Economic analysis of Equine Herpes Virus within the Dutch commercial horse sector

Thesis Business Economics

BEC-80424

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Date:	February, 2014

Preface

This essay is in the context of my minor thesis in Business Economics at the Wageningen University. The subject of my minor thesis is: 'Economic analysis of Equine Herpes Virus within the Dutch commercial horse sector'. I really liked this subject because I am interested in horses and the economic impact diseases can have.
Since I own a horse myself it is even more interesting to see what the impact of Equine Herpes Virus is as my horse could get infected too. The difficulty of this subject was that there is not much quantitative data present and that a lot of assumptions had to be made.

I would like to thank everybody who helped me with my report, especially my supervisor Monique Mourits. I also want to thank Mr Van Maanen (Gezondheidsdienst Dieren) for helping me by providing information.

Tara Vollebregt
February 5, 2014

Summary

Equine Herpes Virus-1 (EHV-1) causes one of the viral diseases which poses a threat to horse health. An infection with EHV can cause different symptoms varying from the mild flu-like symptoms, to the more severe abortions and neurological symptoms. The neurological form can cause severe problems and can even lead to the death of the horse.

EHV-1 is able to spread through air over short distances and by direct contact between horses. Currently vaccines only prevent against the respiratory form, no prevention is claimed against the abortion or neurological form.

EHV-1 is endemic in the Netherlands. Every year the virus occurs somewhere, but most of the time the amount of horses infected stays low and the infection is therefore seen as normal business- and/or entrepreneurial risk. The responsibility of the control of the virus lies with the sector itself and not with the government.

In this report the objective is to perform an economic risk assessment on EHV-1 within the Dutch commercial horse sector. The commercial sector consists of around 10% of the total number of stables in the Netherlands but houses more than 60% of the total horse population.

The economic evaluation primarily focuses on an introduction of EHV1-impact on the riding schools as they are the commercial part of the horse-keeping sector in which the expected likelihood of EHV-1 is the highest.
For the economic evaluation a deterministic, partial budgeting approach is used. The costs accounted for are divided in direct costs and consequential costs. In total 4 analyses have been evaluated to obtain insight on the EHV-1impact of an individual infected stable, the average expected losses per year per riding school present and the impact of an outbreak on the level of the national horse husbandry. The first performed analysis focusses on the financial impact for the situation that one horse gets the neurological form at a riding school. This situation is split into two variants. In the first variant, the horse that gets infected is euthanized whereas in the second variant the horse fully recovers and is able to join in the lessons after some time. In the analysis where it is assumed that one horse which is owned by the riding school gets the neurological variant and is euthanized after four days of illness the costs count up to around 23,000 euros. On the other hand there is the horse that gets the neurological variant and recovers and is able to participate in the lessons after eight weeks. Here the costs lie around 22,000 euros and therefore do not differ much from the euthanized horse case.
Secondly, given the expected costs of an infected riding school the expected average losses per riding school are estimated by accounting for the yearly observed incidence of EHV-1 on Dutch riding schools. A riding school is partly also a boarding stable. Around 60% of the horses present are owned by the riding school. So, not all horses that get EHV-1 are owned by the riding school and then not all the costs are for the owner of the riding school. When a horse gets infected that is not owned by the riding school, still the costs for the owner of the riding school were calculated to lie between 18,000 and 21,000 euros. This is mainly caused by the fact that the stable has to close down so no lessons can be given.
On average, 2 horses are affected during an outbreak, which corresponds to a total of costs of €25,949 per EHV-1 outbreak for a riding school owner.
Thirdly, based on these expected average losses per year the cost effectiveness of vaccine application at riding schools is evaluated. Here it is shown that vaccination of all horses owned by the riding school costs €2640 on a yearly base. Trading the vaccination costs with the calculated average yearly cost of an EHV1-outbreak, which was €3.10 per horse, this leads to the conclusion that the vaccination costs are 25 times larger and therefore, vaccination is not cost effective.

Last, an outbreak of EHV-1 in Belgium in 2009 is used to calculate ex post the costs in a real outbreak accounting for the spread between stables. In total 96 horses were housed the riding school where the virus was first discovered. Of this 96, twenty became ill, showing fever and eight of them showed neurological symptoms. In the end, six horses had to be euthanized because they showed severe ataxia and paralysis. It is calculated that the riding school lost €52,397. Next to that, seven other premises got infected and all their costs were added to the losses of the riding school. This lead to a total loss of nearly €85,000 for the outbreak in Belgium in 2009.

It can be concluded that there is a financial impact of some significance of an EHV-1 introduction at a riding school. For an average riding school these costs are in the order of €20.000. Also, there is a difference between the direct and the consequential costs. Consequential costs are partly independent of the size of the outbreak whereas the direct costs are calculated per horse and therefore differ for different numbers of horses infected.

In this study, the focus was only on riding schools. However, also the other commercial stables (mare breeding stables, boarding stable, rearing stable etc.) suffer when there is an outbreak of EHV-1. The combat of the disease should be related to the business itself, the sector and the government. The business itself should report when EHV-1 is on its stable. The sector should provide information to every stable in the Netherlands and the government may try to keep the overall view so that the virus can be kept under control faster.

Samenvatting

Equine Herpes Virus-1 (EHV-1) veroorzaakt één van de virale ziekten welke een bedreiging vormen voor de gezondheid van het paard. Een infectie met EHV kan tot verschillende symptomen leiden, variërend van milde griepachtige verschijnselen tot abortus en neurologische symptomen. De neurologische vorm kan ernstige problemen veroorzaken en uiteindelijk leiden tot de dood van het paard.

EHV-1 is in staat om zich over korte afstanden door de lucht te verspreiden en daarnaast ook via direct contact tussen paarden. Op dit moment zijn er geen vaccins die claimen te beschermen tegen de neurologische of abortus vorm, er is alleen bescherming mogelijk tegen de respiratoire vorm.

EHV-1 is endemisch in Nederland. Elk jaar vindt er wel een introductie van het virus op een bedrijf plaats, maar meestal is het aantal dieren dat daarbij geïnfecteerd raakt laag en daarom wordt de infectie gezien als een normaal bedrijfs- of ondernemersrisico. De verantwoordelijkheid voor het onder controle houden van het virus ligt daarom bij de sector zelf en niet bij de overheid.

In dit rapport is het doel om een economische risicobeoordeling uit te voeren voor EHV-1 in de Nederlandse commerciële paardensector. De commerciële paardenhouderij vertegenwoordigt slechts 10% van het totale aantal stallen in Nederland, maar huisvestigt echter meer dan 60% van de aanwezige paardenpopulatie.

De economische evaluatie is gedaan voor de manege omdat voor dit commerciële bedrijfstype de hoogste kans op een EHV-1 besmetting wordt verwacht. Voor de economische evaluatie is gebruik gemaakt van een deterministische en partiële budgetteringsbenadering. De berekende kosten zijn daarbij onderverdeeld in directe kosten en indirecte kosten. In totaal zijn 4 analyses uitgevoerd om inzicht te krijgen in de EHV-1 impact op het niveau van een afzonderlijk besmet bedrijf (individueel bedrijf), de gemiddeld kosten per jaar per manege (sector) en de kosten per uitbraak op nationaal niveau.
De eerste uitgevoerde analyse berekent the financiële impact voor de situatie dat één paard de neurologische variant krijgt op een manege. Deze situatie wordt onderverdeeld in twee varianten. In de eerste variant wordt het geïnfecteerde paard geëuthanaseerd, terwijl in de tweede variant het paard volledig hersteld en na enige tijd weer in de lessen wordt gebruikt. In de analyse waar aangenomen wordt dat één paard dat eigendom is van de manege de neurologische variant krijgt en wordt geëuthanaseerd na vier dagen tellen de kosten op tot ongeveer €23,000. Aan de ander kant is er het paard dat de neurologische vorm krijgt en volledig hersteld en meedoet in de lessen na acht weken. Hier tellen de kosten op tot €22,000 en zo is te zien dat er weinig verschil zit tussen de twee analyses.

Ten tweede, gegeven de verwachte kosten van een geïnfecteerde manege zijn de verwachte verliezen per manege geschat waarbij rekening is gehouden met de jaarlijkse incidentie van EHV-1 op Nederlandse maneges. Een manege is gedeeltelijk ook een pensionstal. Ongeveer 60% van de aanwezige paarden is eigendom van de manegehouder. Dus niet alle paarden die ziek worden zijn eigendom van de manegehouder en dus zijn altijd alle kosten voor de manegehouder. Wanneer een paard geïnfecteerd raakt dat geen eigendom is van de manegehouder, zijn de kosten voor de manegehouder nog steeds berekend te liggen tussen €18,000 en €21,000. Dit wordt grotendeels veroorzaakt door het feit dat de manege dicht gaat en geen lessen kunnen worden gegeven.

Gemiddeld vertonen 2 paarden tijdens een uitbraak neurologische symptomen, hetgeen resulteert in €25,949 aan EHV-1 uitbraak kosten voor een gemiddeld getroffen manege.

Ten derde, gebaseerd op de verwachte gemiddelde verliezen per jaar kan de kost effectiviteit van vaccineren op maneges worden geëvalueerd. Hier wordt laten zien dat het jaarlijks €2640 kost om alle paarden in eigendom van de manegehouder te vaccineren. Wanneer dit wordt vergeleken met de berekende gemiddelde jaarlijkse kosten, welke €3.10 per paard, leid dit tot de conclusie dat the vaccinatie kosten 25 keer groter zijn en dat vaccinatie daarom niet kost effectief is.
Als laatste is een uitbraak van EHV-1 in België in 2009 gebruikt om ex post de kosten van een echte uitbraak te berekenen en daarbij rekening te houden met de verspreiding tussen stallen. In totaal waren er 96 paarden gehuisvest in de manege waar het virus ontdekt werd. Van deze 96 zijn er 20 ziek geworden en acht hiervan lieten neurologische symptomen zien. Aan het einde werden zes paarden geëuthanaseerd omdat zij zeer ernstige ataxie en verlamming lieten zien. Het is berekend dat de manege €52,397 verloor. Daarnaast zijn zeven andere stallen besmet geraakt en hun kosten zijn opgeteld bij die van de manege. Dit leed tot een totaal verlies van bijna €85,000 voor de uitbraak in België in 2009.

Er kan worden geconcludeerd dat er een financiële impact van enige betekenis is bij introductie van EHV-1 op een manege. Voor een gemiddelde manege zijn deze kosten rond de €20.000. Daarnaast is er een verschil tussen de directe en indirecte kosten. De indirecte kosten zijn gedeeltelijk onafhankelijk van de grootte van de uitbraak, terwijl de directe kosten worden berekend per paard en dus verschillen voor verschillende aantallen geïnfecteerde paarden.

In deze studie ligt de focus alleen op de maneges. Echter, ook de andere commerciële stallen (merriehouderij, pensionstal, opfok enz.) hebben te lijden onder een uitbraak van EHV-1. De bestrijding van de ziekte moeten worden gerelateerd aan het bedrijf zelf, de sector en de overheid. Het bedrijf zou zelf moeten rapporteren wanneer er een geval van EHV-1 is op zijn stal. De sector moet informatie verstrekken aan elke stal in Nederland en de overheid kan proberen om het overzicht te houden, zodat het virus onder controle sneller kunnen worden gehouden.

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1. Introduction

Rhinopneumonitis (caused by Equine Herpes Virus-EHV) is one of the viral diseases which pose a threat to horse health. An infection with EHV can cause different symptoms varying from the mild flu-like symptoms, to the more severe abortions and neurological symptoms (ataxia or paralysis). The infection starts in the respiratory system. Most horses recover completely from the respiratory infection. However, the neurological form can cause severe problems and even lead to the death of the horse. Once a horse gets infected with EHV, there is a possibility the animal remains a carrier of the virus for the rest of its life (Coster, 2012).

Rhinopneumonitis is endemic in Europe, so also in the Netherlands. Every year the virus occurs somewhere, but most of the time the amount of horses infected stays low and the infection is therefore seen as normal business- and/or entrepreneurial risk. As a business-related disease, the control of Rhinopneumonitis is considered not to be the responsibility of the government but of the horse sector itself. The sector - represented by the Sectorraad Paarden - is acting upon this responsibility by keeping horse owners aware of the disease by informing them about its occurrence and - in case of an outbreak - by strongly advising to prevent unnecessary contacts between horses and to vaccinate susceptible horses.

Most of the time the disease has a mild course; horses present flu-like symptoms and recover quite fast. However, during an EHV outbreak in the beginning of 2012, there was a major concern because there were several horses that presented the abortion and/or the neurological form of the virus. During this outbreak, questions were asked in the Dutch House of Representatives if it should become compulsory to report when the neurological variant of EHV is suspected on a stable. Until today this question was rejected and it is still not obligatory to report a suspicion of the neurological form of EHV.

Rhinopneumonitis has an impact on the individual affected stable as well as the horse-sector as a whole. A normal flu-like outbreak does not have a high risk factor in the Netherlands, but an outbreak containing the abortion and neurological form may pose a serious economic risk to the Dutch horse-business. Quantitative insight in the expected economic risk per individual stable is, however, lacking.

The main objective of this study is to perform an economic risk assessment on rhinopneumonitis within the Dutch commercial horse sector. To reach this objective, the following research questions will be answered:

a) What variations are there within the disease?
   - What is the frequency of occurrence of the different variations?
   - What are the losses related to the disease variations?
b) Which vaccines are on the market?
   - What is the effectiveness of those vaccines?
   - What are the costs of the vaccines?
c) What do horse owners do to prevent infection with the disease?
d) What is recommended when EHV occurs and what is done in practice by the horse keeping sector?
e) Should the combat of the disease be related to the business itself, the sector or the government?
   - Is there a difference in risk for the different types of horse keeping businesses?
   - Is this a risk that should be shared with others?

2. Literature study on EHV and the Dutch horse-sector

2.1 Equine herpes virus (EHV)

2.1.1 Equine Herpes virus subtypes

Equine herpes virus is a group of viruses of the family Herpesviridae that affects horses. There are five equine herpes subtypes known, of which Equine Herpes Virus-1 (EHV-1) and EHV-4 are the two most common and most severe forms. Both viruses are ubiquitous in horse populations worldwide and produce an acute febrile respiratory disease upon primary infection. Besides an inflammation of the airways, EHV-1 could affect the reproductive and neurological systems resulting in abortion and neurological disorders, whereas EHV-4 causes primarily respiratory problems.

EHV is spread through aerosolised droplets, infecting horses through inhalation or ingestion, after which it multiplies in the respiratory tract. While EHV-4 stays in the nose, an EHV-1 infection is followed by a cell-bound viremia, via which the virus can reach the organs (Delesalle and v/d Boom, 2012). The viremia can persist for at least 14 days, and is a prerequisite for the neurological and abortion form because it allows transport of the virus to the vasculature of the pregnant uterus or the central nervous system (CNS) where it can infect the endothelial cells (Lunn et al, 2009). When, following that, the virus multiplies in the uterus of the pregnant mare this can lead to an abortion. When the multiplication occurs on the endothelial cells of the CNS, this can lead to serious neurological problems (myeloencephalopathy).

The EHV-1 abortion form is more common than the EHV-1 neurological form which is quite rare (Delesalle and v/d Boom, 2012). During an outbreak of the neurological form, typically about 10% of the infected horses develop neurological symptoms. The abortion form can have attack rates in excess of 50% (Lunn et al, 2009).

Infection can stay silent (subclinical infection) but in some cases the infection can have specific symptoms like fever, lethargy, anorexia, nasal discharge, oedema of the limbs and coughing (Delesalle and v/d Boom, 2012). Once a horse gets infected with EHV, there is a possibility that the animal remains a carrier of the virus for the rest of its life. The virus can be released again by these carriers due to stress or a lower resistance of the horse (Coster, 2012). The virus becomes latent in around 80% of the infected horses (Welch et al, 1992).

2.1.2 Prevention

2.1.2.1 Prevention from introduction on a stable

Prevention is based on isolation procedures and implementation of a regular vaccination program. The virus mainly spreads through direct contacts between horses, so prevention of contacts between horses is the most important measure to prevent the introduction of the virus. Therefore, horses that are new on a stable or horses that have been on transport to another location should stay apart from the other horses (especially pregnant mares) for about 3-4 weeks before they can interact with them. Pregnant mares should be kept apart from newly weaned foals and one-year old horses because these young horses most often carry the virus and might transmit the virus to the pregnant mares that might abort the unborn foal (Delesalle and v/d Boom, 2012).

The vaccines that are currently on the market prevent against the respiratory form, so the flu-like symptoms. There is no vaccine that claims to prevent against the abortion or neurological form. Vaccines are mainly used to limit the excretion of the virus. Therefore it is important to apply the vaccination businesswise, so to vaccinate all horses on a stable. When not all horses are vaccinated on a stable, the virus is still able to spread via the unvaccinated group. Horses need to be vaccinated every six months, because of the decrease in protection the vaccines gives. Pregnant mares should be vaccinated in months

5, 7 and 9 of the pregnancy to decrease the risk of abortion (Slater et al, 2006). Bryans and Allen (1982) reported that in 3 years of vaccination use, 140 out of 20,223 non-vaccinated mares that got infected aborted (0.69%) compared to 14 out of 6806 (0.18%) vaccinated mares that got infected with EHV.

Although there is no vaccine that claims to protect against the neurological form, it is still advised to vaccinate the horses because it lowers the severity of respiratory symptoms, lowers the spread of the virus in the respiratory tract and it lowers the pressure of infection (SRP, 2009).

In The Netherlands, currently the following inactivated EHV-1 & 4 vaccines are available: Equip (EHV-1, 4, Pfizer Animal Health); Pneumequine (only EHV-1, Merial); Resequin Plus (infl, reo, EHV-1, 4, Virbac); Equilis Resequin (infl, EHV-1, 4, Intervet) (Delesalle and v/d Boom, 2012). Published scientific evidence on the efficacy and the safety of the available vaccination strategies for horses is limited. There is research done, but the results are not or only partly published, which makes it difficult to make conclusions about the efficacy of the different vaccines (Kydd et al, 2006).

2.1.2.2 Prevention from spread within a stable

When a neurological EHV-1 case is suspected on a stable, immediate isolation is strongly advised (Goehring et al, 2010). Goehring et al (2010) gives the following precautions in preventing the spread of the neurological form within a stable:

1. Neurological suspected cases should be kept under strict barrier precautions with as few people as possible. Contacts with the infected horse should be minimized as much as possible.
2. Neurological cases should be housed in a separate building.
3. Exclusive care providers should be assigned to the neurological cases.
4. Once there is a (suspected) neurological case, recording of the rectal temperature of all horses at a stable twice daily is advised. In this way, any additional cases of fever can be thoroughly investigated.

When there is an abortion, any contact of other horses with the dead foal, the placenta, the amniotic fluid and the aborted mare must be prevented. Furthermore, the foal should be send to the GD Animal Health Service for autopsy. When EHV is confirmed, the same precautions with respect to the aborted mare are advised to be taken as in case of a neurological form. Next to that, thorough disinfection of the place of abortion should take place so the virus cannot spread to other horses. Due to the fact that the sending of the dead foal and the autopsy take some time, the disinfection of the stable should start as soon as the dead foal is removed from the place.

So, in case of an outbreak of the abortion or neurological form, the two most important measures that have to be taken are the isolation of the infected horse and the disinfection of the stable.

2.1.2.3 Prevention from spread between stables

To prevent spread of the virus between stables, horses are advised not to leave the location until 28 days after recovery of the last clinical case (Delesalle and v/d Boom, 2012). The virus can only spread over very short distances through the air, so it is not possible to infect other stables as long as they are not directly located next to the infected stable.

2.1.3 Treatment

There is no specific treatment to cure EHV infection. Rest and nursing care are indicated to minimize secondary bacterial complications.

2.1.3.1 Respiratory form

The respiratory disease due to EHV-1 infection is often mild and no specific treatment is required. Anti-pyretic medication can be prescribed when fever is 40°C or above. Antibiotics should be given when secondary bacterial infection is suspected (Lunn et al, 2009). It is not likely that a respiratory form develops into neurological form. When this happens the symptoms will be noticeable in the first few days of the infection. When, for instance, the horse has the respiratory form for 5 days without showing any neurological symptoms, it will not develop the neurological form.

2.1.3.2 Neurological form

Regarding the treatment of the neurological form, the focus mainly lies in supporting the animal. The horse should be kept in a safe, well-bedded area, especially when they have severe incoordination and have difficulty rising (Lunn et al, 2009). Attention must be paid to the emptying of the bladder of the infected horses. Some infected horses develop a spastic bladder sphincter with an impaired bladder emptying as a result. Some of these horses eventually show colic. It is advised to carry out a bladder catheterization three times daily for at least three days. Rectal paralysis does not occur that often, but when it occurs, regular manual emptying of the rectum and purging are prescribed. Paretic horses can be supported by an abdominal girth (Delesalle and v/d Boom, 2012).

When a horse is able to stand for itself, complete recovery is very likely. Recovery takes several months but the horse recovers completely. For horses that lie down for more than 24 hours and cannot stand up by themselves the prognosis is very poor and it is advised to euthanize these horses (Delesalle and v/d Boom, 2012).

When looking at the medical treatment, it is symptomatic. Supporting therapy with intravenous fluid, anti-inflammatory medication such as corticosteroids and antibiotics (in case of a secondary bacterial infection) can provide relief. Antiviral medications such as acyclovir and valacyclovir may potentially be beneficial in case of an active viremia (shown by fever).

2.1.3.3 Abortion form

The abortion form causes the death of the unborn foal, or a seriously ill foal that is born but will die soon after birth. The mare does not suffer of any symptoms. There is no treatment for the foal and it is unnecessary for the mare (SRP, 2009).

2.1.4 Economic consequences

Given the severe horse health impact of EHV-1 infections, main focus of this study is on the economic assessment of consequences related to EHV-1, which appears worldwide in countries with a horse business of some significance. The economic impact related to EHV-1 infections can be divided into two subclasses: direct costs and consequential costs.

Direct costs

Direct costs are costs that originate from measures aimed at controlling the infection and eradicating the virus. Direct costs related to EHV-1 are:

- Veterinary costs; these are costs that are made to treat the ill horse. To treat the horse, antibiotics, anti-inflammatory and anti-viral agents are used. Next to that, when a horse has severe neurological symptoms and is unable to stand by itself an abdominal carrier band can be used to keep the horse on its feet. Also, when EHV-1 is suspected, a nasal swab is send to the ‘Gezondheidsdienst voor Dieren’.
- Costs of disinfection materials; to prevent further spreading of the virus, the stables have to be disinfected. Halamid is prescribed by veterinarians to disinfect the stable (Delesalle and v/d Boom, 2012). Secondly, a disinfection mat can be used so that people move in the stable can disinfect their shoes before entering. Thirdly, people working with the infected horses could use a disposable overall so that after treating the ill horse they can

throw it away and are able to work with other horses without having to change all their clothes.

- Euthanasia and collection of the dead horse; in some severe neurological cases, the horse might need to be euthanized. When the horse is dead, it has to be collected by Rendac, a company that collects, processes and destructs animal carcasses and waste material. When the horse is euthanized, the value of that horse is lost as well.
- Labour costs; when a horse gets infected, the labour requirement goes up because the horse has to be treated and cared for in an intensive way.
- Feed intake costs; when a horse gets infected it will eat less than the normal ration; saving some costs.

Consequential costs
Consequential costs are costs related to measures which are aimed to prevent further spread to yet unaffected horses and indirect consequences of having a diseased animal at the stable. EHV-1 consequential costs are related to:

- Preventive care of other horses; when other horses are present at the stable, their temperatures has to be taken every day to see if they present fever which might indicate infection with EHV-1.
- Closure of the stable; when EHV-1 is suspected at a stable it has to shut down to prevent any further spreading of the virus in the surrounding area. This means that no one is allowed to enter or leave the stable with a horse. Also, no lessons can be given or events organized. When a horse is euthanized, there is no possibility to immediately buy a new horse, because no new horses are allowed on the stable, so there remains an empty stable until at least four weeks after the last recovery of the infected horses.
- Reputational damage; this differs for the different types of horse-keeping businesses. A riding school might have less damage on this part. There might be some customers that leave to ride somewhere else but others will come in their place. On the other hand, there are the mare breeding stables which might have more losses on this part because when EHV-1 is present at such a stable, people will buy their horses at another stable and the owner might lose a lot of potential customers.
- Recovery time affected horse; when an affected horse recovers, it will not be able to perform his daily activities immediately after his recovery. It will take some time to get at full strength again, longer than the four weeks of closure, reducing the lesson-revenues in the period thereafter.

2.1.5 Cases from the past

The neurological form caused by EHV-1 is reported with increasing frequency. Consequently, in the horse-keeping business concern is raised about the fact that the prevalence as well as the morbidity and mortality are rising (Gryspeerdt et al, 2011).

In the last year (2013) there were three cases in the Netherlands that were reported in the media (KNHS.nl). The last case in the Netherlands was in November 2013. On the 18th of November Rhinopneumonitis was confirmed in Lienden. Here, one horse got infected with the neurological form. Three days later, on the 21st of November, EHV-1 was confirmed in Uden. Two horses got infected with the neurological form and one of them had to be euthanized. Earlier that year, on the 9th of August, EHV-1 was confirmed in two horses in Nieuwkoop. They showed neurological symptoms and both had to be euthanized. Moreover, on the 22nd of March, EHV-1 was confirmed on a stable in Aerdenhout. It is not confirmed that these locations were all riding schools. However, it is expected that these were riding schools because other types of horse-keeping businesses normally do not report EHV-1 cases.

During these three cases the Sectorraad Paarden advised for the subsequent period of four weeks upon detection the following measures with respect to the organisation of riding events in the direct surrounding area of the affected stable:

- Do not allow horses from the affected location.
- Horses from the direct surrounding area of the affected stable have to do a clinical examination by a vet and a nose swab has to be taken and the outcome should be negative. When the horse is found healthy and the nose swab comes out negative, the horse is allowed to enter the event.
- When an event takes one day, do not place the horses in a stable.
- Clinical examination on arrival by a vet.
- Avoid direct contact between horses.
- No shared food and drinking water supply, usage of own buckets and feeders.

The three cases that appeared in the Netherlands are not well documented in literature. For this reason, two well documented cases in close proximity of the Netherlands are discussed in the following section to illustrate the development of the infection between farms.

2.1.5.1 Belgium, 2009

During the outbreak of 2009, at least 13 different stables were hit by the neurological case. In the article of Gryspeerdt et al (2011) seven of these stables were studied in more detail. A morbidity of 26% was seen, with an incidence of the neurological form of 43% in the affected horses. This outbreak was characterized by a fast occurrence of the ataxia and paralysis immediately after the fever had faded.

The progress of the outbreak was as follows (see fig. 1) (Gryspeerdt et al, 2011):

Primary outbreak

In May and June of 2009 an outbreak of EHV-1 occurred in a riding school with 96 horses. At this stable lessons and contests took place frequently and horses where regularly transported to contests outside the premise. Shortly after the onset of fever in two mares on the 14th and 26th of May (age 5 and 20), a large contest was organized at this riding school, with horses coming from different stables. This contest was held because there was no suspicion of EHV1-induced neurological disease yet. After this, neurological symptoms developed in six other horses of which the most severely cases had to be euthanized. On the 8th of June EHV-1 was suspected and the riding school was completely shut down at that time.

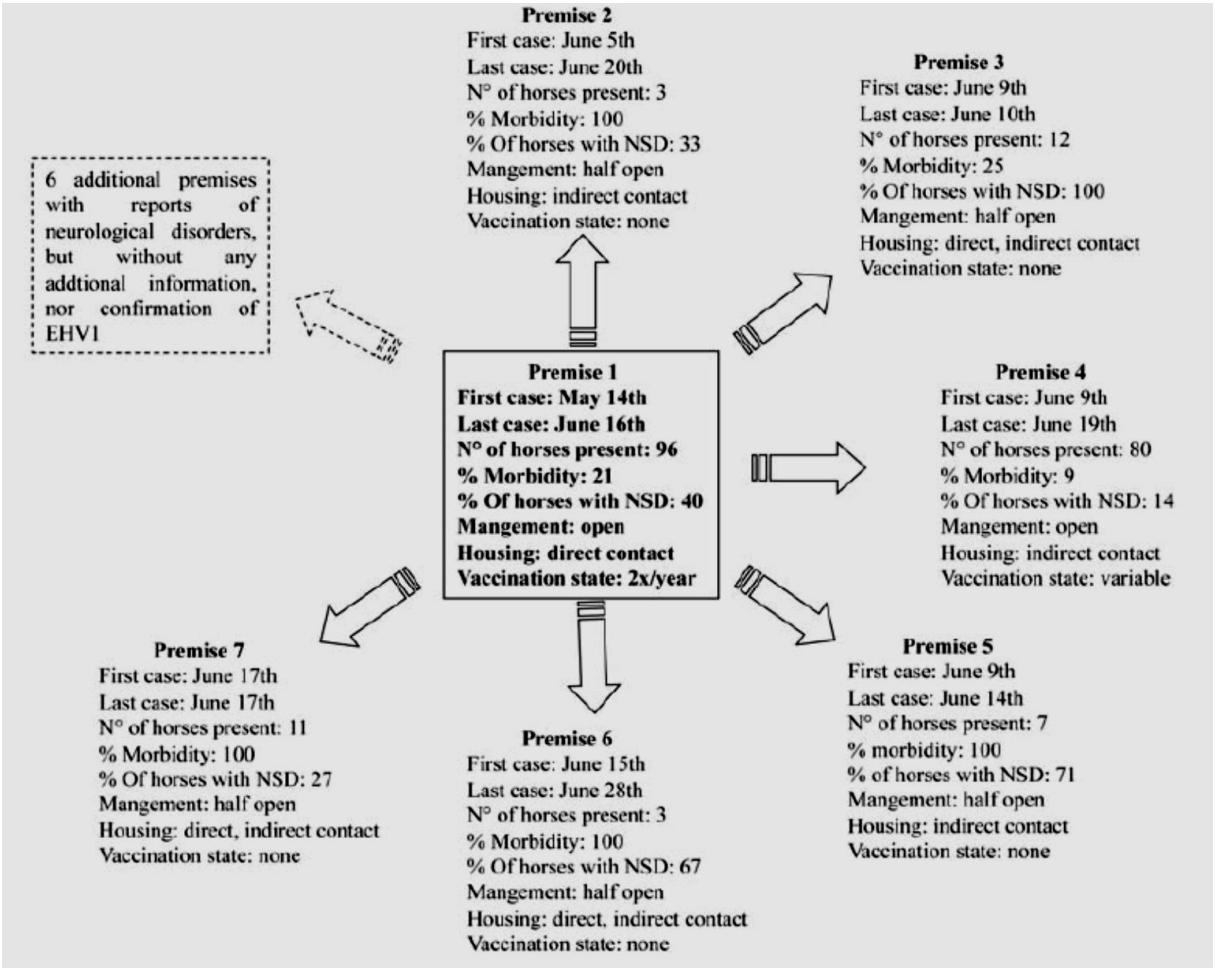

Figure 1: Schematic overview of the course of the outbreak of EHV-1-induced neurological disorders on the different premises. NSD: nervous system disorders; open management: public riding school with incoming and outgoing horses; half-open management: private premise, but where horses attend competitions at other premises; closed management: private premise, no contact with other horses or premises; housing with direct contact: stables separated from each other by bars; housing with indirect contact: stables separated from each other by full walls (Source: Gryspeerdt et al, 2011).

Secondary outbreaks

From June 5 until June 28, several stables reported neurological disease after attending the jumping contest at the riding school. After the outbreak at the riding school (=stable 1), 34 horses on other stables got feverish of which 15 developed neurological signs (Table 1).

Table 1: Description of the animals on the premises with EHV1 associated neurological disorders (Gryspeerdt et al, 2009).

Premise Nr.	Total Nr. of horses present			Total nr. of affected horses			Nr. of affected horses with neurological disorders		
	Male	Female	Total	Male	Female	Total (%)	Male	Female	Total (%)
1	53	43	96	8	12	20 (21%)	2	6	8 (40%)
2	1	2	3	1	2	3 (100%)	0	1	1 (33%)
3	2	10	12	0	3	3 (25%)	0	3	3 (100%)
4	42	38	80	2	5	7 (9%)	0	1	1 (14%)
5	3	4	7	3	4	7 (100%)	1	4	5 (71%)
6	2	1	3	2	1	3 (100%)	1	1	2 (67%)
7	5	6	11	5	6	11 (100%)	1	2	3 (27%)
	108	104	212	21	33	54 (26%)	5	18	23 (43%)

2.1.5.2 Belgium, 2003

During an outbreak of the EHV-1- induced neurological disorders in horses in 2003 in Belgium on at least 10 stables fever was reported. On seven of these stables, neurological symptoms were seen. Of all horses at those stables, 42% showed fever and were anorexic. Neurologic disorders were seen in 15% of all horses. The neurological symptoms that were seen were mainly ataxia and paralysis of the hind legs and tail (76% of the affected horses). Cerebral disorders such as blindness, torticollis and apathy were observed in 24% of the neurological affected horses. The mortality during this outbreak was 10% (van der Meulen et al, 2003).

The outbreak of 2003 proceeded as follows (van der Meulen et al, 2003):

Primary outbreak on a riding school

On February 6, a horse, housed at a riding school consisting of 41 horses, became pyretic and began coughing. Two days later a second horse that had been in direct contact with the first, became anorexic. By February 9, both horses seemed clinically normal and the second horse attended the jumping event that was held at the riding school. On February 10, a third horse became febrile and showed ataxia of the hind legs and tail. No EHV-1 infection was suspected, so the riding school remained open for horses from other stables. However, on February 13, the second horse became ataxic and 8 others showed fever. The third horse got severely ill and was euthanized on February 14. Later that month, five other horses had to be euthanized due to severe illness or poor clinical condition.

Secondary outbreaks

Horses from other stables visited the riding school frequently during lessons or competitions. Nine of the stables (1-9 in Table 2) that had been in contact with the riding school reported fever. Next to that, a stable that had been in contact with stable 3 (10 in Table 2) also reported fever. See table 2 for an overview of clinical symptoms shown on the different stables. Next to the neurological disorders, on three of the in-contact stables, in total five abortions were reported within one month after the febrile period. Whether these abortions could be related to the EHV-1-induced outbreak is not clear.

Table 2: Number of horses affected by EHV-1 infection at the riding school and on the in-contact stables 1-10 (van der Meulen, 2003).

Stables	**Total no. of horses**	**No. of horses with**					**No. of euthanized horses**
		Fever	Neurological disorders			Abortion/neonatal death	
			Ataxia of hind legs	Paralysis	Cerebral disorders		
Riding school	41	11	4	4	2	0	6
1	7	1	1	0	0	0	0
2	4	1	0	0	0	0	0
3	20	20	1	0	0	2	0
4	6	1	0	1	0	0	1
5	16	4	0	1	1	1	1
6	7	4	0	0	0	2	0
7	4	2	1	0	0	0	0
8	4	1	0	0	0	0	0
9	1	1	0	1	0	0	1
10	1	1	0	1	0	0	1
All (%)	111	47 (42%)	7 (6.4%)	8 (7%)	3 (2.7%)	5 (4.5%)	10 (9%)

When looking at these two cases, people are tempted to say that the virus mainly occurs at riding schools. The reason for this might be that at a riding school there are a lot of contacts between horses. Horses come from other places to take lessons or join in a contest. Another reason for the fact that it looks like most of the time the virus starts at a riding school might be that they are the only type of business that reports cases of EHV. Other types of horse-keeping business might also have the virus but they simply do not report that because they are afraid of reputational damage.

2.2 Structure horse-keeping business sector in The Netherlands

To be able to calculate the costs of an outbreak of Rhinopneumonitis the structure of the Dutch commercial horse-business should be explored and described. In the following section this structure is explained.

2.2.1 The Dutch horse-keeping business

In the Dutch horse-business the main purposes of the horse-keepers are breeding, trading, sports and recreation. This is different from the other agricultural sectors, where the most important function is food production. The horse-keeping business is mainly seen as a hobby (90%) and only a small portion is seen as commercial (10%) (Agricola et al, 2008). There are a lot of different types of stables in the commercial sector (studs, boarding stables, trading stables, mare breeding stables, rearing stables, riding schools etc.). Mare breeding stables, rearing stables, riding schools and boarding stables represent the largest part of the commercial horse-keeping sector. Agricola (2008) mentions that there are around 81,000 stables in the Netherlands, of which 10% is commercial. As can be seen in Table 3 the four stable types that are looked at in this study count up to 6283 of the 8100 commercial stables (78%) in the Netherlands. In addition, these stables differ in their economic activities and will therefore be affected with varying degrees at times of an EHV outbreak.

Clear quantitative information about the horse-keeping sector is missing. Using the expected population size of 450,000 animals (horses and ponies), and information from different sources (Agricola et al, 2008; Rijksen and Visser, 2005; Schuring, 2005; Mourits and Saatkamp, 2010; KNHS, 2012; Neijenhuis et al, 2012) the structure of the commercial horse-business is estimated (Table 3).

Important assumptions that have been made to make this overview are:

- There are about 81,000 stables, of which 10% is commercial (Agricola, 2008).
- 38,000 foals are reared every year (Rijksen and Visser, 2005). Suppose that 30% of the yearly 38,000 foals born are born on a mare breeding stable. This will be around 11,400 foals. Assuming and average of 6 foals per business, this brings the number of mare breeding stables to about 2,000. Using the information of the survey held by Schuring (2005) (appendix 1), the number of equines held at mare breeding stables is set to 31.
- In the rearing stables the number of horses is the same as the number of foals born each year, times the number of years they stay in the rearing stable which is around 3. Therefore, the number of horses in rearing stables will come to: 38,000*3 years= 114,000. Next to the stud and mare breeding stables which rear in total around 64,000 animals a year (Schuring, 2005), and the presumption that 30% of the hobby bred foals are also reared there (28,000 foals * 3 years * 30% = 25,200), leads to the fact that the remaining 24,800 foals need to be housed in rearing stables. Assuming an average amount of 49 animals per stable (Schuring, 2005) there need to be a minimal amount of 506 rearing stables. In this study, the amount is rounded to 520 stables.
- 1/3 of the private owned horses are housed in a pension (riding school or boarding stable) (Agricola, 2008). The number of private horses kept on riding schools and boarding stables is equal to 87,200 (37,200 on riding schools and 50,000 at boarding stables, appendix I).

- Using the internet (www.telefoongids.nl) the amount of riding schools registered came to 1263. Looking at the information on riding schools given by Rijksen and Visser (2005), the number of horses on riding schools in 2013 is around 69,465 (own estimation). Using this information, the total number of equines at the riding school will be 69,465/1263 = 55.
- Agricola et al (2008) mentioned 2465 boarding stables in the Netherlands. Assuming that this amount did not change much over the past 5 years the amount used in this study is 2500. Then, the number of equines at the boarding stable will be 50,000/2500 = 20.

Table 3: The composition of the Dutch commercial horse-keeping sector

Type of stable	Number of stables	Total number of equines at the stable[1]	Total number of equines per stable-type
Riding school	1263	55	69,465
Boarding stable	2500	20	50,000
Mare breeding	2000	31	62,000
Rearing stable	520	49	25,480
Others	1817	35	63,595
Total in The Netherlands	**8100**		**270,540**

1) The definition of equines is here seen as horses and ponies together.

There are 68,920 registered competition riders in the Netherlands, which resulted in 744,884 starts in 2012 (KNHS, 2012). This means that on average, each rider started in 10.8 competitions. In total there are 209,267 members of the KNHS. The number of recreational riders at riding schools and boarding stables is estimated at 340,000 people (Schuring, 2005). Next to that there are also people who enjoy watching the equestrian sports on television or visit events. This number is estimated to be around 425,000 people (Schuring, 2005).

2.2.2 Group- vs. Individual housing at commercial stables

In The Netherlands there are several housing systems. There is the traditional individual housing and there are different group housing systems (traditional, Hit active, Paddock-paradise). Per type of housing the amount of contact between horses differs, and so the infection pressure of Rhinopneumonitis might differ as well. In the following paragraphs, the different housing systems and the amount of social contacts in the different housing systems will be discussed as it was done in Neijenhuis et al, 2012.

2.2.2.1 Traditional individual housing

Figure 2: Example of individual housing

Individual stables in the traditional housing are placed in rows of which the partition is most often completely closed so no contact is possible between the horses. The front of the stable can be completely closed with bars or there is a half open door through which the horse can put his head. The stables of which the front has a half open door could allow social contact between horses in opposite rows, however most of the time the distance between those two opposing rows is more than 2.5m which prevents any direct contact between the horses. So, in individual housing it is not possible for the horses to have social contact with other horses. This might be beneficial when there is an outbreak of Rhinopneumonitis on the stable because than it is advised to separate horses

and avoid any contact. However, when horses are not able to have any social contacts the welfare of these horses goes down which is not accepted by the Sectorraad Paarden which states that a horse should have the ability to have daily social contact with at least one other horse (Neijenhuis et al, 2012).

2.2.2.2 Traditional group housing

Traditional group housing is mostly seen in rearing establishments where young horses are reared in groups of horses of the same age. However, also adult horses are sometimes kept in groups. Group housing is better related to the social needs of the horse. A lot more social interaction is possible than when a horse is kept in an individual stable.

Figure 3: Example of traditional group housing

When a virus like Rhinopneumonitis occurs at such a stable, the possibility that more than one horse gets infected is a lot bigger because of the high ability of contact between the horses. So, in group housing systems the pressure of infection lies a lot higher than in individual housing systems. It is also important in group housing that the horses are kept in stable groups. When this is not the case, the horses are constantly trying to find out the hierarchy in the group which might lead to severe wounds which can lead to infections and a lower welfare in the horses (Neijenhuis et al, 2012).

2.2.2.3 HIT active stable

The starting point of a HIT active stable is that horses are kept in a group, have the possibility to move around a lot in the open air, have interaction and have the possibility to eat a lot of small portions of food per day. Horses are mainly kept outdoors, but have the possibility to go indoors as well. There is a stable to introduce new horses so the possibility of fights goes down. Also, there are individual stables away from the group housing, so when a virus occurs in the group, quarantine measures can be taken easily so that the pressure of infection goes down. The difference with the traditional group housing is that the horses are mainly kept outdoors, and the amount of space per horse is much more (100m^2 in HIT active stable) (Neijenhuis et al, 2012).

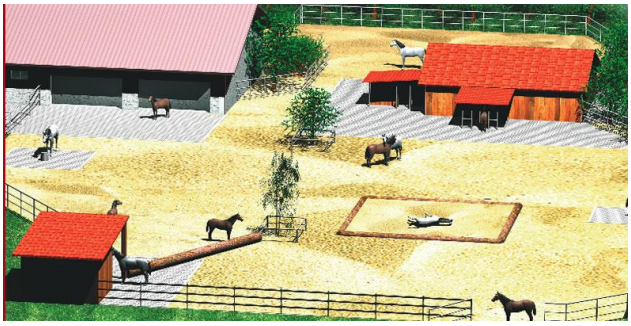

Figure 4: Example HIT active stable

2.2.2.4 Paddock Paradise

The starting point of a paddock paradise is that horses are kept in a group and have to get their food and water through a natural way and thereby have social interaction. The idea is that horses in the wild often follow the same way towards foraging places and thereby follow each other. A lot of space is provided (approx. 5 ha). Around the buildings a path is made along which the horses can find their food and water. In this way the horses are stimulated to walk a lot which is good for the circulation and so for the welfare of the horse. A lot of contact between the horses is possible which might be a problem when a virus occurs, because in contrast to the HIT active stable, here there are no individual stables so the horse that gets infected is not easily separated from the group and therefor the pressure of infection is rather high. It is possible to separate a horse by placing it in a separate meadow but then it is still possible to have contact with other horses (Neijenhuis et al, 2012).

Figure 5: Example paddock paradise

To conclude, there is a difference in pressure of infection in the different housing systems. Most of the time, this pressure is higher in group housing. However, when next to the group housing, individual stables are present to provide quarantine when necessary, the pressure of infection can be the same as in individually kept horses. In this study, the focus will be on the traditional individual housing and the traditional group housing. The reason for this is that these are the two most common types of housing in The Netherlands.

3. Materials and methods

3.1 Structure of the economic evaluation

In this study, the financial risk of an outbreak of Rhinopneumonitis is evaluated. As EHV-1 is the subtype that causes the neurological and abortion variant, resulting in the most severe economic consequences, the assessment of the economic consequences will be based on the expected impact of an EHV-1 outbreak.

The evaluation is made for the commercial part of the horse-keeping sector (section 2.2.1) in The Netherlands with the highest expected likelihood of EHV-1 occurrence, viz. the riding schools. Moreover most information on EHV-1 outbreaks is known from that type of horse-keeping business. In the Netherlands, riding schools consists on average of 55 horses (see table 3) of which 60% (33 horses) are owned by the owner of the riding school and 40% (22 horses) are privately owned by others. On average 1263 riding schools are registered in the Netherlands.

The assessment of the financial impact of an introduction of EHV-1 on riding schools is done by the use of a deterministic, partial budgeting approach. The assessment consists of a number of predefined analyses to obtain insight on 1) the impact of an individual infected stable, 2) the average expected losses per year per riding school present and 3) the impact of an outbreak on the level of national horse husbandry.

As far as possible, the assessments are made by the use of real data. However, some required information about the consequences and/or costs is seriously lacking and in those cases estimations were used, based on expert knowledge and literature insights.

3.2 Input settings cost categories

The costs related to the impact of an EHV-1 outbreak on a riding school are divided in direct cost and consequential costs. Following the outline of the cost categories as presented in section 2.1.4 the input settings of the defined cost categories are determined as follows:

Direct costs:

Direct costs are costs that are directly related to the treatment of an EHV-1 diseased animal.

- Veterinarian costs: the call out charges of a veterinarian is set at €25. Veterinarians may come round twice a week during the time the disease is present, resulting in €50 per week. (As veterinarians do not place their prices on the internet a forum was used to calculate the call out charges: www.bokt.nl).
- Costs of treatment with antibiotics, anti-inflammatory agents and anti-viral agents: €200 per week (own estimation based on experience with horse antibiotics treatment).
- Cost of carrier band when horse cannot stand up by itself: €3166 (http://www.andersonsling.com).
- Costs of euthanasia: €250 (www.bokt.nl). On average cost of removal of the carcass by Rendac: €45 (www.rendac.nl).
- Nasal swab send to GD: €35 (www.gddeventer.nl).
- Disinfection material stable (Halamid): €100 (Delesalle and v/d Boom, 2012; www.bol.com).
- Disinfection mat: €195 (www.flexxolutions.nl).
- Disposable overalls: €50 (http://disposables.thaly.nl).
- Reduction in feed costs due to illness: €40.83 per week per animal (own estimation based on ZLTO, 2012 and www.pavo.nl). Normally a horse eats about 11kg/day (www.pavo.nl), of which the costs are €385 per month (ZLTO, 2012). This means that the costs are €12.83 per day when the horse is healthy. It is expected that an ill horse eats about half the amount of a healthy horse (55%). Feed costs of an ill animal will be on average €7 a day (€12.83 per day * 55%= €7). This leads to a difference of €-5.83 a day,

or €40.83 per week. However, when a horse is euthanized, during the following five weeks in which the stable is empty, there are less feeding costs due to the fact that there is one horse less that needs to be fed. This leads to €449 cost reduction (€12.83 * 35 days = €449).
- Own labour: additional case resulting in labour costs of €342.85 per week when a minimum wage is assumed (www.rijksoverheid.nl).
- When a horse has to be euthanized, there is a loss of the value of the horse. The value of an average horse is set to €1050 (www.veemarkt.nu).

Consequential costs:
The consequential costs at a riding school mostly consist of the fact that the stable closes and no lessons are given. Moreover, when a riding school has to close down, it is not possible to organize events during that period. Next to that, it is assumed that a riding school loses around five customers when it has to close down. Once re-opened, these available customer places will be filled again after a month.
Next to the treatment of the infected horse, also preventive care is given to the other horses present. Preventive care consists mainly of the temperature monitoring of the non-infected animals. This preventive care is given until the last infected horse recovers or two weeks after the infected horse is euthanized due to the incubation period of the virus.

Below, the settings of the underlying cost components are described in detail:
- No lessons: €3344 per week. There are 38 hours of lessons at a riding school, each using on average 8 horses. The price of one lesson is €11 (Appendix I; ZLTO, 2012; Schuring, 2005). (38 hours/week*8 horses*€11/hour=€3344).
- Losing customers: €55/week (when on average 5 customers go away when there is an outbreak, €11/lesson*5 customers=55). After re-opening these places will be filled again after a month.
- Preventive care other horses, which consist of checking the temperature of all horses each day: €86 per week (own indication (by assuming 10 hours of labour per week given labour costs of €342.85 per week). This is done until the last infected horse recovers. In the case of euthanasia, it is assumed that preventive care takes place until two weeks after the euthanasia of the horse.
- In case the diseased horse is owned by the riding school and recovers, it is assumed that the animal is not able to resume riding lessons for an additional 2 weeks after re-opening of the stable resulting in €264 revenues foregone (12 lessons/week *€11/lesson*2 weeks=€264)
- In case the diseased horse is a boarding horse (so a horse that is not owned by the riding school) and dies or gets euthanized this horse stable place stays empty until four weeks after re-opening. Boarding revenues forgone equal €57.50 per week (see appendix I, price of pension for one horse per month is on average €230 which is €57.50 per week).
- During the presence of the disease it is not possible to organize events which will result in €150 less per month = €37.50 per week (own estimation based on own knowledge and costs made by own riding club (rvcentaur)).

3.3 Performed analyses
The performed assessment-analyses are structured as follows:
- Ex ante evaluation on riding school level; what if one case of the neurological form is present?
- Ex ante evaluation on sector level; given the current incidence, what are the average costs for a riding school?
- Ex ante evaluation on sector level; what is the cost effectiveness analysis of vaccination?
- Ex post evaluation at national horse husbandry level; what was the impact of a case in Belgium on the level of horse husbandry?

The first analysis focusses on the financial impact for the situation that one horse gets ill at a riding school. This situation is split into two variants. In the first variant, the horse that gets infected is euthanized whereas in the second variant the horse fully recovers and is able to join in the lessons after some time. Beside the course of the disease a subsequent distinction is made regarding the ownership of the diseased horse. When this horse is owned by the riding school, the owner of the riding school will be responsible for the complete costs. However, when the diseased horse is one of the boarded horses than the direct costs are no longer the responsibility of the riding school owner.

Given the expected costs of an infected riding school the expected average losses per riding school are estimated by accounting for the yearly observed incidence of EHV-1 on Dutch riding schools. Based on these expected average losses per year the cost effectiveness of vaccine application at riding schools is subsequently evaluated.

In the final analysis, the well-documented outbreak of EHV-1 in Belgium is used (Gryspeerdt et al (2011)), to calculate ex post the costs in a real outbreak accounting for the spread between stables, illustrating the possible impact on the level of horse husbandry.

3.3.1 Assumptions related to the ex ante assessment analyses on expected costs and vaccine costs effectiveness

In the first analysis it is assumed that one animal gets the neurological variant of EHV-1 at a riding school. No preventive vaccination took place at the stable. The horse is owned by the riding school and therefore the riding school is responsible for all the costs. In the article of Gryspeerdt et al (2011) the average number of days that the animal is ill before euthanasia is 3.5 days. In this evaluation the animal is euthanized after 4 days of illness. The other horses in the stable are controlled until two weeks after the start of the first case due to the incubation period of the virus which is about 10 days (personal communication 2014, Mr Van Maanen, GD). Moreover, the stable is closed until 28 days after the euthanasia of the horse in line with the recommendation of the Sectorraad.

In the subsequent evaluation the assumption is made that the animal recovers totally from the illness and can be used in lessons again after eight weeks. Based on the literature found this is rather fast and therefore the minimum economic loss is calculated. In this case, the direct cost of euthanizing are no longer accounted for. When a horse is not able to stand for itself, its prognosis is very bad and euthanasia is advised. Therefore, the horse in this evaluation is able to stand for itself, so the costs for the carrier band are not considered as well. When a horse is infected with the neurological form, it will take about eight weeks before all symptoms are gone and a horse is fully recovered. In this evaluation it is assumed that the horse will get the symptoms at day 1, and then they worsen until a plateau is reached after 3 days. After that the symptoms gradually go down until the horse is completely recovered after two months. It is assumed that the infected horse will eat half of its ration during seven days after which it will eat the normal amount of food again. Therefore the feed cost savings are set to €-41 (€-5.83*7 days = €-41). The infected horse will be placed in quarantine and the other horses present will be controlled for two weeks after the start of the symptoms in the first horse. None of the other horses show any symptoms and the stable will be re-opened 28 days after the first two weeks of infection of the first horse. So, the stable is closed for 6 weeks. However, after re-opening of the stable, the infected horse is still not able to participate in the lessons for another 2 weeks.

To account for ownership, the costs of both evaluations are weighed to the average percentage of own horses versus boarded horses on the riding school. On average 40% of the horses present are owned by other people than the owner of the riding school, reflecting the horses placed in pension at the riding school. The other 60% are horses kept by the owner of the riding school and are used in the lessons given at the riding school (ZLTO,

2012). The differences in costs calculated for boarded versus own horses are an advantage to the owner of the riding school.

Given the expected costs of an infected riding school the expected average losses per riding school are estimated by accounting for the yearly observed incidence of EHV-1 on Dutch riding schools which is on average 5 cases per year.

Based on these expected average losses per year the cost effectiveness of vaccine application at riding schools is evaluated. This is done by taking the average cost of vaccinating the horses owned by the riding school and compare them to the average expected costs per riding school estimated by accounting for the yearly observed incidence of EHV-1 in the Netherlands.

3.3.2 Assumptions made in calculating the financial impact of the 2009 outbreak in Belgium

To see how much it costs when there is an outbreak at a riding school, we looked at the case discussed in section 2.1.5.1. Here, a riding school got infected with the EHV-1 virus. In total 96 horses were housed at the stable of which 20 became ill, showing fever and 8 of these 20 infected horses showed neurological symptoms. Of these eight, six horses had to be euthanized because they showed severe ataxia and paralysis. To complete the calculation of the costs made during the outbreak in Belgium in 2009, the following assumptions had to be made because the information was not given in the article by Gryspeerdt et al (2011).

- In the cases of severe ataxia or paralysis, euthanasia is expected.
- During the time that a horse showed fever, antibiotics were prescribed by a veterinarian.
- The stables, not being the riding school were the infection started, are privately owned so no lessons or events are organized.
- When a horse had to be euthanized, its place is filled again after three weeks.

In total the time between the first case and the recovery of the last case was six weeks. However, the stable closed down 3.5 weeks after the occurrence of the first case. The stable remained closed until 28 days after the last recovery, which leads to six weeks of closure.

4. Results

The economic impact as a result of an EHV-1 infection on riding schools is calculated with the use of the defined assessment-analyses.

4.1 Ex ante analysis riding school: one neurological case euthanized

In the first analysis it is assumed that one horse - owned by the riding school - gets the neurological variant and is euthanized after four days of illness. The assumptions made for this analysis are mentioned in section 3.3.1.

The direct costs related to this situation are calculated on the values as defined in section 3.2 and presented in table 4. Total direct costs equalled to €5012 of which 63% results from the cost of the carrier band and 21% form the lost value of the horse.

Table 4: Average costs when the first and second horse get infected and euthanized at a riding school

Direct costs	First horse (€)	Second horse extra (€)
Veterinarian call out charges	50	
Antibiotics, anti-inflammatory and anti-viral agents	200	200
Carrier band	3166	3166
Nasal swabs send to GD	35	
Disinfection stable (Halamid etc.)	100	
Disinfection mat	195	
Disposable overalls	50	
Euthanasia of the horse	250	250
Collection of the dead horse	45	45
Reduction feed costs	-472	-472
Additional labour	343	343
Value of the horse when euthanized	1050	1050
Total direct costs	5012	9594
Consequential costs	**First horse (€)**	**Second horse extra (€)**
Preventive care other horses during 3 weeks	258	
Not possible to organize events during 5 weeks	188	
No lessons during 5 weeks	16720	
Loss of customers	220	
Total consequential costs	17386	
Total direct + consequential costs	**22398**	**26980**

The consequential costs at a riding school mostly consist of the fact that the stable closes and no lessons are given. One week of closure corresponds to €3344 revenues foregone. The riding schools closes for 5 weeks so in total €16,720 is foregone t (5 weeks * €3344 = €16,720). These total consequential costs correspond to €17,386. Total costs (direct + consequential) related to the presence of one neurological case resulting in euthanasia of the affected horse corresponds to €22,398.

Given the fact that a horse is on average euthanized within the first week (4 days after the start of the symptoms), there will be no direct costs after the first week as long as no other

horses get infected. The costs during the first week account for 40% of the total costs. However, the consequential costs occur also beyond the first week. Because of the closure of the stable and a temporary loss of customers some costs even extend over a period of two months.

In addition, the most likely situation is that 2 horses become infected during an outbreak on a stable. When two horses get infected the direct costs will go up. The costs for treatment, euthanasia, and collection of the dead horse, the reduced feed costs and value of the horse lost when euthanized can be multiplied by two (Table 4). The consequential costs do not change because the measures were already taken for the first case so, assuming that the second case occurs close to the first, the consequential costs will stay the same. So, when looking at the most likely situation when a neurological outbreak occurs at a stable, the total costs will lie around €26,980.

4.1.1 Ex ante analysis riding school: one neurological case recovered

In this situation the same horse gets ill as in the first scenario only in this scenario the horse recovers fully and can be used in lessons again after eight weeks. As shown in the assumptions made in section 3.3.1, the stable is closed for 6 weeks. However, after re-opening of the stable, the infected horse is not able yet to participate in the lessons for another 2 weeks. As a horse is used in 12 lessons á €11 a weeks there will be an additional loss of €264. The additional labour to take care of the horse are needed during these 8 weeks of recovery, representing extra costs of €686

In table 5 it is shown that the total costs based on this scenario correspond to €22,183. So, the costs when a horse fully recovers are slightly lower than when a horse is euthanized. This is because when a horse recovers there are no losses because of euthanasia and no replacement horse has to be bought, so direct costs are about €4500 lower but the consequential costs are higher because the stable is closed for a longer period of time and therefore the losses due to the fact that no lessons are given are about €3000 higher. In addition, also the foregone revenues because the horse is not able to participate in the lessons for another two weeks after re-opening make the consequential costs higher than when the horse has to be euthanized.

When accounting for the expected recovery rate of 44% (based on the article by van der Meulen et al, 2003; see table 2) the expected average costs of an outbreak reflecting the most likely situation of two infected horses is estimated as follows;

The chance of both horses being euthanized = (1-0.44)*(1-0.44) = 0.31. The chance that both horses recover = 0.44*0.44 = 0.19. The chance that one horse is euthanized and one horse recovers = 2*0.44*0.56 = 0.49.
The costs of the possible situations are as follows: costs both euthanized = €26,980 (see table 4). The costs when both horses recover: 22,183+200+-41+686 = €23,028. When one horse recovers and one is euthanized the direct costs for the recovered horse in table 5 (€950, common costs, for instance disinfection material, are used once because in case of a second infected horse they were already present for the first infected horse) are added to the direct costs of the second horse getting ill and euthanized in table 4 (€4582). This count up to €5532 for the direct costs. To this the consequential costs calculated in table 5 (€20,908) are added. The consequential costs of the recovered horse are taken because these were calculated for the longest period of time so all costs were taken into account. Then, the average costs of an EHV-1 outbreak on a riding school correspond to: €5638+€20,908 = €26,440.
Then the weighted average costs are: 0.31*26,980+0.19*23,028+0.49*26,440 = €25,695.

Table 5: Costs when one infected horse fully recovers

Direct costs	€
Veterinarian costs call out charges	50
Antibiotics, anti-inflammatory and anti-viral agents	200
Nasal swabs send to GD	35
Disinfection stable (Halamid etc.)	100
Disinfection mat	195
Disposable overalls	50
Reduction feed costs	-41
Additional labour	686
Total direct costs	1275
Consequential costs	**€**
Preventive care other horses during two weeks	172
Not possible to organize events during 5 weeks	188
No lessons during 6 weeks	20.064
Losing of customers during a month	220
Infected horse not participating in lessons during two weeks	264
Total consequential costs	20908
Total direct + consequential costs	**22183**

4.1.2 Average costs for the owner of the riding school

A riding school is most of the time also partly a boarding stable. About 40% of the horses present are owned by other people and placed in the boarding stable part of the riding school (ZLTO, 2012). Therefore, not every horse that gets EHV-1 is owned by the owner of the riding school and so, not always all costs are for the owner of the riding school. In 40% of the cases the horse is owned by someone else and he has to pay for the direct costs. In Table 6, the costs are calculated for the owner of the riding school when the infected horse is not owned by the riding school. The scenarios used are the same as the ones described in section 4.1 and 4.1.1.

When a horse gets infected that is not owned by the riding school still the costs for the owner of the riding school lie between 17,000 and 21,000 euros (table 6). This is mainly caused by the fact that the stable has to close down so no lessons can be given. When the horse is euthanized, the empty stable cannot be filled immediately again and, as this was a privately owned horse, the owner of the riding school loses some boarding money.

Accounting for the rate of recovery (44%) and the risk of own horses being ill (60%) the average cost of one case of EHV-1 for a riding school owner can be calculated.
There are different situations when a second horse gets infected:

- Weighted costs when two horses are euthanized (E) and owned by the riding school 0.56*0.56*(0.6*0.6)*26,980 = €3046.
- Weighted costs when two horses are euthanized but one horse is owned by the riding school and one horse is privately owned: 0.56*0.56*(2*0.4*0.6)*26,980 = €4061.
- Weighted costs when two horses are euthanized but both are boarding horses: 0.56*0.56*(0.4*0.4)*26,980 = €1354.

- Weighted costs when both horses recover (RR) and are owned by riding school: RR=0.44*0.44*(0.6*0.6)*23,028 = €1605.
- Weighted costs when both horses recover but one is owned by the riding school and one is a boarding horse: 0.44*0.44*(2*0.4*0.6)*23,028 = €2140.
- Weighted costs when both horses recover and both are boarding horses: 0.44*0.44*(0.4*0.4)*23,028 = €713.
- Weighted costs when one horse recovers and the other is euthanized and both are owned by the riding school: 2*0.44*0.56*(0.6*0.6)*26,440 = €4691.
- Weighted costs when RE and one is owned by the riding school and one is a boarding horse: 2*0.44*0.56*(2*0.4*0.6)*26,440 = €6254.
- Weighted costs when RE and both horses are boarding horses: 2*0.44*0.56*(0.4*0.4)*26,440 = €2085.

When all cost are added, there is the weighted average costs for the owner of the riding school when there is an outbreak of EHV-1 at their stable. These weighted average costs equals €25,949 per EHV1-outbreak.

Given the incidence of 5 outbreaks per year, the most likely situation of two horses infected on a stable and the total registered number of riding schools being 1263, the expected average cost for a riding school owner on a yearly base can be calculated as follows: 1263 riding schools divided by 5 outbreaks a year means that every riding school is infected once every 252 years. Therefore the average cost for a riding school owner on a yearly base is €25,949/252 = €103.

Table 6: Cost for owner of the riding school when infected horse is not owned by riding school. Both when euthanized and when recovered.

Direct costs	Euthanized (€)	Recovered (€)
Disinfection stable (Halamid etc.)	100	100
Disinfection mat	195	195
Disposable overalls	50	50
Reduced feed costs	-472	-41
Total direct costs	-127	304
Consequential costs	**€**	**€**
Preventive care other horses	258	172
Idle boarding stable for 4 weeks	230	
Not possible to organize events	188	188
No lessons	16720	20064
Loss of customers	220	220
Total consequential costs	17616	20644
Total direct + consequential costs	**17489**	**20948**

4.1.3 Vaccination vs. no vaccination

When a horse is vaccinated and it still gets the virus, the costs lay €80 higher per horse than when a non-vaccinated horse gets infected, but the chance of getting the neurological form is lower as well as the transmission within the stable. Looking at scenario 1 in section 4.1, the costs without vaccination equal €22,398 when only one horse develops the neurological form.

On average, 55 horses are kept at a riding school (table 3). To vaccinate them all, will cost €4400 per year (55 horses*€80=€4400), of which 60% of the horses are owned by the owner of the riding school. So €2640 are the costs of vaccination for the owner of the riding school (0.6*€4400 = €2640) on a yearly base.

The maximal possible costs that can be prevented by vaccination can be calculated as follows: by multiplying the average costs of one outbreak by the chance of being affected by the disease within a year, the resulting expected yearly costs equal €103 per school or €3.10 per horse owned (55*0.6 = 33 horses owned by riding school) by the riding school. Trading of the € 80 vaccination costs with the €3.10, vaccination costs are 25 times larger than the losses that can maximal be prevented. Next to that, the vaccination does not prevent against the neurological form, it only helps to lower the possible secondary cases at a stable. Therefore, for the owner of the riding school it absolutely is not profitable to vaccinate the horses against EHV-1.

4.1.4 Calculation of the outbreak in Belgium in 2009

To see how much it costs when accounting for spread between stables in case of an outbreak at a riding school, we looked at the case discussed in section 2.1.5.1. Here, a riding school got infected with the EHV-1 virus. In total 96 horses were housed at the stable of which 20 became ill, showing fever and 8 of these 20 infected horses showed neurological symptoms. Of these eight, six horses had to be euthanized because they showed severe ataxia and paralysis.
First, the costs are calculated for the riding school itself (Table 7), after that, the costs are calculated for the whole outbreak considering the other seven premises (Table 8).

In Table 7 the following costs can be seen:

- Treatment costs; these are calculated as the costs of the treatment per day (200/7=€28.57), times the amount of days the horse was ill, plus the costs of the veterinarian call out charges (€50). When a horse was euthanized, an extra €250 was added for euthanasia. It is assumed that the horses that had to be euthanized and were ill for more than one day were hung in a sling (€3166).
- Rendac; when a horse was euthanized, €45 were calculated to let Rendac collect the dead horse.
- Labour; the minimum wage of a person of 23 years old or older was used to calculate the amount of labour for the weeks the virus was at the stable (6*342.85=€2057.10).
- Food; the amount was found by dividing the costs of food mentioned in section 3.2 by 7 (amount of days in a week) and then multiply that amount by the time the horse was ill. For example: (-40.83/7)*4=€-23.32. It is assumed that the recovered horses started eating their normal ration after the days of illness. When the horse is euthanized the costs are the same as calculated in section 3.2 (€-472).
- Value euthanized horse; the value of a horse as used in section 3.2.
- Preventive care other horses; the amount used in section 3.2, multiplied by six (amount of infected weeks). So, 86*6=€516.
- Empty stable; when a horse is euthanized the stable cannot be filled before the re-opening of the stable. All horses were euthanized between the 7th and 11th of June so these stables remained empty for six weeks (57.5*6=€345).
- No events can take place for six weeks so 37.5*6=€225.
- No lessons can take place for six weeks: 3344*6=€20,064.
- Losing of customers; the empty spaces will be filled again after one month after re-opening (4*55=€220).

This all sums up to a total amount of € 48,790. When this riding school got infected with EHV-1 it was not suspected to be EHV-1 immediately. Therefore the costs for this riding school came to about €50,000. When it would have been confirmed earlier as EHV-1 the

costs for this riding school would not have been a lot lower, but the spread of the virus to other stables would have been a lot less due to the faster closure of the riding school.

Table 7: Calculation of the costs on the riding school in Belgium in 2009

Horse	Duration illness (days)	Treatment costs	Rendac	Labour	Food	Value euthanized horse	Preventive care other horses	Empty stable	No events	No lessons	Losing customers	Total costs
1	4	164,28		2057,1	-23,32		516		225	20064	220	
2	5	192,85			-29,15							
3	5	192,85			-29,15							
4	3	135,71			-17,49							
5	4*	3530,28	45		-472	1050		345				
6	3	135,71			-17,49							
7	3	135,71			-17,49							
8	3	135,71			-17,49							
9	3	135,71			-17,49							
10	3	135,71			-17,49							
11	3*	3501,71	45		-472	1050		345				
12	5*	3558,85	45		-472	1050		345				
13	5*	3558,85	45		-472	1050		345				
14	3*	3501,71	45		-472	1050		345				
15	3	135,71			-17,49							
16	7	249,99			-40,81							
17	4	164,28			-23,32							
18	3	135,71			-17,49							
19	1*	275	45		-472	1050		345				
20	7	249,99			-40,81							
		20226,32	270	2057,1	-3158	6300	516	2070	225	20064	220	**48790**

* Horse euthanized after number of days mentioned.

Due to the fact that in the first 3 weeks no EHV-1 was expected, the stable held a jumping competition with horses from several other premises. Of these premises, 7 reported EHV-1 cases in the three weeks following the jumping contest. The costs are calculated for each of these stables in Table 8.

Some assumptions are made because the information in Gryspeerdt et al (2011) is not detailed enough:

- In the cases of severe ataxia or paralysis, euthanasia is expected.
- During the time that a horse showed fever, antibiotics were prescribed by a veterinarian.
- The stables are privately owned so no lessons or events are organized.
- As the stables are privately owned no costs are present for empty stables.
- It should be noted that these premises were not all riding schools (premise 4 was probably a riding school with 80 horses present) but privately owned stables or boarding stables with at most 12 horses present (premise 3).

Table 8: Calculated costs in premises infected by the riding school in 2009 in Belgium (*= euthanized horse after mentioned number of days).

Premise	Horse	Duration	Treatment costs	Rendac	Labour	Food	Value euthanized horse	Preventive care other horses	Total costs
2	1	3*	3501.71	45		-472	1050		
	2	3	110.71			-17.49			
	3	3	110.71			-17.49			
	Total		3723.13	45	1028.55	-506.98	1050		**5339.70**
3	1	2	25			-11.66			
	2	2	25			-11.66			
	3	1	25			-5.83			
	Total		75		205.71	-29.15		86	**337.56**
4	1	3	110.71			-17.49			
	2	3	110.71			-17.49			
	3	3	110.71			-17.49			
	4	3	110.71			-17.49			
	5	3	110.71			-17.49			
	6	3	110.71			-17.49			
	7	17*	3687.42	45		-472	1050		
	Total		4351.68	45	1028.55	-576.94	1050	86	**5984.29**
5	1	2	25			-11.66			
	2	2	25			-11.66			
	3	3	110.71			-17.49			
	4	2	82.14			-11.66			
	5	2	82.14			-11.66			
	6	7	300			-40.81			
	7	5	192.85			-29.15			
	Total		817.84		685.7	-134.09			**1369.45**
6	1	5	192.85			-29.15			
	2	3*	3501.71	45		-472	1050		
	3	2	82.14			-11.66			
	Total		3776.7	45	685.7	-512.81	1050		**5044.59**

7	1	3*	3501.71	45		-472	1050	
	2	3*	3501.71	45		-472	1050	
	3	2	82.14			-11.66		
	4	3	110.71			-17.49		
	5	3	110.71			-17.49		
	6	3	110.71			-17.49		
	7	3	110.71			-17.49		
	8	3	110.71			-17.49		
	9	3	110.71			-17.49		
	10	3	110.71			-17.49		
	11	3	110.71			-17.49		
	Total		7971.24	90	342.85	-1095.58	2100	**9408.51**
Total costs all premises								**27484.10**

When all costs made by each premise are summed this leads to a total costs of €76,274. So, if there is a stable at which EHV-1 occurs without it being labelled as EHV-1, this can cost up to about €76,000. However, during the outbreak in Belgium in 2009, six additional premises had reports of neurological disorders after attending the jumping contest at the riding school. They did not have any additional information nor confirmation of EHV-1. The average costs per premise per horse are, however, €1261. Based on this average cost per horse and on the average number of horses present estimated to be 7 (excluding premise 4 with 80 horses), the average costs on the other six premises is estimated to be equal to €8827 per premise (1261*7=8827). So, the costs might have been 8827*6=€52,962 higher if the cases at those premises were also caused by EHV-1, resulting in the total costs of this outbreak of €129,236.

5. Discussion

There are five subtypes of the disease of which EHV-1 and EHV-4 are the most well-known and most often occurring types. The costs related to the disease are calculated for EHV-1 infections on an average riding school. These costs vary around €22,000 for the analyses that one horse gets infected with the neurological variant.

There is no real difference in costs between the analysis that one horse gets infected and has to be euthanized or the case that a horse gets infected and fully recovers (both lie around €22,000). A reason to euthanize the horse instead of trying to make it recover may be that when a horse has the neurological variant of EHV-1 the chance of full recovery is not very likely and it is not very likely that the horse is able to participate in all lessons after recovery (personal communication 2014, Mr van Maanen, GD). In that case euthanasia of the horse and replacement by a horse which is capable to participate in all lessons would be more economical efficient.

As far as possible, the evaluations are made by the use of real data. However, some required information about the consequences and/or costs is seriously lacking and in those cases estimations were used, based on expert knowledge and literature insights. The yearly average costs for a riding school are €103. So, on a yearly base the risk of EHV-1 is not very high. However, when a riding school is infected with EHV-1, the consequences are high (average costs of an EHV-1 outbreak are €25,949). Therefore, in case a riding school is hit the consequences are large but the risk of getting the infection is not that big.

Currently there are four vaccines on the market in the Netherlands. None of these vaccines claims to prevent against the neurological and abortion form. Nowadays, between 5 and 10% of the horses present in the Netherlands are vaccinated against EHV (personal communication, 2014; Mr van Maanen, GD). The reason why so little horses are vaccinated might be the fact that the vaccination does not prevent the neurological form of EHV-1 and that all horses present at a stable should be vaccinated to have any effect. Another reason might be that the vaccination costs lie considerably higher than the average yearly costs of an EHV-1 outbreak. Vaccination was calculated to cost €80 per horse per year. After calculating that the average costs of an outbreak per horse per year are around €3.10, the costs of vaccination are about 25 times higher and therefore the vaccines are currently not cost-effective.

Question is if it is possible to insure the losses made by an infection of EHV-1. The four current largest horse insurances (Hippozorg, Equipe, Paardenverzekeraar.nl and EFO) all mention that none of the insurances compensates when a horse has to be euthanized. These costs are always for the owner of the horse. Hippozorg also mentions in their Health insurance that they do not compensate when the chance of recovery of the horse is less than 50%. So, it is difficult to insure a horse for all costs an EHV-1 infection entails. If compensation is given, only the direct costs can be compensated because these are the only costs that are directly related to the infected horse. Indirect costs are disregarded.

In addition, there is the risk of carriers. Once a horse is infected with EHV-1 there is a possibility that after recovery the horse is a carrier of the virus. The virus can be released again by these carriers due to stress or a lower resistance of the horse (Coster, 2012). The virus becomes latent in around 80% of the infected horses (Welch et al, 1992). It is thought by experts (personal communication 2014, Mr Van Maanen, GD) that carriers form an increased risk compared to non-carriers. However, there are many carriers because of the fact that most horses already were in contact with EHV-1 or EHV-4 at a young age. For EHV-1 the seroprevalence is about 30% and for EHV-4 the seroprevalence is >90%. Most young horses only get the respiratory form. So, it is impossible to manage the carriers at the stables (apart from the effort it would take to identify the carriers). The most important measures that

can be taken is to prevent reactivation by stress and the separation of groups within a company (for instance separate the horses that stay at the stable from the horses that participate in competitions outside the stable and the separation of young horses from pregnant mares). So, in general the carriers are a risk factor in the horse-keeping business, but there are so many carriers that this risk cannot be prevented and they were not accounted for in the calculations.

The costs calculated were related to the riding school. These costs can be compared to the other types of commercial horse keeping businesses, e.g. the mare breeding stable, rearing stable and boarding stable.

- At a mare breeding stable the risk of abortion is high because there are a lot of pregnant mares present. When this happens a foal is lost which means loss of income because these foals need to be sold to provide income for the owner of the stable. Average costs that are lost when one foal is born dead are €3000 (appendix I). However, the contacts with other stables are low so the risk of introduction of the virus is low. Therefore, the costs for the owner of a mare breeding stable will be lower in comparison to the riding school because the consequential costs will be considerably lower as no private horses are housed on a mare breeding stable and no lessons are given.
- At a rearing stable the contacts between the horses is high because they are mainly group housed. Therefore, when an infection is present it is able to spread more easily than when there is an infection on a stable where the horses are individually housed. Around 30% of the horses are owned by other people than the owner of the stable (appendix I), so not all direct costs are for the owner of the stable. Horses are housed at the rearing stable until they are old enough to be ridden. They stay at the rearing stable for about 2.5 years and during this time their value goes up from €3000 when they come to the stable to €6300 when they leave the rearing stable (appendix I). Also, once a group of young horses is together, there is no contact with other horses which makes the introduction of the virus only possible at the start, when the horses are placed together for the first time. The costs for the owner of the rearing stable will be lower than in comparison to the riding school, because on a rearing stable no lessons are given and once horses are together they will stay there for 2.5 years so the owners will still pay for their horses when there is an outbreak of EHV-1 at the stable.
- At a boarding stable also the costs are not that high for the owner of the stable as he is not the owner of the horses. The horses are placed in pension at a boarding stable and are privately owned by other people than the owner of the stable. The contacts of these stable with other stables can be quite high because people take their horses to events or lessons at other stables. So, when there are a lot of different contacts between the horses the risk of getting an infection is higher. When related to the riding school, the boarding stable also has to close down but most of the revenues will still be there because the owners of the horses still pay for their stable. Next to that, the direct costs are not for the owner of the stable so the economic risk for the owner of the stable is lower. In comparison to the riding school the costs for the owner of a boarding stable will be considerably lower.

At this moment it is not exactly known how many stables get EHV-1 during a year in the Netherlands because it is not compulsory to report to the government when there is a suspected EHV-1 case at a stable. There is no legislation from the government that tells people how to respond when there is an EHV-1 case at their stable. The riding schools might report when there is a case of EHV-1 at their stable because of the high contact level with horses from other stable. However, the other commercial horse keeping businesses probably are reserved when it comes to reporting the presence of EHV-1 at their stables.

EHV-1 is already endemic in The Netherlands. However, no preventive measures are taken by the government. Looking at the impact an introduction of EHV-1 on a stable can have, maybe there should be some kind of preventive care done by the government. At first, it is

important to let all stables report when there is a suspicion of EHV-1 on their stable. Due to making the reporting compulsory, the costs of an outbreak would decrease because the virus would not be able to spread between stables.

There is a possibility that there is a difference between the reporting behaviour of the different types of commercial horse-keeping businesses. For instance a mare breeding stable might be reserved in reporting an EHV-1 case whereas a riding school might report this faster because there reputational damage will not be that large. Also the number of contacts between horses of different stables is far higher at a riding school than at a mare breeding stable so therefore the risk of infection is higher at a riding school. Also the hygiene measures taken at a mare breeding stable are higher than at a riding school which also reduces the risk of infection. The consequences are different for the four largest types of commercial horse-keeping businesses. Still there is a problem that EHV-1 is not reported in time, and then a large outbreak can occur due to the fact that the stable does not close down fast enough.

The analyses made are deterministic. In a follow-up study, one option would be to try to make the deterministic calculations done in this study stochastic. The added value of the stochastic calculation could be that there can be a correction for the time it takes before the virus is detected. For instance in the Belgium case it took four weeks before the stable was closed and so a lot of other stables got infected. Next to that, by using a stochastic calculation, the number of cases can be varied to see what the costs would do if more or less horses are infected in time. However, currently it is very difficult to get clear numbers. This should be solved first before a stochastic calculation is possible. Notwithstanding the fact that the calculations done in this study were only basic case assumptions the costs are large and the vaccination is not cost-effective.

6. Conclusion

It can be concluded that there is a financial impact of some significance of an introduction of EHV-1 at a riding school. For an average riding school these costs are in the order of €20.000. Also, there is a difference between the direct and the consequential costs. Consequential costs are partly independent of the size of the outbreak whereas the direct costs are calculated per horse and therefore differ for different numbers of horses infected.

The chance of getting the virus is very low and therefore the averaged costs a year are not very high (€103/riding school). As insurance companies only compensate a small part of the losses related to EHV-1 outbreak, riding school could prepare themselves for an outbreak by keeping a specific amount of money aside especially to bridge the period without revenues in case of an outbreak of EHV-1.

In this study, the focus was only on riding schools. However, also the other commercial stables (mare breeding stables, boarding stable, rearing stable etc.) suffer when there is an outbreak of EHV-1. The combat of the disease should be related to the business itself, the sector and the government. The business itself should report when EHV-1 is on its stable. The sector should provide information to every stable in the Netherlands and the government may try to keep the overall view so that the virus can be kept under control faster.

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Figures:
2) Neijenhuis et al 2012 (individual stable)
3) Neijenhuis et al 2012 (group housing)
4) Aktivestall.de (HIT active stable)
5) Neijenhuis et al 2012 (paddock paradise)

8. Appendix I:

Omschrijving gemiddeld bedrijf per bedrijfstype
(Bron: Schuring, 2005; KWIN, 2008)

Gemiddelde hengstenhouderij		
aandeel enkel paardenhengsten	70%	
aandeel enkel ponyhengsten	20%	
aandeel gemengd	10%	
aantal dekhengsten	3	
aantal dekkingen per hengst	82	
tarief/dekking	776	
marktwaarde	€ 120.000	
aantal ponydekhengsten	3	
aantal dekkingen per hengst	23	
tarief/dekking	€ 135	
marktwaarde	€ 5.100	
	paard	pony
aantal houders	540	160
aantal hengsten	3	3
opfok in eigendom (stuks)	27	27
opfok van derden (stuks)	11	11
tarief opfok mnd weide	€ 100	€ 100
tarief opfok mnd stal	€ 125	€ 125
marktwaarde opfok start 4 mnd	€ 3.000	€ 522
marktwaarde eind opfok 36 mnd	€ 6.300	€ 1.096

Gemiddelde merriehouderij	
aandeel paardenmerrie houderijen	75%
aandeel gemengde pony/paarden merriehouderijen	25%
aantal merries	8
aantal veulens	6
marktwaarde fokmerrie	€ 9.500
marktwaarde veulen 4 mnd	€ 3.000
opfokpaarden in eigendom	9
opfokpaarden van derden	8
aanhoudingspercentage eigen veulens	0,5
totaal aantal paarden	31
1:3 verhouding; aantal paard	21
1:3 verhouding ; aantal pony	10
tarief opfok mnd weide	€ 100
tarief opfok mnd stal	€ 125
marktwaard opfok start 4 mnd	€ 3.000
marktwaarde eind opfok 36 mnd	€ 6.300

Gemiddeld opfokbedrijf	
aantal paarden	46
aantal pony's	3
opfok in eigendom (aantal)	32
Opfok van derden (aantal)	17
tarief opfok mnd weide	€ 100
tarief opfok mnd stal	€ 125
marktwaard opfok start 4 mnd	€ 3.000
marktwaarde eind opfok 36 mnd	€ 6.300

Gemiddelde pensionhouder	
aantal pensionpony's	4
aantal pensionpaarden	16
tarief ponystalling per maand	€ 200
tarief paardenstalling per maand	€ 230
marktwaarde pensionpaard	€ 3.000
marktwaarde pensionpony	€ 900

Gemiddelde manege	
aantal manegepony's	15
aantal managepaarden	15
lesuren per pony/jaar	542
privelesuren per pony/jaar	93
buitenrituren per pony/jaar	112
tarief lesuur pony	€ 9
tarief privelesuur pony	€ 24
tarief buitenrituur pony	€ 11
marktwaarde manegepony	€ 1.200
aantal jaren inzet	10
restwaarde	€ 350
gemiddelde waarde manegepony	€ 775
lesuren per paard/jaar	535
privelesuren per paard/jaar	80
buitenrituren per paard/jaar	126
tarief lesuur paard	€ 11
tarief privelesuur paard	€ 24
tarief buitenrituur paard	€ 13
marktwaarde mangepaard	€ 2.200
aantal jaren inzet	9
restwaarde	€ 500
gemiddelde waarde mangepaard	€ 1.350
aantal pensionpony's	8
aantal pensionpaarden	23
gemiddelde waarde pensionpony	€ 900
gemiddelde waarde pensionpaard	€ 3.000

tarief ponystalling per maand	€ 212
tarief paardenstalling per maand	€ 246
totaal aantal pony's	23
totaal aantal paarden	38
totaal aantal dieren	61

Gemiddelde africhtings/sportsstal			
pony's	3		
paarden	27		
	totaal	eigen	derden
keuringsklaar	9	0	9
zadelmak gemaakt	5	1	4
in training	9	3	6
in training en in sport	7	3	4
totaal	30	7	23
tarief/mnd keuringsklaar	€ 485		
tarief/mnd zadelmak	€ 480		
tarief/ mnd training	€ 495		
tarief/mnd in sport	€ 510		
gemiddeld tarief	€ 493		
marktwaarde afgericht paard	€ 6.000		
marktwaarde getraind paard	€ 10.000		

Gemiddelde sportpaardenhandelaar	
omloopsnelheid (# paarden /box / jaar)	2.4
pony's	1
paarden	38
marktwaarde paard	€'15.000
marktwaarde pony	€ 5.000

Gemiddelde 'markt' handelaar	
omloopsnelheid (# paarden / box / jaar)	8
pony's	12
paarden	17
marktwaarde paard	€ 2.500
marktwaarde pony	€ 900

Gemiddelde prive stal	
gemiddeld aantal dieren	2.4
aantal pony's	1
aantal paarden	1.4
marktwaarde paard	€ 3.000
marktwaarde pony	€ 1.000