Department
for Environment,
Food & Rural Affairs

Risk assessment on the likelihood of spread of Brucella canis to Great Britain from any country worldwide, in July 2023

August 2025

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Contents

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Technical summary

Brucella canis is a zoonotic bacterial disease predominantly transmitted between dogs through genital secretions. Vertical transmission between pregnant dogs and puppies has been observed, suggesting there is a risk of spread to other dogs through contact with birthing fluids. Non-reproductive transmission routes through urine and other secretions in kennel environments have also been observed.

Brucella canis is endemic in stray dog populations globally. *B. canis* is not a World Organisation for Animal Health (WOAH) listed disease, therefore evidence of prevalence on individual country level is limited, making it difficult to assess the risk of importing infected dogs. There has been a global rise in the detection of *B. canis* human infections (Lucero et al., 2010). Previous risk reviews carried out by the Human Animal Infection and Risk Surveillance (HAIRS) group on the risk *B. canis* presents to humans concluded that individuals at greatest risk of exposure are those with potential contact with *B. canis* contaminated materials. In particular, contact with fluids and tissues associated with breeding and parturition, in an occupational or domestic setting. The potential impact of human *B. canis* infection was considered greatest for those with underlying health concerns or Brucella specific risk factors (UK Health Security Agency, 2023).

Cases of *B. canis* have been reported in imported dogs in Great Britain (APHA, 2023a). Currently, the movement of dogs into Great Britain is governed by 2 regimes: commercial imports and non-commercial movements. The commercial import of dogs applies when there is a change of ownership of the dogs upon arriving in Great Britain or more than 5 dogs travel simultaneously (unless for a competition or event). The non-commercial movement of dogs into Great Britain applies when pet dogs travel together with their owner.

This risk assessment was commissioned to address the concerns of rising *B. canis* detections in dogs imported into Great Britain, and the ongoing risks associated with further importation of dogs into Great Britain. There was specific interest in understanding which animals are the highest risk for importing and subsequently transmitting *B. canis* to either dogs or foxes resident in Great Britain. The focus was on comparing the risk between dogs entering via the commercial or non-commercial route and neutered versus unneutered dogs.

The risk questions were:

1. What is the risk of at least one dog entering Great Britain, either under non-commercial or commercial rules, whilst infected with *B. canis* over the next year?

2. What is the risk of onward transmission to naïve dogs and wildlife in Great Britain once a *B. canis* infected dog has entered Great Britain?

3. What is the consequence, in terms of impact at the national level, of the entry and onward transmission of *B. canis* within Great Britain?

The annual likelihood that at least one infected dog would enter Great Britain via the commercial route was **very low** from New Zealand and Australia and **high** for all other countries. The annual likelihood that an infected pet dog would enter Great Britain for a short visit before travelling back to their home country was **negligible** for New Zealand and Australia, **low** for Western Europe and **medium** for all other countries. The annual likelihood that an infected pet dog from Great Britain would become infected while travelling abroad was **very low**.

The likelihood of onward transmission of infection to a naïve dog in Great Britain was estimated to be **high** for transmission to offspring of an infected dog, **medium** for breeding mates of an infected dog and **low** for transmission to all other dogs through environmental contamination. The likelihood of transmission to wildlife through environmental contamination was **very low**.

For the consequence assessment the national impact was assessed as **moderate** for an unneutered dog living with multiple other dogs or **minor** for infection in neutered dogs or dogs living without close proximity to other dogs. If infection occurred in foxes then the impact was assessed as **moderate.**

There was high uncertainty associated with the likelihood of entry of at least one *B. canis* infected dog and onward transmission of infection to a naïve dog in Great Britain due to multiple data gaps. Key gaps were the prevalence of *B. canis* in individual countries, the true country of origin of dogs entering Great Britain, and the frequency with which a pet dog from Great Britain would mate with an infected dog abroad and vice versa. Transmission between wildlife and the domestic dog was also uncertain.

Introduction

Brucella canis is a bacterial disease which is predominantly transmitted between dogs through genital secretions and is one of the causes of canine brucellosis along with *B. abortus, B. melitensis* and *B. suis* (Cosford, 2018). Clinical signs of *B. canis* infection include discospondylitis, joint pain, epididymitis and infertility in male dogs, and uterine infections and abortions in female dogs (Cosford, 2018). These signs are not specific to *B. canis*, which can complicate diagnosis. Vertical transmission between pregnant dogs and puppies has been observed, suggesting there is a risk of spread to other dogs through contact with contaminated birthing fluids. Other non-reproductive transmission routes through urine and other secretions in kennel environments have also been observed (Kaden et al., 2014; Shoukat et al., 2017). There is currently no vaccination available for *B. canis*. Treatment has limited success and does not prevent onward transmission to other dogs or humans (Buhmann et al., 2019).

All positive cases of *B. canis* detected in Great Britain are now reportable to the APHA, but not to the World Organisation for Animal Health (WOAH) with all previous canine cases in Great Britain originating in imported dogs (APHA, 2023a). There has been a rise in the global detection of human infections due to *B. canis* (Lucero et al., 2010). *B. canis* has been described as having moderate pathogenicity in humans (Godfroid et al., 2010). However, those who are immunosuppressed are more vulnerable to infection and severe symptoms. There are also concerns for higher transmission risk for those working in close contact with dogs, such as veterinary practices or breeders. For most cases of human infections with *B. canis*, there is an identifiable previous contact with infected dogs or contaminated biological materials in the laboratory (Santos et al., 2021b).

B. canis is endemic in stray dog populations in Central America, South America, Mexico, and Southern USA. There are reports of infection in Asia and Africa. More recently confirmed cases have been reported in Germany, Sweden, Austria, Netherlands, Italy, Hungary, Spain, and Switzerland (Buhmann et al., 2019). New Zealand and Australia have strict importation requirements for *B. canis* and claim freedom from disease (Spickler, 2018). As *B. canis* is not a WOAH notifiable disease, there is limited evidence to ascertain global prevalence and the risk of importation of infected dogs.

This risk assessment was commissioned to address the concerns of rising *B. canis* detections in dogs imported into Great Britain, and the ongoing risks associated with further importation of dogs into Great Britain. There has been a continued increase of dogs entering Great Britian from Eastern European countries, where *B. canis* is known to be present.

Currently, the movement of dogs into Great Britain is governed by 2 regimes for commercial imports and non-commercial movements, respectively. The commercial import of dogs into Great Britain is governed by the Trade in Animals and Related Products Regulations 2011 in England and relevant equivalents in Scotland and Wales (collectively known as TARP). TARP applies to the import of:

- more than 5 dogs per person travelling (unless for a competition or event)
- dogs for sale, rehoming or any other form of transfer of ownership of the animal, including rescue dogs
- dogs that do not enter GB travel within 5 days of their owner or a person authorised by the owner to transport the dog on their behalf.

TARP does not apply to the non-commercial movement of dogs provided that the movement is of five or fewer animals accompanied by their owner or an authorised person. The non-commercial movement of dogs into Great Britain is regulated by assimilated direct legislation, primarily Regulation (EU) No 576/2013 on the non-commercial movement of pet animals.

This assessment considers the entry of dogs under TARP (hereafter termed the 'commercial route') and Regulation (EU) No 576/2013 (hereafter termed the 'non-commercial route'). It includes an entry, exposure and consequence assessment. The entry assessment covers the annual likelihood of importing at least one dog infected with *B. canis*. The exposure assessment covers the likelihood of onward infection to another dog or fox within Great Britain and the consequence assessment identifies the biological, environmental, and economic consequences of *B. canis* in Great Britain.

This risk assessment considers the animal health risks in Great Britain associated with *B. canis.* As *B. canis* is zoonotic, the public health aspects of *B. canis* have been addressed in an independent assessment by the Human Animal Infection and Risk Surveillance group (HAIRS; UK Health Security Agency, 2023). The findings of both assessments must be considered when considering risk management options that have implications for both animal and public health. Previous HAIRS risk reviews on the risk *B. canis* presents to the UK human population concluded that individuals at greatest risk of exposure to *B. canis* are those with potential contact with *B. canis* contaminated materials, especially fluids and tissues associated with breeding and parturition, either in an occupational or domestic setting. The potential impact of human *B. canis* infection is greatest for those with underlying health concerns or Brucella specific risk factors (PHE 2021) (UK Health Security Agency, 2023).

Risk framework

The approach used was based on the framework set out by WOAH (OIE., 2004). The probabilities are expressed qualitatively as Negligible, Very Low, Low, Medium, High and Very High (EFSA, 2006). The definitions of the probabilities are based on those by EFSA (2006) and defined in the supplementary information (Table 1). The overall likelihood for each pathway was obtained by qualitatively combining the individual likelihoods of each pathway step occurring using the matrix in Table 2 of the supplementary information. As the estimates were essentially conditional probabilities where the probability of each step occurring is estimated given that the previous step has already occurred, a risk matrix approach was applied (Gale et al., 2010). Using this approach means that the lowest likelihood from each pathway is selected. Uncertainty associated with the estimates for the probabilities are categorised according to Table 4 of the supplementary information.

Risk questions

1. What is the risk of at least one dog entering Great Britain, either under non-commercial or commercial rules, whilst infected with *B. canis* over the next year?

2. What is the risk of onward transmission to naïve dogs and wildlife in Great Britain once a *B. canis* infected doghas entered Great Britain?

3. What is the consequence, in terms of impact at the national level, of the entry and onward transmission of *B. canis* within Great Britain?

Uncertainties

Entry assessment uncertainties include:

- country specific prevalence of *B. canis* is unreliable due to data being low quality and outdated.
- some papers were written in the 1980's, limiting their usefulness in estimating current prevalence.
- some countries do not publish relevant data.
- country specific testing requirements are unclear.
- *B. canis* is not a WOAH listed disease, so surveillance is at the discretion of individual countries.

- confidence in accuracy of country of origin for commercial imports through the Directive 92/65 (TARP) is good. However, there may be some illegal movement and, or fraud in some countries, where commercial dogs are deliberately moved to take advantage of the free movement of animals within the EU.
- country of origin of dogs moving under the non-commercial route is currently unavailable, as the requirement to provide this information was removed from travel forms in 2014.
- the number of pet dogs not from Great Britain which enter Great Britain for the purpose of mating, and vice versa, is unknown.
- accurate number of dogs imported illegally into Great Britain and the methods of illegal importation are unknown.

Exposure assessment uncertainties include:

- uncertainty surrounding the sensitivity and specificity of commercial tests used outside of APHA
- there is no requirement to test dogs for *B. canis* in Great Britain. Not all infected dogs will display overt clinical signs, therefore the prevalence in Great Britain's dogs is not known
- unknown number of dogs that are test positive and managed rather than euthanised. Such dogs could remain infectious for a prolonged period of time
- unknown efficacy of neutering and treatment with antibiotics in reducing infection risk to dogs
- unknown frequency of informal or formal artificial insemination or breeding by dogs, and if any testing for *B. canis* is carried out
- the minimum infectious dose through the venereal route, environmental exposure or aerosol transmission has not been determined
- the level of contact between domestic dogs and foxes which could result in transmission to domestic wildlife species

Consequence assessment uncertainties include:

- the rate of transmission between red foxes
- impact of population control or culling of red foxes
- susceptibility of other wildlife species in Great Britain to *B. canis*
- number and frequency of dogs travelling within Great Britain for any purpose including breeding and holidays

Assumptions

The assessment was carried out with the following assumptions:

- countries with higher populations of stray dogs have higher incidences of *B. canis.*
- in the absence of any data, Baltic countries have a similar *B. canis* prevalence as the worst-case prevalence of surrounding regions.
- the estimated data calculated using historic percentages and applied to current pet imports are an accurate reflection of current pet imports per country.
- pet imports from 2011 to 2014 for New Zealand and Australia provide a suitable proxy for the current number of pet imports for New Zealand and Australia.
- pets that reside in Great Britain on holiday abroad would have a lower likelihood of exposure as they're less likely to be in contact with the general dog population of the country they are in.
- red foxes represent a suitable native wildlife host in Great Britain.
- in this assessment neutering refers to surgical orchidectomy in male dogs and the spaying of bitches (ovariectomy or ovariohysterectomy). alternative forms of neutering such as chemical castration are not considered.
- exposure could be through direct contact with infectious fluids from an infected dog, or through indirect contact with a contaminated environment or fomite.
- the non-commercial route also includes re-entry of pets to Great Britain after holidays. It was assumed that the percentage of animals entering Great Britain from individual Member States has remained the same since 2014. This was estimated using the percentages each Member State contributed to the total number of dogs (Crotta et al., 2022). However, data indicates that imports from certain areas such as Eastern Europe are increasing (APHA, 2023a, APHA, 2023b). As such, this assumption may cause the risk to be underestimated.

Risk pathways and overview

Entry risk pathways

The framework for the entry assessment is outlined in Figure 1. It consists of 3 pathways:

Pathway 1: Legal commercial movement of infected dogs into Great Britain. This considers the likelihood of a dog infected in another country entering Great Britain through legal channels for the commercial import of dogs through use of the TARP regulations, (the commercial route).

Pathway 2: Legal pet movement of infected dogs into Great Britain via the non-commercial route. This considers the likelihood of a dog infected in another country entering Great Britain, (the non-commercial route).

Pathway 3: Illegal commercial or pet movement of infected dogs into Great Britain. This considers all illegal movements of dogs into Great Britain. This can be through fraudulent use of legal channels or circumventing them. This pathway is considered because controls can be put in place for legal movements, but the risk will remain for illegal channels even if pre or post import testing requirements are introduced in the future.

Figure 1: The risk pathways for this entry assessment

These are divided between legal commercial, legal pet, and illegal movements of dogs into Great Britain.

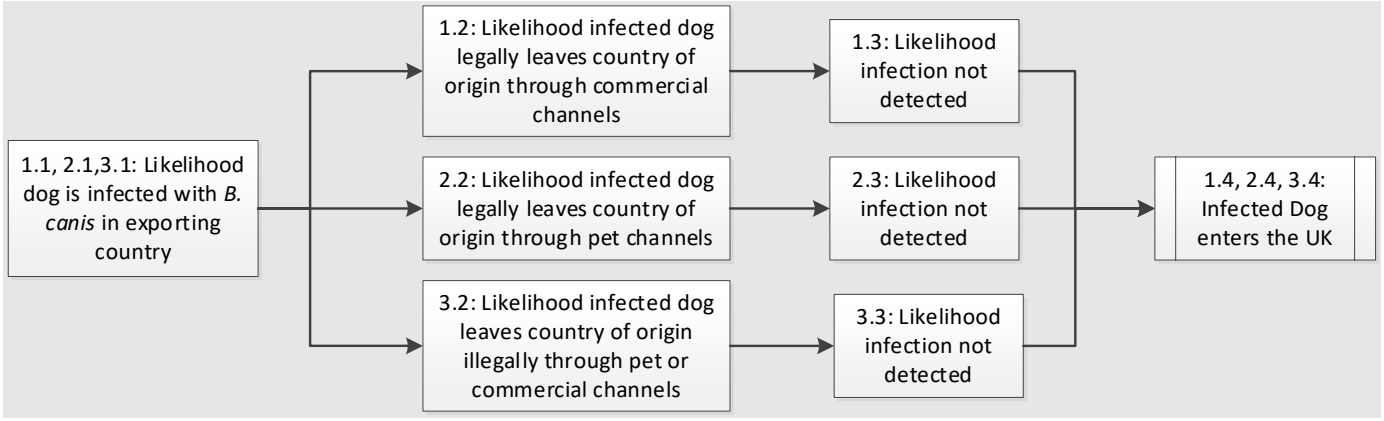


Figure 1 shows the risk pathway starting with the likelihood of a dog being infected with *B. canis* in the exporting country and initially considers the likelihood that the dog leaves the country of origin through either legal commercial, legal pet, or illegal routes. The risk pathways then consider the likelihood that *B. canis* infection in the dog is not detected and the likelihood that the infected dog enters the UK.

Exposure risk pathways

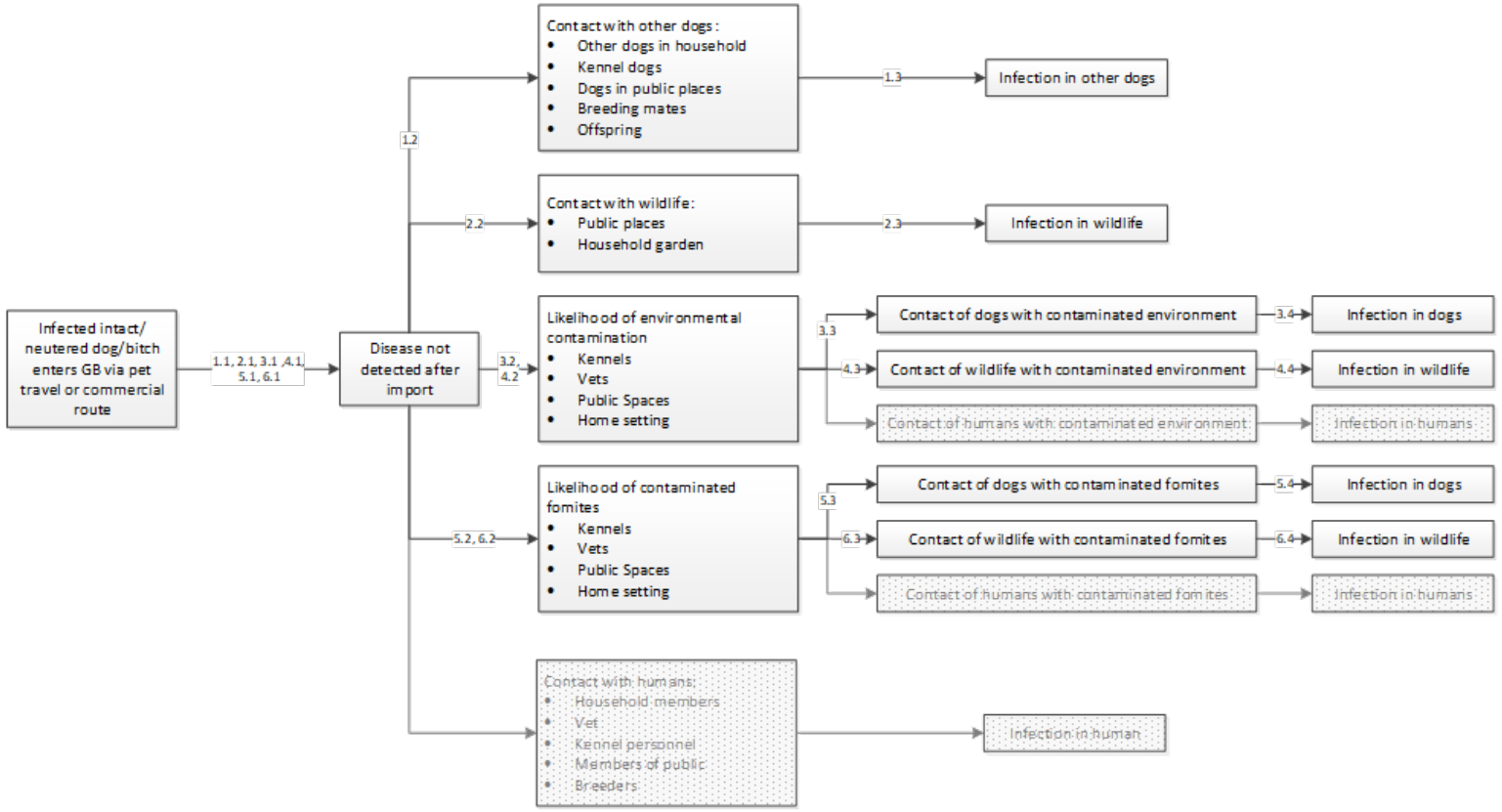
The framework for the exposure assessment is in Figure 2 and consists of 6 pathways. Each pathway assesses the likelihood of onward infection in either a naïve dog or wildlife within Great Britain through direct or indirect exposure to a dog infected with *B. canis*. The exposure assessment assumes that a dog infected with *B. canis* has already entered Great Britain. The pathways are:

- **Pathway 1:** Infection in dogs from direct contact with infected dog
- **Pathway 2:** Infection in wildlife from direct contact with infected dog
- **Pathway 3:** Infection in dogs from contact with contaminated environment
- **Pathway 4:** Infection in wildlife from contact with contaminated environment
- **Pathway 5:** Infection in dogs from contact with contaminated fomite
- **Pathway 6:** Infection in wildlife from contact with contaminated fomite

Figure 2 shows the risk pathway starting with the likelihood of an infected intact or neutered dog entering GB by pet travel or commercial route. The pathway considers the likelihood disease is not detected and spread through contact with other dogs, wildlife, environmental contamination or fomites to dogs and wildlife.

Figure 2: Risk pathways for exposure assessment

Human routes of exposure are not assessed in this report, but are included here for completeness, and as such have been greyed out in the exposure diagram.



Consequence overview

This consequence assessment aimed to identify biological, environmental and economic consequences associated with the entry, establishment and spread of the hazard, together with an estimate of their likely magnitude and likelihood of occurrence (WOAH, 2010). The consequence assessment covers the likelihood of spread beyond the initial case, and the impact within each population up to national level. The definitions (Supplementary Information Table 3) have been adapted from food safety consequence assessments (Adell et al., 2021).

For the purposes of this assessment:

- index location refers to the location of the first detected case, including other dogs within that household, and foxes within the same family group and territory
- local spread refers to spread outside of that family group, but within the same county, for example to other dogs sharing local communal parks, or foxes in neighbouring territories within the same county - this may involve more than one detected case
- national spread refers to spread greater than the local area as defined above. This may involve more than one detected case

Risk estimation

Methods

The entry assessment considered the number of dogs entering Great Britain from individual countries and the prevalence of *B. canis* in the country of origin. Accurate calculations for prevalence of infection were not possible as legislation with regards to *B. canis* differs from country to country, and no mandatory surveillance is carried out. Due to the lack of prevalence information at the country level for *B. canis*, countries have been grouped together to enable assessment. The country groupings used follow those of the 'Spatial risk assessment framework for assessing exotic disease incursion and spread through Europe' (SPARE) assessment which grouped countries based on geographical and epidemiological considerations, predominantly based on the United Nations (UN) sub regions (Simons et al., 2017). The country groupings listed are:

- Western Europe
- Eastern Europe
- Commonwealth of Independent States (CIS) Countries

- Baltic Countries
- Middle East
- North Africa
- West Africa
- East Africa
- Southern Africa
- South America
- Central America
- North America
- Caribbean
- Oceania
- Southern Asia
- Eastern Asia

The prevalence was assessed for the whole group, not at individual country level, using ad-hoc studies and surveillance (Horigan 2021). The likelihood that a dog was infected with *B. canis* was based on this grouped prevalence, and the likelihood was aggregated according to the number of dogs imported from each group of countries.

The annual likelihood of entry of at least one infected pet dog not from Great Britain entering Great Britain for a short stay differs between Western Europe and any other country group. This is because the likelihood of one dog being infected is the same (**very low**) for both groups. However, when aggregating the likelihood of one dog by the actual number of dogs entering Great Britain in one year, considerations must be made to the number of dogs required for the likelihood to enter the next probability category. This will vary according to where on the scale the likelihood of an individual infected dog being imported lies. For Western Europe this is estimated to be at the lower end of the Very Low category, determined by the prevalence of *B. canis* in this group. All other country groups are estimated to be at the higher end Very Low, mostly due to a lack of data on prevalence.

Dogs can enter Great Britain through the commercial or non-commercial routes. For the commercial route, the likelihood of a dog being infected was based on the grouped country of origin. However, it is acknowledged that this may not be accurate as it may only refer to the country in which it first entered an EU border control post (BCP). Due to free movement of animals through the EU this becomes difficult to assess how long and where a dog may have resided within the EU.

For the non-commercial route, 2 different categories were assessed:

- pet dogs from Great Britain returning home accompanied by their owners after a short stay (7 to 14 days) abroad (hereafter “resident” dogs)

- pet dogs not from Great Britain entering Great Britain for a short stay (7 to 14 days) (hereafter “visiting” dogs)

The risk of at least one infected dog entering Great Britain through these routes was assessed individually using the prevalence of infection in the country of origin. The likelihood of exposure of a pet dog in the country visited, and the volume of pets travelling were also considered.

The exposure assessment considered the likelihood of onward transmission of infection should an infected dog enter Great Britain. The populations at risk were naïve dogs and wildlife, namely red foxes, as antibodies to *B. canis* have been detected in wild canid species (Randhawa 1977; McCue 1988; Carmichael 1990; Oliveira-Filho 2012; Castellanos 2020; Galarce et al., 2021). The pathways assessed were exposure by direct contact with infectious fluids from an infected dog, or indirect contact with a contaminated environment or fomite. These pathways were considered separately to account for the added factors of environmental survival of *B. canis* over time depending on the conditions and time between when the secretions are deposited and when contact occurs.

The consequence assessment uses methodology from food safety assessments to assess the likelihood of onward spread within a population, for example within the red fox population. Using the same methodology, the impact is assessed at national level, based on the potential biological, environmental, and economic consequences.

The overall likelihood of entry of at least one infected dog and onward transmission of *B. canis* to a naïve dog or wild animal within Great Britain was assessed. This was done by combining the likelihood that at least one infected dog would enter Great Britain (output from the entry assessment), with the likelihood that either a naïve dog or wildlife would become infected (output from the exposure assessment).

Results

Estimated prevalence levels

The initial step of the entry assessment served to establish the presence and prevalence data available for *B. canis* globally. No data were available for any of the 3 countries in the Baltic group, so this group was assumed to have the same risk as the worst-case score of surrounding regions (EEU and CIS groups).

The likelihood that a dog is infected with *B. canis* in an exporting country group were:

- **very low** for New Zealand and Australia (considered separately from the rest of Oceania)
- **low** for Western Europe
- **high** for all other country groups.

Dogs travelling via the commercial route

The likelihood that at least one infected dog would enter Great Britain within the next year from New Zealand and Australia was **very low** for the commercial route as these countries claim freedom from disease and have low volume of dogs travelling to Great Britain. The annual likelihood that at least one infected dog would enter Great Britain through the commercial route from any other country group was **high**.

Dogs travelling via the non-commercial route

The annual likelihood of at least one infected visiting dog entering Great Britain is **negligible** for New Zealand and Australia, **low** for Western Europe and **medium** for all other country groups (Table 2). The likelihood of at least one resident dog becoming infected with *B. canis* whilst abroad was **very low** for all country groups.

Exposure assessment

Neutered status of the infected dog affected the likelihood of exposure or onwards transmission of *B. canis* to other dogs in Great Britain, assuming an unneutered dog is mated. The likelihood of infecting another dog was estimated to be **high** for offspring and **medium** for breeding mates of an unneutered infected dog. The likelihood of onward transmission from a neutered dog to a naïve dog in Great Britain (assumed to occur through a contaminated environment) was **low**, with high uncertainty,

The risk of exposure by direct or indirect contact resulting in infection in wildlife was considered to be **very low**. This was associated with high uncertainty due to the limited surveillance in red foxes in Great Britain.

Table 1: Qualitative risk estimates for the likelihood that onward transmission occurs in naïve dogs or wild animal as a result of importing a B. canis infected dog (uncertainty in brackets)

Population	Origin country group	Route of entry and dog category	Annual likelihood of importing of at least one infected dog	Likelihood of onward transmission to naïve dog/wildlife	Likelihood of importing at least one infected dog AND onward transmission of infection to a naïve dog/wildlife
Naïve dog	NZ and Australia	All - unneutered	Very Low (Low)	High (Medium) for offspring; Medium (High) for breeding mates	Very Low (Low)
Naïve dog	NZ and Australia	All - neutered	Very Low (Low)	Low (High)	Very Low (Low)
Naïve dog	Western Europe	Visiting dog - neutered	Low (High)	Low (High)	Low (High)
Naïve dog	Western Europe	Visiting dog - unneutered	Low (High)	High (Medium) for offspring; Medium (High) for breeding mates	Low (High)
Naïve dog	All country groups except NZ, Australia and W Europe	Visiting dog - neutered	Medium (High)	Low (High)	Low (High)
Naïve dog	All country groups except NZ, Australia and W Europe	Visiting dog - unneutered	Medium (High)	High (Medium) for offspring; Medium (High) for breeding mates	Medium (High)
Naïve dog	All country groups except NZ & Australia	Resident dog - neutered	Very Low (High)	Low (High)	Very Low (High)
Naïve dog	All country groups except NZ & Australia	Resident dog - unneutered	Very Low (High)	High (Medium) for offspring; Medium (High) for breeding mates	Very Low (High)

Population	Origin country group	Route of entry and dog category	Annual likelihood of importing of at least one infected dog	Likelihood of onward transmission to naïve dog/wildlife	Likelihood of importing at least one infected dog AND onward transmission of infection to a naïve dog/wildlife
Naïve dog	All country groups except NZ & Australia	Commercial dog originating from abroad - neutered	High (High)	Low (High)	Low (High)
Naïve dog	All country groups except NZ & Australia	Commercial dog originating from abroad - unneutered	High (High)	High (Medium) for offspring; Medium (High) for breeding mates	High (Medium) for offspring; Medium (High) for breeding mates

Consequence assessment

The impact of an incursion of *B. canis* depends on the number of other dogs that an infected dog lives with, and therefore the likely size of an outbreak. If an infected, unneutered dog lives with multiple other dogs (assumed to be at least 5 other dogs) than the impact is likely to be **moderate.** Likewise, if infection spread into the fox population, then this is also likely to have a **moderate** impact. However, the impact of a case being imported in a neutered dog or a dog not in close contact with other dogs is likely to be **minor.** As *B. canis* is an exotic disease in Great Britain, there would likely be a delay before it is detected in red foxes, in the event of onward transmission to wildlife, unless a surveillance system is in place, which may affect the amount and geographical size of spread before detection (Table 2).

Table 2: Qualitative risk estimates for the likelihood of local and national spread in naïve dogs and wildlife, and the impact of a disease incursion

Population	Origin Country group	Route of entry and dog category	Likelihood of local spread	Likelihood of national spread	Overall likelihood of spread	Impact at national level
Naïve dog	NZ and Australia	All - unneutered	≤5 contacts Medium (Medium)	≤5 contacts Medium (Medium)	Very Low (Low)	Minor
Naïve dog	NZ and Australia	All - unneutered	>5 contacts High (Medium)	>5 contacts High (Medium)	Very Low (Low)	Moderate
Naïve dog	NZ and Australia	All - neutered	≤5 contacts Very Low (Medium)	≤5 contacts Very Low (Medium)	Very Low (Low)	Insignificant
Naïve dog	NZ and Australia	All - neutered	>5 contacts Low (Medium)	>5 contacts Low (Medium)	Very Low (Low)	Minor
Naïve dog	Western Europe	Visiting dog - neutered	≤5 contacts Very Low (Medium)	≤5 contacts Very Low (Medium)	Low (High)*	Insignificant
Naïve dog	Western Europe	Visiting dog - neutered	>5 contacts Low (Medium)	>5 contacts Low (Medium)	Low (High)*	Minor

Population	Origin Country group	Route of entry and dog category	Likelihood of local spread	Likelihood of national spread	Overall likelihood of spread	Impact at national level
Naïve dog	Western Europe	Visiting dog - unneutered	≤5 contacts Medium (Medium)	≤5 contacts Medium (Medium)	Low (High)	Minor
Naïve dog	Western Europe	Visiting dog - unneutered	>5 contacts High (Medium)	>5 contacts High (Medium)	Low (High)	Moderate
Naïve dog	All country groups except NZ, Australia and W Europe	Visiting dog - neutered	≤5 contacts Very Low (Medium)	≤5 contacts Very Low (Medium)	Low (High)*	Insignificant
Naïve dog	All country groups except NZ, Australia and W Europe	Visiting dog - neutered	>5 contacts Low (Medium)	>5 contacts Low (Medium)	Low (High)*	Minor
Naïve dog	All country groups except NZ, Australia and W Europe	Visiting dog - unneutered	≤5 contacts Medium (Medium)	≤5 contacts Medium (Medium)	Medium (High)	Minor
Naïve dog	All country groups except NZ, Australia and W Europe	Visiting dog- unneutered	>5 contacts High (Medium)	>5 contacts High (Medium)	Medium (High)	Moderate
Naïve dog	All country groups except NZ & Australia	Resident dog - neutered	≤5 contacts Very Low (Medium)	≤5 contacts Very Low (Medium)	Very Low (High)	Insignificant
Naïve dog	All country groups except NZ & Australia	Resident dog - neutered	>5 contacts Low (Medium)	>5 contacts Low (Medium)	Very Low (High)	Minor
Naïve dog	All country groups except NZ & Australia	Resident dog - unneutered	≤5 contacts Medium (Medium)	≤5 contacts Medium (Medium)	Very Low (High)	Minor
Naïve dog	All country groups except NZ & Australia	Resident dog - unneutered	>5 contacts High (Medium)	>5 contacts High (Medium)	Very Low (High)	Moderate
Naïve dog	All country groups except NZ & Australia	Commercial dog originating from abroad - neutered	≤5 contacts Very Low (Medium)	≤5 contacts Very Low (Medium)	Low (High)*	Insignificant

Population	Origin Country group	Route of entry and dog category	Likelihood of local spread	Likelihood of national spread	Overall likelihood of spread	Impact at national level
Naïve dog	All country groups except NZ & Australia	Commercial dog originating from abroad - neutered	>5 contacts Low (Medium)	>5 contacts Low (Medium)	Low (High)*	Minor
Naïve dog	All country groups except NZ & Australia	Commercial dog originating from abroad - unneutered	≤5 contacts Medium (Medium)	≤5 contacts Medium (Medium)	High (High)	Minor
Naïve dog	All country groups except NZ & Australia	Commercial dog originating from abroad - unneutered	>5 contacts High (Medium)	>5 contacts High (Medium)	High (High)	Moderate
Wildlife	NZ and Australia	All - neutered and unneutered	High (High)	High (High)	Very Low (High)	Moderate
Wildlife	All country groups except NZ & Australia	Resident dog	High (High)	High (High)	Very Low (High)	Moderate
Wildlife	All country groups except NZ & Australia	Visiting dog - neutered and unneutered	High (High)	High (High)	Very Low (High)	Moderate
Wildlife	All country groups except NZ & Australia	Commercial dog originating from abroad - neutered and unneutered	High (High)	High (High)	Very Low (High)	Moderate

Discussion

This risk assessment considers the animal health risks associated with *B. canis* to Great Britain. However, *B. canis* is a zoonotic disease that impacts public health. The public health aspects of *B. canis* has been addressed in an independent assessment by the Human Animal Infection and Risk Surveillance group (HAIRS) (UK Health Security Agency, 2023). The findings of both assessments must be considered when considering risk management options that have implications for both animal and public health. The HAIRS September 2023 current risk review and statement on the risk *B. canis* presents to the UK human population concluded that individuals at greatest risk of exposure to *B. canis* are those with potential contact with *B. canis* contaminated materials, especially fluids and tissues associated with breeding and parturition, either in an occupational or domestic setting (UK Health Security Agency, 2023).

The likelihood of entry of at least one dog infected with *B. Canis* in the next year was highest for dogs arriving through the commercial route, assessed as **high**. This likelihood is supported by data from APHA which shows that 55 *B. canis* positive dogs were imported in 2022, although the country of origin could not be accurately determined (APHA, 2023a).

Assessing the difference in risk of entry between neutered and unneutered dogs was not possible due to a lack of data. Unpublished data from APHA indicates that of the 100 dogs diagnosed with *B. canis* after entering Great Britain since 2020, 43 were neutered, 25 were intact and 32 had unknown neutering status. Unneutered infected stray or rescue dogs may be neutered prior to export to Great Britain but still present a risk of disease entry into Great Britain (APHA, 2023a, Gibson et al., 2021).

For onward transmission of infection in dogs, offspring and breeding pairs were at the highest risk of infection by direct contact with infectious fluids. This demonstrates that the risk from entry of an unneutered dog which may be used for breeding is higher than that for a neutered dog. Other dogs kept in the vicinity of a whelping bitch could be exposed where lack of biosecurity measures gives rise to contact with birthing and parturition fluids. The overall likelihood of entry and onward transmission in any population from a dog arriving from Australia or New Zealand was **very low** as these countries declare freedom from disease.

Should an infected dog enter Great Britain, there was a **very low** likelihood of onward transmission of infection to wildlife through direct or indirect contact. This was associated with high uncertainty due to the limited disease surveillance in red foxes in Great Britain. As *B. canis* is exotic to Great Britain and there are currently no surveillance programmes in place in wildlife populations, there will be a delay between the first transmission of the disease to wildlife and the disease being detected. There

are very few published studies which investigate the presences of antibodies in wild canids and so the epidemiology of the disease in wild species is not currently well understood. Should *B. canis* be transmitted to red foxes in Great Britain, there is a **high** likelihood, with high uncertainty, that it will spread from fox to fox at the local and national level.

B. canis testing is not included in EU Animal Health Law, and there is no common legislative framework to tackle the disease.

Proposed measures to reduce transmission through infected live dogs include testing before importing to GB and to extend this to stray and rescue dogs, or if the dog were being moved for breeding purposes (Tymczak et al., 2022). Countries which at present claim freedom from disease, such as Australia, currently put import restrictions only on unneutered dogs. However, the evidence gathered for this risk assessment suggests that infected neutered animals could still pose a risk of onward transmission of disease to dogs within Great Britain.

B. canis has been increasingly detected in imported dogs entering Great Britain, since it was made reportable (Defra 2023). For this risk assessment, there was specific interest in understanding which categories of dogs are the highest risk for importing and transmitting *B. canis* in Great Britain. Results from this assessment found that the likelihood of onward infection was greatest for imported unneutered dogs which are mated. Such dogs could be imported through the commercial route or residing pets returning to Great Britain which go abroad to be mated without any pre-testing or vice versa. The likelihood of infection is greatest for offspring, breeding mates and other dogs which may have access to contact with birthing and parturition fluids.

There was high uncertainty associated with many of the risk estimates assessed due to lack of data. If the number of dogs entering Great Britain were to increase, then it is likely that the aggregated risk to animal health will also increase.

Supplementary information

The terminology used to define the qualitative likelihoods used in this risk assessment were based on those by EFSA (2006). The risk estimate was the probability or likelihood that something could occur based on the definitions in Table 3. Qualitative likelihoods and probabilities were assessed for each stage of the relevant framework within the entry and exposure assessments (see individual sections). As these estimates were essentially conditional probabilities, these were combined using a risk matrix approach (Gale *et al.*, 2010, Table 4). In this approach, individual likelihood estimates are consecutively combined using the matrix in Table 4. That is, first step 1 and step 2 are combined, then the result of this combination is combined with step 3, and so on. Using this approach essentially means that the lowest likelihood from the pathway is selected.

An overall uncertainty estimate was assessed for each:

- commodity, country and hazard combination in the entry assessment
- commodity, subpopulation and hazard combination in the exposure assessment
- subpopulation/hazard combination in the consequence assessment

These scores were assigned using details from Table 5.

Finally, the definitions for the impact on infection on each population have been adapted from food safety consequence assessments (Adell et al., 2021).

Table 3: Definitions for the qualitative likelihoods used in this assessment, based on EFSA (2006)

Risk level	Definition
Negligible	Event is so rare, does not merit consideration
Very low	Event is very rare, but cannot be excluded
Low	Event is rare, but does occur
Medium	Event occurs regularly
High	Event occurs very often
Very high	Event occurs almost certainly

Table 4: Matrix for the multiplication of two qualitative likelihoods (Gale et al., 2010)

	Results of probability 1: Negligible	**Results of probability 1: Very Low**	**Results of probability 1: Low**	**Results of probability 1: Medium**	**Results of probability 1: High**	**Results of probability 1: Very High**
Results of probability 2: Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Results of probability 2: Very Low	Negligible	Very Low	Very Low	Very Low	Very Low	Very Low
Results of probability 2: Low	Negligible	Very Low	Low	Low	Low	Low
Results of probability 2: Medium	Negligible	Very Low	Low	Medium	Medium	Medium
Results of probability 2: High	Negligible	Very Low	Low	Medium	High	High
Results of probability 2: Very High	Negligible	Very Low	Low	Medium	High	Very High

Table 5: Descriptors of each consequence level (Adell et al., 2021)

Descriptor	Description
Insignificant	Insignificant impact; little disruption to normal operation; low increase in normal operation costs
Minor	Minor impact for small population; some manageable operation disruption; some increase in operating costs
Moderate	Minor impact for large population; significant modification to normal operation but manageable; operation costs increased; increased monitoring
Major	Major impact for small population; systems significantly compromised and abnormal operation, if at all; high level of monitoring required
Catastrophic	Major impact for large population; complete failure of systems

Table 6: Qualitative categories for expressing uncertainty given the available evidence; based on definitions within the literature (EFSA, 2006, Spiegelhalter and Riesch, 2011)

Uncertainty category and definition	Type of information/evidence to support uncertainty category
Low Further research is very unlikely to change our confidence in the assessed risk	• Solid and complete data available (e.g. long-term monitoring results) • Peer reviewed published studies where design and analysis reduce bias (e.g. systematic reviews, randomised control trials, outbreak reports using analytical epidemiology) • Complementary evidence provided in multiple references • Expert group risk assessments, specialised expert knowledge, consensus opinion of experts • Established surveillance systems by recognised authoritative institutions • Authors report similar conclusions
Medium Further research is likely to have an important impact on our confidence in the risk estimate	• Some but no complete data available • Non peer-reviewed published studies/reports • Observational studies/surveillance reports/outbreak reports • Individual (expert) opinion • Evidence provided in a small number of references • Authors report conclusions that vary from one another
High Further research is very likely to have an important impact on our confidence in the risk estimate	• Scarce or no data available • No published scientific studies available • Evidence is provided in grey literature (unpublished reports, observations, personal communication) • Individual (non-expert) opinion • Authors report conclusions that vary considerably between them

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