Socio-economic aspects of BVDV control

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4.1. Executive summary

In this position paper, the current knowledge on socio-economic aspects of the control and prevention of Bovine Virus Diarrhoea (BVD) is compiled and evaluated. The work was carried out against the background of future decision making, particularly for farmers and countries which still harbor the virus.

First, the existing scientific literature was reviewed. A categorization into 5 groups was made, according to the aim of the studies involved.
Several studies report the financial-economic consequences of initial outbreaks of BVDV. A large variation in losses was reported, ranging from € 19 to € 600 per cow present. It should be stressed that these reports refer to incidental cases. However, it can be concluded that in case of introduction of BVDV in naïve herds, the financial-economic losses can be large.

Various studies were carried out on the average financial losses for cattle herds. The estimations range from € 30 to € 60 per average cow present. This figure can be interpreted as the maximum benefits achievable from eradication of BVDV from the herd. However, risks of re-infection were not considered, and hence the associated losses with re-introduction neither. These can be considerable, particularly if the herd has become naïve for BVDV again after a couple of years. Hence, in most cases the average long-term benefits will be lower than maximum achievable, particularly in cases of relatively high risks of re-introduction. Nevertheless, annual losses due to BVDV on farms in areas with risks of exposure to BVDV can be considerable.

At the level of the national livestock sector, studies indicated a loss due to BVDV under endemic conditions of € 15-20 per cow present. Compared to other production diseases such as mastitis and lameness, the financial-economic importance of BVDV can be considered as ‘moderate’. However, in contrast to the other diseases, eradication of BVDV, be it from individual farms or complete livestock sectors, is possible. In other words, the potential gross benefits of eradication of BVDV might be larger than those of other diseases. These studies however did not include the net benefits, i.e. costs for eradication, costs for biosecurity and risks (and consequences) of re-introduction.

The studies mentioned so far were based on empirical data. Also, simulation studies on the economics of BVDV at the herd level have been carried out, using computer models. The advantage of such approaches is that the whole system can be studied in an integrated way, provided that sufficient information for input is present. These studies are somewhat contradictory in answering the question: is eradication of BVDV at the herd level

economically sensible. However, all studies emphasize the risk of re-introduction of BVDV on the farm after eradication as a very important decision making factor. Therefore, in low risk areas, eradication could be feasible, but in high risk areas, eradication could be questionable: either because of losses associated with re-introduction or the extra costs for increased biosecurity.

Two studies were reviewed which focused on nation-wide eradication of BVDV: a model study for France and an ex-post evaluation of the Norwegian program. The first study indicates that nation-wide eradication is possible and the second is based on the actual eradication of BVDV from the Norwegian cattle population. The costs of such programs can apparently vary quite a lot, thereby affecting their Benefit/Cost-Ratio (BCR). The Norwegian study shows positive financial-economic effects (i.e. a BCR larger than 1) already after a few years, in contrast to the French study where it took approximately 15 years to reach break-even. It should be noted that these two examples applies clearly different control schemes. However, no single advice applicable for all situations exist. Specific conditions could determine the profitability of nation-wide programs.

The second part of this position paper deals with conceptual and theoretical considerations on endemic disease control in general and BVDV in particular. A general framework for the decision making process is described. Various distinct steps in the decision making towards implementing control programs are described. The framework can be used for various levels of decision making, ranging from the farm level to the national sector. Furthermore, the various levels of decision making and their respective decision making criteria are described. It is emphasized that, beside financial-economic criteria, also other criteria are important, e.g. animal welfare and ethics, regional and national economic impacts and veterinary impacts. The degree of importance depends on the level of the decision makers, but also on the preferences of the latter. The complexity of economic decision making in a broad sense is illustrated. This framework could be used in future decision making on control and prevention of BVDV.

In the third part, the financial-economic considerations with respect to BDVD are explored in a qualitative way. It has been shown, that changing the status of BVDV from the level of a production disease to the level of sector or national importance will affect the economic impact of presence of the disease at various levels of the economy. E.g., in case BVDV gets an official OIE-status, countries which are free of the disease could receive favorable trade conditions. Loss of this status due to re-emergence of BVDV could have negative economic effects due to trade restrictions. The economic impact of such an event is determined by the type of products involved (animals, semen, or other products) and the importance of these products for a national cattle sector. At this moment, this impact cannot be predicted.

Based on the review and inventory made, some conclusions on the economic aspects of control and eradication of BVDV can be drawn:

- Occurrence of BVDV can cause great financial-economic costs in naïve herds;
- On average, at the sector level BVDV can be regarded as an important livestock disease, however less important than mastitis and lameness;
- BVD can be eradicated from individual farms as well as within an entire country;
- Since BVDV in principal can be eradicated, the gross avoidable losses approach the current average losses observed (this is in contrast to e.g. mastitis);
- For the net financial-economic effect of eradication of BVDV, the following should also be taken into account: (1) the probability of re-introduction, (2) the associated losses with

this event (which can be high if the herd is naïve), and (3) the biosecurity measures required to reduce this probability. In the literature, these issues have been disregarded in most cases; this hold both at the level of the individual farm and the livestock sector;
- It can be observed that various countries have given priority to national eradication of BVDV (e.g. the Nordic countries), and some literature show a BCR larger than one; however, not all relevant factors were included in these studies, hence a comprehensive financial-economic justification for such decisions should be further investigated;
- In situations with a high risk of re-introduction of BVDV after eradication, on-farm control of BVDV does not seem to be not sensible from a financial-economic point of view;
- Provision of an official status to BVDV (e.g. OIE-listing) could have adverse financial-economic consequences for farmers in countries not officially free from BVDV, even if the farm itself if BVDV-free; the magnitude of these effects particularly depend on (1) the products involved and (2) the possible consequences of harboring BVDV.

For individual farmers and national livestock sectors that are still facing the decision whether or not to eradicate BVDV from their herd(s), scientific based decision support is important. The current state-of-the-arts in financial-economic literature on BVDV is not unequivocal, i.e. a science-based decision in favor of controlling BVDV in countries not yet free of the disease (mandatory control programs) cannot be taken on the available knowledge currently present. This holds also for individual farms. However, it should be realized that other criteria can be of importance too, such as animal welfare, socio-ethics, etc. Moreover, conditions can change over time, e.g. eradication in adjacent countries or farms could reduce the probability of re-introduction, which increases the likelihood of the long term benefits of eradication of BVDV.

Several gaps of knowledge, i.e. requirements for future research have been identified. Particularly the following are of importance:
- In case of absence of ‘outside’ pressure, i.e. in case of continuing voluntary programs for individual farms, decision support tools (i.e. computer models) which simulate alternative scenario’s for on-farm BVDV control from a whole farm management perspective are required; these tools should be adaptable to specific regional and farm conditions which vary between and within European countries;
- In areas with a high prevalence, and therefore with a high risk of re-introduction, the impact of a collaborative (regional) approach should be studied, which should include the development of regional decision support tools (on top of the one already mentioned); these tools should provide insight in the between-herd spread of BVDV in case of various collaborative control efforts;
- In case of ‘outside’ pressure, insight in the trade impact of occurrence of BVDV for the whole sector is a must, because also non-infected herds could be economically affected; insight in this aspect requires sector-wide economic modeling of various livestock commodities which could be affected by the presence of BVDV.

4.2. Recommendations

a. A first recommendation would be, to bring clarity about the future official status of BVDV: will there be an official status of the disease, and if so, what will be the consequences of not being BVDV free at the level of the national livestock sector and for individual farmers. This is important, because such a status could be a major driving force with a financial-economic impact for the stakeholders.

b. At this moment, there is no sufficient scientific evidence that supports a decision from a mere financial-economic point of view to control BVDV in any case or in any country. More insight in the pros and cons for various countries and regions therefore is required. Therefore, country and farm specific conditions should be studied.

c. Considering three levels of decision making, the following recommendations are suggested:
   Farming conditions with regard to BVDV can vary considerably, both between farms within a country or region, and between regions and countries. Hence, for decision support at the **farm** level (i.e. a voluntary approach), farm specific conditions have to be accounted for. Farm specific decision support tools have been developed for specific conditions (e.g. for The Netherlands). Adaptation to other countries and conditions is recommended. Furthermore, adaptations that take the whole farm business into account (and are not restricted to mere BVDV) are advocated.
   Specific **regional** conditions (e.g. high prevalence) have an impact at both individual farmers and the region itself. Considerations on a regional approach should be supported by research specifically focused on that region. The development of decision support tools, focused on decision making options at this level is therefore recommended. Such pc-based tools should take account for (1) the various control options possible, and (2) the impact of monitoring of BVDV on rapid detection of new cases (re-introduction) and the ability to eradicate new cases quickly.
   If decisions have to be made at the **national** level (e.g. as a result of an official status of BVDV), insight in the consequences of (re-)occurrence of BVDV for the entire livestock sector is required. Research on the impact of e.g. trade restrictions therefore is recommended.

4.3. Objectives

The overall objective of work package 4 of the BVDV control network has been to compile and evaluate the current knowledge on socio-economic aspects of decision making on the control and prevention of BVDV, with special reference to the European situation.

More specifically, the objectives were as follows:

- To evaluate the socio-economic aspects of different control strategies and criteria in the process of deciding upon a strategy;
- To evaluate methods and data requirements appropriate for describing and analysing the attitudes and decisions of farmers, stakeholders and other key actors in one or several member countries;
- To evaluate methods for incorporation of the sociological context into the decision and management process of BVDV in particular, and endemic infectious diseases in general.

4.4. Introduction

Bovine Virus Diarrhoea (BVD) is a viral disease of cattle. A large range of clinical signs are associated with BVDV infection, from sub-clinical manifestations to severe clinical disease. In the latter case, the direct disease effects include fever, inappetence, respiratory and gastrointestinal symptoms, infertility, increased embryonic mortality and foetal death, mummification and abortion (Baker, 1995) As a consequence, these direct effects cause reduced production performance. In young stock, this includes increased mortality rates, reduced growth rates and increased culling rates (Lindberg, 2003). In adult cattle, performance effects are, for example, reduced conception and pregnancy rates, increased abortion rates and a reduction in milk production, and increased replacement rates (Lindberg, 2003). BVDV can also cause indirect effects, e.g. a higher probability of mastitis resulting from immuno-suppression (Lindberg, 2003; work package 2).

Obviously, both the direct and indirect disease effects of BVDV cause financial losses for the primary producers. In turn, less-efficient use of resources results in losses for society (Dijkhuizen and Morris, 1997). Moreover, the occurrence of BVDV causes impaired animal welfare due to increased morbidity and mortality, adverse side-effect or intangible loss. Impaired animal welfare causes ‘loss’ to Society as a whole (McInerney, 2004) i.e. it is an ‘externality’ of animal production. BVDV may cause additional externalities, for example reduced efficiency of food production associated with infertility and leading to otherwise avoidable environmental degradation (Garnsworthy, 2004) Despite their detachment from the farm business, such externalities can have financial implications for farm businesses perhaps through reduced demand for livestock products and hence reduced output prices and/or through restrictions imposed by society on farm businesses in an effort to limit the negative externalities. Such restrictions may increase in future now that farm subsidies have been decoupled from production and their receipt or level may be conditional on conformance to specific standards of farming practice aimed at safeguarding animal health, animal welfare and the environment (‘cross-compliance’). Finally, occurrence of BVDV within a population, endangers efforts to improve the general level of animal health status, a self-proclaimed aim within the European Union.

Within Europe, prevalence of BVDV varies enormously. The Scandinavian countries (Norway, Sweden, Finland and Denmark) are almost free of BVDV, whereas in other countries such as The Netherlands and The United Kingdom sero-prevalence estimates exceed 50% (Lindberg, 2003; Moen, 2004; work package 2).

Different approaches in controlling and preventing BVDV between European states can be observed. In Nordic countries such as Norway, Sweden and Denmark, authorities are active in promoting and supporting BVDV control programs, resulting in programs that are almost mandatory. In contrast, in most other European countries, e.g. The Netherlands and The United Kingdom, authorities are more reluctant, leaving BVDV control to the livestock sector. In both these countries, control programmes exist, but participation is voluntary for the producers and only some participate.

Successful, socially and financially sustainable control and prevention of BVDV depends on various aspects. For the **individual producers**, the most important are: the economic impact of BVDV on the farm (i.e. the financial losses (s)he can avoid by eradicating BVDV), the costs of control and subsequent prevention, and the likelihood of re-occurrence of the disease (which depends amongst others on the BVDV prevalence in the broader environment). For the **livestock sector** (i.e. the collective cattle producers within a country), a major additional point for consideration is the question whether or not in the future BVDV occurrence will result in trade restrictions for livestock products and/or animals. This would be the case if biosecurity demands applicable to BVDV was to be included in the OIE Terrestrial Code. Such restrictions would not only affect diseased herds, but also herds within a country free of BVDV. Depending on the type of restrictions, this issue could have considerable financial-economic welfare implications for the society if the sector is net-exporting for e.g. live animals (Saatkamp et al., 2000). For **society** as a whole, additional aspects play a role, such as losses due to inefficient use of resources and animal welfare. These externalities may be 'internalised' in future as explained earlier at which point they directly affect decisions of the individual producer.

Currently, questions on how to proceed with BVDV control and prevention are discussed. Norway and other Scandinavian countries are strong supporters of BVD to be regarded as an OIE listed disease (Anonymous, 2002), a point of view which is not shared by some other EU member states.

Given the differences between European countries with regard to current prevalence of BVDV, preferences of producers and society as well as other environmental conditions (e.g. prices and costs for BVDV programs), questions on BVDV control and prevention should be dealt with on a country specific basis. The main questions in this respect are: (1) is control and prevention of BVDV economically feasible or not from a farm and/or sector point of view both in the short and in the long run, and (2) if so, which approach or strategy would be most suitable to achieve and maintain the BVDV-free status. The main aim of this paper is to address these issues.

The economic literature with respect to BVDV is fragmented and scarce, country-specific and predominantly focused on the losses caused by the virus at the farm level. Within the near future, this is unlikely to change. Therefore, the main aim of this position paper is to give a comprehensive overview of all issues related to decision making on BVDV control and prevention. In this way, guidelines will be provided and knowledge gaps indicated. Finally, requirements for further socio-economic research with regard to BVDV will be listed and discussed.

4.5. Overview of existing economic literature on BVDV

This literature review includes approximately 30 publications, not all of them being original. Quite some variation between these publications exists with regard to aim, scope, approach and methodology used and factors included in the research. Moreover, the existing literature sometimes is rather country and/or situation specific. All this makes extrapolation of the results to other conditions and generalization of the conclusions questionable. A comprehensive review of the economic literature on BVDV can also be found in Houe (2003). In this overview, however, the number of studies has been extended. Moreover, particular attention has been paid to the potential use of the publications in economic decision making on control and eradication of BVDV.

Below, a categorization of the papers into 5 groups has been made, depending on the aim of the study. In turn, the publications are of two major types. Those discussed in sections 4.5.1, 4.5.2 and 4.5.3 all refer in some way to the estimation of losses, whereas the publications discussed in sections 4.5.4 and 4.5.5 focus more on decision making. In section 4.6, the main findings of these publications are drawn into the general framework of economic assessments and put into the broader perspectives of decision making on the control and prevention of BVDV.

4.5.1. Financial-economic losses due to initial outbreaks cases of BVDV

A number of publications deal with the financial-economic losses due to initial BVDV outbreaks in apparently BVDV naïve or free herds. These herds had no immunity or protection developed against BVDV at the moment of introduction of BVDV in the herd. Hence, the observed impact of the disease can be regarded as a worst case scenario, and the losses associated as a kind of possible maximum over a limited period of time (i.e. several months up to one year).

The basic approach which all these studies more or less had in common was, that the clinical observations made with regard to mortality, morbidity and sometimes also the impact on production, was transferred into monetary values using market prices. (The potential dangers of using market prices in this context are highlighted by Bennett and Ijelpaar (2003) who used border prices instead.) Moreover, only the direct effects of BVD were included, leaving indirect effects such as increased occurrence of other diseases unconsidered.

Bennett and Mawhinney (1999) calculated the losses due to an initial BVDV outbreak at £ 9,065 for a 100-cow British dairy herd, i.e. € 137 per cow present in the herd.

Duffell et al. (1986) estimated the financial loss incurred from an initial BVD-MD infection in a 67-cow British dairy herd to be between a minimum of £ 1,720 and a maximum of £ 4,115, depending on the way the died or culled animals were replaced (as calves or down calving heifers respectively). These figures imply values between € 39 and € 92 per cow present.

Pritchard et al. (1989) reported a case of a combined initial infection with BVDV, Leptospira hardjo and Coxiella burnetii in a 183-cow dairy herd in Great Britain, and estimated the total combined financial-economic losses to be over £ 50,000, i.e. € 410 per cow present.

A BVD outbreak in a Dutch 100-cow dairy herd was reported by Stelwagen and Dijkhuizen (1998), which resulted in losses of over DFl. 96,000, i.e. € 455 per cow present.

Wentink and Dijkhuizen (1990) reported the financial-economic effect of BVD outbreaks at several Dutch dairy herds to vary between € 19 and € 130 per cow present.

In Denmark, Houe et al. (1994) calculated the losses due to initial cases of MD only occurring on 8 relatively large dairy farms as being between € 30 and € 89 per dairy cow present.

Finally, a rough estimation of the financial-economic losses due to acute outbreaks in Canada at 7 dairy herds made by Carman et al. (1998) showed that these losses were between $ 40,000 and $ 100,000 for the whole herd, i.e. approximately € 240 and € 600 per average cow present.

When comparing these figures, the large variation in estimated losses immediately becomes clear: a minimum of € 19 and a maximum of € 600 per cow present. Various causes can be mentioned, e.g. the severity of the outbreak itself, specific farm and regional conditions, items included (e.g. only loss and replacement of animals or also other losses such as reduced milk production, treatment costs, etc.), whether or not other diseases also interfered, etc. Therefore, a comparison between these studies in order to estimate an overall or 'typical' figure does not make much sense.

A point of methodological critique is, that in all studies financial-economic valuation was based on market prices instead of opportunity costs. This might have led to a slight overestimation of the losses. However, on the other hand, indirect disease effects were not included either.

Another issue which should be realised is, that these losses are incidental, and refer to a limited time period (several months up to one year); a positive side effect is namely that herd immunity is acquired, which makes the herd less vulnerable in the years after the outbreak. Moreover, the actual probability of incurring these losses, i.e. the probability of introduction of BVDV into a largely or completely susceptible herd, seems to be quite low (but not zero) in countries where BVDV is still endemic.

However, despite the fact that criticism is possible on these studies, the figures quite clearly show, that without any doubt initial infections of BVDV in naïve herds can cause large financial-economic losses for individual farmers.

4.5.2. Average financial-economic losses due to BVDV at the herd level

Several studies dealt with estimating the average financial-economic losses due to BVDV at the herd level. In contrast to the previously described cases, account was taken, or an attempt was made to do so, of a more or less continuous level of infection, or at least a continuous risk of infection.

To enable this, some kind of economic modelling was performed. However, different approaches can be observed, varying from Partial Budgetting (PB) to complete system simulation. All approaches had in common, that first the disease situation and its consequences were estimated, either by data collection and subsequent statistical analysis, or by simulation. Thereafter, the epidemiological outcomes were transferred into monetary terms by putting financial values on the various disease cases. In the latter, mostly market values instead of opportunity costs and border prices were used (see methodological comment above).

Chi et al. (2002) randomly collected blood samples from 90 dairy herds in Eastern Canada to obtain an estimation of the number of herds and animals infected with BVDV, bovine leucosis virus, Mycobacterium avium subspecies paratuberculosis, and Neospora caninum. Subsequently, these disease data were included in a Partial Budget model to estimate the average direct financial-economic losses and treatment costs due to an infection with these diseases. This model was stochastic, to account for the natural variation of occurrence of the diseases. The total losses and costs for a 50-cow infected herd with BVDV were calculated at CDN$ 2,422, being € 34 per average cow present. The costs of treatment only made up 2% of this figure, hence the remaining 98% was due to losses due to BVD.

Gunn et al. (2000) estimated the yearly losses due to BVDV for British dairy herds over a 10-year period. In a stochastic Markov-Chain simulation model, the probability of (re-)infection was included, which made a calculation of the average yearly losses and costs more realistic. Their study showed a median loss due to BVDV over a 10-year period for a 50-cow dairy herd to be £ 10,300 (range £ 5,200 to £ 21,200), i.e. € 31 per average cow per year. Depending on the milk price, this would imply a loss of 9 to 19% of the farm income.

For Scottish beef herds, a similar study showed an estimate of £ 37 (range £ 32 to £ 43), i.e. € 58 per average cow per year (Gunn et al., 2004).

Sørensen et al. (1995) developed a more analytical stochastic simulation model to study the impact of BVDV infections on farm net revenues (FNR) over a 10-years period. They demonstrated a marked effect of BVDV infection on FNR if new infections do not occur regularly, i.e. only during the initial years of simulation. With regularly occurring new BVDV infections (i.e. semi-continuous presence of PI-animals), the impact on FNR varied considerably only in the first 4 years; thereafter, the difference in FNR with herds free of BVDV was only very small.

Fourichon et al. (2004) estimated the financial-economic losses due to on-going BVDV infections on French dairy herds. They used estimated production effects of BVDV from epidemiological sources, and considered all product effects possible. Hence, they tried to include also the indirect effects of BVDV due to the increase of other diseases resulting from immunosupression. The disease data was used in a PB model, and the calculated effects showed a financial-economic loss varying from € 60 to €100 per cow-year for average and severely affected herds respectively.

Based on these studies, a rough estimation of the annual average costs per cow due to BVDV would be to lie between € 30 and € 60, a considerable amount. At first sight, it is very temptative to interpret these losses as the net benefits of eradication, i.e. these maximum losses due to BVD are also the total avoidable losses (McInerney et al., 1992). Disregarding the issue of discounting, this would mean, that a farmer could spend on average approximately € 30/cow/year on eradication, monitoring and additional prevention. For a single herd however, operating in a wider surrounding of other herds which are or could be a source of potential (re-)infection, there always exist the probability of (re-)infection. The associated losses, which could be high, particularly in case of complete susceptibility resulting from eradication after a couple of years (see the above described cases), should be taken into account as well. This implies less financial space for eradication than the € 30 originally suggested.

Nevertheless, the described studies show that if individual farmers are more or less continuously confronted with BVDV (i.e. an endemic on-farm situation), either because of continuous presence in the herd or because of regular new introductions from outside the herd, the total annual (avoidable and non-avoidable) losses most likely are considerable.
It is also interesting to note, that apparently continuous exposure to BVD virus results in far much lesser losses than irregular exposure (see: Sørensen et al. (1995)). In this context, it should be made clear that also under endemic situations continuous exposure is rare, as PI animals tend to be few (low within–herd prevalence) and regularly will leave herds due to death, for slaughter or for sale. In case of a relatively long period of non-exposure and a high replacement rate, the possibility exist that a considerable pool of susceptible animals emerges, resulting in a reduced herd immunity, simply because PI animals are not systematically/intentionally removed (Lindberg and Houe, 2005).

4.5.3. Financial-economic losses due to BVDV at the level of the national livestock sector

Several studies have been carried out to estimate the financial-economic losses and costs at the level of the national livestock sector. In all cases, first, based on epidemiological survey information, an estimation was made of the incidence of BVDV, divided into various relevant age and disease classes. Subsequently, the impact on production performance of the various age/disease combinations was included. Finally, monetary values were included to estimate the annual financial-economic costs of BVDV. The latter included both direct losses due to the disease in terms of expected output loss, costs for treatment and costs for prevention (Bennett et al., 1999). Hence, indirect losses and wider economic aspects were not included. Moreover, fixed market prices for livestock commodities were assumed.

Bennett et al. (1999) and Bennett (2003) developed a series of spreadsheet models to estimate the total annual output losses and input expenditure for various endemic diseases in Great Britain. Total financial-economic impact for BVDV was estimated at £18m for dairy and beef cattle together (range m£ 5 and m£ 30, due to incidence and disease effects considered); in Euros, these figures are m€ 27, m€ 7.5 and m€ 45 respectively. Compared to other endemic livestock diseases, BVD ranked 4th, after mastitis (m£ 121, m€ 182), lameness (m£ 48, m€ 72) and enteric disease (m£ 29, m€ 44). However, such comparisons must be interpreted with care. They represent the current cost of the disease, not what it could be if the total cost of the disease were minimised or the costs of achieving minimum cost status (McInerney, 1996). As different diseases are at different points with respect to their optimal economic position, direct comparison of diseases on the basis of their current cost is not valid. As BVDV is an insidious viral disease with no direct treatment options it could be argued that current BVDV costs tend to underestimate its true economic importance compared to other more tractable and/or less stealthy diseases.

Bennet and Ijpelaar (2003) presented an update of these estimations. They used border prices, i.e. prices at which the livestock commodities could be produced elsewhere (e.g. New Zealand or Australia) and included transport costs to Great Britain. Although slightly lower, these border prices reflect better the true economic value of these commodities. Moreover, they included aggregated animal welfare effects of the various diseases, based on estimation by experts. The results showed an increase of the estimated financial-economic impact of BVDV, being m£ 40 (m€ 60). The ranking of the aggregated animal welfare impact was 4th, after lameness, mastitis and infectious bovine keratoconjuctivitis.

Given the fact of approximately 3.9m calvings per year, these figures imply that the annual losses and costs due to BVDV for Great Britain approach £ 10 (€ 15) per head.

Houe et al. (1993) used a similar type of approach to estimate the total annual losses due to BVDV infections in Denmark, which showed to be m£ 13 (m€ 20) per million calvings, i.e. € 20/cow/year. These estimations were made before the onset of the national BVDV eradication program. Subsequent calculations assuming a BVDV strain with a high virulence showed that the estimated annual losses would increase up to m$ 57 (m€ 52), i.e. more that two-and-a-half times higher (Houe, 1999).

The first pictures that emerge from these studies is, that a rough estimation of the costs due to BVDV in presumed ‘normal’, endemic conditions with a moderate to high prevalence lies somewhere between approximately € 15-20 in Great Britain and Denmark (in the latter case before the start of the eradication program). Since epidemiological studies show, that the endemic situation of BVDV in Great Britain is reasonably similar to that in most other EU member states, except for the Nordic ones, these estimates could be used as an approximation for these countries as well.

It is again tempting to interpret these estimates as the potential benefits of complete nation wide eradication of BVDV; in other words, the figure of € 15-20 represents the total avoidable costs. However, some remarks can be made in this respect.

First, a nation wide program would in most countries imply increased costs for monitoring and prevention, particularly if more strict legal regulation is required; Bitsch et al. (2000) point out, that this would be the case in most countries. In turn, this would reduce the avoidable costs (McInerney, 1996) and hence the net benefits of an eradication program.

Second, the risk of re-emergence of the disease should be taken into account. There is no literature available on the consequences hereof, but large incidental losses cannot be excluded, and should be subtracted from the avoidable costs. These potential losses would increase as the eradication scheme progressed and increasing proportions of the national herd became naïve to BVDV. At the same time, costs of finding remaining sources of BVDV infected livestock may increase as infected herds become rarer and restricted to farms that are in various ways less accessible. The risk of re-infection and how it is affected by the implementation of regional/sectoral control is discussed further in the position paper of work package 2.

Finally, the impact of nation wide eradication of BVDV on the supply of livestock commodities should be considered. For decision making at the farm level, fixed output prices can be used, because the impact of improved efficiency on the total supply is negligible. However, if an entire sector comprising millions of animals improves production efficiency by eradicating a livestock disease, a (temporary) increase in total supply cannot be excluded (Dijkhuizen and Morris, 1997). This holds even more, if several countries operating on the same market (i.e. the common EU market) eradicate BVDV. According to economic theory, a so-called shift in the supply curve ultimately would result in reduced commodity prices for producers, and hence a reduction in the avoidable losses. The magnitude depends on various factors, e.g. the size of the increased supply and the time span in which this will occur.

Despite these aspects, these estimations for the national livestock sector clearly show the economic importance of BVD in presumed ‘normal’, endemic conditions. Compared to the losses caused by diseases such as mastitis and lameness, the financial-economic impact of BVD should be regarded as ‘moderate’. However, when considering avoidable losses, the relative importance of BVD could increase: in contrast to the other diseases, BVDV potentially can be eradicated completely. The latter would also have an impact on the externalities of the disease, i.e. improved animal welfare (see: Bennet and Ijpelaar, 2003).

4.5.4. Economic modelling to compare decision alternatives at the herd level

The advantage of using computer based epidemiological-economic models for decision support is, that all relevant factors influencing the decision making can be included in one study. However, quite often, if not always, values of some of the key parameters are uncertain due to lack of empirical data. Moreover, there is always the risk of the model not completely representing the real world. However, this approach showed in many occasions to be a valuable aid in decision support (Dijkhuizen and Morris, 1997).

Bennett (1992), amongst others, pointed out the relevant stages which should be included in the design of a general disease control decision support system (DSS):

– integration of relevant epidemiological and disease information into a disease model;
– combining the former with a production system model to simulate the effects of the disease on production performance;
– inclusion of other information, such as disease control options, to simulate the epidemiological impact of the various decision options;
– inclusion of a financial-economic module to evaluate the financial-economic impact of the various alternative decision options;
– incorporation of other relevant factors which affect the decision making, e.g. the decision makers' preferences and risk attitude, to support the decision making in ways most in line with the goals and preferences of the decision maker.

Computer simulation modelling has both advantages and limitations (Bennett, 1992; Dijkhuizen and Morris, 1997); on both, a lot can and has been stated. DSS offer the possibility to incorporate all relevant aspects to the decision problem, and study them simultaneously. In this way, a comprehensive analysis can be carried out, and e.g. interactions between different factors can be studied. Moreover, they can be built relatively easily, quickly and cheaply. Major limitations include the uncertainty of values of key parameters, and the danger of incorrectly representing the system which is studied. One of the outcomes of almost all simulation studies is, that they indicate scarcity of empirical data on one of more aspects relevant to the decision making process. Such outcomes can be used to criticise simulation modelling and its outcomes (which often is done). However, revealing such scarcities can be regarded as a valuable outcome too, also with regard to interpreting the results of empirical studies. Moreover, simulation modelling offers the opportunities, if carried out carefully, to partially deal with these uncertainties through sensitivity analysis and validation (see e.g. De Vos et al., 2005).

Perfect representation of the system studied by a simulation model is an illusion. However, careful validation (both internal and external) can reveal the usefulness and credibility of the outcomes. Thereby it should be kept in mind what the main purpose of the DSS is: support of making choices, not providing exact estimation of costs and benefits in any circumstance.

Finally, the use of DSS and model outcomes should be a part of the decision making process, i.e. they should not monopolize the decision making, thereby neglecting other aspects. Ideally, DSS should be used interactively with the decision maker to explore the full contents of the decision making problem and interpret outcomes within the right context.

Preferably, risky events (e.g. the chance of re-introduction of BVDV) and the decision makers' attitude towards risk should be included in the DSS as well (Hardaker et al., 1997).

Several studies regarding decision making at the herd level have been performed.
Pasman et al. (1994) described a state-transition model to evaluate economically the decision options 'no intervention' and 'culling carriers' in a BVDV-infected herd (re-infection from outside sources was not considered). It was calculated that the 'no intervention' option would result in almost complete immunity of animals having an age above 1 year. The 'culling carriers' option would result in high immunity and reduced losses because of less clinical

problems due to BVD, however, the expenditures for testing and culling was quite high and did not outweigh the benefits. Moreover, they simulated the economic impact during the first year after an outbreak of BVD in a completely sero-negative herd, which turned out to be DFl. 85,000 (€ 38,500), being € 385/cow present. It was concluded that out of both decision options, the ‘no intervention’ option should be preferred for financial-economic reasons.

Houe et al. (1994) performed a Decision-Tree Analysis (DTA) for herds with outbreaks of MD, including (1) no blood testing, (2) blood testing of animals within the risk group and subsequent removal of PIs, and (3) blood testing of the entire herd and subsequent removal of PIs. They concluded, that testing the risk group and removal of PIs in most cases would be the best option to control BVDV, provided that in this way the infection risk was reduced and precautions would be taken to prevent further reintroduction of BVDV in the herd.

Stott et al. (2003) used the Markov Chain-based Monte Carlo approach to simulate the effect of various levels of biosecurity on the within-herd spread of BVDV in a 100-cow Scottish beef herd. Biosecurity was defined in such a way, that the probability of BVDV introduction from outside sources was included as well. The results of these simulations was subsequently used as inputs for linear optimization using linear programming. The aim was to determine the optimal level of biosecurity, which satisfied the achievement of a certain (user defined) target income with the minimum of BVDV risk given the available resources and constraints; the latter were derived from user defined whole-farm characteristics. The results showed that particularly in fully susceptible herds total costs can be high if the risk of re-introduction of BVDV is also relatively high; total expected costs of approximately £ 35 per cow/yr (€ 53) were calculated for susceptible herds with low levels of biosecurity. Increasing the latter resulted in a reduction of the annual costs to below £ 25/cow/yr (€ 38), however on the expense of an increased variation (i.e. risk) of the latter figure. This clearly shows the potential of benefits resulting from investments in biosecurity in these susceptible herds. However, they also concluded that when whole-farm financial risk was taken into account, the optimal disease-control level might be different from the decision that minimises the expected total costs of the disease itself.

Groenendaal (1998) and Groenendaal and Horst (2000) developed a Markov Chain-based stochastic simulation model to carry out calculation of Cost-Benefit-Ratios (CBR) of various control scenarios for BVDV at Dutch dairy herds. This model was further developed and adapted to the current voluntary BVDV programme offered by the Dutch Animal Health service (Saatkamp et al., 2005). The possible scenarios included test-and-cull of PIs, increased biosecurity and vaccination. Basis for comparison between scenarios was the CBRs between a situation without control and one adopting a particular scenario. Preliminary results show, that particularly with relative high probabilities of re-introduction of BVDV from outside sources, control measures should not be favoured either because of a negative CBR or because the return of investment time is quite long. Vaccination as an additional prevention measure was not economically sensible under Dutch conditions.

These studies show some kind of contradictory results. Houe et al. (1994) and Stott et al. (2003) tend to be positive on the financial-economics of prevention and control of BVDV, whereas the other studies tend to be more critical. All studies have in common the emphasis to reduce the risk of re-introduction of BVDV: a high risk has negative consequences on the financial-economic feasibility of prevention and control of BVDV. Apparently, this risk seems to be a critical factor in deciding pro or con control of BVDV at the herd level. From these studies, it can be concluded that BVDV eradication at the farm level could be worthwhile from a financial-economic point of view in areas where the natural risk of re-introduction of BVDV is low due to e.g. favourable natural conditions. If natural conditions are less favourable (e.g. in The Netherlands with a relatively high sero-prevalence amongst herds), the costs of additional measures to reduce the risk of re-introduction could become that high that eradication of BVDV is not worthwhile from a financial-economic point of view. This is particularly the case with vaccination.

4.5.5. Cost-Benefit Analyses of national livestock sector BVDV eradication programmes

Empirical evidence clearly show, that complete nation wide eradication of BVDV is possible. This implies that potentially all current losses can be avoided instead of only a part (McInerney et al., 1992).

Dufour et al. (1999) used deterministic computer simulation to evaluate ex ante the economic feasibility of eradicating BVDV in France. The study was carried out for a fictitious average population at regional level, representing approximately 1.2% of the total French cattle population. Annual base-line costs caused by BVDV in the absence of an eradication program was estimated at approximately mUS$ 1 (i.e. US$ 10.5 per adult cow). Within the BVDV eradication program, they assumed that annually 9,500 animals were introduced in the region and should be tested for BVDV. Moreover, besides monitoring based on general bulk tank milk Elisa, extensive serology and virology on individual animals at (presumed) BVDV positive herds was carried out in order to remove PIs. Costs for removal of PIs was included, and turned out to be approximately 30% of the total program costs in the first year. The total program costs for the first year were estimated at approximately mUS$ 1.8 (i.c. US$ 7.7 and US$ 19 per animal and adult cow present respectively). The prevalence of PIs reduced and became 0 after 10 years, resulting in a gradual reduction of the program costs to approximately mUS$ 0.5 in year 10 and mUS$ 0.35 in year 20. Apparently, the intensive testing for PIs did not result in a faster eradication of PIs than 10 years. They concluded that eradication of BVDV in France would become cost-effective only after 15 years, and therefore adaptation of such a program is questionable.

An extensive ex post CBA of the Norwegian BVDV control program was carried out by Valle et al. (2005). They used the actual program costs during the 10 years of operation as a basis. Benefits, i.e. reduced losses due to BVD, were defined as the difference between the expected direct losses without the program and the observed direct losses during the course of the program. Both data on costs and benefits were included in a stochastic simulation model for further analysis. An average loss at the onset of the program of NOK 77 (approximately € 11) per calving per year was calculated. A gradual reduction of BVDV prevalence was observed, which resulted in an almost complete eradication after 10 years. During the course of the program, benefits increased. A Net Present Value of the entire program over the entire period of mNOK 130 was calculated (range from mNOK 51 to mNOK 201), i.e. m€ 18 (range from m€ 7 to m€ 27). It should be noted however, that at the onset of the program, 75% of the herds were naïve to BVDV, which could imply high on-farm losses in case of re-introduction of BVDV; in turn, this would have an increasing effect on the programs' benefits. Also, strict biosecurity measures, involving a ban on purchasing animals by BVDV-free herds from herds that were not free, very much reduced the probability of re-infection of BVDV-free herds, and thereby increased the benefits. On the other hand, control and eradication costs could be kept very low at approximately US$ 2.7 per adult cow. Main reasons for these were use of bulk milk samples as the basis for distinguishing BVDV-free herds from others and collection of pooled first-calver's milk samples by the farmer if the herd was previously tested positive. Hence, both benefits and costs were amplified in a desired way. From this study, it can be concluded that under certain conditions, sector wide eradication of BVDV is possible and cost effective, provided that re-introduction can be avoided.

Both studies came to quite different conclusions: Dufour et al. (1999) questioned the economic feasibility of regional eradication of BVDV, whereas Valle et al. (2005) were positive. A closer look reveals some of the probable reasons for this difference in outcomes. First of all, the estimated average yearly losses appeared to be quite the same: US$ 10.5 and 11 per adult cow respectively. Moreover, in both studies eradication of BVDV (i.e. PIs) was achieved within approximately 10 years. However, a very large difference can be observed in the program costs: US$ 19 and 2.7 in Dufour et al. (1999) and Valle et al. (2005) respectively, both during the first year. Valle et al. (2005) did not include costs associated with removal of PIs, which accounted for 30% of the program costs in Dufour et al. (1999). Even then, the difference in program costs is remarkable. Main reasons for this appears to be, that Dufour et al. (1999) used extensive blood testing on individual animals, which make up approximately 50% of the total program costs during the first year (note: Valle et al. (2005) do not provide a specification on this issue). In contrast, in the Norwegian program predominantly testing of pooled milk samples was used, which kept program costs low. Although a little speculative, approximately 80% of the difference in program costs can be explained in this way.
Hence, it seems likely that the difference in conclusion between both studies can be explained largely by the much higher program costs assumed by Dufour et al. (1999), resulting from extensive individual testing and (replacement) costs for removed PIs. A key question in this respect seems to be: are the assumptions made by Dufour et al. (1999) absolutely required to obtain eradication of BVDV under their conditions, or could a less intensive and therefore less costly program such as the Norwegian one also result in eradication of BVDV under French conditions? In other words: are less costlier alternatives for the approach by Dufour et al. (1999) possible, provided they would have the same eradicative effect on BVDV?
Given the available literature, these questions can not be answered, unfortunately. In comparing both programs, some key differences can be observed however which could justify higher assumed program costs in other conditions as those in Norway.
The average herd size assumed by Dufour et al. (1999) was 71 animals compared to 36 in Norway. In populations with relative small herd sizes, eradication of BVDV is believed to be easier, hence requiring less rigid and therefore less expensive control programs.
There was a considerable difference in initial sero-prevalence between both studies. Based on empirical observations, Dufour et al. (1999) assumed only 25% of the herds and 54% of the animals to be sero-negative, whereas 75% of the Norwegian herds were assumed to be naïve to BVDV. Moreover, whereas in Norway extremely strict legal-based biosecurity was applied with regard to e.g. trade of animals, it seems likely that this was not the case in France (e.g., Dufour et al. (1999) assumed 9,500 (4%) new animal introductions into the population annually). This would justify more intense sampling and testing of individual animals, with accompanying higher program costs. The latter holds also, if a more intense and less transparent trade pattern is assumed.
Finally, it is noteworthy that in both studies the risks of re-introduction of BVDV in the population after complete eradication is not considered. This would cause losses, and hence would reduce the BCR of the eradication program. Such a risk presumably will be lower in a rather isolated population like the Norwegian, compared to the French conditions.

Both studies show, that eradication of BVDV within a region or country is possible. However, the comparison of both studies also shows that the program costs can vary considerably, and in return can affect the BCR of the program. In future decision making in other countries beside those that already have adopted or completed an eradication program, careful ex ante studies aimed at comparing various different eradication programs is therefore absolutely required. Such studies should focus on (1) the ability of the programs to eradicate BVDV, (2) the course of BVDV prevalence and (3) the duration until complete eradication, and (4) the total financial-economic costs of such a program including costs associated with re-introduction after complete eradication, prevention and monitoring. Preferably, also the indirect losses caused by BVDV (i.e. indirect benefits) should be taken into account. Only then, an economic-sound decision can be made whether regional or national eradication is economically feasible or not. Examples of such approaches for other diseases exists, e.g. for IBR (Vonk Noordergraaf, 2002).

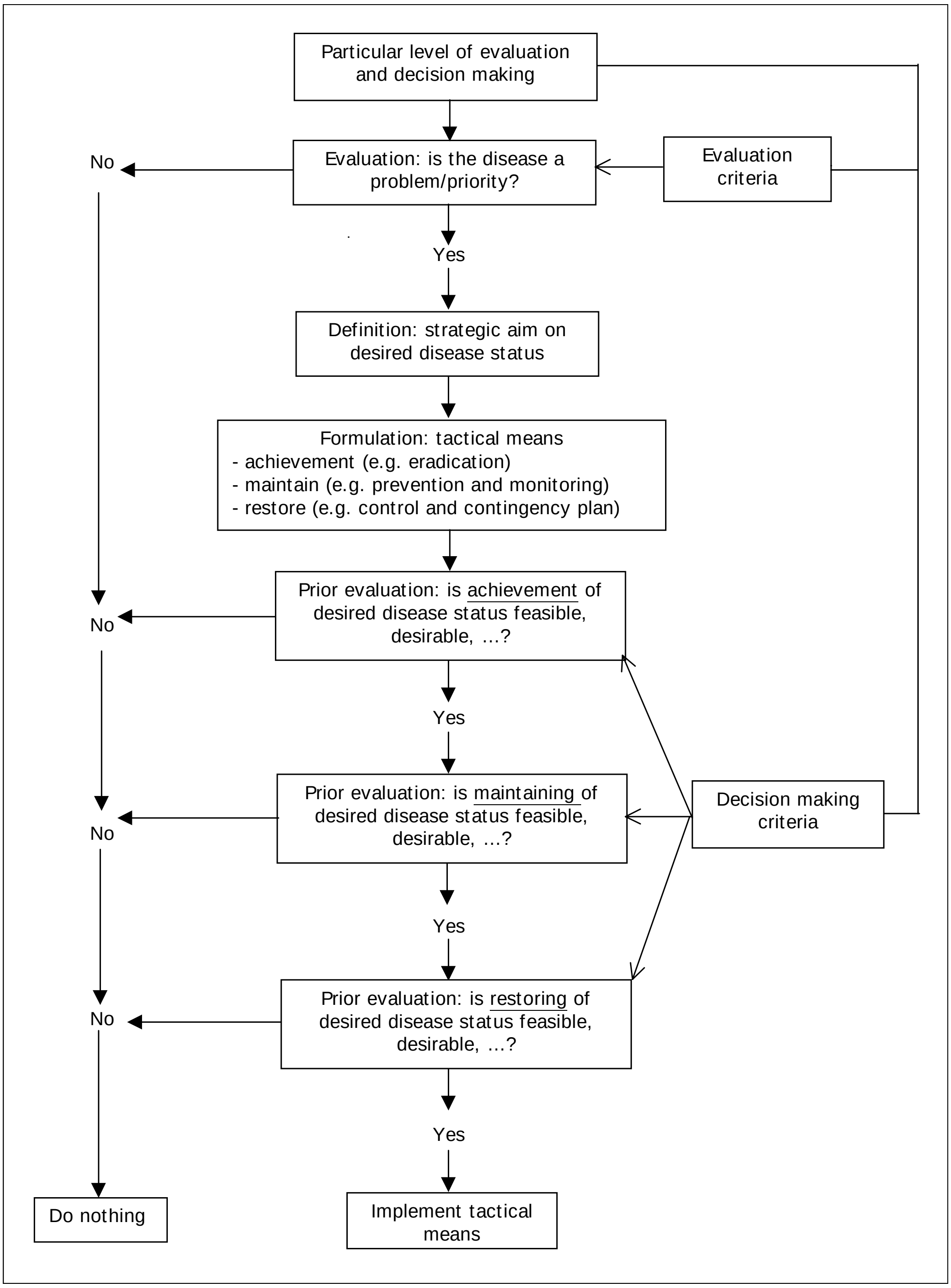
An important consideration before any regional or national disease eradication programme is to establish an appropriate partnership between and commitment towards the programme from all stakeholders concerned. This point is made in the Animal Health and Welfare Strategy for Great Britain (Defra et al., 2004). This may partly explain why BVDV can be successfully eradicated from a relatively cohesive and geographically isolated community such as the Shetland islands (Synge et al., 1999) but not from France or mainland Great Britain for example. It should be appreciated that farmers and the farming community are not the only beneficiaries of BVDV eradication due to the removal of considerable ‘externalities’. If the eradication programme is sufficiently widespread such that supply of animal products is significantly increased, then product prices are likely to fall to the detriment of farmers, particularly those who were free of BVDV in the first place. The major beneficiaries will then be consumers who pay less for animal products. This situation is explained in the context of hypothetical eradication of Johne’s disease from the USA by Losinger (2005).

4.6. Conceptual and theoretical considerations on endemic disease control in general and BVDV control in particular

4.6.1. General framework for decision making on disease control and prevention

In figure 1, a general framework for decision making on livestock diseases, currently present in a population, is presented. This can be applied at any level of decision making. Four distinct points of evaluation or decision making respectively can be seen.

Figure 1. General framework for decision making on livestock diseases currently present within a population.



The starting point is the definition of the level of evaluation and decision making, e.g. the farm, the livestock sector or society as a whole. For each level, particular criteria for evaluation and decision making can be derived, such as veterinary criteria, farm economic criteria and social criteria (for an elaboration: see Chapter 3).
Starting question is: can the disease be regarded as a problem and should this problem be given priority? Depending on the appropriate evaluation, their weights and consequently their ranking, this question can be answered either positively or negatively. In the latter case, i.e. if the disease is not regarded as a problem and/or a priority, then the status quo (i.e. do nothing) is the logical outcome. In contrast, a positive answer should be followed by the definition of a strategic aim, i.e. the desired disease status. Subsequently, formulation of the tactical means to achieve, maintain and, if required, to restore (e.g. in case of new disease outbreaks) this disease status should be carried out.
Next steps are prior evaluations of the following issues:
- is achievement of the desired disease status feasible and/or desirable given specific decision criteria;
- is maintaining this disease status feasible and/or desirable;
- is restoring this disease status feasible and/or desirable.

These prior evaluations should be subject to specific decision criteria. If all evaluations are positive, implementation of the tactical means, control and eradication of the disease, should follow. However, if one or more of the evaluations results in a ‘no’ answer, the ultimate result will be: do nothing.
It should be noted that several different strategies for eradication, prevention and control can be subject to these prior evaluations, out of which some can be suitable and some not.

From this framework, the following list of **requirements for economic decision making** can be derived:
- the **levels** of evaluation and decision making which can or should be considered;
- the evaluation and decision making **criteria** associated with these levels;
- a definition of the desired disease status (i.e. the **strategic aim**) per level for which the disease is considered to be a problem and/or priority;
- formulation of **tactical means** to achieve, maintain and if necessary restore the desired disease status, e.g. eradication and control strategies;
- **methods** for prior evaluation of these tactical means.

4.6.2. Decision making on control and prevention of Bovine Viral Diarrhoea

In this section, the requirements listed above will be elaborated for BVD as specifically as possible. In most cases, the same approach is applicable to other diseases as well. Part of the information used in this section results from discussions within the Thematic Network.

4.6.2.1. The levels of evaluation and decision making

With regard to BVD, the following levels of evaluation and decision making were identified:
- the farm level, with the farmer as decision maker;
- the livestock sector at the regional level, with some form of regional sector authority as decision maker, e.g. a regional farmers’ cooperative or union;
- the livestock sector at the national level, with some form of national sector authority as decision maker, e.g. a national union or product board;

– the society, with the national government as decision maker.

Currently, in most EU countries the farm level is the predominant level of decision making: the farmer decides whether or not (s)he will participate in a voluntary control and prevention program, initiated at the farm level, or higher.
The regional sector is only applicable in larger countries, such as the United Kingdom (UK), Germany and France. In these countries, the livestock sector within the region has some kind of autonomy. With regard to the region, specific aspects can be considered, such as epidemiological isolation (e.g. the Shetland and Orkney Islands within the EU), socio-demographic aspects (e.g. in Brittany in France) or the political structure of the country (e.g. the Länder in Germany). Indeed, in some EU countries, evaluation and decision making on BVDV at the regional sector level can be observed, e.g. The Shetland Island and Orkney Islands in the UK and Brittany in France. Semi-mandatory eradication programs were carried out during the last couple of years.
In the Scandinavian countries Norway, Denmark, Sweden and Finland, BVDV is regarded as a problem of the national sector or even a priority for society (a clear distinction cannot be made in these cases). In these countries, mandatory control and prevention programs currently are running.
It can be observed that voluntary programmes are only applied if the decision making level is the farm level. At higher levels, (semi-)mandatory programmes eventually have to be applied, although there are examples where such large-scale programmes have been voluntary at the onset.

4.6.2.2. Evaluation and decision making criteria

4.6.2.2.1 Evaluation: is BVDV a problem and should control and prevention be given priority?

In Table 1, evaluation criteria for the four levels are presented. These evaluation criteria can be derived e.g. from (panel-) interviews or questionnaires focused on goals and preferences with groups of stakeholders, relevant for the particular level of concern. In principal, both evaluation and decision making criteria are not related to the disease as such, i.e. can be applied to any livestock disease; in the application of these criteria, the impact a disease has on the particular criteria is valued, as will be explained later.

Table 1. Levels of evaluation and accompanying evaluation criteria for BVDV.

Evaluation criteria	Evaluation level			
	Farm	Sector/region	Sector/national	Society
Veterinary	+	+	+	+
Farm economic	+	+	+	+
Sectoral/regional economic		+	+	+
Sectoral/national economic			+	+
National welfare economic				+
Ethical/animal welfare	+	+	+	+
Social		+	+	+
Food security and safety				+
International situation	+	+	+	+

Note: although food security and safety is an evaluation criterion for society, in the case of BVDV it is not applicable

At the farm level, primarily veterinary criteria (e.g. morbidity and mortality), economic criteria (e.g. losses due to BVDV, compared to losses due to other diseases) and ethical and animal welfare criteria are important.
At the sector level within a region, also (regional) social criteria can be of importance (e.g. because of a close link between the regional society and the livestock producers). Moreover, regional economic criteria should be included, mainly for two reasons. First, BVDV can have a negative impact on the regional cattle sector as a whole, i.e. all farms within the region are affected somehow. Second, if there is a variation in economic impact of BVDV on farms within the region, in some cases a collaborative approach can be regarded as the most appropriate way of dealing with the disease.
With regard to the national sector, the same holds as for the regional sector (note: in small countries like e.g. The Netherlands, there is no distinction between both), however also national sector economic criteria should be included.
Evaluation at the level of society as a whole should consider preferences of all members of society, i.e. also those not directly involved in livestock production. Hence ethical/animal welfare and food security and safety evaluation criteria should be included as well (note: with regard to BVDV, there is until now no evidence of BVDV endangering food safety and security, hence these criteria can be disregarded).
Self evidently, international requirements (e.g. requirements regarding freedom of BVDV if OIE listed) are an evaluation criterion at all levels.

4.6.2.2.2 Decision making on prevention and control of BVDV.

Decision making deals with allocating scarce resources in such a way that the maximum level of satisfaction is achieved. The latter is subjective by nature, because each individual has a different ranking of preferences or criteria which should be fulfilled. Hence, decision making deals with making choices (e.g. complete eradication of BVDV versus only reduction of the impact of the disease) and allocating resources to achieve that goal (e.g. participation in a control programme, either with or without use of vaccines, etc.)
'Decision maker' in this respect can be defined as: the person or body who owns the decision problem and is actually responsible for deciding what to do about it and in which way this should be done. In the case where several levels regard BVDV as a problem, probably the highest level of aggregation will be 'appointed' as the decision maker. However, it is also imaginable that a lower level is appointed, and facilitation from higher levels will take place.(This is the general thrust of the approach to endemic animal disease control in Great Britain set out in the Animal Health and Welfare Strategy (Defra et al., 2004)).
The goals or strategic aims will be elaborated in the next paragraph.

When it comes to decision making on animal health, usually these decisions affect various aspects of animal production, i.e. these are multi-criteria decisions. Each decision taker (i.e. the decision maker) or stakeholder however has different priorities and preferences with regard to these criteria, hence weighing between the various decision criteria is inevitable.
The following decision criteria can be identified (it should be realized that each criterion can be broken-down further into several so-called sub-criteria or indicators (Huirne et al., 2002), not described here):

- veterinary criterion: the ability of a strategy to (1) achieve, (2) maintain and (3) restore the desired BVDV status;
- farm-economic criterion: the ability of a particular strategy to be financially profitable and hence will contribute to the farms net profit (i.e. the benefit/cost-ratio of the strategy and the expected time to return on investment);

- welfare-economic criterion: the ability of a strategy to contribute to an increase in Gross Domestic Product (GDP), i.e. to enhance the efficiency of cattle production;
- international feasibility criterion: the likelihood that a strategy is in compliance with international (legal) obligations of a particular country, and if not, that implementation of that strategy would not have adverse effects for the country;
- international-economic criterion: the possible effects of a strategy in a particular country for other countries;
- ethical or animal welfare criterion: the ability of a strategy to improve animal welfare;
- ecological criterion: the effects of a strategy on the environment, nature and biodiversity;
- psychological criterion: the effects of a strategy on the mental situation of those affected;
- food security and safety criterion.
- distortion criterion: the possible adverse effects of a strategy on daily life, e.g. reduces mobility of people.

Not all decision criteria most likely will apply to every level of decision making. In table 2, an overview is presented of relevant decision criteria for separate levels of decision making.

Table 2. Levels of decision making and accompanying criteria for BVDV.

Decision criterion	Farmer	Regional sector	National sector	Government
Veterinary	+	+	+	+
Farm economic	+	+	+	+
Regional economic		+	+	+
Sector economic			+	+
National welfare economic				+
International feasibility		+	+	+
International economic				+
Ethical/animal welfare	+	+	+	+
Psychological	+	+	+	+
Ecological				+
Food safety and security				+
Distortion				+

4.6.2.3. Definition of desired BVDV status

Given the four levels of decision making distinguished above, the following strategic aims regarding the desired BVDV status can be defined:

- the individual farmer: if (s)he considers BVDV as a problem, the aim would be to achieve and maintain a BVDV-free status of the farm, preferably accompanied with a certificate. Alternatively, a farmer could also aim at merely a reduction in the impact of BVDV without complete eradication from the herd;
- the regional sector authority: if BVDV is regarded by all farmers within the region as a collective problem, or if a collective approach to BVDV would be more economical from a regional point of view, decisions on BVDV should be made by the appropriate regional

sector authority, aimed at eradication of BVDV throughout the region, either or not accompanied with some kind of official status;
- the national sector authority: the same as for the regional sector authority;
- the national government: if the (supra-)national society regards BVDV as a problem, the national government should aim at eradicating BVDV from the country, most likely supported by some kind of legislation, aiming at the status of officially free of BVDV.

A key issue in this respect will be the degree in which control of BVDV can be approached 'voluntarily'. Basically this will come down to the question: will freedom of BVDV be given a (semi-)official status, without which also other farmers beside the affected ones will be confronted with (e.g. trade restrictions at regional or national scale). The most profound way in this respect will be BVDV regarded as an OIE listed disease. If so, either the national sector or the government will have to take the initiative; if not, other levels of decision making also are possible.

4.6.2.4. Tactical means to achieve, maintain and restore the desired BVDV status

Tactical means refers to ways to control or eradicate, prevent and monitor BVDV. In practice, no clear distinction between these three is being made: all approaches include elements of each other. Moreover, all practically applied approaches include combinations of the single measures described below. However, a distinction should be made if the BVDV-status of a particular farm affects other farms within the region or country.

4.6.2.4.1 Means to achieve freedom from BVDV

Regardless of the level of decision making, prime focus should be on the individual farm because of the current endemic nature of BVDV. Throughout Europe, farmers practice different ways to achieve freedom of BVDV, either in co-operation or independently:
- participation in a test-and-cull based eradication program focused on culling permanently infected (PI) animals, as these animals are the prime source of maintaining BVDV within the herd;
- vaccination against BVDV, aimed at either eradication or at reducing the clinical impact of the disease (note: this latter option will not result in freedom of disease);
- enhanced bio-security of the farm, aimed at preventing BVDV being (re-) introduced on the farm.

4.6.2.4.2 Means to maintain freedom from BVDV

Basically, increased bio-security is the predominant way of trying to prevent BVDV from introduction once eradicated, be it at the level of the individual herd or at a wider level. This could be accompanied by vaccination, although this is not regarded as sufficient.
Monitoring the disease-free status is regarded as a necessary accompanying measure, particularly if this status is (semi-)officially recognized. Moreover, monitoring is a means to detect at a preferably very early stages re-introduction of BVDV.

4.6.2.4.3 Means to restore freedom from BVDV

In case of reintroduction of BVDV on a **farm**, the farmer can decide to re-start the same procedure as with achieving freedom of BVDV; this could take approximately one year. However, at regional or higher levels, the situation can be more complex, if the (semi-)official BVDV-status of the **region or country** will be changed after reintroduction of BVDV at only one particular farm; this will be the case e.g. if BVDV is regarded as an OIE listed disease. If this change of status will result in e.g. trade restrictions or other adverse effects for not only the farm affected, lots of other, non-affected farms will also be confronted with adverse effects as long as this change of status remains in power. Both the magnitude of the adverse effects, as well as their duration, are determining factors in such cases. As a consequence, a rapid regional or national eradication of BVDV could be desirable, in which case more rigid disease control measures would be considered.

4.6.2.5. Economic methods for prior evaluation of means and strategies

In terms of methods for economic evaluation of means and strategies for control, a distinction can be made between methods focussing on a part of the decision making problem and those claiming to be more comprehensive. The former include issues such as diagnostic tools, vaccination, epidemiology and clinical trials to study the veterinary and zoo-technical impact of BVDV, all based on more or less real-life experimentation, veterinary-epidemiological data analysis and clinical trials. Other WorkPackages within the Thematic Network deal with these issues.

A comprehensive study primarily focused on decision making should integrate all these separate issues, and should include socio-economic aspects as well. Real-life experimentation in such cases becomes quite difficult. If real-life experimentation is undesirable or even impossible, costly or disruptive, and also if strategies or approaches have to be evaluated which have not been applied yet, computer simulation (i.e. veterinary-economic modelling of BVDV) is an attractive alternative (Dijkhuizen and Morris, 1979). Since fundamentally different situations can be distinguished, various integrated approaches should be applied, depending e.g. on the level of decision making (on-farm simulation models should include different aspects compared to e.g. sectoral models), the strategic aims (eradication, monitoring), etc.

4.7. Financial-economic considerations with regard to the eradication, prevention and control of Bovine Virus Diarrhea Virus

Despite the fact that decision making on BVDV can or should be regarded as a multi-criteria decision problem (see above), the financial-economic impact of BVDV is of utmost importance for all decision making levels considered. Therefore, particular attention should be given to this issue.

Starting from a current situation of endemic BVDV, be it on a farm or within a region, three distinctive periods should be considered, irrespective of the economic level:

- the period until achieving the BVDV-free status, be it on the farm, within the region, within the sector or the country;
- the period of maintaining the BVDV-free status;
- the period after possible reintroduction of BVDV until restoring the normal disease-free status.

The first period can be regarded as a period of investment, e.g. in BVDV eradication, monitoring, bio-security, etc. Financial-economic aspects of prime importance are: the costs of the eradication programme.

The second period can be regarded as ‘return on investment’, e.g. by increased production efficiency, higher product prices, etc. (although it is possible that prices may fall as explained

above, see Losinger (2005)). Basically, some kind of Benefit/Cost-Analysis (BCA) could provide insight into the economic impact of eradication of BVDV.
Additional to both periods, other costs should be considered as well: costs for monitoring and costs for increased bio-security. The first are usually an integral part of an eradication and control program, the latter can be regarded as 'fixed costs' to reduce the probability of re-introduction of BVDV.
With regard to the third period however, the economic impact very much depends on factors such as the economic level considered, the impact of the control measures, possible changes in status and accompanying trade restrictions, etc. E.g. for re-introduction on a farm only the farmer is confronted with the adverse consequences, whereas re-introduction within a region could have adverse consequences for all farmers within that region if trade restrictions are imposed. Moreover, crucial will be the types of products on which such restrictions are imposed.

The financial-economic impact of BVDV, particularly in case of re-introduction, largely depends on the following factors:
- the economic level considered;
- the definition of the 'normal' disease-free situation;
- the effect of reintroduction of BVDV on this normal situation, particularly for other farmers, i.e. will this result in some kind of trade restrictions and if so, which products will be affected (animals, products such as meat and dairy products, semen, etc);
the control strategy applied in trying to restore the normal disease-free situation.

In table 3, an overview of the financial impact of occurrence of BVDV in different situations in presented. The first column (BVDV present but varying in degree per farm) reflects more or less the current situation, i.e. BVD being basically endemic and not subject to control at a larger scale. In such a situation, economic theory explains that farmers affected face a loss, and those that are not have a comparable gain. Both consumers and society will have a comparable loss due to higher prices and less efficient use of resources.
However, if the status of BVD will be changed from an endemic disease to a disease which is eradicated in certain areas (can or will have consequences at a higher level, i.e. non-affected farmers within a region or country), some financial-economic consequences can change. This particularly depends on the type of measures imposed after re-introduction of the disease within that larger area to control BVD, i.e. either or not trade or transport restrictions, and the type of products included in such measures. Hence, it should be realized that collective measures for control/eradication could have financial-economic implications for non-affected herds.

Table 3. Financial-economic impact of BVDV in different situations with regard to economic level considered and (changes in) BVDV status.

Economic level	BVDV status, confirmation of this status and possibilities for trade restrictions			
	BVDV present but varying in degree per farm	BVDV-free within the region, present in the rest of the country	BVDV-free within the country	BVDV-free within the country
	Not or with farm certificate	Not or with (only regionally or nationally recognized) regional status	Not or with (only nationally recognized) national status	Officially recognized national status OIE-List B
	Only voluntary between-farm restrictions, based on BVDV-free certificate	Voluntary/mandatory within region between-farm restrict-ions, based on BVDV-free	Yes, within the country but no export restrictions	Yes, within the country and export restrictions
BVDV affected individual producer	A direct relation between degree of BVDV and economic losses.	Financial losses depend on control strategy, compensation payments and impact of BVDV.	Financial losses depend on control strategy, compensation payments and impact of BVDV.	Financial losses depend on control strategy, compensation payments and impact of BVDV.
BVDV non-affected individual producer	Financial advantage compared to BVDV affected producers.	Financial losses depend on the degree and impact of trade restrictions and products affected; in case no trade restrictions, financial advantage compared to BVDV affected producers.	Financial losses depend on the degree and impact of trade restrictions and products affected; in case no trade restrictions, financial advantage compared to BVDV affected producers.	Financial losses if trade restrictions are imposed, depending on the type of products involved, particularly in net-exporting countries.
Regional cattle sector	Due to price adjustment no relation between degree of BVDV and income of cattle farmers.	Financial losses depend on control strategy, compensation payments and impact of BVDV.	Not applicable	Not applicable
National cattle sector	Due to price adjustment no relation between degree of BVDV and income of cattle farmers.	Due to price adjustment no relation between degree of BVDV and income of cattle farmers.	Moderate loss, depending on control strategy, compensation payments and impact of BVDV.	Significant loss particularly for net-exporting countries, resulting from price drops on domestic market.
Agri-industry	Note	Note	Note	Note
Consumer	Economic loss due to less-efficient production and higher prices.	Hard to determine	Hard to determine	Incidental advantage if trade restrictions distort markets, particularly in net-exporting countries
National economy	Economic loss due to less-efficient production and less-efficient use of resources.	Hard to determine	Hard to determine	The aggregated effect is hard to determine

Note: it is assumed that price changes are passed on to the consumers fast and completely, therefore possible effects are not specified.

4.8. Discussion and conclusions

In this section, the main findings of the reviewed literature (4.5) are put into the broader perspectives of decision making (4.6) on the control and prevention of BVDV. This is done from two perspectives: the individual farm and the livestock sector.

4.8.1. Is BVDV an economic problem?

The case studies described in section 4.5.1 indicate that introduction of BVDV into naïve herds with unprotected animals can cause great financial-economic costs, i.e. large adverse consequences. Ahl et al. (1993) define risk as the probability of occurrence of an adverse event times the consequences of that event. However, neither the studies described in this section, nor others, provide an indication of the probability of occurrence. Therefore, in terms of decision making under risk, the value of these case studies is rather limited. What they do indicate is, that the potential economic danger of BVDV introduction on farms is great, and should not be neglected. In other words, BVDV is a potential threat or problem, which cannot be disregarded but should be studied further (see: Figure 1). Today, realistic estimates on the incidence of new infections can be retrieved from ongoing control programmes (see work package 2).

The average yearly on-farm direct losses estimated in the studies described in section 4.5.2 showed, that BVD is potentially an important economic livestock disease. Estimations of the direct losses for the national livestock sector, described in section 4.5.3, confirm this. However, this importance most likely is less than mastitis or lameness. The question remains if the direct losses estimated are avoidable or not. In contrast to e.g. mastitis and lameness, BVDV can in principle be eradicated, either on an individual farm or within the entire sector. This implies that in principle these losses are avoidable, provided the eradication is complete and lasting (i.e. no re-introduction of BVDV in the long run). In that case, these (avoidable) losses estimated should be set against the additional expenses required to obtain complete and lasting eradication, e.g. costs for eradication, monitoring and certification and prevention. In case re-introduction of BVDV cannot be excluded, the total costs of such a re-introduction (i.e. losses due to the disease and control costs) should be subtracted as well. On the other hand, possible reduced indirect losses due to reduced incidence of other diseases because of the eradication of an immunosuppressive agent (BVDV) should be taken into account as well. Hence, an estimation of the ‘true’ avoidable losses at the farm level is still lacking. Nevertheless, although the magnitude of this problem still is not completely clear, the studies described clearly indicate BVD as a financial-economic problem, both for farmers and for the entire livestock sector. In a broader economic context, not only these financial-economic aspects are part of the problem, but also (see: Table 1): veterinary aspects (morbidity, mortality) and animal welfare aspects; from the perspective of the livestock sector, also the international situation can be included if other countries are BVDV-free and possible trade restrictions could be the case if BVDV is still present. (Economics can estimate the financial impact of non-market goods such as animal welfare using a variety of techniques (e.g. Bennett, R., and Blaney, R. (2003) and these can then be included in the decision support CBA).

Based on the studies dealing with the estimation of losses due to BVDV, it can be concluded that BVDV is an economic problem for livestock owners and the sector as a whole, both for

financial-economic and other reasons such as veterinary and animal welfare. Sero-epidemiological evidence shows, that this most likely holds for most EU member states.
A clear indication of the magnitude of this problem, e.g. in terms of 'true' avoidable financial-economic losses, cannot be derived from these studies. However, the studies do suggest that it is reasonably safe to classify BVD as being one of the important livestock diseases after mastitis, lameness and fertility disorders in most of the EU member states.

4.8.2. Should BVDV be given priority from an economic point of view?

Considering BVD as an economic problem in the broader context, the next question which should be addressed (see: Figure 1) is: should solving the BVDV problem be given priority? In other words, is BVDV such a big problem to the individual farmer or the livestock sector, that allocation of scarce farm or sector resources to BVDV is justified above such an allocation to solve other problems, be it disease problems or others? This implies, that an BVDV control program with a BCR above 1 is not an economic justification of adopting this program, because other projects or investment could contribute more to the benefit of the decision maker. Based on the studies described in sections 4.5.1 to 4.5.3, the question raised above can not be answered, neither for the farm nor for the sector level. Other scientific literature addressing this issue could not be found either.

As pointed out earlier, ideally a MCA including the various decision options and criteria should be carried out to answer the above raised question. Alternatively, CBA at the farm level or Social Cost-Benefit Analysis (SCBA) for the sector or country (as proposed by Bennett and Done (1986)), could be carried out. Examples of such analyses have not been published so far.

What can be observed, however, is that in some countries the livestock sector has given priority to BVDV control. The Nordic countries and parts of Germany, Austria, Great Britain, France and Italy have started eradication programs. Apparently, these countries/regions perceived BVDV as such a big problem and/or threat, that priority could be justified. Arguments in favour were (see: e.g. Valle et al. (2005), Lindberg (2003) and Greiser-Wilke et al. (2003)): (1) the presumed economic losses based on CBA-studies, (2) the possibility of indirect veterinary and economic effects due the immunosupression, (3) the veterinary effects in terms of morbidity and mortality, and (4) the animal welfare effects. These programs have proven to be successful in eradicating BVDV in Norway, Sweden, Finland and Denmark. Nevertheless, a sound economic justification for allocating the scarce resources to BVDV instead of other problems of the livestock sector could not be found. Moreover, Dufour et al. (1999) concluded the opposite.
Also, it can be observed that individual farmers throughout the EU join voluntary BVDV control programs.
Hence, it can be concluded that eradication of BVDV has been given priority in quite some cases. However, a clear science-based economic justification can not be found in the literature, and should therefore be investigated.

4.8.3. Is achievement of eradication of BVDV feasible from a financial-economic point of view?

All studies reviewed agree on at least one thing: BVDV has adverse economic effects, i.e. the average losses associated with the disease are substantial, and in incidental cases outbreaks can cause even large losses. It seems also safe to state, that in most cases, the costs associated with the eradication are less than the long term benefits in terms of increased production efficiency. This holds for both individual farms (sections 4.5.1, 4.5.2 and 4.5.4) and the sector level (sections 4.5.3 and 4.5.5). An important assumption to this statement is: re-introduction of BVDV is disregarded, and hence also the costs associated with reducing this re-introduction. This issue will be addressed in the next section.

4.8.4. Is maintaining of the BVDV-free status feasible from a financial-economic point of view?

After obtaining the status of BVDV-free, the pay-back period starts, and the longer this period is, the higher the BCR of eradication. However, both individual farmers and the livestock sector should face the possibility of re-introduction of BVDV. In order to limit this probability, additional bio-security measures are required, which have financial-economic implications. The latter can be quite county or region specific. In favourable, more isolated regions, these costs can be relatively low, e.g. in the Nordic countries and isolated areas such as the Shetland and Orkney Islands. Other, more continental areas, face a higher risk of re-introduction of BVDV, i.e. higher costs for prevention.

The existing literature does not explicitly address the costs for prevention of introduction of BVDV. However, Dutch studies (e.g. Groenendaal and Horst (2000) and Saatkamp et al. (2005), which focus on combined efforts to eradicate BVDV and maintain freedom of BVDV at the herd level, indicate that in these conditions, eradication and prevention at the herd level can be questioned.

This raises the question if a joint effort, e.g. at the regional level, to eradicate BVDV and maintain freedom of BVDV, is not a better solution. In the Nordic countries, such an effort proved to be rather successful. However, program costs and bio-security costs were relatively low. The question if this holds also for ‘less favourable’ countries cannot be answered based on the existing literature.

4.8.5. Is restoring the BVDV-free status feasible from a financial-economic point of view?

Facing the risk of re-introduction, the last question to be answered is: is restoring BVDV-freedom sensible in case introduction has occurred at a farm or in a region? Farm level studies for The Netherlands indicate, that if the probability of re-introduction is relatively high, the answer would be negative, particularly if the sero-prevalence at re-introduction is rather low. In such cases, the losses associated with re-introduction are quite high (see e.g. Groenendaal and Horst (2000) and Saatkamp et al. (2005)).

At the sector level, an additional criterion for consideration will be: what is the international situation? If all surrounding countries and/or trade partners will have a BVDV-free status, the pressure for regaining freedom of BVDV will be high. Also from a financial-economic point of view, because possible trade restrictions will caused additional economic losses on top of the production losses.

However, an explicit answer to this question based on the current literature cannot be given.

4.9. Requirements and availability of methods and data to evaluate control and prevention strategies/scenarios against Bovine Virus Diarrhoea Virus

With regard to future decision making, insight into two issues is important:
- Is BVD a problem and should it be given a priority?
- What is the veterinary and financial-economic impact of control/eradication, prevention and monitoring?

For both questions, of course, the level of decision making should be the start of the exploration.

4.9.1. Identification of the problem and priority setting

As described above, elicitation of evaluation criteria and their comparative weights can be useful in problem identification and priority setting procedure. In Tables 1 and 2, evaluation and decision making criteria for BVDV are listed. Particularly for evaluation and decision making levels higher than the farm level, these criteria should be more elaborated (inclusion of e.g. sub-criteria or indicators). Moreover, and this holds particularly for evaluation at the level of society and decision making at national level, weighing and ranking of these criteria is important. Only then, a comprehensive evaluation is possible.
For BVDV, such information is not available yet. However, because these criteria are not strictly disease dependent, use can be made of other studies. Huirne et al. (2002) described such an approach and data for FMD. Hence, basic methodology is available, and some basic data as well.
Such formal procedures are usually quite elaborative, however. At the farm level, interactive and implicit communication between farmer and advisors (i.e. his/her vet) is usually sufficient to reveal whether or not controlling BVDV should be given attention. At higher levels of decision making, a more explicit discussion involving all relevant stakeholders is the minimum which is required. Use of ‘check lists’ based on Tables 1 and 2 will be very useful.

4.9.2. Prior estimation of veterinary and financial-economic impact of BVDV

For questions regarding prior estimation of the impact of disease, integrated epidemiological-economic simulation modeling has proven to be quite useful (Dijkhuizen and Morris, 1997). However, different levels of decision making require different approaches.

4.9.2.1. Farm level

In case the prime interest is control and prevention at the farm level, simulation models that mimic within herd spread of BVDV and its financial-economic impact, subject to different control and prevention scenarios, is required. Several of such model are currently available for BVDV:
Gunn et al. (2004) described a model for Scottish beef herds, estimating the losses associated with BVDV. With this model, an indication of benefits and costs of BVDV control can be obtained;
Gunn et al. (forthcoming) adapted this model for Scottish dairy herds;

Groenendaal (1998) developed a decision support model estimating the B/C-ratio of BVDV control for Dutch dairy herds. This model was later adapted to new and more sophisticated BVDV control programmes (Saatkamp et al., forthcoming).
All these models focus only on BVDV control and prevention in an isolated way, i.e. they only deal with the single question: is BVDV control and prevention as such financially-economic beneficial or not. The aspect of on-farm resource allocation is not considered. However, from a total farm management point of view, this is quite important because of limited resources available, i.e. competition between farm activities. Stott et al. (2003) addressed this issue for Scottish beef herds, using a combination of simulation modeling and linear optimization, a so called MOTAD approach (Minimization Of Total Absolute Deviation) (see: Hardaker et al., 1997).
With regard to farm level evaluation and decision making, several different tools are currently available. For application to farm and region specific situations, these tools have to be adapted further, which is currently being carried out (Gunn et al., forthcoming)

4.9.2.2. Regional and sector levels

If the prime focus of interest is extended beyond the level of the individual farm, not only estimation of the impact of control and prevention of BVDV for individual producers is required. E.g., prior evaluation of a regional or even more wider scale program requires insight in (1) the impact on between-farm spread and (2) the 'quality' of monitoring programs. In terms of model output parameters, this means: an estimation of the R_h (basic reproduction ratio of between-herd spread of BVDV, which should be less than 1 for effective programs) and an estimation of the probability of detecting BVDV-positive herds and the time between (re-)introduction and detection.
Examples of such models applied to other diseases have been described, e.g. for *Leptospira hardjo* (Graat et al., 2001; Saatkamp et al., 2005) and paratuberculosis (Roermund et al., 2005). These models have a generic approach, in principle allowing for adaptation to BVDV.

4.9.2.3. National level

For a comprehensive socio-economic prior evaluation at the national level, two issues should be included additionally. First, the impact of BVDV on national economic welfare, and second a comprehensive multi-criteria analysis including all decision criteria.
To estimate the impact on national economic welfare of re-introduction and subsequent control of BVDV within a country, only approaches for highly contagious diseases such as FMD and Classical Swine Fever (CSF) have been described so far, e.g. by Mangen and Burrell (2001) and Berentsen et al. (1991). Although adaptation of these models to BVDV requires re-parameterization (i.e. additional data collection), in principle these approaches can be used within serious problems.
Huirne et al. (2002) presented a comprehensive evaluation of FMD control and prevention strategies for The Netherlands. They applied a Multi-Criteria Analysis (MCA), to take account for all relevant decision criteria, e.g. also less easily quantifiable aspects such as animal welfare and psychological aspects of the decision problem. Again, this basic methodology is in principle applicable to BVDV.

4.10 Future outlook, research agenda and conclusions

4.10.1 Current state of the arts

The available veterinary and economic literature quite clearly shows, that BVD can have serious consequences at the farm level: both from the veterinary, animal welfare and financial-economic points of view. Moreover, experiences in the Nordic countries show, that on-farm and sectoral/national eradication of BVDV is possible. Hence, striving to achieve and maintaining eradication should be considered seriously for countries which still have an endemic situation with regard to BVDV.

Generally, two approaches are possible: voluntary and (semi-)mandatory. Voluntary approaches are directed towards the farmer, and hence should be in his/her interest. At the moment, basic veterinary and economic methodology is available to support farmers in this decision problem. However, the existing models still are quite area and/or situation specific, and should be adapted to the specific conditions for application. Although this is not as easy as often thought, this is possible with relatively limited resources and within a reasonably short period of time. Hence, on-farm decision support on control, prevention and monitoring of BVDV is not a major future constraint.

Semi-mandatory approaches at regional or national level include more aspects, as was illustrated, e.g. between-farm spread during eradication and after re-introduction and possible welfare aspects. To decide whether it is in the interest of a particular region or country to eradicate BVDV, basic methods specific for BVDV are not available. However, for other types of diseases they are, e.g. for Aujeszky’s Disease, Classical Swine Fever and IBR. BVDV-specific adaptation however requires quite some time and resources, particularly if various different conditions within the EU should be taken into account.

4.10.2 Driving forces in future decision making

Various driving forces in future decision making can be observed within the EU and beyond. First, official listing of BVD at the OIE list would require reconsideration of the BVD situation in countries in which the disease is currently endemic, i.e. the pros and cons of nation wide eradication. Besides mere disease specific aspects, also possible trade implications should be taken into account.

In some countries beside the Nordic countries, national eradication programs have started, e.g. in Austria. Although there is a common goal within these countries, possible trade effects are restricted within the country or between participating farmers.

In the remaining countries, BVDV is still dealt with on an individual basis, hence only farm specific arguments drive the decision on whether or not to tackle BVD or not.

From all three mentioned, the possibility of OIE listing is the major driving force in future decision making, and countries should anticipate on this, i.e. study the consequences of such a measure. To do such things properly, the outline of such a listing should be clear: what are the possible adverse consequences for farmers, regions and/or countries harbouring BVDV. Based on that, studies on the consequences and on the optimal ways of dealing with these can be carried out.

4.10.3 Main knowledge gaps

Given the above, particular emphasis should on studying the veterinary and financial-economic consequences of regional approaches to control BVD. This holds particularly for those countries in which the disease is still endemic and have not yet decided on going towards a sectoral or national eradication of BVDV, e.g. The Netherlands, Portugal and the United Kingdom.
Without 'outside' pressure (e.g. OIE listing), it should become clear for these countries what the consequences of either maintaining or improving the current BVDV situations are, and whether or not tackling BDVD should be given priority. Such studies should also facilitate decision making in anticipation of possible future changes in the international setting of BVDV.

4.10.4 Conclusions

From the above, the following conclusions can be drawn:

- BVDV can have a serious impact at individual herds: financial-economics losses, high morbidity and mortality, impaired animal welfare; this is particularly the case in naïve herds; hence, BVDV can be a serious disease problem from an economic point of view;
- Literature is less unanimous on the question whether BVDV is a such a big economic problem that addressing this problem is always justified; both at the herd and sector level, various studies conclude differently;
- Eradication of BVDV has been given priority in some countries (i.e. the Nordic countries) and has been successful in these countries; however, extrapolation of these decisions to other countries cannot be based on current scientific literature: in these countries, other conditions with regard to BVDV can exists, and other priority preferences might exist;
- A key question with regard to the decision to eradicate, maintain and eventually restore freedom of BVDV seems to be the probability of re-introduction; if this is rather low, or can be kept rather low at low costs, eradication programs will have a good chance to be economic feasible (hereby disregarding other investment allocation possibilities); however, if the probability of re-introduction is high and costly bio-security measures should be implemented to reduce this probability to acceptable levels, the financial-economic feasibility of an eradication program seems to be questionable;
- In areas with a high prevalence, a joint effort of all farmers to eradicate BVDV seems to be more sensible than efforts at the individual farm level; reduction of the risk of re-introduction of BVDV can be carried out at lower costs, whereas the benefits of this reduced risk will be for all farmers;
- Further research is required, particularly on the epidemiological and economics impact of BVDV control at the regional level; basic methodology is largely available, however adaptation to specific BVDV conditions is lacking.

4.11 References

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