subunit vaccine. After the outbreak vaccinated animals are logistically channelled and slaughtered. The meat of vaccinated animals is used for human consumption in the Netherlands.
- *vacC_Xkm*
Emergency vaccination of finishing pigs and piglets in X (1, 2 or 3) km around infected premises instead of preventive culling. Sows are excluded from vaccination to minimise the risk of persistently infected piglets being undetected. The vaccine strain used is C strain. After the outbreak vaccinated animals are logistically channelled and slaughtered. The meat of vaccinated animals is used for human consumption in the Netherlands.
- *vacC_Xkmcul*
Emergency vaccination of finishing pigs and piglets in X (1, 2 or 3) km around infected premises instead of preventive culling. Sows are excluded from vaccination to minimise the risk of persistently in-

fectured piglets. The vaccine strain used is C strain. After the outbreak vaccinated animals are culled and the products of the animals are destroyed.

Economic data used

Given the objective of the study only the economic differences between the different vaccination strategies were evaluated. No estimate was made for the EU strategy or the culling strategy.

To evaluate the economic consequences of the different vaccination control strategies, an existing economic model is used in Backer et al. (2009). This model is based on partial budgeting since the main objective of this research is to compare the effects of different vaccination control strategies. In partial budgeting only those costs and benefits that are expected to differ substantially between alternatives are included. In the next section the costs that are included or excluded in the model are addressed in more detail. Also the used values in the calculations are given. Price data of 2012 were used. In case recent data are not available (e.g. because some costs can only be determined after an outbreak) they are based on historical data indexed for a price level of 2012. For this indexation price indexes of CBS were used.

Table 2.2 Economic input parameters used in the economic evaluation (price level 2012)					
Direct costs					
Operational costs					
Screening and sampling			Clearing and disinfection		
Taking samples as suspect	298,684	€/infected farm	Sows	502	€/animal
Execution of screening	244,444	€/infected farm	Piglets	0.00	€/animal
Total screening and sampling	543,128	€/infected farm	Fattening pigs	188	€/animal
Taxation and materials per culled farm			Vaccination costs		
	7,180	€/culled farm			
Destruction (transport included)			Sows	0.00	€/animal
Sows	109	€/animal	Piglets	2.26	€/animal
Piglets	0.00	€/animal	Fattening pigs	2.26	€/animal
Fattening pigs	15	€/animal	Test costs		
			Elisa	5,00	€/sample
			PCR	50,00	€/ sample
Value loss of vaccinated animals			Value of compensated animals including feed		
Piglets	13.25	€/animal	Sows	467	€/animal
Fattening pigs	45.00	€/animal	Piglets	45	€/animal
			Fattening pigs	106	€/animal
Indirect costs					
Empty farm buildings during outbreak			Repopulation costs		
Sows	0.99	€/animal/day	Sows	181	€/animal
Piglets	0.00	€/animal/day	Piglets	0.00	€/animal
Fattening pigs	0.20	€/animal/day	Fattening pigs	12	€/animal
Costs of transportation prohibition of non-infected farms with fattening pigs, first 6 weeks	11.01	€/animal			

Short explanation of the different costs included in the calculations:

- *Operational costs*
These are costs related to screening and sampling based on the total cost of the 2001 epidemic in the Netherlands (Huirne et al., 2002). These costs occurred in the period from the day of the first outbreak until 28 days after the last outbreak.
- *Costs of clearing and disinfection*
The labour costs of culling of animals and disinfection of farms (based on Huirne et al. (2002)).

- *Compensation for culled pig herds*
The costs of culled animals is the number of culled animals times the value of each animal. The costs of destructed feed is the number of culled animals times the average value per animal of the stock of feed present on the farm.
The value of culled animals was based on value tables which are regularly updated.¹ Values were calculated as averages over all ages, since the stage in the production cycle is unknown for individual farms.
- *Costs of empty housing*
The costs of empty housing between moment of culling and moment of repopulation after the epidemic and a 30-day period after last detection.
- *Costs of culling and disinfection*
The labour costs of culling of animals and disinfection of farms, based on Huirne et al. (2002).
- *Costs of repopulation*
The culled farms incurred costs after repopulation because of suboptimal utilisation of their capacity.
- *Costs of transportation prohibition of non-infected farms and welfare slaughter*
The costs of non-infected farms in an area with a transport prohibition for a 6 week period because of missed returns were calculated. Only these costs were calculated for finisher pigs. It is assumed that sows will not have welfare problems and will not lose value during a transport prohibition. After 6 weeks, piglets will be placed within an area within which there are finishing farms that have places available because they could slaughter pigs. The value loss compared to animals in non-infected areas will be difficult to estimate given the fact that an outbreak of CSF in the Netherlands with its large dependence of export of live piglets will have a detrimental effect on piglet prices.
- *Costs of empty houses and repopulation of non-infected farms in infected compartments*
Replacement pigs are sufficiently available in the Netherlands in the area with movement restrictions to prevent empty housing.
- *Costs of vaccinating*
The labour costs of vaccination of animals and the vaccine costs (both E2 as well as C-strain vaccines).
- *Cost of testing*
Test costs vary between the different tests. The laboratory costs of serology² are estimated at approximately €5 per sample and for PCR for testing of C-strain vaccinated animals at approximately €50 per sample (Bouma pers. communication). In the initial calculations it is assumed that 10% of the vaccinated animals need to be additionally tested (1 animal per pen).
- *Value loss of vaccinated animals*
The value loss of vaccinated animals is the number of vaccinated animals times the average value loss of each animal if sold on the Dutch market. The estimates for the value loss of products from vaccinated pigs were based on previous research by Van Asseldonk and Bergevoet (2011, unpublished data). In the initial calculations it is assumed that the products of vaccinated animals can be sold as fresh meat. The impact of additional value loss, in case heat treatment of products is needed for C-strain vaccinated animals, is discussed in Chapter 4.
- *Costs of logistic processing of vaccinated animals*
During the epidemic and the 30-day period after last detection vaccinated pigs are processed similarly to non-vaccinated animals. Vaccinated animals that are still alive after this period, have to be logistically slaughtered and corresponding costs were calculated. Vaccinated hobby animals were not slaughtered and incurred no additional costs.

¹ To improve the process of valuation of animals culled during an epidemic the Dutch Competent Authorities and the livestock sector agreed upon method for valuation ('Waardetabellen'). Based on this an annually updated value table prepared by the Agricultural Economics Institute (LEI) for different types of animals is created.

² E2-ELISA for non-vaccinated animals and Ems for vaccinated animals.

Excluded in the calculation

Export market losses were *excluded* from the economic analysis. The reason is twofold: 1) it is not likely that these losses differ substantially between the evaluated alternatives in this study and 2) it is almost impossible to determine these losses unambiguously since the losses are determined by the duration of the outbreak, the level of observation (affected area, the Netherlands or the EU) the time horizon of observation,¹ as well as ripple effects. The epidemiological data suggest that the duration of the outbreak for E2 subunit vaccine and vaccines based on C-strain is almost equal; therefore expected time to resume export is almost equal. So export losses are assumed to be similar. Note that the Netherlands is a net exporting country of pigs and pork (Table 2.3). Although the export losses are not different between the two evaluated strategies these losses for both strategies are expected to be substantial.

Table 2.3 Export volume of live pigs and pork from the Netherlands in 2012		
	Per week	Per year
Piglets (# animals)	124.505	6.601.710
Fatteners (# animals)	14.919	3.594.100
Pork meat in '000 kg	14.919	790.750
Source: PVE, 2012.		

- *Enforcement costs* were *excluded* from the calculations. Enforcement costs are costs related to the involvement of police, army, customs etc. to ensure compliance with the movement restrictions an execution of regulations. The enforcement costs are not likely to be different between the two evaluated scenarios. In the previous FMD outbreak in the Netherlands they were estimated to amount to €335.484 a day. There are two issues with respect to these enforcement costs:
 - these enforcement costs are not eligible for reimbursement under the EU Veterinary Fund;
 - these costs are difficult to estimate, since they depend on the location of the outbreaks, enforcement deemed necessary by the competent authorities and the expected cooperation of farmers in the affected areas.

Also excluded:

- Costs that can occur during an epidemic of CSF in not primary affected branches as horses, pigs and cattle farming and arable land and the costs of non-agricultural industry as tourism are also not analysed (i.e. spill-over effects).
- In this evaluation only the economic effects of the occurrence of the first outbreak in a Densely Populated Livestock Area (DPLA) are evaluated, the effects of a first outbreak occurs in a Sparsely Populated Livestock Area (SPPA) are not evaluated.

Best case scenario

In the calculations presented in Chapter 3 it is assumed that market access is not influenced by the vaccine choice. This is for vaccination with the C-strain the *best case* scenario. In case products originating from animals vaccinated with C-strain need additional measures before entering the market, market excess is denied for a longer time or additional processing of products is needed which has substantial impact on the cost of the strategy. The economic impact of each of those additional measures is addressed in Chapter 4.

¹ Vrolijk and Poppe (2010) observed that following the CSF outbreak in November 1998 the lowest pork prices since World War II were observed as a reaction of increased production following the lower production in the Netherlands during the outbreak.

3 Results

3.1 Total costs and differences between vaccination strategies

In Table 3.1 the control costs (excluding costs borne by farmers), the losses for the farmers as well as the total losses are given. The losses borne by farmers include empty farm buildings during outbreak, repopulation costs and the value loss of vaccinated animals. In Figure 3.1 to Figure 3.3 the distribution of the total losses of the different control strategies are given for the different programme iterations.

Table 3.1 Losses of the different controls strategies in case of an outbreak of CSF in a DPLA in the Netherlands (in million € per outbreak)									
	Control			Farmers			Total		
		Percentile			Percentile			Percentile	
	Mean	0.05	0.95	Mean	0.05	0.95	Mean	0.05	0.95
vacE2_1km	35.63	12.13	74.10	12.77	2.57	29.80	48.40	15.40	103.82
vacE2_2km	27.59	11.18	50.33	17.64	4.93	35.36	45.23	16.56	84.85
vacE2_3km	25.02	11.05	44.68	23.12	7.65	44.60	48.15	19.66	87.85
vacC_1km*	32.40	11.91	62.05	10.99	2.63	25.16	43.40	14.70	85.90
vacC_2km*	26.75	11.43	48.32	15.93	4.44	31.03	42.68	16.73	77.96
vacC_3km*	25.21	11.14	42.20	21.03	6.90	39.14	46.24	19.31	80.07
vacC_1kmcul*	75.97	21.73	158.68	9.84	1.65	26.88	85.81	23.76	184.88
vacC_2kmcul*	108.15	34.20	204.48	11.80	2.32	28.51	119.95	36.76	231.53
vacC_3kmcul*	140.58	50.76	256.40	14.20	3.19	32.71	154.78	53.64	287.59

*PCR test for 1 animal per pen.

As can be seen from Table 3.1 and Figure 3.1 the total costs differ substantially between the evaluated strategies:

- Vaccination in a circle of 2 km has for all three the evaluated vaccination circles the smallest total losses. The share of the losses directly borne by farmer increases when the vaccination radius increases.¹ Whereas the cost for the government decreases with increasing diameter when vaccination to live strategies are applied.
- The strategies that involve vaccination with the C strain followed by culling of the vaccinated animals have the highest losses.
- Vaccination strategies that include a vaccination to live strategy are substantially less costly than strategies that involve large-scale culling. For the two vaccine types Vac E2_2km (€45.23m) and VacC_2km (€42.68m) have the lowest total losses.
- The share of the control costs in the total losses is higher in strategies that involve culling of animals. In the vaccination to live strategies a large part of the losses are incurred at farm level. These are mainly losses related to the value loss due to channelling of vaccinated animals.

In Figure 3.1 the results of the vacE_1km, vacE_2km and vac E_3km strategies are given. As can be seen from Figure 3.1, large differences occur in possible outcomes when iterations are sorted on the losses of the outbreak. Losses gradually increase, but at higher percentile values (>0.95) losses rise steeply. These are the outbreaks that get out of hand (spread amongst larger regions etc.). The lines of the different strategies cross. For example the vacE_1 km strategy for almost 50% of simulated small outbreaks has the lowest costs. These are small outbreaks with limited spread from initially infected farms. After his point VacE_2km has the smallest losses. Vac E-3km has never the smallest losses.

¹ Farmers also participate in the control costs by means of the Animal health fund. Financing mechanisms are discussed in Chapter 4.

Figure 3.1 Distribution of outcomes of the simulations for the vacE_1km, vacE_2km and vacE_3km. The x-axis gives the percentile and the y-axis total losses in million €

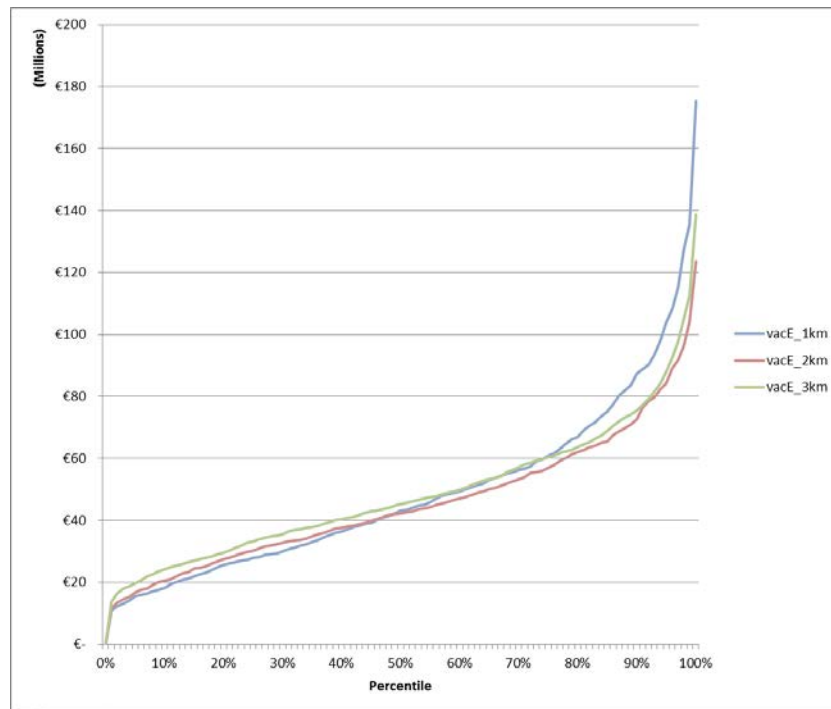


Figure 3.2 compares the losses of the different C-strain strategies. As can be seen from Figure 3.2 vaccination with the C-strain followed by culling of the vaccinated animals is a costly control strategy. The losses increase substantially when the vaccination area increases.

Figure 3.2 Distribution of outcomes of the simulations for the different vaccination strategies with the C strain. The x-axis gives the percentile and the y-axis total losses in million €

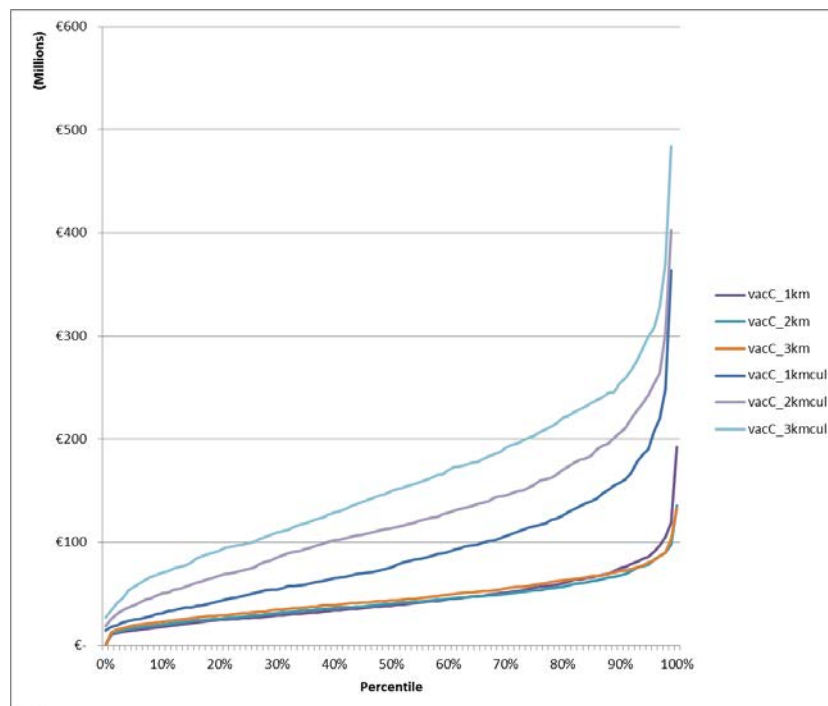


Figure 3.3 Distribution of outcomes of the simulations vacE2_2km and VacC_2km. The x-axis gives the percentile and the y-axis total losses in million €

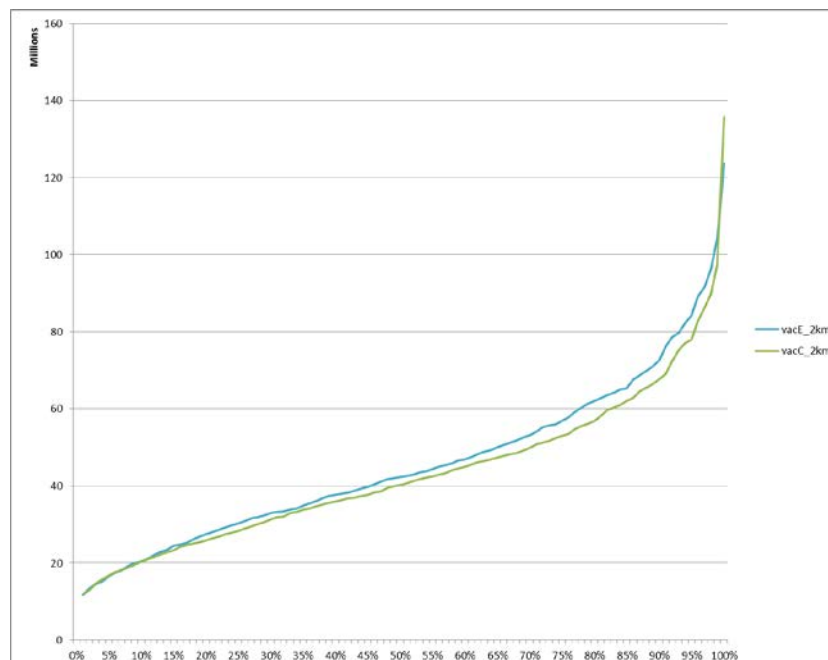


Figure 3.3 compares, vacE2_2km, VacC_2km. As can be seen from Figure 3.3 the difference between the two strategies is marginal. Also the differences between the two strategies when the outbreak is getting extremely out of hand is (>95% percentile) is relative small.

4 Discussion

In the discussion the impact of alternative assumptions on the costs of C strain use in comparison with the E2 subunit vaccine use will be addressed.

The impact of enforcement costs

Enforcement costs are mainly affected by the duration of the outbreak and to a smaller extent by the size of the outbreak. These costs can be substantial. In previous outbreaks it was estimated to be as high as €335.000 per day. However, these costs are very much influenced by policy decisions on how extensive the enforcement effort should be. It is expected that in future outbreaks farmers' cooperation will increase especially when a vaccination to live strategy will be applied. Furthermore cooperation increases when 1. it is clear beforehand what the price of culled animals will be; 2. it is known which arrangements will be in place for products of vaccinated animals; and 3. transport of animals to slaughter houses from farms in areas with movement restrictions will be possible after a relatively short period. When this is clear beforehand possible incentives for farmers to move animals illegally from infected to non-infected areas will decrease. The amount of enforcement measures and hence the costs per day are determined by the confidence of the government in compliance of stakeholders with the movement restrictions.

Export losses and losses related to trade restrictions

Total effects of the export losses are determined by size and duration of the outbreak, control strategy applied and especially the country/area affected. Therefore they vary substantially and can only be determined after the outbreak.

Due to an epidemic the national and international market access for animals of susceptible species and their products is restricted. An epidemic of CSF will result in trade restrictions that are to a large extent related to the epidemic per se and do not depend on the specific characteristics of the control strategy chosen.

As the last CSF crisis in the Netherlands showed, the effect can be long-lasting. The disrupted production during the outbreak in 1997 and the resulting high prices for non-affected farmers increased production which led to lowest prices since World War II in November 1998 (Vrolijk and Poppe, 2008). So it may take several years before the situation from before the epidemic is restored.

Possibility of consumption of products originating from C-strain vaccinated pigs

From an economic perspective vaccination with the C-strain can only be considered when it is possible to apply 'a vaccination to live' strategy. This means strict channelling of the vaccinated animals should be ensured and that trade partners show a willingness to accept non-vaccinated animals from a country that eradicated an outbreak of CSF with a non-DIVA vaccine.

Compensation by Veterinary Fund and the Dutch Animal Health Fund

Council Decision 90/424/EEC of 26 June 1990 on expenditure in the veterinary field brings together all Community financial measures for the eradication, control and monitoring of animal diseases and zoonoses. It lays down the relevant procedures governing the Community's financial contribution. Co-financing is foreseen in the event of an epidemic livestock disease; typically the MS in which the disease outbreak occurred submits a claim and the Commission then determines the actual reimbursement according to the eligibility criteria in place. Council Decision 90/424/EEC allows for co-financing 50% of the costs of compulsory and pre-emptive slaughter and of related operational expenditure (this co-financing is 60% for Foot-and-Mouth Disease). In Council Decision 90/424/EEC the type of losses covered are described, these are:

- Costs of compensation to owners the market value of compulsory slaughtered animals or destroyed eggs.
- Costs associated with the compulsory slaughter of animals.

- Costs associated with the destruction of carcasses and/or eggs.
- Costs associated with cleaning, disinfecting, and disinfection of holdings.
- Costs associated with the destruction of contaminated feed stuffs and/or milk.
- Costs associated with the destruction of contaminated equipment.
- In connection with vaccination, eligible expenditures.

The other 50% of the costs have to be borne by the Member States. In the Netherlands the pig sector contributes to the maximum of 26m per 5 year period in the direct costs of outbreaks by means of the Dutch Animal Health Fund. Costs related to enforcement of the regulation and value loss of vaccinated animals are not eligible to EU's contribution (or contribution by the Dutch Animal Health Fund).

In the case of serious market disturbances due to restrictions imposed by the veterinary authorities in the case of outbreaks of animal diseases like FMD or CSF, exceptional market support measures can be introduced by the Commission in order to support the farmers affected by these restrictions. The cost categories that are eligible for co-financing have recently been specified in more detail in Regulation 349/2005. These exceptional market support measures are implemented under the authority of DG AGRI. Such measures can only be introduced once MSs have introduced the veterinary measures necessary to stamp out epizootic diseases, 'only to the extent and for the duration strictly necessary to support the market concerned.'

Additional value loss of C-strain vaccinated animals in case a heat treatment of products is required

The value loss of vaccinated animals in case of E2 vaccination is estimated at €13.25 per piglet and €45 per fattening pig (Table 2.2). These are the costs due to logistic slaughtering and suboptimal value of fresh meat. In case the products of C-strain vaccinated animals have to be heat-treated an additional value loss of at least €0.2 per kg have to be considered.¹ This results in an additional value loss of 16 € per vaccinated animal. For the vacC_2km strategy Backer et al. (2013) estimate that on average 616.000 animals have to be vaccinated of which after the lifting of restrictions about 2/3 are expected to be still present (the remaining are slaughtered during the outbreak phase). The additional value loss due to heat treatment of products of vaccinated animals is estimated at €6.5m.²

Economic impact of different end-screenings scenarios

Compared to non-vaccinated farms the test procedure for vaccinated farms involves a more intensive screening. There are two options that need to be considered as end-screening strategy:

1. Testing of a sample size that ensures that the number of undetected sero-positive animals is equal or smaller than applying the prescribed end-screening in case of applying EU or Cul 1 strategies. For this Backer et al. (2013) assume a number of 1 animal per pen of vaccinated animals to be tested (this is assumed in our initial calculations);
2. Testing of all vaccinated animals (option 2).

The additional number of samples and costs related to this for strategy E2_2km and C_2km are given in Table 4.1. As this table shows especially in case a vacC_2km is used substantial additional tests costs have to be expected due to the high costs for performing a PCR test.

Table 4.1		Test costs during the end-screening			
		option 1			option 2
	1 animal per pen tested		all vaccinated animals tested		
	# of animals (x 1,000)	test costs (in million €)	# of animals (x 1,000)	test costs (in million €)	
vacE2_2km	41	0.21	422	2.11	
vacC_2km	37	1.85	388	19.4	

¹ Estimate based on Hoste et al. (2007).

² 2/3 of 616.000 animals * 80 kg slaughter weight * €0.2.

5 Conclusions

From an economic perspective based on this research the following can be concluded with respect to vaccination radius and vaccination strategies:

- Vaccination in a 2-km radius around infected farms is the preferred strategy compared to 1 or 3 km;
- C-strain use results in slightly smaller economic losses compared to C2 subunit vaccine in case:
 - Products of C-strain vaccinated animals do not need an additional heat treatment;
 - Of the vaccinated animals only 1 animal per pen has to be tested with PCR;
 - Export markets accept non-vaccinated products from the area with C-strain vaccination.

At present the small economic advantage in the optimal situation of vaccination with C-strain compared does not outweigh these constraints and uncertainties.

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Appendix 1

Huidige Strategie bestrijding Klassieke Varkenspest (KVP) in Nederland

Uitgangspunten

Uitgangspunt in de draaiboeken KVP is dat er in een cirkel van 2 kilometer rondom besmette bedrijven ge-vaccineerd gaat worden.

Op varkensbedrijven worden op de bedrijven die in de vaccinatiecirkel liggen alle dieren behalve zeu- gen gevaccineerd. Het betreft vleesvarkens, fokberen, opfokzeugen en zuigende en gespeende biggen. De zeugen worden bij KVP *niet* gevaccineerd. Een bedrijf wordt in principe maar één keer gevaccineerd. Indien een bedrijf meerdere keren in een vaccinatiecirkel komt te liggen worden alleen nieuwe/pasgeboren dieren die nog niet gevaccineerd waren gevaccineerd en de dieren die bij de eerste vaccinatie jonger dan vier weken oud waren.

Maatregelen tijdens de uitbraak

In de gebieden rondom uitbraken gelden onder andere restricties voor vervoer van en naar locaties met gevoelige dieren en wordt ook ander vervoer van agrarische voertuigen zoveel mogelijk beperkt. Zodra een besmetting is bevestigd zullen de maatregelen die in de EU-richtlijn genoemd zijn uitgevoerd worden. Dit betekent het ruimen van het besmette bedrijf, maar ook het instellen van een beschermingsgebied met een straal van tenminste 3 km om het besmette bedrijf. Daarnaast wordt een toezichtsgebied met een straal van tenminste 10 km om het besmette bedrijf ingesteld. Indien besloten wordt om te gaan vaccine- ren zal er een vaccinatiegebied ingesteld worden. In het vaccinatiegebied zijn, op basis van de richtlijn, dezelfde maatregelen van toepassing als in het beschermingsgebied en toezichtsgebied.

In de draaiboeken worden drie zogenaamde fases onderscheiden. De maatregelen die voor het vacci- natiegebied in aanvang van kracht zullen zijn (fase 1: geldt van het begin van vaccinatie tot 30 dagen na de laatste vaccinatie), zijn identiek aan het maatregelpakket van het beschermingsgebied en toezichtsge- bied. In de afbouw van de maatregelen worden de maatregelen van fasen 2 en 3 van kracht. Fase 2 gaat in na fase 1 en is geldig tot een gunstige uitslag van de screening bekend is, fase 3 gaat in na de scree- ning en is geldig tot Nederland door de EU vrij wordt verklaard.

De maatregelen in fase 2 zijn gelijk aan de maatregelen in fase 1: vatbare dieren mogen met een ont- heffing vervoerd worden rechtstreeks naar een slachthuis binnen of buiten het vaccinatiegebied. In fase 3 is het vervoer van vatbare dieren, met ontheffing, toegestaan tussen bedrijven *binnen het vaccinatiege- bied*. Het vervoer van vatbare dieren naar een locatie buiten het vaccinatiegebied is verboden, tenzij de dieren met ontheffing rechtstreeks naar een slachthuis gaan.

Samenvattend: gedurende de uitbraakperiode (fase 1 tot en met fase 3) is er sprake van kanalisatie in zowel het vaccinatiegebied, beschermingsgebied en toezichtsgebied van alle gevoelige dieren en hun pro- ducten uit het gebied (figuur 1). Kanalisatie houdt in dat de producten afzonderlijk herkenbaar bewerkt en separaat opgeslagen moeten worden (separaat opslaan zal naar verwachting zulke grote consequenties hebben, dat NVWA heeft aangegeven dat duidelijke identificatie voldoende is).

Maatregelen na de uitbraak

Ook na de uitbraak gelden er nog steeds beperkingen voor de afzet gevaccineerde dieren en hun pro- ducten. De duur van deze periode met beperking na de uitbraak is afhankelijk van de dierziekte. De inter- pretatie van de richtlijnen is hieronder weergegeven¹ (persoonlijke mededeling: Akkerman, 2009).

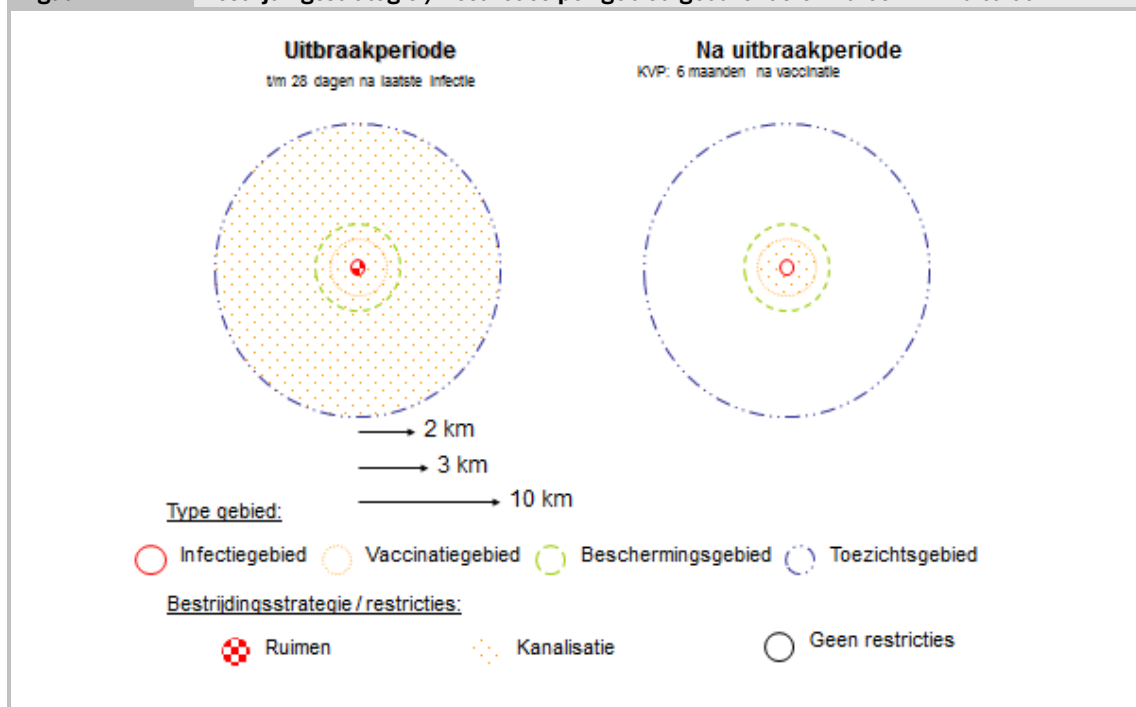
Voor KVP geldt dat hier onderscheid gemaakt wordt tussen gebruik van levend (niet-marker-) en markervaccin. Bij niet-markervaccin geldt dat het vlees gedurende zes maanden (na laatste vaccinatie) een *hittebehandeling* moet ondergaan. Bij gebruik van een markervaccin (art. 19 lid 9 Richtlijn 2001/89/EG)

¹ Eén van de speerpunten binnen het EU project 'Animal Health Strategy' is de herziening van de wetgeving voor dierziektebestrijding. Hierbij zal zeker de mogelijkheid van vaccinatie als bestrijdingsinstrument, maatregelen tijdens vaccinatie, vermarkten van producten en vlees van gevaccineerde dieren herzien worden (meer gericht op de praktijk).

gelden andere procedures. In art. 19 lid 8 9 Richtlijn 2001/89/EG staat vermeld dat, in afwijking van lid 5 en 6, de maatregelen zoals genoemd in art 4 kunnen worden ingetrokken onder genoemde voorwaarden. Door dit laatste artikel kan de periode van zes maanden worden verkort.

Bij vaccinatie tegen KVP worden op de vermeerderingsbedrijven in de vaccinatiegebieden de aanwezige biggen met markervaccin gevaccineerd (en de zeugen niet, dit in tegenstelling tot MKZ). De tijdshorizon met beperkingen voor afzet van producten van gevaccineerde dieren is begrensd tot de levensduur van de gevaccineerde dieren. Er zijn maar een relatief korte tijd gevaccineerde dieren op het bedrijf aanwezig. Na ongeveer 70 dagen (de gemiddelde afleverleeftijd van een big naar het vleesvarkenbedrijf) na de laatste vaccinatie zullen, bij afwezigheid van verdere vervoersbeperkingen, geen gevaccineerde dieren meer op het zeugenbedrijf aanwezig zijn. Op een vleesvarkensbedrijf worden in de vaccinatiegebieden alle aanwezige dieren eenmalig gevaccineerd. Dit betekent dat binnen ongeveer drie maanden deze dieren aan het slachthuis geleverd zullen zijn. De maximale duur met beperkingen is dus circa een half jaar (duur van big tot met aflevering vleesvarken).

Figuur A.1 Bestrijdingsstrategie / restricties per gebied gedurende en na een KVP-uitbraak



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