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SCIENTIFIC REPORT

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Knowledge mapping of risk mitigation measures against vector-borne diseases

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The declarations of interest of all scientific experts active in EFSA's work are available at https://open.efsa.europa.eu/experts.

Abstract

A comprehensive synthesis of current evidence on surveillance, prevention and control measures for 25 selected vector-borne diseases (VBDs) affecting animals in the EU is presented here. The assessment integrates evidence from systematic literature reviews, modelling studies, field investigations and expert judgement. The aim is mapping the availability and effectiveness of risk mitigation measures (RMMs), including surveillance, movement restrictions, vaccination, culling, medicinal treatments, on-farm biosecurity and vector control. Of the 25 VBDs considered, 13 are listed under the EU Animal Health Law (AHL) and categorised according to disease control priorities, while 12 additional non-listed diseases were included based on vector presence and epidemiological relevance. Surveillance emerges as the most comprehensively documented mitigation category and is recognised as the cornerstone of VBD risk management. Evidence supports its critical role in early detection, situational awareness and timely response through integrated monitoring of hosts, vectors, pathogens and environmental drivers. Movement restrictions are supported by a moderate evidence base, primarily derived from modelling studies, indicating that they can reduce transmission under specific epidemiological conditions; however, their stand-alone effectiveness is difficult to quantify in real-world outbreaks. Vaccination shows high efficacy and effectiveness for several key VBDs, including African horse sickness virus, bluetongue virus, lumpy skin disease virus and Rift Valley fever virus, with substantial reductions in infection, morbidity and mortality. Evidence for culling is limited and highly disease-specific, and its effectiveness is generally contingent on the combination with other control measures. Medicinal treatments are limited to some groups of pathogens and demonstrate variable effectiveness, with emerging concerns regarding drug resistance. Biosecurity and vector control measures are supported by heterogeneous evidence, with chemical vector control showing robust entomological efficacy, but limited empirical data linking vector reduction to disease incidence. The report identifies key knowledge gaps and uncertainties across RMM categories and provides targeted recommendations for research to strengthen future VBD mitigation capacity in the EU.

KEYWORDS

biosecurity, movement restrictions, risk mitigation measures, surveillance, vaccination, vector control, vector-borne diseases

CONTENTS

SUMMARY

This document provides a comprehensive overview of the currently available surveillance, prevention and control measures for 25 selected vector-borne diseases (VBDs) affecting animals in the European Union (EU). It synthesises evidence from systematic literature reviews (SLRs), modelling studies, field trials and expert opinions to assess the efficacy of various risk mitigation measures (RMMs) including surveillance, movement restrictions, vaccination, culling, medicinal treatments, biosecurity practices and vector control. The report also identifies knowledge gaps and offers recommendations for future research to enhance VBD management.

Of the 25 VBDs, 13 are listed under the EU Animal Health Law (AHL) and categorised by disease control priority (categories A, C, D and E). Category A diseases (e.g. African horse sickness virus (AHSV), Rift Valley fever virus (RVFV), lumpy skin disease virus (LSDV)) require immediate eradication; category C diseases (bluetongue virus (BTV)) focus on preventing spread to disease-free areas; category D diseases (e.g. epizootic haemorrhagic disease virus (EHDV), equine infectious anaemia virus (EIAV), *Trypanosoma evansi (T. evansi)*) involve movement restrictions; category E diseases (e.g. *Coxiella burnetii (C. burnetii)*, West Nile virus (WNV)) require EU-wide surveillance. The remaining 12 VBDs are not currently listed but meet criteria for inclusion based on vector presence and epidemiological impact.

Surveillance of vector-borne diseases

Surveillance is emphasised as the cornerstone of mitigating VBD risks in livestock, enabling early detection and guiding timely interventions. It involves systematic tracking of hosts, vectors, pathogens and environmental factors to anticipate disease emergence. Risk-based targeting prioritises surveillance in vulnerable regions with established vectors or intense livestock movement. Vector surveillance includes mapping distribution, abundance, seasonality and pathogen testing, complemented by monitoring abiotic variables like temperature and rainfall to predict vector proliferation. Standardised case definitions and efficient communication channels facilitate rapid reporting. Analytical tools such as GIS and remote sensing support identification of hotspots and early warning systems. Surveillance data encompass vector competence, host species, diagnostic test performance, infectious periods, prevalence and pathogen survival in matrices.

Movement restrictions

Movement restrictions are moderately supported by evidence, primarily from modelling studies, showing they can reduce transmission of several VBDs such as African horse sickness virus (AHSV), bluetongue virus (BTV), Rift Valley fever virus (RVFV), lumpy skin disease virus (LSDV) and *Coxiella burnetii*. Effectiveness depends on vector dispersal patterns, presence of wildlife reservoirs, timing, zone size and compliance. While movement bans can delay or reduce spread, their standalone effect is difficult to isolate in field outbreaks due to concurrent control measures. Optimising restriction zones (e.g. 20 km control zones for BTV) can balance epidemiological benefits and economic costs. Empirical data on real-world effects of movement bans and animal movement patterns in the EU are limited and recommended for further research.

Vaccination

Vaccination demonstrates high efficacy and effectiveness for several VBDs with available data. Controlled trials, field studies and modelling confirm substantial reductions in infection rates, morbidity and mortality for diseases including:

- African horse sickness virus (AHSV): Live recombinant and attenuated vaccines provide up to 100% protection, significantly reducing mortality and infection risk; eradication achieved after high coverage vaccination campaigns.
- Bluetongue virus (BTV): Inactivated vaccines show 60%–100% infection reduction and 100% morbidity reduction in ruminants; vaccination limits transplacental transmission and reduces viraemia.
- *Borrelia burgdorferi s.l.* (Lyme disease): Recombinant vaccines in dogs show 73–100% efficacy in reducing infection and clinical signs.
- Lumpy skin disease virus (LSDV): Vaccination reduces infection risk and disease severity with efficacy ranging from 62% to over 97%, with Neethling strain-based vaccines generally providing better protection that sheeppox strain-based vaccines.
- Rift Valley fever virus (RVFV): Live-attenuated and inactivated vaccines provide full protection in trials; modelling indicates up to 90% incidence reduction with proactive vaccination.
- *Coxiella burnetii*: Vaccination reduces bacterial shedding and abortions but rarely achieves complete pathogen elimination; effectiveness is better when applied before pregnancy in seronegative animals.

Limitations include scarce efficacy data for emerging or non-listed VBDs, insufficient information on vaccine durability and cross-protection and variable effectiveness in zoonotic parasites like *Leishmania infantum*.

Culling

Evidence on culling as a risk mitigation measure is limited and disease-specific. Selective or total culling alone is often insufficient and more effective when combined with vaccination or other control measures. Summary findings include:

- *Borrelia burgdorferi s.l.*: No definitive evidence for culling wildlife; some studies show that deer population reduction decreases tick abundance.
- *Coxiella burnetii*: Targeted culling combined with vaccination contributed to control success; culling alone was ineffective in models.
- *Leishmania infantum*: Contradictory evidence; some field studies associate culling seropositive dogs with reduced incidence; others find no effect.
- Lumpy skin disease virus: Modelling and field experience indicate that culling clinical cases supports control but is less effective than vaccination; it requires zoning and movement bans.
- Rift Valley fever virus: Modelling suggests that culling within 20 km of cases is effective but involves large-scale animal loss.

Medicinal treatments

Medicinal treatments vary widely in availability and efficacy across diseases. Substantial data exist for *Leishmania infantum*, *Trypanosoma evansi* and *Trypanosoma vivax (T. vivax*), with treatments reducing morbidity or parasite loads but rarely eradicating infection. Drug resistance is an emerging concern, particularly for trypanosomes in endemic regions. Examples include melarsenoxide cysteamine hydrochloride is effective against surra disease in multiple species; diminazene diaceturate shows varied efficacy; resistance reported in some regions; combination therapies and alternative drugs like isometamidium chloride and ascofuranone demonstrate effectiveness in some contexts. Knowledge gaps include limited data on treatment impact on transmission and drug resistance trends, prompting recommendations for systematic monitoring and novel therapeutics development.

On-farm biosecurity measures

Biosecurity practices encompass farm management, pasture management, hygiene, reproduction management, animal movement and veterinary health management. Evidence from 92 studies indicates multiple protective and risk factors, though findings are heterogeneous and sometimes contradictory. Protective measures include quarantine, cleaning/disinfection during birthing and shelter access. Risk factors involve contact with other animals or herds, poor hygiene and certain grazing practices. Contradictory evidence exists for rodent control, indoor housing, species mixing and grazing types. Standardised EU-wide biosecurity scoring and research on compliance metrics are recommended.

Vector control

Chemical vector control has a robust evidence base with efficacy varying by vector species, chemical substance and application route. Substances such as fipronil, permethrin and deltamethrin show high median efficacy against mosquitoes, midges, ticks and sandflies. However, field evidence linking vector mortality to reductions in disease incidence is limited. Data on insecticide resistance are fragmented, and concerns exist regarding long-term sustainability amid climate change and ecological impacts. Recommendations include longitudinal field studies linking vector control to epidemiological outcomes, mapping insecticide resistance in EU vectors and testing integrated vector management approaches combining chemical, environmental and biological methods.

Knowledge gaps and research recommendations

Cross-cutting research priorities include:

- Developing harmonised EU-wide performance indicators and biosecurity scoring systems.
- Expanding experimental and field research on diagnostic accuracy and vector surveillance.
- Strengthening One Health integrated surveillance approaches.
- Conducting empirical studies on movement restriction effectiveness.
- Monitoring drug resistance emergence and evaluating treatment impacts on transmission.
- Mapping insecticide resistance and testing integrated vector management.
- Investigating vaccine durability, cross-protection and optimal vaccination timing under varying ecological conditions.

This report serves as a foundational synthesis of current knowledge on VBD mitigation in the EU, supporting ongoing monitoring and future EFSA risk assessment addressing risk mitigation strategies.

1 | INTRODUCTION

1.1 | Background as provided by the requestor

In the last two decades, the EU has been significantly affected by various diseases of animals transmitted by arthropod vectors ('vector-borne diseases'), such as mosquitoes (e.g. West Nile fever), biting flies (e.g. lumpy skin disease), ticks (e.g. Crimean-Congo haemorrhagic fever) or biting midges/*Culicoides* (e.g. bluetongue, epizootic haemorrhagic disease). The EU is also at risk of a wide range of serious vector-borne diseases such as Rift Valley fever or African horse sickness.

Recent data and epidemiological events show the increase of such vector-borne diseases (VBDs) either in the vicinity of the EU, in EU trading partners or within the EU, concomitant with the progressive widening of the geographical extent of competent vectors such as *Culicoides* and mosquitoes, some of them being able to transmit zoonotic pathogenic agents (e.g. *Aedes* and sandflies).

In April 2017, at the request of Directorate-General for Health and Food Safety (DG SANTE), EFSA published a scientific opinion on 36 VBDs, assessing their risk of introduction into the EU through movement of livestock or pets. This was considered a first screening, and it was already at that time recommended in the assessment that it should be updated.

In January 2020, also at the request of DG SANTE, and following reports of the occurrence of the disease in North Africa, EFSA published a scientific opinion on epidemiological update and risk of introduction of Rift Valley fever (RVF) into Europe.

Since 2018, 12 VBDs have been listed under the Animal Health Law (AHL) and categorised by Commission Implementing Regulation (EU) 2018/1882[1] under various categories of listed diseases, depending on the level of intervention and the measures taken at EU level, and with reference to their vector species.

Those diseases largely differ one from another, in terms of pathogenic agents, host species, vector species, as well as in terms of impact and zoonotic potential. However, it is relevant to consider them together as regards their specificity of being vector borne and what this entails in terms of risk assessment and risk management, in view of the relative rapid evolution of the geographic distribution of vectors concerned.

It is relevant to ask support from EFSA and the relevant EU Reference Laboratories to analyse the situation and get scientific advice assessing animal health risks linked with VBDs. The scientific advice should address in particular the likelihood of introduction of new VBDs in the EU and of spread of VBDs currently affecting the EU, the role of climate evolution in this introduction or spread and the potential evolution of the virulence or transmissibility of those VBDs. Considering the zoonotic nature of some of these VBDs, work in cooperation with European Centre for Disease Prevention and Control (ECDC) appears relevant too.

This piece of scientific advice should explore and propose options to mitigate the risks of introduction and to address the suitable surveillance, prevention and control of VBDs in the EU, including through vaccination.

1.2 | Terms of Reference as provided by the requestor

In the light of the above:

1 In accordance with Article 31 of Regulation (EC) No 178/2002, the Commission requests EFSA to provide scientific and technical assistance on the epidemiology of VBDs; the following aspects are of particular relevance for the scientific reports:

1.1 Provide a mapping/horizon scanning/compilation/description of the VBDs that are currently listed in the EU AHL (hereafter 'listed VBDs'), as well as other VBDs not listed but formerly assessed and deemed to have a potential impact and therefore deserving attention (hereafter 'non-listed VBDs'), including their geographic distribution in the EU, neighbouring regions or other regions presenting a particular risk due to epidemiological considerations.

1.2 provide a mapping/horizon scanning/compilation/description in the EU and neighbouring countries of the currently known, as well as potential new, vectors competent for 'listed VBDs' and 'non-listed VBDs'.

1.3 provide a mapping/horizon scanning/compilation/description of the currently available surveillance, prevention and control measures for listed and non-listed VBDs in the EU; this includes the collection of data on the efficacy of these measures (e.g. vaccination efficacy, efficacy biocidal treatments or repellents, animal treatments or insect nets or other husbandry practices);

1.4 Describe the potential pathways for listed and non-listed VBDs currently present in the EU to spread, and those not currently present in the EU to be introduced, including via intra EU movements or entry into the EU of animals, products of animal origin, plant material or means of transport, equipment, packaging materials, transport water and feed and fodder and other material, carrying viruses and/or vectors; and

1.5 Monitor the geographic spread and potential impact of listed and non-listed VBDs already circulating in the EU, considering among others their transmissibility (per se or linked to vector activity), virulence and zoonotic potential. The monitoring will include:

1.5.1 Yearly update of the mapping requested in 1.1, 1.2 and 1.3;

[1]Commission Implementing Regulation (EU) 2018/1882 on the application of certain disease prevention and control rules to categories of listed diseases and establishing a list of species and groups of species posing a considerable risk for the spread of those listed diseases. OJ L 308, 4.12.2018, p. 21.

1.5.2 Six-monthly newsletter with important highlights about possible changes in distribution, transmissibility, virulence or zoonotic potential of listed and non-listed VBDs inside or outside the EU;
1.5.3 Contribution to monthly automated West Nile fever monitoring reports in collaboration with ECDC.

2 In accordance with Article 29 of Regulation (EC) No 178/2002, the Commission requests EFSA to provide a scientific opinion on the risk posed by VBDs for the EU; the following aspects are of particular relevance for the scientific opinion:
2.1 Assess the probability of introduction (i.e. the probability of entry of the pathogen from extra or intra EU origin, exposure and establishment) of listed and non-listed VBDs identified in 1.1, into previously free EU Member States, considering the relevant pathways identified in 1.4; describe possible options to prevent such introduction.
2.2 Assess the extent of spread of listed and non-listed VBDs in the previously free EU Member States, after local transmission has taken place, with a potential expected timespan for this spread.
2.3 Assess the impact of the introduction and potential further spread of listed and non-listed VBDs during 1 year after the introduction.
2.4 Critically assess the currently available risk mitigation measures for VBDs in the EU, in particular different biosecurity and surveillance systems, regionalisation and vaccination tools; and
2.5 Assess the need for the development of these and further measures within the EU, notably to enable safe intra-EU movements of animals from affected or non-affected areas.
Consider and describe the uncertainty related to any of the above.

1.3 | Interpretation of the Terms of Reference

This report addresses Term of Reference (ToR) 1.3 by providing a state-of-the-art overview of all available mitigation measures for vector-borne diseases (VBDs) currently listed by Regulation (EU) 2016/429,[2] Regulation (EU) 2020/687[3] and Regulation (EU) 2018/1882[4] (collectively referred to as the Animal Health Law, AHL) and not listed VBDs identified as having potential relevance due to their potential epidemiological impact ('non-listed VBDs'). Non-listed diseases were included if they met *all* the following conditions:

- The pathogen is absent or of unknown status in more than 50% of EU Member States.
- A competent vector is present in the EU.
- The pathogen has been proven to infect domestic animal species present in the EU.
- Clinical signs are present in infected animals *or*, if animals are asymptomatic, the disease causes severe disease in humans.
- Sufficient data are available, i.e. primary data on pathogen distribution, pathogenesis in animals, epidemiology and competent vectors.

The resulting 25 VBDs that fulfilled the criteria provided above (12 listed by Commission Implementing Regulation (EU) 2018/1882; 13 not listed) are summarised in Table 1. Information used to address these criteria was gathered through an initial scoping review of the scientific literature and complemented by expert judgement provided by the EFSA Working Group on Vector-Borne Diseases. The results were subsequently updated during report drafting based on findings from the systematic literature reviews conducted for ToR 1, including the classification of data availability (Appendix B).

To address ToR 1.3, this report presents the main types of mitigation measures defined in the Animal Health Law for the various categories of listed diseases (see at https://doi.org/10.5281/zenodo.19090857 for a detailed summary of the measures). Importantly, the report does not provide an assessment of the effectiveness of each mitigation measure by disease. However, evidence from scientific literature on the efficacy of these measures is gathered for both listed and non-listed diseases. The types of mitigation measures dealt with in this report are:

- Surveillance (both for the pathogenic agent and the competent and/or potential vector)
- Movement restrictions
- Vector control measures
- Vaccination
- Culling
- Medicinal treatments
- On-farm biosecurity measures.

This report provides a static summary of the mitigation measures as a basis for the annual update that is requested in ToR 1.5.1. In the updates, new evidence found since the previous reports will be highlighted and detailed information about the mitigation measures are provided on the online disease profiles.[5] Furthermore, a 6-monthly newsletter with highlights on the 25

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0429.
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0687.
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1882.
[5] https://animal-diseases.efsa.europa.eu/.

VBDs (ToR 1.5.2) as well as monthly monitoring reports on WNV (ToR 1.5.3.) will be provided as part of the monitoring activities request in ToR 1.5.

To address ToR 1.1, 1.2 and 1.4, three other dedicated Scientific Reports (SR) have been prepared. These reports summarise the current knowledge on:

- Structured overview of the main characteristics of the 25 selected VBDs (ToR 1.1) (EFSA, 2026a);
- Competent vectors of the 25 VBDs and their geographic distribution in the EU and neighbouring countries (TOR 1.2) (EFSA, 2026b); and
- Risk pathways for their introduction into VBD-free countries in the EU (ToR 1.4.) (EFSA, 2026c).

These three SRs (EFSA, 2026a, 2026b, 2026c), together with the present report on mitigation measures of the VBDs, serve as the evidence base for two Scientific Opinions (SO) (see Figure 1). In the first SO, the risk of introduction, spread and impact of the selected 25 VBDs will be assessed, thereby addressing ToR 2.1, 2.2 and 2.3 of the mandate. In addition, an Expert Knowledge Elicitation will be carried out to:

- Review and digest the compiled evidence,
- Critically assess the current risk mitigation strategies in the EU,
- Identify the most appropriate mitigation measures for the 25 selected VBDs under various epidemiological scenarios,
- Evaluate the need for further development or adaptation of these and other mitigation measures, especially to support safe intra-EU movements of animals from affected or unaffected areas.

The outcomes of the expert elicitation will form the basis of the second Scientific Opinion that will address ToR 2.4 and 2.5 of the mandate about risk mitigation measures for VBDs (Figure 1).

The assessment protocol about translation of ToR 1.3 into subquestions, evidence needs and assessment methods is reported in Appendix A.

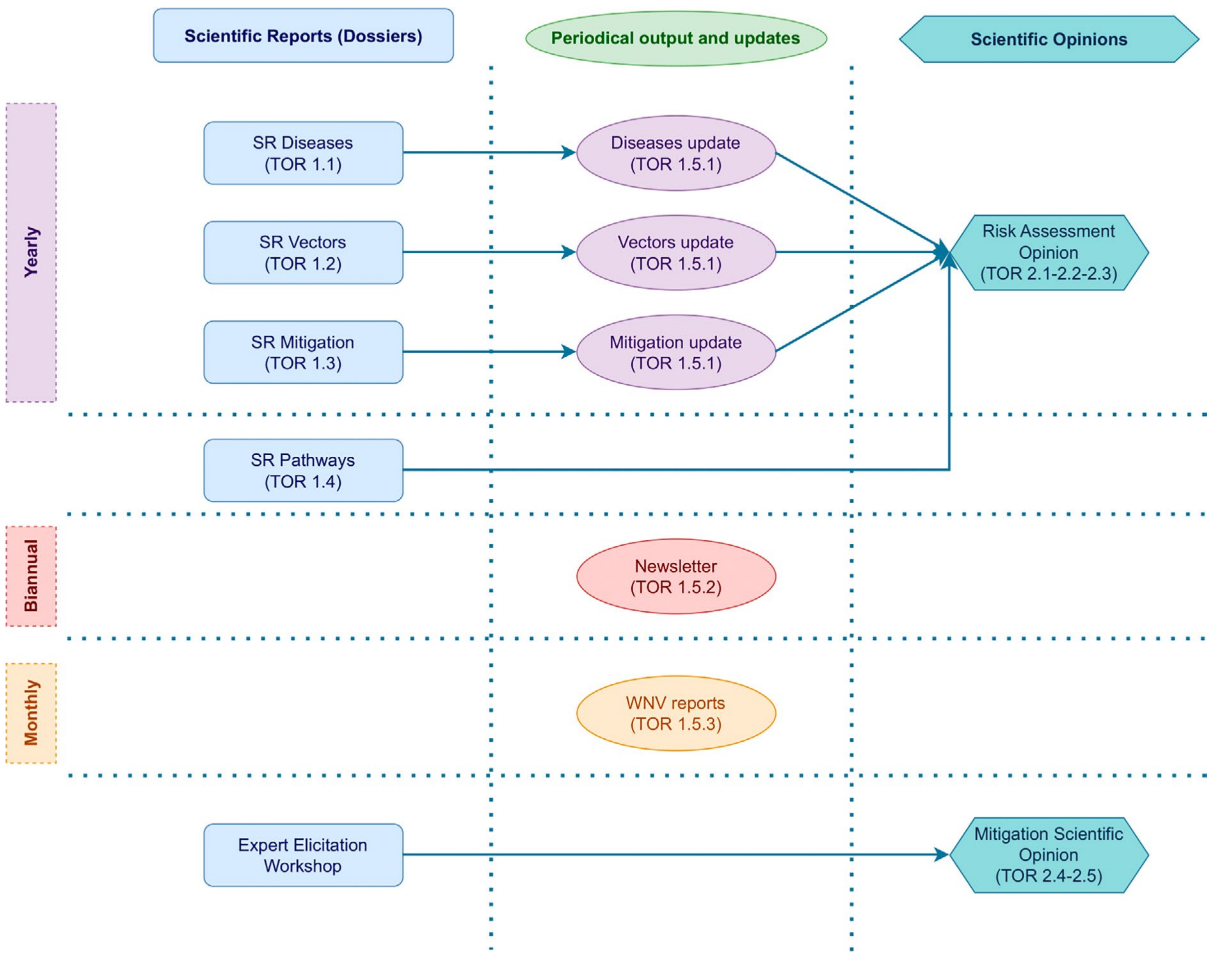

FIGURE 1 VBDs mandate workflow and outputs periodical update.

TABLE 1 Vector-borne diseases that met the eligibility criteria to be included in TOR 1.

Disease -agent	Listed disease in AHL*	Data availability**	Vector group	Pathogen present in EU	Vector(s) present in EU	Listed in WOAH	Zoonotic potential	Main amplifying hosts	Dead-end hosts	Clinical signs in animals
African horse sickness virus (AHSV)	A, D, E	++	Culicoides	✗	✓	YES		Equids		✓
Akabane virus (AKAV)		++	Culicoides	✗	✓	NO		Domestic ruminants		✓
Besnoitia besnoiti (*B. besnoiti*)		++	*Stomoxys*, Tabanidae***	✓	✓	NO		Cattle		✓
Bluetongue virus (BTV)	C, D, E	+++	Culicoides	✓	✓	YES		Ruminants, camelids	Dogs	✓
Borrelia burgdorferi s.l. (*B. burgdorferi*)		+++	Ixodidae	✓	✓	NO		Wide host range, rodents, birds	Dogs horses, humans	✓
Bovine ephemeral fever virus (BEFV)		++	Culicoides	✗	✓	NO		Cattle		✓
Cache Valley virus (CVV)		+	Culicidae	✗	✓	NO		Deer	Ruminants, horses, humans	✓

(Continues)

TABLE 1 (Continued)

Coxiella burnetii (*C. burnetii*)	E	+++	Ixodidae	✓	✓	YES		Wide host range, ruminants	Humans	✗
Crimean-Congo haemorrhagic fever virus (CCHFV)		++	Ixodidae	✓	✓	YES		Wide host range, ruminants	Equids	✗
Eastern equine encephalitis virus (EEEV) **** and Western equine encephalitis virus (WEEV)****	E	+	Culicidae	✗	✓	YES		Birds	Equids, humans	✓
Epizootic haemorrhagic disease virus (EHDV)	D, E	++	Culicoides	✓	✓	YES		Cattle, cervids		✓
Equine infectious anaemia virus (EIAV)	D, E	++	Stomoxys, Tabanidae***	✓	✓	YES		Equids		✓
Japanese encephalitis virus (JEV)	E	++	Culicidae	✗	✓	YES		Swine, birds	Equids, humans	✓

TABLE 1 (Continued)

Leishmania infantum (*L. infantum*)		+++	Phlebotominae	✓	✓	YES		Canids, cats, lagomorphae ,	Equids	✓
Lumpy skin disease virus (LSDV)	A, D, E	++	*Stomoxys*, Tabanidae, Culicidae, Culicoides ***, Ixodidae	✓	✓	YES		Cattle		✓
Rift Valley fever virus (RVFV)	A, D, E	+++	Culicidae	✗	✓	YES		Ruminants, camelids	Humans	✓
Schmallenberg virus (SBV)		++	Culicoides	✓	✓	NO		Ruminants		✓
Shuni virus (SHUV)		+	Culicoides Culicidae	✗	✓	NO		Domestic ruminants, horses	Humans	✓
St. Louis encephalitis virus (SLEV)		+++	Culicidae	✗	✓	NO		Birds	Horses, humans	✓
Tick-borne encephalitis virus (TBEV)		++	Ixodidae	✓	✓	NO		Wide host range, wild rodents	Humans	✓

(Continues)

TABLE 1 (Continued)

Trypanosoma evansi (T. evansi)	D, E	++	Stomoxys***	✓	✓	YES	Unclear	Ruminants, camelids, equids	Humans, Pigs	✓
Trypanosoma vivax (T. vivax)		+++	Glossinidae, Tabanidae, *Stomoxys****	✗	✓	YES	Non-zoonotic	Ruminants, camelids, equids		✓
Venezuelan equine encephalitis virus (VEEV)	D, E	+	Culicidae	✗	✓	YES	Zoonotic	Horses, wild rodents	Humans	✓
Vesicular stomatitis virus (VSV)		+	Culicoides	✗	✓	NO	Zoonotic	Cattle, equids, pigs	Humans	✓
West Nile virus (WNV)	E	+++	Culicidae	✓	✓	YES	Zoonotic	Birds	Horses, humans	✓

*Listed disease categories and definition as described in Regulation (EU) 2016/429. **Data availability based on the systematic literature reviews available on the Disease Profiles (https://animal-diseases.efsa.europa.eu/) and VectorNet for vector competence: +++well documented (> 100 publications), ++some papers available (51–100 publications), + only few papers available (0–50 publications). ***Mechanical transmission. ****EEEV and WEEV will be considered together in this report, in line with the AHL and WOAH terrestrial code. However, their risk will be assessed separately in the Scientific Opinion addressing ToR 2.1–2.3.

Table legend		
Pathogen type	**Zoonotic potential**	**EU distribution**
Virus Bacteria Parasite	Zoonotic Non-zoonotic	✓ Present in the EU ✗ Absent in the EU

2 | METHODOLOGIES

2.1 | Overview of disease categories in the Animal Health Law

Of the 25 VBDs, 13 are listed under the Animal Health Law (AHL, Regulation (EU) 2016/429) and Commission Delegated Regulation (EU) 2020/687. An overview was compiled for the 13 VBDs, including their classification within the respective categories of listed diseases. Detailed summary tables of all mitigation measures applicable to these diseases in Categories A, C, D and E of the AHL, henceforth called 'listed diseases', are provided at this link https://doi.org/10.5281/zenodo.19090857 condensed to indicate which of the following mitigation measures are mandatory for each listed disease: surveillance for early detection; zoning, movement restrictions; vector control measures; vaccination; culling; medicinal treatments; on-farm biosecurity measures; and transport vehicle requirements. The analysis in this report focuses on the evidence available for these main mitigation measure types.

2.2 | Evidence collected to support the assessment of different mitigation measures

2.2.1 | Surveillance

The evidence required to describe the available surveillance systems for various vector-borne diseases (VBDs) is based on systematic literature reviews (SLRs), the extracted data are available at https://doi.org/10.5281/zenodo.19234573. This regularly updated information is also available online in the individual disease profiles for each VBD, which can be found at https://animal-diseases.efsa.europa.eu/. A summary of the aspects addressed by these reviews is provided below.

2.2.1.1 | *Surveillance components for each of the 25 VBDs*

Vector species targeted by surveillance: This is addressed through the SLR on vector competence (ref).

Animal host species targeted by surveillance: The relevant host species for each disease were determined based on three main sources: (1) an SLR of field studies which reported the detection of these 25 VBDs in animals; (2) an SLR of experimental infections of animals with each of the 25 VBDs; and (3) a review of all data reported to the World Organisation for Animal Health (WOAH) regarding the occurrence of those diseases which are listed by WOAH, and for which data are regularly reported by countries and made available publicly through the World Animal Health Information System (WAHIS).[6] The information from these three sources was complemented by expert opinion to determine the species which are most relevant for transmission, and those species that are dead-end hosts. This information as well as details on the SLR methodology is compiled in the accompanying report about vector-borne diseases (EFSA, 2026a). The protocol of the SLR is described by Dórea et al. (2022).

Animal products matrices targeted by surveillance: A dedicated scientific report was produced focusing on the relevant pathways of transmission for each of the VBDs, including which matrices are relevant (EFSA, 2026c).

In addition, evidence regarding the relevant animal matrices for each VBD is provided through two of the SLRs regularly conducted by EFSA on these agents (Dórea et al., 2022): (1) the SLR of experimental infections of animals with each of the 25 VBDs and (2) the SLR investigating pathogen survival in several matrices.

2.2.1.2 | *Specificity and sensitivity of the available diagnostic tests to detect the VBD agent in any of the surveillance components*

This information is the subject of a dedicated SLR focused on extracting data from published peer-review literature on the sensitivity and specificity of diagnostic tests approved for use in the detection of the 25 VBDs (including antibody detection tests) (Dórea et al., 2022). This information is compiled in the accompanying report on vector-borne diseases (EFSA, 2026a), which details the SLR methodology and results.

2.2.1.3 | *Ranges of minimum infection rate (MIR) in field collected vectors tested in different epidemiological situations*

This is addressed through the SLR about vector status of potential vector species of 36 vector-borne pathogens, where MIR ranges in vectors are reported (Massoels et al., 2023).

[6] https://wahis.woah.org/.

2.2.1.4 | *Ranges of prevalence in hosts or matrices tested in different epidemiological situations*

This information is collected regularly through the SLR of field studies which reported the detection of these 25 VBDs in animals, also referred above in the host species topic (Dórea et al., 2022). This information is compiled in the accompanying report on vector-borne diseases (EFSA, 2026a), which details the SLR methodology and results.

2.2.1.5 | *Duration of infectious period in hosts*

This information is collected through the SLR of experimental infections in animal hosts with any of the 25 VBDs, also referred above in the host species topic. This information is compiled in the accompanying report on vector-borne diseases (EFSA, 2026a), which details the SLR methodology and results (the detailed protocol is provided in Dórea et al., 2022).

2.2.1.6 | *Duration of infectious period in vectors*

This information is collected through the SLR on vector competence (VectorNet project); with full details found in the published protocol (Massoels et al., 2023).

2.2.1.7 | *Transmission pathways of VBDs*

A dedicated scientific report was produced focusing on the relevant pathways of transmission for each of the VBDs, including which matrices are relevant (EFSA, 2026c).

In addition, evidence to compile the relevance transmission mode for each VBD is provided through three of the SLRs regularly conducted by EFSA on these agents (Dórea et al., 2022): (1) the SLR of field studies which reported the detection of these 25 VBDs in animals; (2) the SLR of experimental infections of animals with each of the 25 VBDs; and (3) the SLR investigating pathogen survival in several matrices. The information from these three sources was complemented by expert opinion and compiled in the accompanying report vector-borne diseases (EFSA, 2026a). The report also details the SLR methodology.

An overview of the relevant models of transmission for each VBD, based on all the sources listed above, was compiled and is presented in the related section of results, 3.2.1.

2.2.2 | Movement restrictions

2.2.2.1 | *What is the effectiveness of movement restrictions to reduce introduction or spread of each of the 25 VBDs vector control measures?*

A systematic literature review was specifically designed to compile evidence regarding the following risk mitigation measures: movement restrictions, culling, vaccination (under field conditions) and biosecurity measures applied on farm. This will be referred in this document as the 'risk mitigation measures SLR'. The literature review covered the publication years 1970–2026 and included peer-review articles for any of the 25 VBDs in scope. The full protocol and extracted data are published at https://doi.org/10.5281/zenodo.19231178.

Any results provided regarding the following outcomes were collected and summarised qualitatively: effect in reduction or VBD incidence or prevalence, including seroprevalence; reduction in outbreak frequency, spread or number of infected holdings; decrease in between-farm or between-region transmission; reduction in disease reproduction rate.

2.2.3 | Culling

2.2.3.1 | *What is the effectiveness of culling to reduce the spread of each of the 25 VBDs?*

The effect of culling in prevention or control of the VBDs was addressed through the same literature review described in Section 2.2.2 (risk mitigation measures SLR). Results were compiled and summarised independently, as presented in the results.

2.2.4 | Vaccination

2.2.4.1 | *What is the efficacy of host vaccination to reduce incidence, or infection rate/morbidity/mortality?*

Information on the efficacy of vaccines in controlled studies (vaccine trials) is collected through the SLR described in the accompanying report on vector-borne diseases (EFSA, 2026a), which details the SLR methodology and results. The extracted data of the SLR to which this report refers to are available at https://doi.org/10.5281/zenodo.19234573. All the regularly updated information is also available online in the individual disease profiles for each VBD, which can be found at https://animal-diseases.efsa.europa.eu/.

The SLR mentioned above only covers studies conducted under experimental conditions. In order to complement this information with evidence about the efficacy of vaccines applied under field conditions, field reports and studies about this latter aspect were included in the *SLR* as described in Section 2.2.2.

2.2.5 | Medicinal treatments

2.2.5.1 | *What is the efficacy of medical treatments to reduce the mortality or morbidity in hosts infected with each of the 25 VBDs?*

Information on the efficacy of medicinal treatments is collected through one of the SLRs conducted regularly to keep up to date information regarding the 25 VBDs in the online disease profiles (Dórea et al., 2022), The extracted data of the SLR to which this report refers to are available at https://doi.org/10.5281/zenodo.19234573. All the regularly updated information is also available online in the individual disease profiles for each VBD, which can be found at https://animal-diseases.efsa.europa.eu/.

These data have been summarised in this report for the 25 VBDs, focusing on the reported efficacy of the treatments in reducing incidence, infection rates, morbidity or mortality.

It is important to note that the SLR included any curative or preventive treatment. Studies in which vector control measures are applied directly to hosts (for instance, the use of insect repellent collars or parasiticides), and the efficacy of the treatment is measured in relation to the (potential) *number of infections prevented*, for a specific VBD, are classified as preventive treatments and also included in the SLR.

2.2.6 | On farm, biosecurity measures

2.2.6.1 | *Which physical, chemical or habitat management measures reduce introduction and spread from farms?*

The effect of on-farm biosecurity measures in prevention or control of the VBDs was addressed through the same literature review described in Section 2.2.2 (risk mitigation measures SLR). The full protocol is published at https://doi.org/10.5281/zenodo.19231178. All studies which reported a biosecurity measure and evaluated it is statistical correlation to a measure of disease burden or transmission (prevalence or seroprevalence, incidence, infection rates, morbidity or mortality) in a multivariate analysis were subjected to data collection. Results were compiled and summarised independently, as presented in the results.

A similar SLR has been previously conducted by EFSA, focusing on reviewing current knowledge, best practices and research gaps in biosecurity in small ruminant farms. The full protocol is available at https://zenodo.org/records/16678557. Any publications identified through this review which apply to the VBD in scope were also included to complement the risk mitigation measures SLR.

2.2.7 | Vector control

Information on the efficacy of vector control measures is collected through one of the SLRs conducted regularly to keep up to date information regarding the 25 VBDs in the online disease profiles (Dórea et al., 2022), which can be found here https://animal-diseases.efsa.europa.eu. The raw data extracted from the studies by which the assessment in the present report is conducted and the summary tables reported in Section 3.2.7 are built are available at https://doi.org/10.5281/zenodo.19188383.

The SLR targets any peer-reviewed study reporting the effect of a chemical treatment which can be applied to animals or the environment, to reduce vector presence or vector exposure. The vector groups covered here are mosquitoes, midges, sandflies and ticks at the time of writing this report. Evidence for other vectors such as biting flies (e.g. *Stomoxys* spp., Tabanidae) that may act as mechanical vectors as in case of LSD will be collected in next outputs and as soon as the SLR will be updated.

In the references section of each disease profile, readers can find the full protocol and can also download all data collected through the SLR. For the assessment on vector control, only active substances or veterinary medicine products currently allowed in the EU by ECHA[7] and EMA[8] were considered.

[7]https://echa.europa.eu/.

[8]https://www.ema.europa.eu/.

3 | ASSESSMENT

3.1 | Overview of disease categories in the animal health law

Table 2 describes the definitions of the different disease categories laid down in Regulation (EU) 2016/429, Art 9), and Table 3 provides the main mitigation measures that need to be applied for each disease Category.

Of the 25 selected VBDs, 13 are listed in the AHL. The category A diseases are those caused by AHSV, RVFV and LSDV and must be eradicated immediately upon detection in the EU. None of the 25 VBDs fall under Category B. BTV is the causative agent of the only disease in Category C, for which measures must be taken to prevent its spread to officially free Member States (MS). Category D diseases are Epizootic haemorrhagic disease virus (EHDV), equine infectious anaemia (EIAV), *Trypanosoma evansi* (pathogen causing surra disease), and Venezuelan equine encephalitis virus (VEEV), where movement restrictions apply between MS. Category E includes *Coxiella burnetii* (the pathogen causing Q-fever), Eastern equine encephalitis virus (EEEV), Western equine encephalitis virus (WEEV), Japanese encephalitis virus (JEV) and West Nile virus (WNV), for which EU-wide surveillance is required. Notably, all measures required for lower categories also apply to higher categories.

The other 12 VBDs are currently not listed in AHL.

TABLE 2 Listed disease categories and definitions as described in Regulation (EU) 2016/429.

Category	Definition
Category A	*Diseases* ***that do not normally occur*** *in the Union and for which* ***immediate eradication measures*** *must be taken as soon as they are detected*
Category B	*Diseases which* ***must be controlled*** *in all Member States with the goal of* ***eradicating*** *them throughout the Union*
Category C	*Diseases which are of relevance to some Member States and for which* ***measures*** *are needed to* ***prevent them from spreading to parts of the Union*** *that are* ***officially disease-free*** *or that have eradication programmes for the listed disease concerned*
Category D	*Diseases for which measures are needed to* ***prevent them from spreading*** *on account of their movements between Member States or entry into the Union*
Category E	*Diseases for which there is a need for* ***surveillance*** *within the Union*

TABLE 3 Mitigation measures' categories and listed disease agents for which they need to be applied.

Measure category	Disease category	Disease agent
Surveillance for early detection	A, C, D and E	RVFV, BTV, EHDV, *T. evansi*, JEV, WNV, LSDV, AHSV, EIAV, VEEV, EEEV, WEEV, *C. burnetii*
Zoning, surveillance and movement restrictions	A, C and D	RVFV, BTV, EHDV, *T. evansi*, LSDV, AHSV, EIAV, VEEV
Vector control measures	A, C	RVFV, BTV, LSDV, AHSV
Emergency* and preventive vaccination	A, C	RVFV, BTV, LSDV, AHSV
Culling	A, C	RVFV, BTV, LSDV, AHSV
Medicinal treatments	A, C	RVFV, BTV, LSDV, AHSV
On farm biosecurity measures	A, C	RVFV, BTV, LSDV, AHSV
Transport vehicle requirements (e.g. biosecurity during transport)	A, C and D	RVFV, BTV, EHDV, *T. evansi*, LSDV, AHSV, EIAV, VEEV

*Emergency vaccination as such is mentioned in article 69 of the AHL Regulation (EU) 2016/429 and only applies to category A.

More detailed listing of the measures applied in each disease category are provided at https://doi.org/10.5281/zenodo.19090857.

3.2 | Evidence collected on risk mitigation measures

3.2.1 | Surveillance

3.2.1.1 | *Surveillance as a cornerstone for mitigating vector-borne disease risks in livestock*

Surveillance plays a central role in reducing the introduction, spread and impact of vector-borne diseases in livestock. By systematically tracking the interactions between hosts, vectors, pathogens and the environment, surveillance enables early detection and guides timely, targeted interventions. A clear understanding of the **host–vector–pathogen system**—including competent vectors, susceptible livestock, reservoir species and ecological drivers – forms the foundation for anticipating when and where disease risks are likely to emerge.

Mitigation begins with risk-based targeting, which directs surveillance efforts towards areas and populations most vulnerable to disease introduction or transmission. Regions with established vector populations, past outbreaks or intense livestock movement are prioritised so that limited resources can be used where they will have the greatest preventive impact.

Surveillance informs control strategies of VBD by integrating **syndromic, clinical and laboratory data**. Early warning signals from syndromic monitoring, combined with veterinary clinical reports and laboratory confirmation, allow authorities to detect unusual events quickly and confirm them with diagnostic accuracy. This multi-step approach increases the likelihood of detecting emerging threats before they escalate.

A major risk mitigating function comes from **vector surveillance and environmental monitoring**. Mapping vector distribution, tracking abundance and seasonality and testing vectors for pathogens provide direct insight into transmission potential. Monitoring abiotic variables such as rainfall, temperature and humidity helps predict periods when vectors are likely to proliferate, enabling proactive measures such as intensified monitoring or vector control.

Because vector-borne pathogens can spread rapidly and sometimes unexpectedly (e.g. in the case of sudden meteorological changes), **timely and continuous reporting** is essential. Standardised case definitions and efficient communication channels ensure that information flows quickly from farmers and veterinarians to authorities, reducing delays that could allow pathogens to establish or spread.

Spatial and temporal analytical tools – GIS, remote sensing and time-series analysis – further enhance risk mitigation by identifying hotspots, detecting trends and supporting **early warning systems**. These tools help authorities anticipate high-risk periods and deploy interventions before outbreaks occur.

Surveillance also mitigates risk by monitoring **animal movements**, which can transport pathogens far beyond vector ranges. Pre-movement testing, certification and quarantine reduce the likelihood that infected animals introduce pathogens into new areas.

A **One Health approach** strengthens mitigation by integrating data across livestock, wildlife, human health and environmental sectors. Many vector-borne pathogens cross species boundaries, and coordinated surveillance improves the detection of zoonotic threats and supports comprehensive control strategies.

Predictive modelling – using climate data and remote sensing indicators – adds another layer of protection by forecasting periods of elevated vector activity or heightened transmission risk. This allows authorities to implement preventive measures such as vaccination or vector management before disease emerges.

Effective mitigation depends on linking surveillance to **preparedness and response capacity**. Rapid diagnostics, emergency vaccination, vector control tools and clear communication strategies ensure that surveillance findings translate into swift, effective action.

Finally, regular **evaluation and adaptation** of surveillance systems ensure they remain effective as risks evolve. Assessing sensitivity, specificity, timeliness and data quality helps maintain system performance, while adaptability is crucial in the face of climate-driven changes, new vector species and shifting pathogen dynamics.

3.2.1.2 | *Knowledge mapping about surveillance of VBDs*

As described in the methodologies section, evidence to support decisions for design and implementation of surveillance was compiled from various sources. Table 4 provides a knowledge map of these sources in relation to the relevance surveillance questions they answer.

TABLE 4 Mapping of the sources of evidence relevant for each of the proposed questions related to designing and implementing surveillance for VBDs.

Questions related to surveillance planning	Sources of evidence available/compiled
1) Which surveillance components are available for each of the 25 VBD agents?	
1A. Which vector species can be targeted by surveillance?	EFSA (2026b)
1B. Which animal host species can be targeted by surveillance?	EFSA (2026a) https://doi.org/10.5281/zenodo.19234573 Disease Profiles (https://animal-diseases.efsa.europa.eu/)
1C. Which animal products matrices can be targeted by surveillance?	EFSA (2026c) https://doi.org/10.5281/zenodo.19234573 Disease Profiles (https://animal-diseases.efsa.europa.eu/)
2) What is the specificity and sensitivity of the available diagnostic tests to detect the VBD agent in any of the surveillance components?	EFSA (2026a) https://doi.org/10.5281/zenodo.19234573 Disease Profiles (https://animal-diseases.efsa.europa.eu/)
3) What are the ranges of MIR in field collected vectors tested in different epidemiological situations?	SLR on the vector status of potential vector species of 36 vector-borne pathogens;[9] not relevant for mechanically transmitted diseases

(Continues)

[9]https://efsa.onlinelibrary.wiley.com/doi/10.2903/sp.efsa.2023.EN-8484.

TABLE 4 (Continued)

Questions related to surveillance planning	Sources of evidence available/compiled
4) What are the ranges of prevalence in hosts or matrices tested in different epidemiological situations?	EFSA (2026a) https://doi.org/10.5281/zenodo.19234573 Disease Profiles (https://animal-diseases.efsa.europa.eu/)
5) How long is the infectious period in hosts?	EFSA (2026a) https://doi.org/10.5281/zenodo.19234573 Disease Profiles (https://animal-diseases.efsa.europa.eu/)
6) How long is the infectious period in vectors?	EFSA (2026a) https://doi.org/10.5281/zenodo.19234573 Disease Profiles (https://animal-diseases.efsa.europa.eu/)
7) What are the modes of transmission of VBDs?	The transmission routes for each VBD were summarised from the various sources reviewed and are presented below in Table 5. How these modes of transmission translate into specific pathways for disease spread, which can be targeted for disease control, is the topic of a complementary report: EFSA (2026c) https://doi.org/10.5281/zenodo.19234573 Disease Profiles (https://animal-diseases.efsa.europa.eu/)

TABLE 5 Transmission routes of VBDs, evidenced through systematic literature review.

Pathogen	Direct contact			Indirect contact							Airborne	
	Animal to animal	Vertical/ transplacental	Sexual transmission	Humans	Rodents	Fomites	Ingestion (feed/water)	Vectors	Environment (manure/soil)	Iatrogenic	Droplets	Inhalation
African horse sickness virus								X				
Akabane virus		X						X				
Besnoitia besnoiti	X							X		X		
Borrelia burgdorferi s.l.								X	X			
Bovine ephemeral fever virus								X				
Bluetongue virus		X						X		X	X	X
Cache Valley virus								X				
Crimean-Congo haemorrhagic fever virus	?				?		?	X				
Coxiella burnetii (Q-fever)		X	X			X		X	X			X
Eastern equine encephalitis virus	X							X				
Western equine encephalitis virus	X							X				
Epizootic haemorrhagic disease virus	?	X						X	?			
Equine infectious anaemia virus		X						X		X		
Japanese encephalitis virus	X							X				
Leishmania infantum								X				
Lumpy skin disease virus			X					X				
Rift Valley fever virus		X						X				
Schmallenberg virus		X	*					X				
Shuni virus		X						X				
St. Louis encephalitis virus								X				
Trypanosoma evansi		X	**				X	X		X		
Trypanosoma vivax								X		X		
Tick-borne encephalitis virus		X						X				
Venezuelan equine encephalitis virus								X				
Vesicular stomatitis virus	X							X				
West Nile virus								X				

*Schmallenberg virus was found in bull semen. However, transmission by natural breeding or artificial insemination has not yet been demonstrated. **Sexual transmission of *T. evansi* could occur in particular cases, but the real impact has not been estimated.

3.2.2 | Movement restrictions

The SLR identified 18 articles reporting on the effectiveness of movement control as a risk mitigation measure for six of the 25 VBD agents: bluetongue virus (9), Rift Valley fever virus (4), African horse sickness virus (2) and one each on Schmallenberg virus, lumpy skin disease virus and *C. burnetii*. All identified studies were modelling analyses. Field observation during disease outbreaks can report success in control but cannot assess the specific effect of any specific measure. Often, movement restrictions are applied along with other control measures and applied to all affected populations; there is no comparison group, and effectiveness can therefore not be estimated. Modelling can be used to investigate the specific control measure but will be influenced by the assumptions used in the model, related to movement restrictions as well as to other factors related to disease spread.

The detailed information provided in each paper regarding the quantitative effect of movement control for risk mitigation was collected and compiled in tables provided in a dedicated repository available at https://doi.org/10.5281/zenodo.19231178. Table 6 presents the overall summary of movement restriction effectiveness for VBD agents for which eligible papers were retrieved. More descriptive summaries of the evidence are also provided below.

TABLE 6 Summary of movement restriction effectiveness from the eligible studies.

Pathogen	Summary of evidence	Number of papers contributing to summary
African horse sickness virus	Protection zones and quarantine procedures are associated with reduced transmission risk	2
Bluetongue virus	Strict movement restrictions are effective at reducing BTV spread if vector dispersal is local. Restrictions are associated with high economic impact.	9
Coxiella burnetii	Movement restrictions reduce risk but are not sufficient to prevent the spread	1
Lumpy skin disease virus	Movement restriction zones reduce probability of spread	1
Rift Valley fever virus	Movement restriction zones are mostly effective to contain RVFV transmission, but restricting livestock trade may only delay the outbreak	4
Schmallenberg virus	Movement restrictions effective at reducing SBV spread if vector dispersal is local.	1

African horse sickness virus

Modelling study results from two papers (de Vos et al., 2012; EFSA AHAW Panel, 2021) show protection zones and quarantine procedures are associated with reduced transmission risk.

Bluetongue virus

The evidence for movement control as a measure to limit the spread of BTV is not unanimous.

- In five modelling papers (de Koeijer et al., 2011; Ensoy et al., 2013; Spooner et al., 2020; Turner et al., 2012; Turner et al., 2019), movement restrictions were shown to be highly effective at reducing BTV spread, with 20 km control zones largely as effective as imposing larger zones.
- However, one study (Tildesley et al., 2019) concluded that 'the cost of any movement ban is greater than the epidemiological benefits' and that movement bans had limited impact on controlling farm-to-farm spread, with similar findings highlighted by Velthuis et al. (2010). Economic costs could be reduced if movement restriction zone radii were optimised (Spooner et al., 2020).
- Two modelling studies showed that the effect is dependent on the pattern of transmission, which depends on vector dispersal (Sumner et al., 2017; Szmaragd et al., 2009). Movement restrictions are effective in reducing disease incidence if vector dispersal is primarily local.

Coxiella burnetii

One modelling study (Pandit et al., 2016) using outbreak data from France concluded that movement restrictions (trade control) can help but are insufficient on their own to prevent the spread of *C. burnetii* due to the significant role of airborne transmission.

Lumpy skin disease virus

According to an EFSA opinion on LSD control measures (EFSA AHAW Panel, 2022a), establishing protection and movement control zones to limit the spread of LSDV is effective in models based on Israel and Albania epidemics. It was concluded that the protection zone of 20 km radius and the surveillance zone of 50 km radius (including movement ban inside the zone) would comprise > 99% of the transmission from an affected establishment if transmission occurred.

Rift Valley fever virus

Three modelling studies (EFSA AHAW Panel, 2020, 2022b; McMahon et al., 2014) concluded that movement restrictions are mostly effective. Protection and surveillance zones of 20 and 50 km radii, respectively, including surveillance and movement restrictions, are recommended to contain RVFV transmission. However, one modelling study (Tennant et al., 2021) suggested that restricting livestock exports and imports from and to an island only delays outbreaks to a season more suitable for transmission, potentially resulting in a more severe epidemic.

Schmallenberg virus

The study by Sumner et al. (2017) concluded, as also observed for BTV, that the impact of restricting livestock movements on the spread of SBV depends critically on assumptions made about the distances over which vector dispersal occurs. If vector dispersal is primarily local, movement restrictions have a substantial impact.

3.2.3 | Culling

The literature review retrieved 15 relevant articles related to six VBD agents: *L. infantum* (7 articles), *Borrelia burgdorferi s.l.* (Lyme disease, 3 articles), *C. burnetii* (3), lumpy skin disease virus (1) and Rift Valley fever virus (1). The detailed information extracted from each paper regarding the effect of culling as a risk mitigation measure for these diseases is provided at https://doi.org/10.5281/zenodo.19231178. A summary of the evidence provided for each disease is presented below.

***Borrelia burgdorferi* s.l.**

No definitive evidence of efficacy of culling (i.e. hunting for wildlife) as a risk mitigation measure was found. Complete removal of deer population through relaxed hunting regulations in a given area proved effective to reduce tick abundance and tick infection rates in an island (Rand et al., 2004) and significant reduction of deer density was reported to reduce Lyme incidence in another field study (Kilpatrick et al., 2014). However, one study monitoring Lyme disease over three seasons did not find a significant association with deer density (Jordan et al., 2007).

Coxiella burnetii

Targeted culling, focusing specifically on shedders and ewes, was reported in two field studies (Piñero et al., 2014; Van den Brom et al., 2015), but the measure was not applied alone. A combination of measures that also included vaccination seems to have been responsible for the success of the strategies. The need to combine strategies was also highlighted by Bontje et al. (2016) models, where culling alone was not effective.

Leishmania infantum

The evidence is contradictory, with culling of seropositive dogs in China (Zhi-Biao, 1989) and Brazil (Franca-Silva et al., 2023) associated with reduced disease incidence in humans, and a significant reduction in 18-month cumulative infection incidence in dogs reported by Werneck et al. (2014). However, Grimaldi Jr. et al. (2012) highlighted that, while a temporary reduction in dog seropositivity may be seen at first, culling was not enough to control the disease. Other studies reported a lack of effect in Brazil (da Rocha et al., 2018; Vaz et al., 2020). Nevertheless, one modelling study (Seva et al., 2017) showed that culling of hares and rabbits could be an effective strategy for controlling outbreaks.

Lumpy skin disease virus

Results from an LSDV transmission model (EFSA AHAW Panel, 2016) showcase total (culling all infected animals) or partial (culling only animals with clinical signs) stamping out policies as a stand-alone measure are less effective than vaccination to control the spread of LSD. Nevertheless, in absence of vaccination, total stamping out has a higher probability of eradicating disease, compared to partial stamping out. Additionally, according to the two-decade experience of LSD epidemics in Israel, culling of cattle displaying evident clinical signs (i.e. lumps all over the body) is a necessary step in the absence of vaccination or when the vaccines are ineffective (e.g. heterologous strain-based vaccines). In any case, the experience showed that culling may work only if accompanied with proper zoning and movement ban of sick animals, since the spread of LSD is usually distance limited and is propagated when sick animals are moved to non-affected areas (EFSA AHAW Panel, 2015).

Rift Valley fever virus

According to modelled results from EFSA's scientific opinion on Rift Valley fever (EFSA AHAW Panel, 2020), culling animals on farms within a 20-km radius of detected cases was identified as the most effective measure for controlling RVF spread but would involve the culling of a large number of animals.

3.2.4 | Vaccination

The results of a systematic review of vaccine efficacy and effectiveness found for 9 out of 25 VBDs are summarised below (Table 6 and text below, full details are available at https://doi.org/10.5281/zenodo.19231178). The SLR includes data from controlled trials, field studies, retrospective analyses and modelling studies, with an emphasis on reported quantitative effectiveness, clinical endpoints and observed effects of vaccination (Table 7).

TABLE 7 Summary from SLR results about vaccine efficacy against VBDs.

Pathogen	Target species	Vaccine type	Reported efficacy/effectiveness
African horse sickness virus	Horses	Live recombinant/Live-attenuated polyvalent	Up to 100% efficacy; reduced mortality and infection risk
Bluetongue virus	Cattle, Sheep, Goats	Inactivated (dead)	60%–100% infection reduction; 100% morbidity reduction
***Borrelia burgdorferi* s.l.**	Dogs	Recombinant (subunit)	73%–100% infection and morbidity reduction
Bovine ephemeral fever virus	Cattle	Live attenuated/ Inactivated	2%–60% vaccine effectiveness; immunity wanes quickly
Coxiella burnetii	Sheep, Cattle, Goats	Inactivated (dead)	Reduced shedding and abortions; incomplete pathogen elimination
Leishmania infantum	Dogs	Recombinant (subunit)	26%–37% effectiveness, which increases when used with insecticide collars (33%–54%); protection against infection not significant
Lumpy skin disease virus	Cattle	Live attenuated	62%–97% efficacy; Neethling strain superior
Rift Valley fever virus	Sheep, Cattle	Live attenuated	Full protection in trials; modelling shows > 90% incidence reduction with high coverage
Trypanosoma vivax	Cattle	Recombinant (subunit)	Significant infection rate reduction
West Nile virus	Horses	Inactivated/Recombinant	Reduced morbidity and mortality; increased survival odds

African horse sickness virus

- Vaccines for AHSV, particularly live recombinant and live-attenuated polyvalent types, demonstrated high efficacy. A controlled trial with ALVAC-AHSV showed 100% protection against infection and disease after a two-dose regimen in horses (Guthrie et al., 2009).
- Field studies vaccination linked to eight- to ninefold lower odds of mortality (Genis et al., 2023; Gordon et al., 2013), reduced infection risk during outbreaks (Grewar et al., 2019) and lower disease incidence (Diouf et al., 2013). In Portugal, the disease was eradicated 1 year after achieving 100% coverage during a vaccination campaign (Portas et al., 1999).

Bluetongue virus

- Multiple inactivated vaccines authorised in the EU provided efficient protection in cattle, sheep and goats. Controlled trials showed vaccine efficacy ranging from 60% to 100% in reducing infection rates and 100% in reducing morbidity (Eschbaumer et al., 2009). Vaccination was also reported to limit transplacental transmission and reduce viraemia (Gubbins et al., 2012; van der Sluijs et al., 2012), with heterologous vaccination providing partial cross-protection (Breard et al., 2015).
- Field and modelling studies confirmed that vaccination reduced mortality and morbidity and slowed outbreak spread, with higher coverage and pre-emptive vaccination reducing outbreak risk and disease incidence (Conraths et al., 2009; Sumner et al., 2013; EFSA AHAW Panel, 2017; Szmaragd et al., 2010).

Borrelia burgdorferi s.l.

- Live recombinant vaccines in dogs[10] showed 73%–100% efficacy in reducing infection and morbidity in controlled trials (Conlon et al., 2000; Grosenbaugh et al., 2016).

[10]The primary target host in the SLR was animals, humans were excluded.

- Field studies showed that incomplete vaccination was still associated with increased infection risk (RR = 21.4), which is substantially reduced when following the full vaccination regimen (Eschner & Mugnai, 2015). Vaccinated dogs also displayed markedly lower seropositivity rates and fewer clinical signs (Hebert & Eschner, 2010).

Bovine ephemeral fever virus

In field studies, vaccine effectiveness varied substantially depending on dose and formulation, ranging from negligible impact (Aziz-Boaron et al., 2014) to 50%–60% effectiveness (Gleser et al., 2023). Although vaccination could delay infection onset, immunity often waned rapidly (Wang et al., 2001), requiring high coverage (> 40%) to shift disease patterns towards less frequent incidence (Ogawa et al., 1993).

Coxiella burnetii

- In one controlled trial (Tomaiuolo et al., 2023), vaccination was reported to have low immunogenicity, requiring adjuvants to increase efficacy.
- Several field studies showed that vaccination effectively reduced bacterial load and the prevalence of shedding in vaginal mucus, milk and uterine fluids, particularly when administered to young or previously seronegative animals before pregnancy (Astobiza et al., 2011b; Hogerwerf et al., 2011; Piñero et al., 2014; Taurel et al., 2012), while other studies reported no significant effect (Astobiza et al., 2011a; Astobiza et al., 2013; Gonzalez-Barrio et al., 2017). Vaccination was also shown to reduce subfertility, abortions and environmental contamination, but effectiveness was limited in animals already pregnant or previously infected, and complete elimination of the pathogen was rarely achieved without sustained long-term use (Astobiza et al., 2011b; Astobiza et al., 2013; Garcia-Ispierto et al., 2015; Guatteo et al., 2008).

Eastern equine encephalitis virus

The SLR identified only one field study for vaccination against EEEV, reporting that annual vaccination protocols in equines were associated with a significantly reduced risk of disease (OR = 0.14) (Ross & Kaneene, 1995).

Japanese encephalitis virus

The SLR identified only one modelling study for vaccination against JEV, which reported that vaccination reduces case incidence by 61%–89%, depending on coverage assumptions (Khan et al., 2014).

Equine infectious anaemia virus

The SLR identified only one controlled vaccine trial study for EIAV, which indicated that a live attenuated vaccine provided full protection against disease and reduced virus shedding in horses (Zhang et al., 2007).

Leishmania infantum

- A modelling study (Seva et al., 2017) indicated that 50%–75% vaccine coverage reduces seroprevalence in dogs, with similar field findings reported by (Grimaldi Jr. et al., 2017), showing significant reduction of overall incidence of infection; however, it did not protect from disease progression in susceptible dogs.
- Another field study (Lopes et al., 2018) compared recombinant vaccines, both alone and in combination with insecticide collars, but failed to demonstrate statistically significant protection against infection.

Lumpy skin disease virus

- Generally, in controlled trials, vaccination provided sufficient protection against infection and disease (Uzar et al., 2022) with Neethling strain vaccines offering better protection than sheep pox vaccines (Ben-Gera et al., 2015; Shafik et al., 2021).
- Field and modelling studies showed vaccination to be highly effective in controlling LSDV, significantly reducing infection risk (Alkhamis & VanderWaal, 2016; Huyen et al., 2025) as well as disease severity (Bich et al., 2024; Ince & Türk, 2020; Punyapornwithaya et al., 2023). However, effectiveness varied by region and vaccine strain, ranging from approximately 62% to over 97% (EFSA, 2019; Klement et al., 2020).

Rift Valley fever virus

- In controlled trials, live-attenuated vaccines (Kortekaas et al., 2014; Miller et al., 2015; Von Teichman et al., 2011) and inactivated vaccines (Kortekaas et al., 2012) provided full protection against infection and disease.
- Modelling studies indicated that vaccination was highly effective, particularly when applied proactively or when targeting cattle to provide cross-species protection (Gachohi et al., 2016). Strategies such as biannual vaccination or rapid

response reduced incidence up to 90%, whereas delayed or slow implementation was associated with substantially lower effectiveness (EFSA AHAW Panel, 2020; McMahon et al., 2014).

Trypanosoma vivax

The SLR identified only one field study by Mkunza et al. (1995), which reported that vaccination with recombinant vaccines led to significantly lower infection rates in cattle, outperforming the prophylactic drug Samorin.

West Nile virus

- Inactivated vaccines in horses reduced viraemia, clinical signs and mortality in controlled trials (Bowen et al., 2014).
- Field studies consistently showed that vaccination reduced the risk of infection (Epp et al., 2007; Rios et al., 2009), disease (Gardner et al., 2007) and case fatality (Salazar et al., 2004; Schuler et al., 2004; Ward et al., 2006).

3.2.5 | Medicinal treatments

Evidence on the efficacy of medicinal treatments, from peer-reviewed articles fitting the inclusion criteria for the SLRs conducted, was available for *Borrelia burgdorferi* s.l. (2 articles), BEFV (1 article), BTV (1), and *L. infantum* (28), *T. evansi* (13), and *T. vivax* (11). Active substances against vectors were included as medical treatment when the aim was to directly reduce the disease incidence and not purely decrease vector population. The detailed information extracted from each paper regarding the effect of medicinal treatments for these diseases is provided at Dórea et al. (2022). A summary of the evidence provided for each disease agent is presented below.

***Borrelia burgdorferi* s.l.**

A study testing three antibiotics in dogs (azithromycin, ceftriaxone and doxycycline) showed that antibiotic therapy reduced the load of *B. burgdorferi s.l.* in the host but failed to eradicate the agent (persistent infection) (Straubinger, 2000). Preventing vector infestation, on the other hand, proved fully effective (Krämer et al., 2020). Acaricidal efficacy was 100% in eight dogs treated with Imidacloprid 10% + flumethrin 4.5% for external use (through collars), resulting in full prevention of pathogen transmission up to 7 months after application.

Bovine ephemeral fever virus

One study (Uren et al., 1989) in cattle (6 animals) showed the effect of anti-inflammatory drugs (phenylbutazone and flunixin meglumine) on preventing clinical signs when administered before disease development (during incubation). No studies reported treatments aimed at preventing or curing infections.

Bluetongue virus

The use of vector control treatments (external use of permethrin) in cattle failed to reduce exposure to bluetongue virus (Mullens et al., 2001).

Leishmania infantum

- The use of collars or spot-on solutions to prevent arthropod infestations in dogs was reported as effective in reducing incidence of leishmaniosis in all reviewed articles (Imidacloprid + flumethrin – 3 papers, Brianti et al., 2014, Brianti et al., 2017, Otranto et al., 2013; Imidacloprid + permethrin – 3 papers, Otranto et al., 2010, Otranto et al., 2007, Goyena et al., 2016; permethrin – 1 paper, Ferroglio et al., 2008; fipronil + permethrin – 1 paper, Papadopoulos et al., 2017; deltamethrin – 4, Ferroglio et al., 2008, Gavgani et al., 2002, Maroli et al., 2001, Papadopoulos et al., 2017).
- Long-term parasite suppression and reduction of infectivity to sandflies in naturally infected dogs after long-term treatment with liposome-encapsulated meglumine antimoniate were reported in one study (da Silva et al., 2012), and cure (defined as absence of parasites in bone marrow aspirates) was reported after treatment with a combination of immunotherapy with *Leishmania infantum*-derived Fraction 2 and chemotherapy with meglumine antimoniate (8 dogs) (Neogy et al., 1994). The use of allopurinol during the period of sandfly activity was *not* shown to prevent the infection of non-infected dogs by *L. infantum* nor help in the elimination of the parasite from dogs with asymptomatic infections (Nascimento et al., 2020).
- Long-term treatment of visceral leishmaniosis in dogs was reported in several studies as efficient in controlling the disease clinical signs in dogs, but no effect in reducing spread or preventing new cases was reported. Meglumine antimoniate was the most frequent treatment reported, alone or in combination with other drugs (Denerolle & Bourdoiseau, 1999;

Guarga et al., 2002; Malmasi et al., 2014; Manna et al., 2015; Miró et al., 2011; Pennisi et al., 2005; Ribeiro et al., 2008). Other drugs shown to support treatment include recombinant cysteine proteinase (Ldccys1) (Ferreira et al., 2014), active hexose correlated compound (Segarra et al., 2017), enrofloxacin (Bianciardi et al., 2004), protein aggregate magnesium-ammonium phospholinoleate-palmitoleate anhydride immuno-modulator (P-MAPA) (Santiago et al., 2013), aminosidine (Poli et al., 1997), dimethasulfonate pentamidine (Rhalem et al., 1999) and a vaccine treatment using *L. braziliensis* disrupted promastigotes for treatment of *L. infantum* infected dogs (Mendes Roatt et al., 2022).

Trypanosoma evansi

Melarsenoxyde cysteamine hydrochloride was repeatedly referred to as the treatment of choice against Surra disease, and its effectivity was demonstrated in camels (Abdel-Rady et al., 2024; Mbaya et al., 2014; Musa et al., 1994; Zelleke et al., 1989), horses (Amjad et al., 2022), goats (Youssif et al., 2007), buffaloes (Lun et al., 1991) and cattle (Desquesnes et al., 2011; Payne et al., 1994). One study showed positive clinical recovery in horses after treatment with antrycide prosalt and isometamedium chloride (Singh et al., 2012). Diminazene diaceturate was effective in disappearance of parasitaemia and restoration of haematological values in cats (da Silva et al., 2009) and cattle (Singh & Chaudhri, 2003), but one study in camels showed that animals relapsed after treatment (Maina et al., 2003).

Trypanosoma vivax

Parasitic drugs were reported to have varying efficiency due to the development of resistance. For this reason, in the detailed table provided at https://doi.org/10.5281/zenodo.19231178, the country of the studies is explicitly labelled. Diminazene diaceturate was demonstrated to reduce incidence of *T. vivax* in cattle in Uganda (Muhanguzi et al., 2014), but persistence suspected to be attributable to resistance was reported in cattle in Nigeria (Odeniran et al., 2019). Combinations of diminazene diaceturate and imidocarb dipropionate (Bastos, Faria, Couto, et al., 2020; Bastos, Faria, de Assis Cavalcante, et al., 2020) or treatment with isometamidium chloride (Couto et al., 2025) were effective in cattle in Brazil. A combination of diminazene aceturate and isometamidium chloride was reported effective in cattle in Uganda (Magona et al., 2004), but resistance to the same treatment combination was reported in Ethiopia (Dagnachew et al., 2015). In Nigeria, *T. vivax* was found to be resistant to homidium chloride but sensitive to diminazene aceturate and isometamidium chloride at the recommended doses (Ogbaje et al., 2015). Footbaths with deltamethrin were reported effective in Burkina Faso (Bouyer et al., 2009). Ascofuranone antibiotic successfully cleared *T. vivax* in cattle in Kenya (Suganuma et al., 2024). In goats, studies with bedevil (Akinwale et al., 2006) and flurbiprofen (Dwinger et al., 1984) both reported failure to control infection with *T. vivax*.

3.2.6 | On farm biosecurity measures

The SLR retrieved 92 articles relevant to biosecurity, with the results summarised below for each VBD agent. The identified biosecurity measures fell into six thematic areas: (1) Farm management, (2) pasture management, (3) biosecurity and hygiene, (4) reproduction and parturition management, (5) movement and trade, and (6) veterinary and health management. The identified biosecurity measure effectiveness may vary depending on the host species, thus, where applicable, the results are described per host species group for each pathogen. The detailed information regarding the quantitative effect of each biosecurity measure for risk mitigation is provided at https://doi.org/10.5281/zenodo.19231178. The overall summary is presented in Table 8.

TABLE 8 Overview of identified biosecurity measures and risk factors.

Pathogen *[host species described]*	Protective (species if different, N studies)	Risk factors (species if different, N studies)	Inconclusive (species if different, N studies)
Besnoitia besnoiti *[cattle]*	• Access to shelter (equines, 1) • Rodent control (*equines*, 1) • Frequent cleaning (1)	• Housing with sick animals (1) • Frequent external worker visits (1)	
Bluetongue virus *[ruminants]*	• Access to shelter (3) • Mixing species in herds (camelids, 1) • Closing stable doors (1) • Participation in events (*camelids*, 1) • Quarantine (1) • Pasture rotation (1) • Keeping genealogical record (1)	• Contact with other herds (1) • Sourcing new animals from outside the herd (4) • Presence of mud/manure (1) • Grazing (1) • Lack of veterinary services (1)	• Access to shelter (1) • Contact with other animals/wildlife (3) • Sourcing new animals from outside the herd (3) • Ventilation/use of windbreak curtains (1) • Use of disinfectants (1)

TABLE 8 (Continued)

Pathogen *[host species described]*	Protective (species if different, N studies)	Risk factors (species if different, N studies)	Inconclusive (species if different, N studies)
Borrelia burgdorferi s.l.		• Presence of trees on pasture (*equines*, 1) • Indoor housing (*dog*, 1) • Recent travel history (*dog*, 1)	• Access to forested habitats (*equines*, 1) • Poor hygienic measures (*equines*, 1)
Bovine ephemeral fever virus *[cattle]*		• Lack of veterinary services (1) • Inappropriate management of manure (1) • Interactions between farm workers (1)	• Car entrance/exit on farm (1)
Coxiella burnetii *[ruminants]*	• Quarantine (2) • Use of disinfectants (3) • Frequent cleaning of feeders (1) • Frequent cleaning of bedding (1) • Use of common watering points (1) • Use of automatic milking systems (1) • Cleaning/disinfection protocols during birthing (6) • Birthing outdoors (1) • Isolation of aborting animals (2) • Separating/isolating animals or parturition (4) • Contact with other herds (1) • Herds combining multiple species (1) • Keeping animals tied or in tie-stalls (2) • Group housing (1) • Indoor housing (1) • Grazing at further distances from farm (1) • Burial of carcasses (1)	• Quarantine (1) • Sourcing new animals from outside the herd (5) • Frequent movement of animals from the farm (1) • Animal loaning (2) • Abroad/unknown origin straw (1) • Sharing equipment with other herds (1) • Agrotourism (2) • No precautions by veterinarian when entering herd (2) • Control of rodents/absence of rodents (2) • Artificial insemination (1) • Artificial insemination by non-trained personnel (1) • Birthing outdoors on farm with pigs (1) • Separating animals or parturition (2) • Contact with other animals (7) • Contact with other herds (4) • Herds combining multiple species (1) • Group housing (1) • Use of windbreak curtains/windshields (2) • Animals kept on fenced ranges (1) • Marginal ground pastures (1) • Open range pastures (1) • Proximity to PCR positive farms (1) • Routine health contract with veterinarian (1) • Contact with small ruminants (*horses*, 1)	• Quarantine (1) • Sourcing new animals from outside the herd (4) • Frequent cleaning of bedding (1) • General hygiene measures (2) • Farm boots/outfit as hygiene precaution when entering herd (1) • Control of rodents/absence of rodents (1) • Artificial insemination (1) • Cleaning/disinfection protocols during birthing/abortion (3) • Birthing outdoors (1) • Isolation of aborting animals (1) • Separating animals or parturition (2) • Contact with other animals (4) • Keeping animals tied or in tie-stalls (1) • Group housing (1) • Indoor housing (2) • Use of windbreak curtains/windshields (1) • Animals kept on fenced farms (1) • Open range pastures (1) • Incineration, or compost of carcasses (1)
Crimean-Congo haemorrhagic fever virus *[small ruminants]*	• Closed housing (1) • Trough-feeding (1) • Presence of rural poultries (1)		Herds combining multiple species (1)
Epizootic haemorrhagic disease virus *[ruminants]*	• Quarantine (1)	• Presence of organic/other waste (1) • Presence of muddy soil (1)	
Equine infectious anaemia virus *[equines]*	• Separating riding equipment (1) • Limiting exposure to sick horses (2) • Routine testing practice (1)	• Sharing water sources with other farms (1) • Use of vaccination pistol (1)	• Separating riding equipment (1) • Purchasing horses (1) • Vaccine against other diseases (1)
Leishmania infantum *[Dogs]*	• Allowing to freely roam at night (1)		• Daily peridomicile cleaning (1)

(Continues)

TABLE 8 (Continued)

Pathogen *[host species described]*	Protective (species if different, N studies)	Risk factors (species if different, N studies)	Inconclusive (species if different, N studies)
Lumpy skin disease virus *[cattle]*	• Contact with other animals (1) • Indoor housing (1) • Grazing (1)	• Sourcing new animals from outside the herd (2) • Presence of livestock collectors/ traders near the farm (1) • Contact with other animals (1) • Contact with other herds (1) • Proximity to farms with clinical signs (1) • Use of communal watering systems (2) • Use of communal feeding systems (1) • Poor management of farm waste (1) • Grazing (1)	• Grazing (1)
Rift Valley fever virus *[ruminants]*		• Sourcing new animals from outside the herd (1)	• Sourcing new animals from outside the herd (1) • Herds combining multiple species (1)
Schmallenberg virus *[small ruminants]*	• Indoor housing (1) • Presence of cattle (1)		
Tick-borne encephalitis virus			• Access to shelter (*equines*, 1)
Trypanosoma evansi *[equines]*		• Promiscuity with dromedaries (1)	• History of venereal disease (1)
Trypanosoma vivax *[cattle]*	• Contact with other herds (1) • Disinfection of gloves for rectal palpation with 1% iodine solution (1)	• Migration during wet or dry season (1) • Recent purchase of animals (1) • Administration of oxytocin using the same syringe and needle (1) • Cattle tethering in communal areas • Insufficient disinfection of gloves for rectal palpation (1)	
Vesicular stomatitis virus	• Access to shelter (*equines*, 1)	• Contact with sick animals (*equines*, 1) • Access to pasture (*equines*, 1)	• Access to shelter (*ruminants*, 1) • Access to pasture (*ruminants*, 1)
West Nile virus [equines]	• Access to shelter (2) • Longer turnout time (1) • Dry-lot pastures (1)	• Recent travel history (1) • Use of fans in stable (1) • Proximity to wildlife parks (1) • Presence of dead birds (1) • Exposure to sick animals (1)	• Recent travel history (1) • Longer turnout time (1) • Use of fly sheets (1) • Dry-lot or other pastures (1)

Besnoitia besnoiti

- **In equines**, access to shelter and rodent control was reported to have a protective effect by Gutierrez-Exposito et al. (2017).
- **In cattle**, housing with seropositive animals (Esteban-Gil et al., 2017) and frequent external worker visits (Talafha et al., 2015) were risk factors, whereas frequent cleaning was associated with reduced seroconversion risk (Talafha et al., 2015).

Bluetongue virus

- **In camelids**, Al-Mamari et al. (2025) reported an association with seropositivity in animals that participate in events and a protective effect of mixing species in herds.
- **In ruminants**, among factors related to farm management, access to shelter was protective in three studies (Cappai et al., 2018; Sana et al., 2022; Sbizera et al., 2024) and inconclusive in one (Adam et al., 2014).

  Animal movement and trade factors, such as sourcing new animals from outside the herd, were identified to have a risk effect in four studies (da Silva et al., 2018; Green et al., 2005; Khair et al., 2014; Pascual-Linaza et al., 2014) although the association was not always significant (Adam et al., 2014; Pascual-Linaza et al., 2014; Torsson et al., 2017). Additionally, quarantine of newly purchased animals was reported to have a protective effect by Cetre-Sossah et al. (2014).

Cappai et al. (2018) reported that the presence of mud and manure was associated with higher disease incidence, but the practice of pasture rotation was protective.

- **In small ruminants**, Torsson et al. (2017) reported that contact with other herds was a risk factor, but this association was not significant for contact with wildlife.
- **In sheep**, Sbizera et al. (2024) reported that keeping a genealogical record was protective, and Hijazeen and Ismail (2020) indicated the risk effect of lacking veterinary services, while the use of disinfectants was not conclusive.
- **In cattle**, Santman-Berends et al. (2010) showed a protective association of closing stable doors during the day, but no conclusive effect was found for ventilation/use of windbreak curtains. The same study also investigated different grazing regimens, reporting that animal grazing was a risk factor. Lastly, contact with other animals was not significantly associated with seropositivity (Adam et al., 2014; Selim et al., 2023).

***Borrelia burgdorferi* s.l.**

- **In horses**, Neely et al. (2021) identified the presence of trees on pasture as a risk factor, but access to forested habitats did not have a conclusive association. Hygienic measures did not show a significant effect (Alruhaili et al., 2024).
- **In dogs**, Usman et al. (2022) reported that indoor housing and recent travel history were each significantly associated with increased disease incidence.

Bovine ephemeral fever virus

- **In cattle**, lack of veterinary services was a risk factor by Hijazeen and Ismail (2020). Another study reported both the inappropriate management of manure and the interactions between farm workers to increase disease incidence (Mirzaie et al., 2017).

Coxiella burnetii

- **In ruminants**, among factors related to animal movement and trade, two studies showed quarantine to have a protective effect (Guesmi et al., 2023; Paul et al., 2012), but this finding was not always significant (Meadows et al., 2015a) or even a risk factor (Barkallah et al., 2018). Sourcing animals from outside the herd was associated with higher seroprevalence in five studies (Boroduske et al., 2017; Menadi et al., 2020; Nusinovici et al., 2014; Obaidat & Kersh, 2017; van Engelen et al., 2014) but not always conclusive (Meadows et al., 2015a; Schimmer et al., 2014; van Engelen et al., 2014; Welch et al., 2024).
  Generally, cleaning and disinfection practices generally had a protective effect: frequent cleaning of feeders (Obaidat & Kersh, 2017) and frequent cleaning of bedding/litter were each protective (van Engelen et al., 2014) with the latter not always significant (Cantas et al., 2011). Non-specific cleaning/hygiene practices were inconclusive in two studies (Barkallah et al., 2018; Nokhodian et al., 2016).
  Using common watering points (Guesmi et al., 2023) and use of automatic milking systems (van Engelen et al., 2014) were protective factors, while sharing equipment with other herds was associated with increased seroconversion risk (Agger et al., 2013). Animal contact with visitors was associated with increased risk in two studies (Agger et al., 2013; Welch et al., 2024). Veterinarians not taking hygienic precautions prior to entering the herd was associated with increased risk (Agger et al., 2013; Paul et al., 2012), and that the effect of using farm boots/outfits as a hygienic measure was inconclusive (Schimmer et al., 2014).
  For reproduction and parturition management, following cleaning/disinfection protocols during birthing was protective in six studies (Carbonero et al., 2015; Elsohaby et al., 2021; Meadows et al., 2015a; Meadows et al., 2015b; Taurel et al., 2011; Welch et al., 2024), highlighting the positive effect of practices such as disinfection of umbilical cord, systematic removal of birthing materials and fetus and the changing of bedding. However, the association was not always conclusive (Meadows et al., 2015a; Meadows et al., 2015b; Welch et al., 2024).
  In addition, separating animals for parturition/abortion was protective in four studies (Dabaja et al., 2019; Elsohaby et al., 2021; Hussain et al., 2022; Welch et al., 2024), but this effect was not always significant (Meadows et al., 2015b; Welch et al., 2024), whereas two studies identified separation as a potential risk factor (Meadows et al., 2015a; Meadows et al., 2015b).
  Among farm management factors, contact with other animals (such as cats, dogs, mice, pigeons or wildlife) was associated with increased risk in six studies (Barkallah et al., 2018; Lafi et al., 2020; Mazeri et al., 2013; Robi et al., 2023; Schimmer et al., 2011; Turcotte et al., 2021); however, this association was not always significant (Belhouari et al., 2022; Cantas et al., 2011; Schimmer et al., 2011). Four studies indicated contact with other herds was a risk factor (Meadows et al., 2015a; Menadi et al., 2020; Obaidat & Kersh, 2017; Rizzo et al., 2016).
- **In small ruminants**, two studies identified the practice of animal loaning as a risk factor (Lafi et al., 2020; Meadows et al., 2015b). Factors associated with rodent and pest control indicated that absence/no knowledge of pests in feed was a risk factor (Schimmer et al., 2014), but this association was not always conclusive (Schimmer et al., 2011). Covering air spaces to control nuisance animals was also associated with higher seroprevalence risk (Schimmer et al., 2011). In goats, one study identified the use of non-domestically sourced straw for bedding as a risk factor (Schimmer et al., 2011).

For reproduction and parturition management, kidding outdoors was protective, but this was identified as a risk factor on farms with pigs (Meadows et al., 2015a). For sheep, lambing outdoors had an inconclusive effect (Meadows et al., 2015b). Artificial insemination was associated with increased risk (Schimmer et al., 2011). In goats, one study indicates the protective effect of burial of carcasses, whereas other forms of disposal were inconclusive (Anderson et al., 2015). Another risk factor was proximity to bulk milk-PCR-positive farms (Schimmer et al., 2011).

For farm management-related factors, herds combining multiple species was a risk factor in one study (Rizzo et al., 2016) and protective in another (Welch et al., 2024), while contact with pigs was inconclusive (Meadows et al., 2015a). Interestingly, contact with other herds was indicated as protective in goats (Welch et al., 2024). Welch et al. (2024) also reported indoor housing of small ruminants as a risk factor, but this effect was not always significant (Schimmer et al., 2014; Welch et al., 2024). In addition, the use of windbreak curtains and/or windshields was associated with higher seroprevalence in two studies (Schimmer et al., 2011; Schimmer et al., 2014), but the effect of windshields was not always conclusive (Schimmer et al., 2011).

Aspects related to pasture management showed that animals kept on fenced ranges were at greater risk, but the association was inconclusive for animals kept on fenced farms (Welch et al., 2024). Grazing at further distances from the farm was indicated as protective in one study (Obaidat & Kersh, 2017), while marginal ground pastures were identified as a potential risk factor (Schimmer et al., 2014), along with open ranges; however, the latter association was not always conclusive (Welch et al., 2024).

- **In cattle**, Paul et al. (2014) reported an increased risk association with frequent movement from the farm. Two studies presented contradictory results, one indicating the protective effect of housing of animals of different ages in the same shed (Czaplicki et al., 2012), while another indicated that group pens can be a risk factor (Turcotte et al., 2021), but the associations were not always significant in the latter study. Keeping animals tied or in tie-stalls was protective (Czaplicki et al., 2012; Neare et al., 2023), but the effect was not always conclusive (Neare et al., 2023), and using disinfectants for sheds was found protective (Czaplicki et al., 2012; Menadi et al., 2020).

  Among factors associated with reproduction and parturition management, the use of AI did not have a conclusive effect (Nokhodian et al., 2016), but performing artificial insemination by non-trained personnel was a risk factor (Agger et al., 2013). Interestingly, having a routine herd health contract with a veterinarian was shown to have a risk effect (Agger et al., 2013).
- **In horses**, one study identified contact with small ruminants as a risk factor (Ansel et al., 2020).

Crimean-Congo haemorrhagic fever virus

In small ruminants, farm management factors such as closed housing, trough-feeding and presence of rural poultry on the farm were each protective (Kasi et al., 2020), whereas the effect of keeping mixed-species herds was inconclusive (Lysholm, Lindahl, Dautu, et al., 2022).

Epizootic haemorrhagic disease virus

In ruminants, the SLR identified only one study (Cetre-Sossah et al., 2014) for EHDV, reporting the protective effect of quarantine, whereas both the presence of organic waste and muddy soil were each risk factors.

Equine infectious anaemia virus

In equines, one study indicated the protective effect of separating riding equipment (Nogueira et al., 2017), but the effect was not always significant (Borges et al., 2013). In addition, sharing water sources with other farms was identified as a risk factor (Pinho et al., 2025). Two studies indicate that limiting exposure to sick horses is protective (Machado et al., 2024; Nogueira et al., 2017), alongside having a routine resting practice (Nogueira et al., 2017). A study by de Padua et al. (2022) reported an increased risk of seroconversion when using vaccination pistols.

Animal sourcing and vaccination against other infections did not show conclusive associations (Barros et al., 2018; Borges et al., 2013).

Leishmania infantum

In dogs, allowing to roam freely a night was found protective by Braz et al. (2021), while daily peridomicile cleaning did not show a conclusive effect (Lopes et al., 2016).

Lumpy skin disease virus

In cattle, animal sourcing from outside the herd was identified as a risk factor in two studies (Kiplagat et al., 2020; Susanti et al., 2023) as well as the presence of livestock collectors/traders near the farm (Susanti et al., 2023). Contact with other animals was identified as a risk factor in one study (Selim et al., 2021), but protective in another (Molla et al., 2018), whereas contact with other herds was associated with higher disease incidence (Susanti et al., 2023).

Proximity to farms with clinical signs was also shown to have a risk effect (Susanti et al., 2023). Two studies indicated increased risk for using communal watering systems (Elsheikh et al., 2024; Selim et al., 2021) and communal feeding systems (Elsheikh et al., 2024). Another study reported the risk effect of poor management of farm waste (Susanti et al., 2023). Two studies indicate the protective effect of indoor housing (EFSA, 2018; Klement et al., 2020).

Cattle grazing practices showed contradicting associations. Allowing animals to roam freely during grazing was identified as protective (Selim et al., 2021), but another study found grazing associated with higher disease incidence (Sethi et al., 2022). Other grazing practices did not have a conclusive effect (Selim et al., 2021).

Rift Valley fever virus

In ruminants, animal sourcing from outside the herd had a risk effect (Sindato et al., 2015), but the association was not always significant (Lysholm, Lindahl, Munyeme, et al., 2022). Herds combining multiple species did not have a significant association (Lysholm, Lindahl, Munyeme, et al., 2022).

Schmallenberg virus

In small ruminants, one study indicated the protective effect of indoor housing (Helmer et al., 2016), while another reported the presence of cattle on goat farms was associated with lower seroprevalence (Kiene et al., 2024).

Tick-borne encephalitis virus

The SLR identified only one study fitting the biosecurity category for TBEV (Gothe et al., 2023), with access to shelter not showing a conclusive association with seroprevalence **in horses**.

Trypanosoma evansi

In equids, promiscuity with dromedaries had a risk effect (Benfodil et al., 2019), whereas positive history of venereal disease did not show a conclusive association (Shorba et al., 2024).

Trypanosoma vivax

- **In zebu**, one study identified herd migration during wet and dry seasons as a risk factor, whereas contact with other herds was associated with lower disease incidence (Majekodunmi et al., 2013).
- **In cattle**, recent animal purchases and administration of oxytocin using the same syringe and needle were identified as risk factors in one study (Bastos, Faria, Couto, et al., 2020; Bastos, Faria, de Assis Cavalcante, et al., 2020), and cattle tethering in communal areas in another (Tegegn et al., 2021). Another experimental field study (Leal et al., 2025) assessed the effectiveness of iodine-based glove disinfection for rectal palpation. The findings indicate that inadequate disinfection (concentrations up to 0.5%) did not prevent infection in cattle, whereas a 1% iodine solution was 100% effective.

Vesicular stomatitis virus

- **In equines**, contact with sick horses (Urie et al., 2018) and access to pasture (Hurd et al., 1999; Urie et al., 2018) were identified as risk factors, whereas access to shelter was protective (Hurd et al., 1999).
- **In ruminants**, access to shelter and access to pasture were not significantly associated with disease incidence (Hurd et al., 1999).

West Nile virus

In equines, recent travel history was associated with higher seroprevalence (Garcia-Bocanegra et al., 2012); however, the effect was not always significant (Gothe et al., 2023). Access to shelter was identified to have a protective effect (Chevalier et al., 2025; Pradel et al., 2009), whereas another study indicated that spending more time outdoors is associated with lower seroprevalence (Gothe et al., 2023), although the association was not always conclusive.

The use of fans in the stable was associated with higher seroprevalence (Rios et al., 2009), while the use of fly sheets did not have a conclusive effect (Gothe et al., 2023). The Gothe et al.'s (2023) study also investigated the different pasture type association with seropositivity and indicated the potential protective effect of dry-lots; however, the effect was not always conclusive. Close proximity to wildlife parks was indicated as a risk factor (Chevalier et al., 2025). Lastly, one study reported the risk effect of the presence of dead birds and the presence of other ill animals (Rios et al., 2009).

3.2.7 | Vector control

For vector control, the results of the SLR are not compiled by disease, but by vector groups, i.e. ticks, mosquitoes, midges and sandflies. Evidence for other vectors involved in the transmission of certain VBDs, such as biting flies (e.g. *Stomoxys* spp., Tabanidae) for LSD, will be collected in next outputs and as soon as the SLR will be updated. The detailed results of each of these SLRs can be found in the respective pages:

- https://animal-diseases.efsa.europa.eu/agent_pages/vectorcontrol_ticks.html
- https://animal-diseases.efsa.europa.eu/agent_pages/vectorcontrol_sandflies.html
- https://animal-diseases.efsa.europa.eu/agent_pages/vectorcontrol_midges.html
- https://animal-diseases.efsa.europa.eu/agent_pages/vectorcontrol_mosquitoes.html

Below summary tables extracted from the SLR mentioned above (Dórea et al., 2022) about efficacy of chemical substances (including repellents) on adult vectors by route of application and target host are reported (Tables 9–12). Tables with data extracted from reviewed studies and related references are available at https://doi.org/10.5281/zenodo.19188383.

TABLE 9 Mosquitoes – median efficacy and 5th and 95th percentiles by host, substance category and route of application.

Study target host	Route	Test substance category	Median efficacy	P5 efficacy	P95 efficacy	*n studies*
Dog	External use – topic/spray	Neonicotinoid + Pyrethroid	73.3%	73.3%	73.3%	1
Dog	External use – topic/spray	Pyrethroid	48.0%	48.0%	48.0%	1
Dog	External use – topic/spray	Pyrethroid + Phenylpyrazoles	68.2%	68.2%	68.2%	1
Not host specific	Environment treatment	Bacteria	61.8%	61.8%	61.8%	1
Not host specific	Environment treatment	Essential oil	42.3%	42.3%	42.3%	1
Not host specific	Environment treatment	Pyrethroid	47.8%	25.4%	77.8%	4
Not host specific	External use – topic/spray	Plant extract	77.9%	77.9%	77.9%	1
Not host specific	Vector directly exposed	Insect Growth Regulator + Fungi	93.8%	93.8%	93.8%	1
Not host specific	Vector directly exposed	Insect repellent	54.0%	54.0%	54.0%	1
Not host specific	Vector directly exposed	Plant extract	0.0%	0.0%	69.1%	3
Not host specific	Vector exposed to treated nets	Pyrethroid	93.0%	93.0%	93.0%	1

TABLE 10 Sandflies – Median efficacy and 5th–95th percentiles by host, substance category and route of application.

Study target host	Route	Test substance category	Median efficacy	P5 efficacy	P95 efficacy	*n studies*
Cattle	Vector exposed to treated nets	Pyrethroid	77.0%	77.0%	77.0%	1
Dog	External use – collar/ear tag	Pyrethroid	96.0%	96.0%	96.0%	1
Dog	External use – topic/spray	Neonicotinoid + Pyrethroid	60.0%	59.2%	60.9%	2
Dog	External use – topic/spray	Oxadiazine + Pyrethroid	53.7%	53.7%	53.7%	1
Dog	External use – topic/spray	Pyrethroid	68.9%	68.9%	68.9%	1
Dog	External use – topic/spray	Pyrethroid + IGR	37.2%	37.2%	37.2%	1
Dog	External use – topic/spray	Pyrethroid + Phenylpyrazoles	94.3%	93.3%	95.3%	2

TABLE 11 Midges – Median efficacy and 5th–95th percentiles by host, substance category and route of application.

Study target host	Route	Test substance category	Median efficacy	P5 efficacy	P95 efficacy	*n studies*
Horse	Vector exposed to treated nets	Pyrethroid	90.0%	81.0%	99.0%	2

TABLE 12 Ticks – median efficacy and 5th–95th percentiles by host, substance category and route of application.

Study target host	Route	Test substance category	Median efficacy	P5 efficacy	P95 efficacy	*n studies*
Cat	External use – collar/ear tag	Neonicotinoid + Pyrethroid	97.6%	94.9%	99.8%	3
Cat	External use – topic/spray	Phenylpyrazoles + IGR + Avermectin + Isoquinoline–pyrazine	74.7%	54.5%	95.0%	2
Cattle	External use – collar/ear tag	Phenylpyrazoles	94.7%	94.7%	94.7%	1
Cattle	External use – topic/spray	Avermectins	17.6%	17.6%	17.6%	1
Cattle	External use – topic/spray	Insect Growth Regulator	79.0%	79.0%	79.0%	1
Cattle	External use – topic/spray	Phenylpyrazoles	85.6%	68.4%	92.6%	3
Cattle	External use – topic/spray	Phenylpyrazoles + IGR	86.5%	86.5%	86.5%	1
Cattle	External use – topic/spray	Pyrethroid	94.7%	94.7%	94.7%	1
Cattle	Oral	Avermectins	98.0%	98.0%	98.0%	1
Cattle	Subcutaneous	Avermectins	49.3%	31.0%	74.0%	3
Cattle	Subcutaneous	Milbemycins	77.6%	77.6%	77.6%	1
Cattle	Subcutaneous	Phenylpyrazoles	67.4%	67.4%	67.4%	1
Chickens	Subcutaneous	Milbemycins	96.6%	96.6%	96.6%	1
Dog	External use – collar/ear tag	Neonicotinoid + Pyrethroid	97.6%	83.8%	100.0%	4
Dog	External use – collar/ear tag	Pyrethroid	90.1%	88.2%	92.1%	2
Dog	External use – topic/spray	Neonicotinoid	27.3%	27.3%	27.3%	1
Dog	External use – topic/spray	Neonicotinoid + Pyrethroid	82.3%	30.7%	94.8%	11
Dog	External use – topic/spray	Phenylpyrazoles	92.4%	54.7%	98.0%	10
Dog	External use – topic/spray	Phenylpyrazoles + IGR	92.0%	48.0%	99.0%	6
Dog	External use – topic/spray	Phenylpyrazoles + Pyrethroid	97.7%	96.9%	99.5%	5
Dog	External use – topic/spray	Pyrethroid	84.5%	84.5%	84.5%	1
Dog	Oral	Isoxazolines	73.5%	22.3%	99.3%	5
Dog	Oral	Spinosyn insecticide	65.8%	65.8%	65.8%	1
Dog	Vector exposed to treated nets	Phenylpyrazoles	82.2%	82.2%	82.2%	1
Goat	External use – topic/spray	Pyrethroid	64.6%	64.6%	64.6%	1
Not host specific	Vector directly exposed	Insect repellent	100.0%	100.0%	100.0%	1
Sheep	External use – topic/spray	Pyrethroid	95.9%	95.9%	95.9%	1
Sheep	Subcutaneous	Avermectins	85.5%	85.5%	85.5%	1
Zebu	External use – topic/spray	Pyrethroid	91.6%	91.6%	91.6%	1

4 | CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations include the three following general aspects for the 25 VBDs:

- How much knowledge is available for each category of risk mitigation measures (RMMs) for vector-borne diseases (VBDs)
- Which knowledge gaps and uncertainties remain, based on the evidence contained in the report
- Recommendations for ad hoc research to strengthen future mitigation capacity.

1. Surveillance

- Surveillance is the most comprehensively documented mitigation category, supported by multiple systematic literature reviews (SLRs) covering vector competence, host range, diagnostic test performance, infection periods, prevalence ranges and pathogen survival.
- Surveillance is recognised as a cornerstone of VBD risk mitigation, with well-established methods for vector surveillance, host surveillance, environmental monitoring and developed modelling. Standardised protocols and abundant crosscutting evidence are available across all 25 VBDs.

Knowledge gaps and uncertainties

- Limited sensitivity/specificity data for certain diagnostic tests and for some host/vector combinations.
- Sparse data for mechanically transmitted diseases, for which vector competence and MIR data are less applicable.
- Gaps in surveillance performance metrics (timeliness, sensitivity of detection systems).
- Limited integration of environmental and climatic predictors into early warning systems for several pathogens.
- Patchy geographical surveillance coverage in some EU regions (particularly for emerging or non-listed VBDs).

Recommendations for ad hoc research

- Develop harmonised EU-wide performance indicators for surveillance sensitivity, timeliness and representativeness.
- Expand experimental and field research on diagnostic accuracy for understudied pathogens, host species and matrices.
- Strengthen research on ecoclimatic early warning thresholds, including e.g. remote sensing–based vector suitability modelling.
- Advance operational research on integrated surveillance (One Health), enabling cross-sectoral data integration.

2. Movement Restrictions

- Evidence about effectiveness of movement restriction is moderate but heterogeneous. Most available studies are modelling analyses (19 articles), demonstrating that movement controls can reduce transmission for several VBDs (e.g. AHSV, BTV, RVFV, LSDV, *C. burnetii*). Effectiveness depends strongly on vector dispersal characteristics, the role of possible wild vertebrate host reservoirs and overall epidemiological contexts.

Knowledge gaps and uncertainties

- Lack of field-based quantification of the stand-alone effect of movement bans (difficult to isolate from other control measures).
- Limited evidence for many VBDs; modelling outcomes vary depending on assumptions about epidemiological characteristics of the disease and simulated effect of control measures.
- Insufficient understanding of how timing, zone size and compliance interact to affect impact.

Recommendations for ad hoc research

- Conduct modelling studies on diseases to determine context-dependent movement restriction effectiveness.
- If possible, develop empirical studies during outbreaks (natural experiments) to quantify real-world effects of movement bans.
- Collect good quality data about animal movements in the EU, including those for wildlife–livestock interfaces, to better assess movement ban effect.

3. Culling

- Evidence is limited and highly disease-specific. Only six VBD agents (*L. infantum*, *B. burgdorferi*s.l. *C. burnetii*, LSDV and RVFV) had any eligible studies. Effects ranged from modest to inconsistent. In many cases, selective culling or stamping out alone is insufficient and only effective when combined with vaccination or other measures.

Knowledge gaps and uncertainties

- Very limited field evidence for most VBDs.
- Uncertain long-term ecological consequences of wildlife or livestock culling.
- For zoonotic parasites (e.g. *L. infantum*), effectiveness varies widely across geographic contexts.

Recommendations for ad hoc research

- Investigate ecological impacts as well as the impact of the geographical scale of wildlife or host population reduction.
- Evaluate cost-effectiveness and sustainability of targeted culling compared with integrated strategies.
- Increase evidence on combined control strategies (e.g. effectiveness of culling + vaccination + vector control).

4. Vaccination

- For vaccination, the evidence base is strong for some pathogens, notably BTV (25 publications), LSDV (20 publications), *C. burnetii* (15 publications) and RVFV (9 publications) while weaker for others. SLRs summarise vaccine efficacy and effectiveness under both experimental and field conditions. Many vaccines show high to very high protective performance, though coverage and timeliness are crucial determinants of population level impact.

Knowledge gaps and uncertainties

- Limited efficacy data for several emerging or non-listed VBDs.
- Lack of durability and cross-protection data for some vaccines (e.g. BEFV, JEV, SBV).
- Sparse information on vaccine performance under field conditions for many pathogens.
- Limited understanding of optimal vaccination strategies (target groups, timing, coverage thresholds).

Recommendations for ad hoc research

- Advance vaccine development for understudied VBDs, especially those with expanding vector ranges.
- Conduct longitudinal field studies to assess waning immunity and cross-serotype protection.
- Develop models identifying optimal vaccination windows under varying climatic and ecological scenarios.

5. Medicinal Treatments

- Evidence availability is variable and disease specific. Substantial data exist for leishmaniasis (58 publications), *T. evansi* (45 publications) and *T. vivax* (11 publications), whereas treatment options for many viral VBDs are scarce. Several treatments reduce morbidity or parasite loads, but eradication of infection linked only to drug treatment is uncommon and drug resistance is an emerging concern or even consolidated concern for certain pathogens in endemic regions such as *Trypanosoma vivax* in the tropics.

Knowledge gaps and uncertainties

- Insufficient evaluation of treatment effects on population-level transmission.
- Limited data on drug resistance trends, especially for trypanosomes.
- Lack of standardised outcome measures (e.g. cure of clinical signs, infectivity reduction).

Recommendations for ad hoc research

- Evaluate treatment impact on host infectiousness and onward transmission.
- Systematically monitor drug resistance emergence across regions.
- Develop novel therapeutics or integrated host–vector treatment approaches.

6. On-Farm Biosecurity

- Evidence is extensive (92 studies) but highly heterogeneous, varying by species, farm system and pathogen. Multiple protective and risk-enhancing practices have been identified, including quarantine, hygiene measures, vector exclusion practices and management of manure, bedding and water sources.

Knowledge gaps and uncertainties

- Contradictory evidence for several measures (e.g. indoor housing, mixing species, grazing practices).
- Limited quantification of the effect size of individual measures versus bundled practices.
- Lack of standardised metrics for measuring biosecurity compliance.

Recommendations for ad hoc research

- Conduct controlled field trials assessing combined biosecurity packages.
- Develop standardised EU-wide biosecurity scoring systems.
- Explore interactions between biosecurity, vector ecology and environmental conditions.

7. Vector Control

- A robust evidence base exists for chemical vector control, summarised separately for mosquitoes (91 publications), midges (8 publications), ticks (69 publications) and sandflies (19 publications). Efficacy varies greatly by species, substance and application route. Several compounds demonstrate high median efficacy (e.g. fipronil, permethrin, deltamethrin), although performance in real-world settings may differ from controlled conditions.

Knowledge gaps and uncertainties

- Limited field evidence linking entomological endpoints (vector mortality) with reductions in disease incidence.
- Despite not directly assessed in this report, there is evidence of fragmented data on insecticide resistance patterns across vector populations.
- Uncertain long-term sustainability of chemical control in the context of climate change, ecological impact and changing vector distributions.

Recommendations for ad hoc research

- Establish longitudinal field studies connecting vector control interventions to epidemiological outcomes.
- Systematically map insecticide resistance in EU vectors.
- Test integrated vector management (IVM) approaches combining chemical, environmental and biological control methods.

Overall recommendations across risk mitigation measure categories

Cross-cutting research priorities may comprise:

- Develop harmonised, comparative frameworks to evaluate RMM effectiveness across pathogens and environments.
- Strengthen data infrastructures enabling integration of surveillance, mitigation performance, climatic data and modelling outputs.
- Promote One Health methodologies bridging animal, human and environmental surveillance.
- Expand research on emerging vector species and invasive pathogens likely to establish under climate change scenarios.
- Invest in experimental and quasi-experimental study designs to overcome limitations of purely modelling-based evidence.

ABBREVIATIONS

AHL	Animal Health Law
AHSV	African horse sickness virus
BTV	bluetongue virus
ECDC	European Centre for Disease Prevention and Control
EHDV	Epizootic haemorrhagic disease virus
EIAV	Equine infectious anaemia virus
JEV	Japanese encephalitis virus
LSDV	lumpy skin disease virus
RMMs	risk mitigation measures
RVFV	Rift Valley fever virus
SLRs	systematic literature reviews
VBDs	vector-borne diseases
VEEV	Venezuelan equine encephalitis virus
VSV	Vesicular stomatitis virus

WAHIS	World Animal Health Information System
WNV	West Nile virus
WOAH	World Organisation for Animal Health

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APPENDIX A

Protocol: Translation of ToR 1.3 into subquestions, evidence needs and assessment methods

TABLE A.1 Protocol for the assessment of ToR 1.3.

ToR 1.3.
Provide a mapping/horizon scanning/compilation/description of the currently available surveillance, prevention and control measures for listed and non-listed VBDs in the EU; this includes the collection of data on the efficacy of these measures (e.g. vaccination efficacy, efficacy of biocidal treatments or repellents, animal treatments, insect nets or other husbandry practices)

Section	Sub-question	Evidence needs	Data collection method/ source	Reporting methods of data collection
1.3.1. Surveillance				
	Which **surveillance components** are available for each of the 25 VBD agents?	Detection of any of the 25 VBDs agents in a surveillance component (e.g. vector surveillance, surveillance of hosts, surveillance in matrices such as bulk milk, wastewater, meat)	• **SLR Vector competence/ vectornet** (Pathogen detection in vector) • **SLR Geo-distribution VBDs/disease profiles** (Pathogen detection in host) • **SLR pathogen survival in matrices/disease profiles** (Pathogen detection in matrices)	• Summary table with relevant surveillance components per VBD with narrative summary
	What is the **specificity and sensitivity** of the available diagnostic tests to detect the VBD-agent in any of the surveillance components**?**	Specificity and sensitivity of the available diagnostic tests used in different surveillance components	• **SLR diagnostic test accuracy/disease profiles** (SP and Se diagnostic tests)	• Summary table of evidence on Se and SP values with short narrative summary
	What are the ranges of **MIR** in field collected vectors tested in different epidemiological situations?	MIR of VBD agents in vectors with description of epidemiological context	• **SLR minimum infection rate range/Vectornet** (Minimum infection rate in field collected vectors)	• Summary table of MIR values found for different VBDs with short narrative summary
	What are the ranges of **prevalence in hosts** or **matrices** tested in different epidemiological situations?	Prevalence values of VBD agents in hosts or matrices with description of epidemiological context	• **SLR Geo-distribution VBDs/disease profiles** (Prevalence in host or matrices such as bulk milk)	• Summary table of prevalence values in hosts and matrices with short narrative summary
	What is the **infectious period** in hosts?	Duration of pathogen detection (PCR or VI) in hosts	• **SLR experimental infections/disease profiles** (Max. number of days post infection for positive PCR or VI tests)	• Summary table of duration of infectious period with short narrative summary
	What is the **infectious period** in vectors?	Duration of pathogen detection (PCR or VI) in vectors	• **SLR vector competence** (Max. number of days after feeding to test positive PCR or VI tests)	• Summary table of duration of infectious period with short narrative summary
	What is duration of **pathogen survival** in matrices?	Duration of pathogen detection (PCR or VI) in matrices	• **SLR pathogen survival in matrices/disease profiles** (Max. number of days post inoculation for positive PCR or VI tests)	• Summary table of duration of pathogen survival with short narrative summary
	What are the **modes of transmission** of VBDs?	• Basic transmission and persistence parameters	• **SLR experimental infections/disease profiles** (Route of infection)	Summary tables of transmission routes and survival time for different VBDs
1.3.2. Prevention and Control				
Movement restriction	What is the **effectiveness** of **movement restrictions** to reduce introduction or spread of each of the 25 VBDs	Types and effectiveness of movement restrictions to reduce introduction or spread of each of the 25 VBDs	• **SLR on movement restrictions** (Introduction or spread rate reduction, delay in epidemic peak, containment prob.)	• Summary table of movement restriction effectiveness • Details: TBD (external report?)

(Continues)

TABLE A.1 (Continued)

ToR 1.3. Provide a mapping/horizon scanning/compilation/description of the currently available surveillance, prevention and control measures for listed and non-listed VBDs in the EU; this includes the collection of data on the efficacy of these measures (e.g. vaccination efficacy, efficacy of biocidal treatments or repellents, animal treatments, insect nets or other husbandry practices)				
Section	**Sub-question**	**Evidence needs**	**Data collection method/ source**	**Reporting methods of data collection**
Vector control measures	What is the **efficacy** of **vector control measures**? What is the **effectiveness of vector control measure**s to reduce spread of any of the 25 VBDs?	Efficacy of vector control measures Effectiveness of vector control measures	• **SLRs vector treatment / Disease profiles** (Mortality rate of vectors after treatments obtained in lab conditions) • **SLRs biocidal effectiveness and resistance/Vectornet** (Incidence rate ratio, entomological indices, Rt reduction...) • **SLR entomological endpoints versus incidence reduction** Reduction of spread/ introduction	• Summary tables of evidence collected SLRs on vector treatments and biocidal resistance
Vaccination	What is the **efficacy** of **host vaccination** to reduce infection rate/ morbidity/mortality? What is the **effectiveness** of **host vaccination** to reduce the incidence of any of the 25 VBDs?	Efficacy of host vaccination Effectiveness of host vaccination	• **SLR on vaccination efficacy/disease profiles** (Reduced infection rate/ reduced morbidity/ reduced mortality) • **SLR on vaccination effectiveness/TBD** (Vaccination effectiveness, Rt <1) Reduction of spread/ introduction	Summarise tables of vaccination efficacy • Summarise tables of vaccination effectiveness • Details: TBD (external report?)
Culling	What is the **effectiveness** of **culling** to reduce the spread of each of the 25 VBDs?	• Effectiveness of culling	• **SLR on culling** (Hazard ratio, epidemic size, face out prob.) Reduction of spread/ introduction	• Summary tables of culling effectiveness with narrative summary • Details: TBD (external report?)
Medicinal treatments	What is the **efficacy** of **medical treatments** to reduce the mortality or morbidity in hosts infected with each of the 25 VBDs?	• Efficacy of treatments	• **SLR on treatment efficacy/ disease profiles** (Reduced mortality, reduced morbidity of infected hosts) Reduction of spread/ introduction	• Summary tables of treatments efficacy with narrative summary
On -farm biosecurity measures	Which physical, chemical, or habitat management measures reduce introduction and spread from farms?	• Evidence of VBDs introduction/spread reduction via biosecurity measures	• **SLRs on biosecurity** Spread rate reduction, delay in epidemic peak, containment prob.	• Summary tables of biosecurity measure effect • Details: TBD link to EUPAHW reports?

Details in disease profile and/or in supplementary report by VectorNet will be provided for all subquestions
List of abbreviations:

- SLR: Systematic Literature Review
- SP: Specificity
- Se: Sensitivity
- MIR: Minimum Infection Rate.

APPENDIX B

Classification of data availability for selected vector-borne diseases

TABLE B.1 Number of publications identified through systematic literature reviews for select pathogens.

VBD	Publication count	Data availability
AHSV	66	++
AKAV	77	++
B. besnoiti	82	++
B. burgdorferi	486	+++
BEFV	67	++
BTV	380	+++
C. burnetii	217	+++
CCHFV	73	++
CVV	24	+
EEEV	31	+
EHDV	72	++
EIAV	55	++
JEV	79	++
L. infantum	560	+++
LSDV	87	++
RVFV	317	+++
SBV	84	++
SHUV	16	+
SLEV	212	+++
T. evansi	72	++
T. vivax	121	+++
TBEV	98	++
VEEV	31	+
VSV	33	+
WEEV	18	+
WNV	191	+++

+ 0–50
++ 51–100
+++ > 100

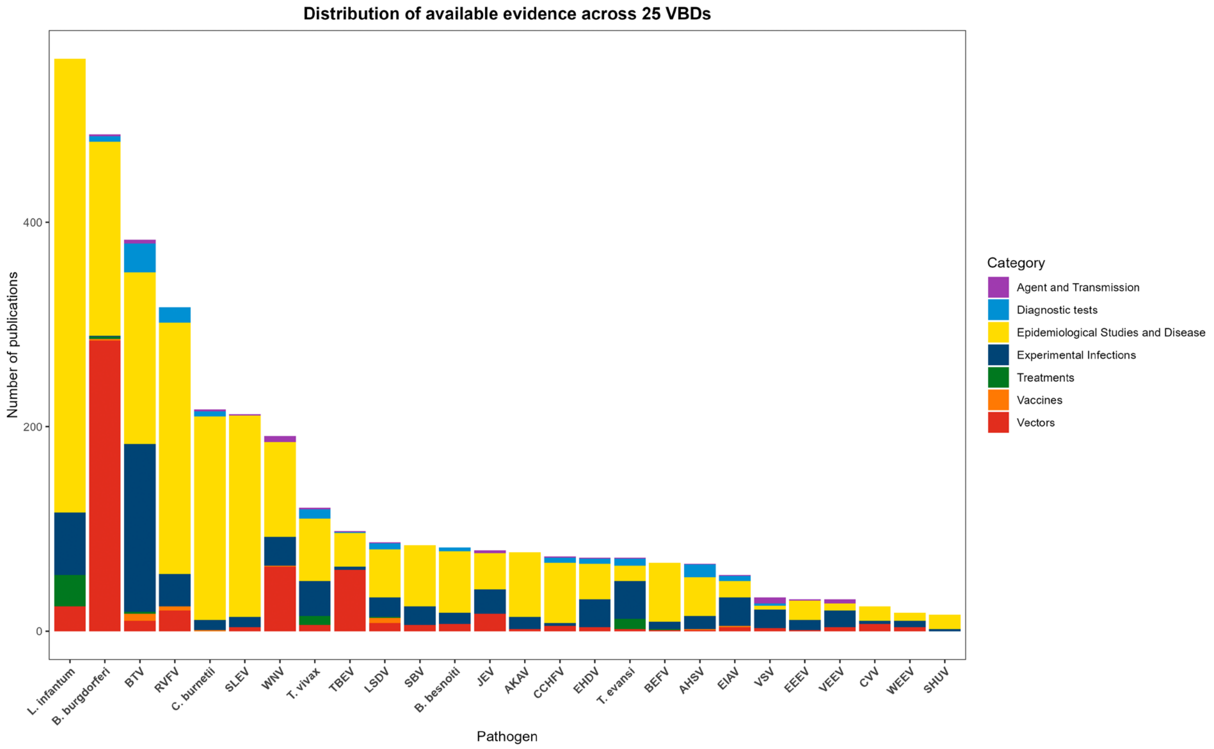

FIGURE B.1 Available evidence by category for the 25 vector-borne diseases (WEEV and EEEV are considered together). *Y*-axis refers to the publications that were considered eligible in the SLR.