Report

Probability of rabies entry to Norway through dogs and cats

Quantitative model, description and results

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1. INTRODUCTION

The present report contains the technical details of the model used to answer questions related to the probability of introducing rabies through the importation of unvaccinated dogs and cats younger than three months from specific countries. Full result tables are reported, and specific elements necessary for proper understanding of the results are discussed. A short version of these elements is included in the report entitled “Probability of rabies entry to Norway through dogs, cats and wild fauna”, by the Norwegian Scientific Committee for Food Safety, Panel on Biological Hazards.

The present quantitative model estimates the risk of importing rabies to Norway through the importation of dogs and cats (hereafter called ”pets”) from specific groups of countries. Two options are considered, the importation of unvaccinated young animals (< 3 months), and the importation of vaccinated and tested adults.

The model estimates in each case:

- The number of infected pets imported each year
- The probability that at least one infected pet will be imported per year and per 10 years.
- The number of years between the importation of each infected pet

2. MODEL DESCRIPTION

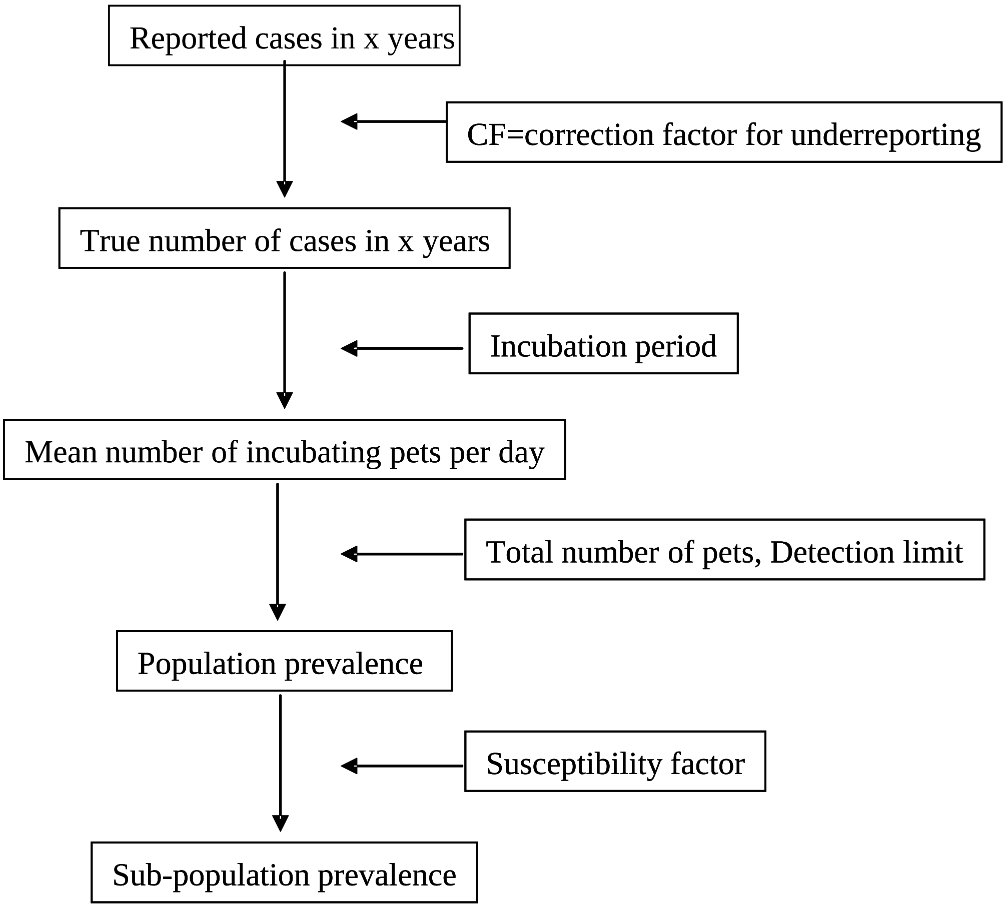
2.1. Tools

The model has been built in Microsoft® Excel 2002 with @Risk 4.5.2 – Professional Edition (Palisade Corporation) as add-in.

2.2. Model

2.2.1. Prevalence of rabies in the exporting countries

To estimate the prevalence of rabies in the exporting countries, the following steps were considered:



The estimated number of cases in *x* years was calculated from reported cases and an estimated correction factor for underreporting:

Estimated cases in x years = Reported cases x CF

The number of cases per year was assumed to have a Poisson distribution with parameter λ. This parameter, representing the mean number of cases per year, was estimated from the previous data, whilst acknowledging our uncertainty about it (Vose, 2000):

λ = Gamma (Estimated cases in x years, 1/x)

The number of years considered (x) was two (2003 and 2004), and a stable situation during these years and up to now was assumed. The results are valid as long as the situation is stable.

The mean number of incubating pets on any a given day was derived from the previous estimate of λ, taking into account the average incubation period, IP:

Mean number of incubating pets = λ x IP / 365.25

The prevalence of incubating pets in the population was calculated by dividing the mean number of incubating pets by the total population of pets:

Population prevalence = Mean number of incubating pets / Total population

However, if the ratio "Mean number of incubating pets / Total population" was lower than the detection limit for prevalence (DL), the population prevalence was considered to be the detection limit.

2.2.2. Rabies prevalence in the sub-population considered

Published international data do not indicate whether the cases are found in pets that are vaccinated or not, or whether they may have been infected before 3 months or not. The prevalence of incubating pets in the sub-population from which exported pets are selected, i.e. vaccinated adults, or unvaccinated pets younger than 3 months, was therefore estimated from the population prevalence by considering the relative susceptibility of these pets as well as the size of the sub-population. The relative susceptibility of the pets (SF) indicates their susceptibility to rabies at the individual level, and is estimated as explained in the next section. A susceptibility factor (SF) of one means that the susceptibility is as high as in the rest of the population, a factor <1 means that the susceptibility is lower. It is assumed that SF is independent of the infection pressure. At the population level, the relative prevalence also depends on the relative size of the sub-population, since this variable influences how many of the total cases may have occurred in this part of the population:

Sub-population prevalence = Population prevalence * SF /[1-subPop(1-SF)]

where subPop is the relative size of the subpopulation, i.e. the fraction of vaccinated pets, and SF is the susceptibility factor of individuals belonging to the sub-population.

This equation can be proven as follows, using the vaccinated population as an example:

Let:

$p(D^+)$ be the population prevalence

$p(D^+/V^+)$ be the probability that a pet is diseased given it's vaccinated, or sub-population prevalence

$p(V^+)$ be the probability that a pet is vaccinated, or relative sub-population size (subPop)

SF be the ratio between the probability that a pet is diseased given it's vaccinated ($p(D^+/V^+)$) and the probability that a pet is diseased given it's not vaccinated ($p(D^+/V^-)$)

Then:

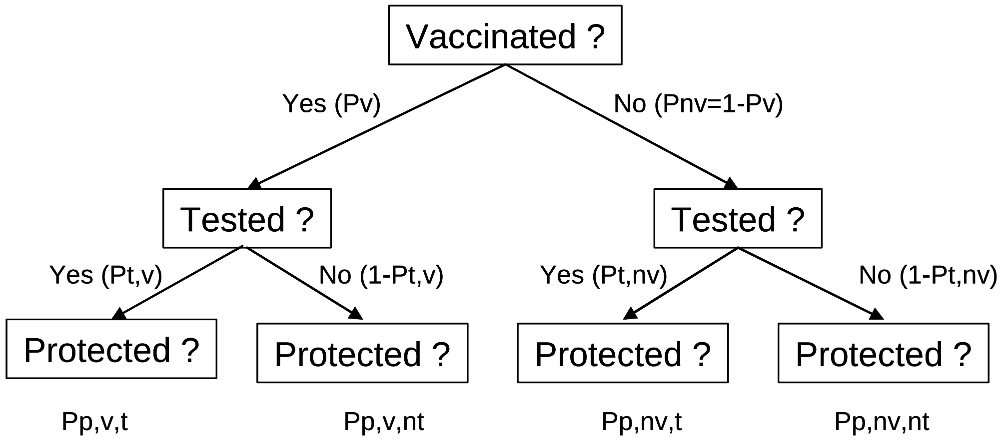
$$
\begin{aligned}
p(D^+) &= p(D^+/V^+)\ p(V^+) + p(D^+/V^-)\ p(V^-) \\
&= p(D^+/V^+)\ p(V^+) + [p(D^+/V^+)/SF]\ p(V^-) \\
&= p(D^+/V^+)\ [\ p(V^+) + p(V^-)/SF] \\
&= p(D^+/V^+)\ [\ p(V^+)SF + p(V^-)]/SF
\end{aligned}
$$

and, since $p(V^-)= 1- p(V^+)$:

$$
\begin{aligned}
p(D^+/V^+) &= p(D^+)\ SF/\ [\ p(V^+)SF + p(V^-)] \\
&= p(D^+)\ SF/\ [\ p(V^+)(SF - 1) + 1] \\
&= p(D^+)\ SF/\ [1- p(V^+)(1-SF)]
\end{aligned}
$$

<u>Susceptibility factor of vaccinated and tested pets:</u>

The following event tree was considered:



The probability that a pet was protected was calculated as:

P(protected) = p1+p2+p3+p4

=Pv*Pt,v*Pp,v,t + Pv*(1-Pt,v)*Pp,v,nt + (1-Pv)*Pt,nv*Pp,nv,t + (1-Pv)*(1-Pt,nv)*Pp,nv,nt

The susceptibility factor was derived as:

$$SF = 1- P(protected)$$

The uncertainties about the probabilities of vaccination (Pv) and testing (Pt,v and Pt,nv) were included in the model by using triangular distributions:

$$P = \text{Triang (min, mode, max)}$$

It was assumed that non-vaccinated adults were 100% susceptible:

$$Pp,nv,t = Pp,nv,nt = 0$$

For vaccinated adults, the uncertainty related to the conditional probabilities for protection given the pets were tested or not, was included in the model by using beta distributions:

$$P = \text{Beta } (s+1, n-s+1)$$

where s and n were obtained from experimental results reported by Jones et al.(2002):
n is number of pets vaccinated, OR vaccinated and tested (with titre ≥ 0,5 IU/ml)
s is number of pets actually protected
For details on numbers used, see 3.2.9.

<u>Susceptibility factor of unvaccinated pets younger than 3 months:</u>
A fixed estimate was used (SF=1).

2.2.3. *Number of cases imported each year*

The number of infected pets imported each year was estimated as:

$$\text{Binomial } (n, prev)$$

where n is the number of pets imported each year and prev is the sub-population prevalence of latent rabies infection.

2.2.4. *Annual probability of importing at least one infected pet*

The annual probability of importing at least one infected pet was calculated as:

$$P_1 = P(X>0) = 1- p(X=0) = 1-(1-prev)^n$$

where X is the number of infected pets imported, n is the number of pets imported each year and prev is the sub-population prevalence of latent rabies infection ((1-prev) is the probability a pet is not infected and $(1\text{-prev})^n$ is the probability none of the imported pets are infected).

2.2.5. *Ten years probability of importing at least one infected pet*

The probability of importing at least one infected pet per ten years was calculated as:

$$P_{10} = 1-(1- P_1)^{10}$$

where P_1 is the annual probability of importing at least one infected pet.
NB: If P_1 very small, then $P_{10} \approx 10.\ P_1$

2.2.6. *Number of years between importation of infected pets*

The expected number of years between two importations of infected pets was calculated from:

$$Y = 1/(prev*n)$$

where n is the number of pets imported each year and *prev* is the estimated sub-population prevalence of latent rabies infection.

2.2.7. *Situation where no or few cases in pets are reported*

When the incidence of reported cases was so low that the detection limit for rabies (DL) was used as the input value for prevalence (see 3.2.6 for estimates), the only stochasticity remaining in the model was related to the effect of vaccination and the susceptibility of the sub-population considered.

For unvaccinated young pets, the susceptibilities of the sub-population and the population were considered equal. There was no stochasticity left in the model, so the output was a single value, directly related to DL and the number of imported pets (n):

The annual probability of importing at least one infected pet can be calculated as:

$$P_1' = 1-(1-DL)^n$$

where n is the number of pets imported each year

The probability of importing at least one infected pet per ten years can be calculated as:

$$P_{10}' = 1-(1- P_1')^{10}$$

The number of years between the importation of infected pets can be estimated from:

$$Y = 1/(DL*n)$$

For vaccinated adults, uncertainties related to the proportion of vaccinated pets and the protection given by vaccination and testing, both led to outputs represented by uncertainty distributions, even when the country prevalence was assumed to be one single value (the detection level).

2.3. Assumptions

- The probability of disease during the time-frame considered is constant and in accordance with reported cases in 2003-4.
- The prevalence is at least the detection limit for rabies.
- The number of imported pets is small compared to the total population.
- The separate importations of pets are independent from each other, i.e. each time a pet is imported, it is taken from the pet population in the exporting country independently of the other pets imported (group importation of siblings, for example, is ignored).
- The probability of disease is homogenous within each country group and within the population considered.
- Inputs, as presented below, are valid approximations of the real situation.

2.4. Simulation

Five thousand iterations were used for each simulation, which ensured convergence of results at a 1.5% level. Sampling was done using Latin hypercube sampling, and a seed of one.

Spearman's rank correlation was used for sensitivity analysis.

3. INPUT DATA

Input data are based on literature, expert opinions, and worst case estimates in the absence of better data. A summary of input data used for the model is given in Table 1, details are reported below.

3.1. Summary

Country group	Group 1	Group 2	Group 3	Group 4
Reported cases in 2003 and 2004	0	3	1	635
Underreporting correction factor	Pert (1,1.5,5)			
Mean incubation period (IP)	38 days			
Total pet population	2.1 * Human population/10			
Human population (thousands)	83 341	212 166	102 823	60 848
Detection level for prevalence (base level)	0.000000005 (five per billion)	0.00000001 (ten per billion)	0.00000005 (50 per billion)	0.000001 (one per million)
Yearly import of pets	100, 1000 or 10 000			
Fraction of vaccinated population	Uniform (0.005,0.05)	Uniform (0.1,0.5)	Uniform (0.1,0.5)	Uniform (0.5,1)
Probability of vaccination given imported	Triangle (0.56, 0.89, 1)			
Probability of tested given imported and vaccinated	Triangle (0.8, 0.98, 0.998)			
Protection factor given vaccinated and not tested	Beta (5539, 80)			
Protection factor given vaccinated and tested	Beta (5539, 11)			
Susceptibility of young pets	1			

Table 1. Summary of input values used in the model for the different country groups.

3.2. Details

3.2.1. *Country groups*

EEA countries were grouped into four categories according to the estimated prevalence of rabies in pets, as based on the criteria described below. The EEA is per june 2005 made up of the 25 European Union (EU) member states plus Iceland, Liechtenstein and Norway. The member states of the EU per june 2005 are Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, UK.

Grouping criteria included the number of reported cases in the country and in nearby areas, both in pets and wild animals, the probability of importation from these nearby areas, and the estimated level of surveillance (areas such as the Czech Republic, where stability may be questionable, were considered to have a reduced capacity for surveillance). Based on these facts and on subjective expert opinion, countries were assigned to the following groups described below (see also Appendix 1):

Group 1 - No rabies cases reported the last two years (except in bats), AND negligible probability of importation from close areas:

Cyprus
Iceland
Ireland
UK
Sweden
Denmark
(Norway)

Group 2 - No rabies cases reported the last two years (except in bats or in imported animals), but non-negligible probability of importation from close areas:

Italy
France
Spain
Greece
Portugal
Belgium
Liechtenstein
Luxembourg
Netherlands
Finland
Malta

Group 3 – Low-prevalence endemic area, with few number of rabies cases reported:

Germany
Austria
Slovenia
Czech Republic *

(* no cases reported in 2003-4 according to OIE or WHO, but 3 cases reported in 2002 in wild fauna, and no reports sent to OIE in 2003 (no data for 2004). The country has an active control policy, since it distributed 2,348,300 baits in 2002 according to the OIE, but is surrounded by endemic areas. Moreover, the political situation suggests that veterinary surveillance might be weakened).

Group 4 – Large numbers of rabies cases reported in domestic and wild animals:

Slovak Republic
Poland
Lithuania
Latvia
Estonia
Hungary

3.2.2. *Number of reported cases*

Official data for European countries in 2003-2004 were obtained from Dr. Carsten J Pötzsch, WHO Collaborating Centre for Rabies Surveillance and Research, Institute of Epidemiology, Friedrich

Loeffler Institute- Federal Research Institute for Animal Health -Seestr. 55, D-16868 Wusterhausen, Germany.

The cases reported were added within each group. Details are shown in Appendix 1.

3.2.3. *Estimated underreporting*

The number of cases reported probably underestimates the actual number of cases. This is dependant on the quality of the surveillance system in place, and is difficult to evaluate precisely. For the present release assessment, in the absence of better data, the same distribution was used for all countries. As in McDiarmid and Corrin (undated internet communication, see reference list), we considered that the real number of cases was at least the number reported, most likely 50% higher than the number reported, and at most 5 times the number reported. The input function was CF = Pert (1,1.5,5).

3.2.4. *Mean incubation period*

Jones et al. (2002) have published an extensive analysis of experimental and natural data on the incubation period of rabies in dogs and cats. They concluded that the mean incubation period was 38.12 days, which was used in our model.

3.2.5. *Total pet population*

It was assumed that there was approximately 1 pet dog and 1.1 pet cat for every 10 people, as estimated for Canada in Jones et al. (2002). Human population data were obtained from Eurostat, via Statistics Norway.

3.2.6. *Detection level for rabies prevalence*

The detection level for rabies prevalence in pets was used as a minimal estimate for the prevalence in different country groups, to account for recent importation of incubating pets as well as the absence of detection of cases. This level differed in the different risk groups, and the value was chosen as an informed guess based on the estimated prevalence of infected pets, which was calculated according to the method described above (see 2.2.1). Results of prevalence estimates for EEA countries are shown in Appendix 1.

In group 4 countries, prevalence estimates of reported cases per million pets varied from 0.4 (Poland) to 20.6 (Estonia), with the detection of 34 to 210 rabid pets in 2003-4. With an underreporting factor of five this would correspond to true prevalences from 2 to 98 infected per million. The large number of reported cases indicates that all were well above the detection level, which was assumed to be one per million for group 4 countries.

In group 3 countries, prevalence estimates of reported cases per million pets were zero in all countries but one (Germany), in which one native case was detected in 2003-4. With an underreporting factor of five this would correspond to a prevalence in Germany of 0.015 infected per million. Since only one case was found, it was assumed that the prevalence was close to the detection level. Due to a constant infection pressure from the local wild fauna, the detection level was assumed to be 0.05 per million for group 3 countries.

In group 2 countries, prevalence estimates of reported cases per million pets were zero in all countries but one (France), in which rabies was diagnosed in three imported dogs. With an underreporting factor of five this would correspond to a true prevalence in France of 0.02 infected per million. The detection of three rabid pets indicates that such a prevalence is easily detected, and a detection level of 0.01 per million was assumed for group 2 countries.

In group 1 countries, no cases were detected. Since the infection pressure is lower than in group 2 countries, a detection level of 0.005 per million was assumed.

In summary, the following values were used in the model:

Group 4 countries: one infected per million pets (0.000001)

Group 3 countries: 0.05 infected per million pets (0.00000005)

Group 2 countries: 0.01 infected per million pets (0.00000001)

Group 1 countries: 0.005 infected per million pets (0.000000005)

3.2.7. *Yearly importation of pets*

In order to estimate the impact of the number of pets that actually will be imported, three scenarios, with respectively 100, 1000 or 10 000 pets imported yearly, were considered.

3.2.8. *Fraction of vaccinated pets in the exporting country*

The estimated fraction of vaccinated pets was based on the presence of a "vaccination programme covering an epidemiologically significant part of the target population in the entire territory or in specifically delineated zones" for dogs and cats in countries belonging to each group, as reported by the OIE (2005). This parameter is reported in Appendix 1. The situation in each country was weighed according to the countries relative population size, and an estimate for the whole group was calculated.

For group 4 countries, all countries have such a programme both in dogs and cats, and a vaccination coverage of 50-100% was assumed (Uniform (0.5,1)).

For group 3 countries, one out of four countries has a vaccination programme in dogs (Germany), none in cats. The situation for the Czech Republic is uncertain. According to our estimates, German dogs account for 40% of the pets in group 3 countries. A vaccination coverage of 10-50% was assumed.

For group 2 countries, 3 out of 11 countries have a vaccination programme for dogs, whilst two have such a programme for cats. The proportion of pets in these countries represent 43% of pets in group 2. A vaccination coverage of 10-50% was assumed.

For group 1 countries, one out of seven countries has a vaccination programme for dogs and cats. The proportion of pets in these countries represents 1% of pets in group 2. A vaccination coverage of 0.5-5% was assumed.

3.2.9. *Susceptibility factor of the sub-population*

Vaccinated and tested pets:

It was acknowledged that pets considered as vaccinated and tested, as required by legislation, are not always really vaccinated and tested. Reasons for this could include fraud, technical problems during vaccination or testing etc. Furthermore, there is always variation in biological responses. Vaccines rarely provide a 100% protection, and serological tests rarely provide an answer of 100% confidence about the protection levels achieved.

As previously used by Jones et al.(2002) for pets imported from North America to Great Britain, the probability of a pet being vaccinated was described by a Triangle (0.56, 0.89, 1) distribution, and the probability a pet was tested, given it was vaccinated, was described by a Triangle (0.8, 0.98, 0.998) distribution,

The lower bounds for the estimated vaccination compliance, was deliberately chosen low to create a reasonable worst-case situation.

The probability of protection, given the pets were vaccinated and tested (or not) was based on results reported in Jones et al. (2002) and presented in Table 2. Nobavac was used in cats and Rabicin or Madivak was used in dogs. Results are pooled in the model.

Vaccine	Number tested	Number ≥ 0.5 IU/ml	Number actually protected
Rabicin	2714	2677	2672
Nobavac	2856	2825	2820
Madivak	47	46	46
SUM	5617	5548	5538

Table 2. Results of vaccination trials, as reported in Jones et al. (2002).

The number actually protected was calculated from the number having an antibody level ≥ 0,5 UI/ml corrected by the estimated sensitivity and specificity of the serological tests which were used (FAVN and RFFIT) (Jones et al., 2002).

The probability of protection, given vaccination without test, was assumed to be Beta (5539, 80). The probability of protection, given vaccination and satisfactory test, was assumed to be Beta (5539, 11). See 2.2.2 for general formula.

Unvaccinated pets younger than 3 months:

It's likely that young pets are less susceptible to contracting rabies than older pets because they've relatively fewer contacts with other animals, including potentially rabid ones. Moreover, if their mother is vaccinated, then they're likely to be protected by maternal antibodies. The vaccination status of the mother is, however, not considered in the Pet Regulation. Also, if a mother should become infected, her pups would have extremely high exposure.

The relative susceptibility of pets younger than 3 months would have been possible to estimate if we had had sufficient data on the age distribution of cases. Due to the lack of such data we used 100% susceptibility as a reasonable worst-case scenario.

4. RESULTS

Results are shown for each group of countries, as defined in 3.2.1.

The following abbreviations are used in the result tables:

Pct = percentile

Max = maximum value obtained during simulation

Min= minimum value obtained during simulation

A summary of results, shown as mean values for each country group, pet category, and number of pets imported, is shown in Appendix 2.

4.1. Importation of unvaccinated dogs and cats younger than 3 months

When no cases are reported, or the detection level (DL) is higher than the estimated prevalence in all iterations, the probability of importing at least one infected pet is a simple function of the estimated DL and the number of imported pets. Since the DL is considered as the prevalence of rabies, outputs represent an upper limit for the estimated probability of introducing rabies from such countries, given the true prevalence is indeed lower than the assumed DL.

In country groups 1 and 3, the DL was always used as the country prevalence, and a simple model was obtained (see 2.2.7). Although probability estimates remain constant, the number of imported infected pets may vary during simulation as a result of stochasticity. In country group 2, due to the detection in France of three imported cases, minor variations in all outputs appeared during simulation. The main tendency is shown in Figure 1, and the details are reported below.

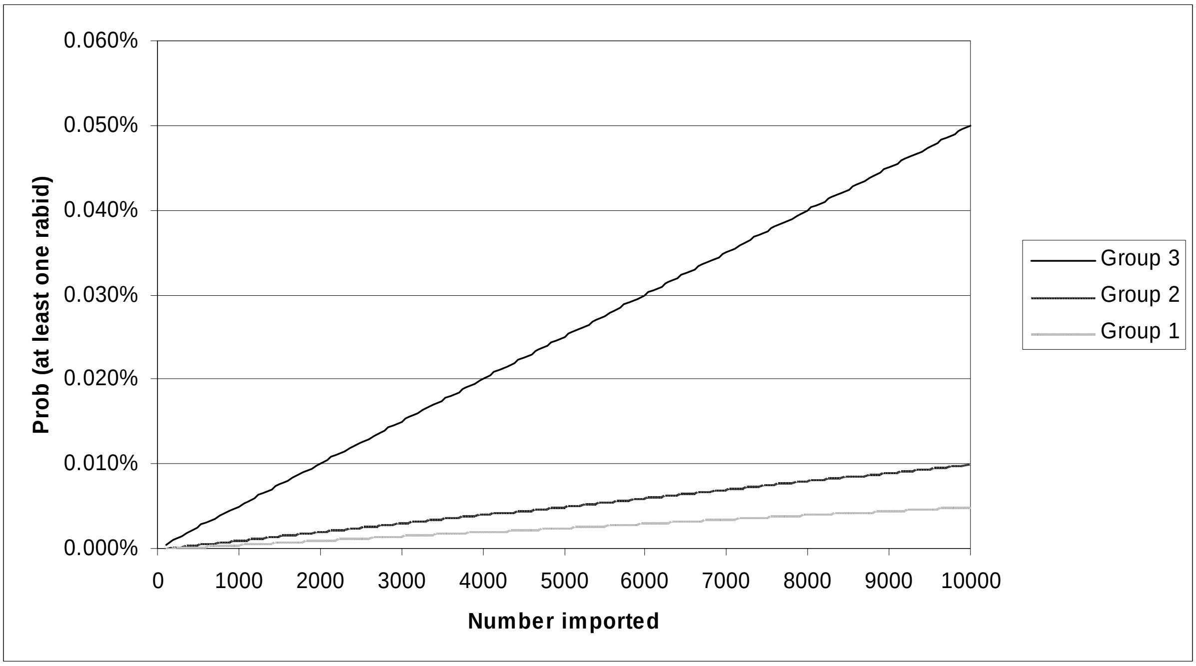


Figure 1. Estimated mean probability of importing at least one infected animal, as a function of the number of imported unvaccinated dogs or cats younger than 3 months from country groups 1, 2 and 3.

Results for 100, 1000 and 10 000 pets in the different risk groups (see 3.2.1 for definition of groups) are shown in Table 3, Table 4, Table 5 and Table 6.

Number of youngs imported from **Group 1**/y		100	1000	10000
Number of infected pets imported per year	Mean	0	0	0
	Median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	0
	Max	0	0	0
Probability of importing >0 infected pets	Mean	0.00005%	0.0005%	0.005%
	0.025pct	0.00005%	0.0005%	0.005%
	Median	0.00005%	0.0005%	0.005%
	0.975pct	0.00005%	0.0005%	0.005%
	Max	0.00005%	0.0005%	0.005%
	Min	0.00005%	0.0005%	0.005%
Probability of importing >0 infected pets in 10 years	Mean	0.0005%	0.005%	0.05%
	0.025pct	0.0005%	0.005%	0.05%
	Median	0.0005%	0.005%	0.05%
	0.975pct	0.0005%	0.005%	0.05%
	Max	0.0005%	0.005%	0.05%
	Min	0.0005%	0.005%	0.05%
Years between importation of infected pets	Mean	2000000	200000	20000
	0.025pct	2000000	200000	20000
	Median	2000000	200000	20000
	0.975pct	2000000	200000	20000
	Max	2000000	200000	20000
	Min	2000000	200000	20000

Table 3. Results of the model after simulating the importation of 100, 1000 or 10 000 unvaccinated dogs or cats younger than 3 months per year from country group 1.

(Example of interpretation: For the importation of 10 000 unvaccinated young pets/y from group 1 countries, the probability of introducing rabies in a ten years period is 0.005%, and the expected number of years between the introduction of rabies is 20 000 years)

Number of youngs imported from **Group 2**/y		100	1 000	10 000
Number of infected pets imported per year	Mean	0	0	0
	Median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	0
	Max	0	0	0
Probability of importing >0 infected pets	Mean	0.00011%	0.0011%	0.011%
	0.025pct	0.00010%	0.0010%	0.010%
	Median	0.00010%	0.0010%	0.010%
	0.975pct	0.00016%	0.0016%	0.016%
	Max	0.00031%	0.0031%	0.031%
	Min	0.00010%	0.0010%	0.010%
Probability of importing >0 infected pets in 10 years	Mean	0.0011%	0.011%	0.11%
	0.025pct	0.0010%	0.010%	0.10%
	Median	0.0010%	0.010%	0.10%
	0.975pct	0.0016%	0.016%	0.16%
	Max	0.0031%	0.031%	0.31%
	Min	0.0010%	0.010%	0.10%
Years between importation of infected pets	Mean	960 014	96001	9600
	0.025pct	626 156	62 616	6 262
	Median	1 000 000	100 000	10 000
	0.975pct	1 000 000	100 000	10 000
	Max	1 000 000	100 000	10 000
	Min	324 431	32 443	3 244

Table 4. Results of the model after simulating the importation of 100, 1000 or 10 000 unvaccinated dogs or cats younger than 3 months per year from country group 2 (5000 iterations)

(Example of interpretation: For the importation of 10,000 unvaccinated young pets/y from group 2 countries, the probability of introducing rabies in a ten years period is 0.11%, with a 95% CI of 0.10-0.16%. The expected number of years between the introduction of rabies is on average 9 600 years, with a 95% CI of 6 262-10 000 years).

Number of youngs imported from Group 3/y		100	1000	10000
Number of infected pets imported per year	Mean	0	0	0.0004
	Median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	0
	Max	0	0	1
Probability of importing >0 infected pets	Mean	0.0005%	0.005%	0.05%
	0.025pct	0.0005%	0.005%	0.05%
	Median	0.0005%	0.005%	0.05%
	0.975pct	0.0005%	0.005%	0.05%
	Max	0.0005%	0.005%	0.05%
	Min	0.0005%	0.005%	0.05%
Probability of importing >0 infected pets in 10 years	Mean	0.005%	0.05%	0.5%
	0.025pct	0.005%	0.05%	0.5%
	Median	0.005%	0.05%	0.5%
	0.975pct	0.005%	0.05%	0.5%
	Max	0.005%	0.05%	0.5%
	Min	0.005%	0.05%	0.5%
Years between importation of infected pets	Mean	200000	20000	2000
	0.025pct	200000	20000	2000
	Median	200000	20000	2000
	0.975pct	200000	20000	2000
	Max	200000	20000	2000
	Min	200000	20000	2000

Table 5. Results of the model after simulating the importation of 100, 1000 or 10 000 unvaccinated dogs or cats younger than 3 months per year from country group 3 (5000 iterations)

(Example of interpretation: For the importation of 10,000 unvaccinated young pets/y from group 3 countries, the number of infected pets imported was zero in 99% or more of the iterations (99%pct=0), which means that we're 99% confident that no rabies cases will be imported a given year. The maximum value was one, which means that no more than one case can be expected (given the assumption that each importation is independent of the others). The mean of all values obtained during the 5000 iterations is 0.0004. Since only zero and one values were obtained, it can be deduced that one infected pet was imported in 20 out of the 5000 iterations, whereas no infected pet was imported in 4980 out of the 5000 iterations).

Number of youngs imported from **Group 4** /y		100	1000	10000
Number of infected pets imported per year	Mean	0.0008	0.005	0.05
	Median	0	0	0
	95%pct	0	0	1
	99%pct	0	0	1
	Max	1	1	2
Probability of importing >0 infected pets	Mean	0.052%	0.52%	5.1%
	0.025pct	0.028%	0.28%	2.8%
	Median	0.05%	0.5%	4.8%
	0.975pct	0.09%	0.9%	8.8%
	Max	0.12%	1.2%	11.2%
	Min	0.024%	0.24%	2.4%
Probability of importing >0 infected pets in 10 years	Mean	0.52%	5.1%	39.9%
	0.025pct	0.28%	2.8%	24.8%
	Median	0.49%	4.8%	38.8%
	0.975pct	0.91%	8.8%	60.2%
	Max	1.17%	11.2%	69.4%
	Min	0.24%	2.4%	21.6%
Years between importation of infected pets	Mean	2 119	212	21
	0.025pct	1 083	108	11
	Median	2 033	203	20
	0.975pct	3 516	352	35
	Max	4 110	411	41
	Min	844	84	8

Table 6. Results of the model after simulating the importation of 100, 1000 or 10 000 unvaccinated dogs or cats younger than 3 months per year from country group 4 (5000 iterations)

(Example of interpretation: For the importation of 10,000 unvaccinated young pets/y from group 4 countries, the number of infected pets imported was zero in less than 95% of the iterations (95%pct=1), which means that we're less than 95% confident that no rabies cases will be imported a given year. The maximum value was 2, which means that no more than two cases can be expected (given the assumption that each importation is independent of the others). The probability of importing at least one infected pet in a ten years period was 39.9%, with a 95%confidence interval of 24.8-60.2%. The expected number of years between the importation of infected pets is 21years, with a 95% confidence interval of 11-35 years.)

4.2. Importation of vaccinated and tested dogs and cats from EEA

4.2.1. *Main results*

Results for imports of 100, 1000 or 10 000 vaccinated and tested dogs and cats from each of the country groups is shown in Table 7, Table 8, Table 9 and Table 10.

Number imported from **Group 1/y**		100	1000	10000
Number of infected pets imported per year	Mean	0	0	0
	Median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	0
	Max	0	0	0
Yearly probability of importing >0 infected pets	Mean	0.00001%	0.0001%	0.001%
	0.025pct	0.000002%	0.00002%	0.0002%
	Median	0.00001%	0.0001%	0.001%
	0.975pct	0.00002%	0.0002%	0.002%
	Max	0.00002%	0.0002%	0.002%
	Min	0.0000002%	0.000002%	0.00002%
Probability of importing >0 infected pets in 10 years	Mean	0.00009%	0.0009%	0.009%
	0.025pct	0.00002%	0.0002%	0.002%
	Median	0.00009%	0.0009%	0.009%
	0.975pct	0.0002%	0.002%	0.02%
	Max	0.0002%	0.002%	0.02%
	Min	0.000002%	0.00002%	0.0002%
Number of years between the importation of infected pets	Mean	15 486 757	1 548 676	154 868
	0.025pct	5 148 282	514 828	51 483
	Median	11 286 488	1 128 649	112 865
	0.975pct	51 561 365	5 156 137	515 614
	Max	569 847 694	56 984 769	5 698 477
	Min	4 490 636	449 064	44 906

Table 7. Results of the model after simulating the importation of 100, 1000 or 10 000 vaccinated and tested dogs and cats per year from country group 1 (5000 iterations).

(Example of interpretation: For the importation of 10 000 vaccinated and tested pets/y from group 1 countries, the expected number of years between the importation of infected pets is 154 868 years, with a 95% CI of 51483-515614 years).

Number imported from **Group 2/y**		100	1000	10000
Number of infected pets imported per year	Mean	0	0	0
	Median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	0
	Max	0	0	0
Probability of importing >0 infected pets	Mean	0.00003%	0.0003%	0.003%
	0.025pct	0.00001%	0.0001%	0.001%
	Median	0.00002%	0.0002%	0.002%
	0.975pct	0.00005%	0.0005%	0.005%
	Max	0.0001%	0.001%	0.01%
	Min	0.0000005%	0.000005%	0.00005%
Probability of importing >0 infected pets in 10 years	Mean	0.0003%	0.003%	0.03%
	0.025pct	0.00005%	0.0005%	0.005%
	Median	0.0002%	0.002%	0.02%
	0.975pct	0.0005%	0.005%	0.05%
	Max	0.001%	0.01%	0.1%
	Min	0.000005%	0.00005%	0.0005%
Years between import of infected pets	Mean	5 612 991	561 299	56 130
	0.025pct	1 846 020	184 602	18 460
	Median	4 145 276	414 528	41 453
	0.975pct	18 665 885	1 866 588	186 659
	Max	218 128 127	21 812 813	2 181 281
	Min	843 658	84 366	8 437

Table 8. Results of the model after simulating the importation of 100, 1000 or 10 000 vaccinated and tested dogs and cats per year from country group 2 (5000 iterations)

Number imported from **Group 3/y**		100	1000	10000
Number of infected pets imported per year	Mean	0	0	0.0002
	Median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	0
	Max	0	0	1
Probability of importing >0 infected pets	Mean	0.0001%	0.001%	0.01%
	0.025pct	0.00003%	0.0003%	0.003%
	Median	0.0001%	0.001%	0.01%
	0.975pct	0.0002%	0.002%	0.02%
	Max	0.0003%	0.003%	0.03%
	Min	0.000002%	0.00002%	0.0002%
Probability of importing >0 infected pets in 10 years	Mean	0.001%	0.01%	0.1%
	0.025pct	0.0003%	0.003%	0.03%
	Median	0.001%	0.01%	0.1%
	0.975pct	0.002%	0.02%	0.2%
	Max	0.003%	0.03%	0.3%
	Min	0.00002%	0.0002%	0.002%
Years between import of infected pets	Mean	1 169 204	116 920	11 692
	0.025pct	413 871	41 387	4 139
	Median	858 038	85 804	8 580
	0.975pct	3 776 805	377 680	37 768
	Max	43 625 625	4 362 563	436 256
	Min	340 686	34 069	3 407

Table 9. Results of the model after simulating the importation of 100, 1000 or 10 000 vaccinated and tested dogs and cats per year from country group 3 (5000 iterations)

Number imported from **Group4**/y		100	1000	10000
Number of infected pets imported per year	Mean	0.0002	0.002	0.03
	Median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	1
	Max	1	1	2
Probability of importing >0 infected pets	Mean	0.03%	0.3%	3%
	0.025pct	0.01%	0.1%	1%
	Median	0.02%	0.2%	2%
	0.975pct	0.06%	0.6%	6%
	Max	0.10%	1.0%	10%
	Min	0.001%	0.01%	0.1%
Probability of importing >0 infected pets in 10 years	Mean	0.26%	2.6%	22.2%
	0.025pct	0.05%	0.5%	5.0%
	Median	0.23%	2.3%	20.8%
	0.975pct	0.6%	6.0%	46.2%
	Max	1.0%	9.5%	63.0%
	Min	0.01%	0.1%	1%
Years between import of infected pets	Mean	5 766	577	58
	0.025pct	1 611	161	16
	Median	4 277	428	43
	0.975pct	19 377	1 938	194
	Max	177 261	17 726	1 773
	Min	1 005	100	10

Table 10. Results of the model after simulating the importation of 100, 1000 or 10 000 vaccinated and tested dogs and cats per year from country group 1 (5000 iterations)

4.2.2.

Level of protection provided by mandatory vaccination and testing

The real protection of dogs and cats imported following mandatory vaccination and testing was estimated to be on average 81%. The mode value was 88.6% and the 95% confidence interval was 61.9-96.2%. The minimum value was 56.0 % and the maximum value 99.7%. The probability distribution is shown in Figure 2.

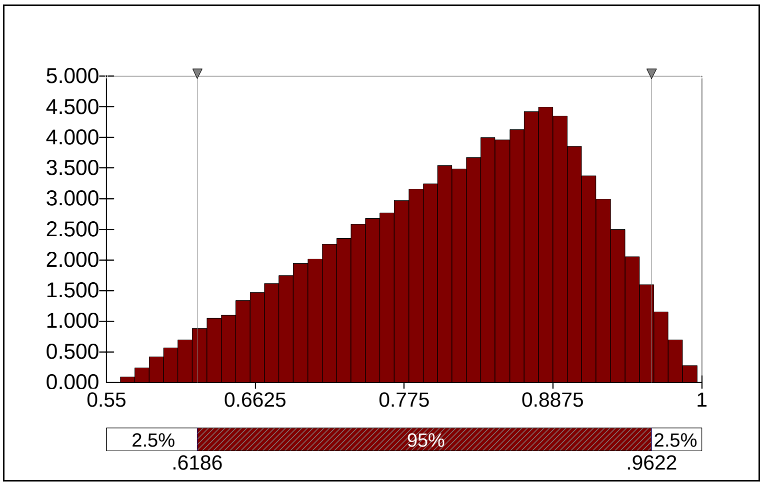


Figure 2. Estimated level of protection of dogs and cats imported following mandatory vaccination and testing.

4.2.3. *Sensitivity analysis*

A sensitivity analysis was performed for the importation of vaccinated and tested dogs and cats from group 4 countries.

The probability of importing at least one infected pet per year (P1) or per ten years (P10), and the number of years between the importation of infected animals (Y) are directly related, so the effect of varying inputs was the same for the three main outputs. These results were most strongly correlated with :

The fraction of vaccinated pets in the exporting country

The fraction of vaccinated pets among imported adults

The underreporting correction factor

Other variables had a correlation coefficient with the outputs lower than 10%.

Correlation coefficients are shown in Table 12.

To illustrate the effect of these variables, extreme values were used.

If the fraction of vaccinated pets in the exporting country was set to 0% or 100%, mean values for P1 were respectively 1.10^{-4} and 5.10^{-4}, whereas mean values for Y were respectively 16 837 and 2 119. That means the probability of importing infected animals changed by a factor of five.

If the fraction of vaccinated pets among imported adults was set to 50% or 100%, mean values for P1 were respectively $4.2.10^{-4}$ and $0.15.10^{-4}$, whereas mean values for Y were respectively 2645 and 200 189. That means the probability of importing infected animals changed by a factor of almost 30. Results obtained after simulation with 100% vaccination and testing from group 4 countries is shown in Table 11.

Number imported from **group 4**/y		100	1000	10000
Number of infected pets imported per year	Mean	0	0.0002	0.0014
	median	0	0	0
	95%pct	0	0	0
	99%pct	0	0	0
	Max	0	1	1
Probability of importing >0 infected pets	Mean	0.0011%	0.011%	0.11%
	0.025pct	0.00012%	0.0012%	0.012%
	median	0.0004%	0.004%	0.04%
	0.975pct	0.007%	0.07%	0.7%
	Max	0.096%	0.95%	9.1%
	Min	0.00004%	0.0004%	0.004%
Probability of importing >0 infected pets in 10 years	Mean	0.011%	0.11%	1.1%
	0.025pct	0.0012%	0.012%	0.12%
	median	0.004%	0.04%	0.4%
	0.975pct	0.070%	0.69%	6.7%
	Max	0.95%	9.1%	62%
	Min	0.0004%	0.004%	0.04%
Years between import of infected pets	Mean	295504	29550	2955
	0.025pct	14284	1428	143
	median	249554	24955	2496
	0.975pct	861374	86137	8614
	Max	2265023	226502	22650
	Min	1046	105	10

Table 11. Results of the model after simulating the importation of 100, 1000 or 10 000 vaccinated and tested dogs and cats per year from country group 4, **assuming full compliance** (100% vaccination and testing) (5000 iterations)

If the underreporting correction factor was set to 1 or 10, mean values for P1 were respectively $1.3.10^{-4}$ and 13.10^{-4}, whereas mean values for Y were respectively 10 630 and 1061. That means the probability of importing infected animals changed by a factor of ten.

Name	Distribution	Correlation coefficient
Fraction of vaccinated pets in exporting country	RiskUniform (50%, 100%)	0.56
Fraction of vaccinated pets among imported adults	RiskTriang (56%, 89%, 100%)	-0.556
Underreporting CF	RiskPert (1,1.5, 5)	0.527

Table 12. Significant inputs according to the sensitivity analysis, performed for the importation of vaccinated and tested dogs and cats from group 4 countries.

4.3. Comparison of mean values

For easier comparison, mean estimates of each output, according to number of imported pets, pet category and exporting country, are grouped in Table 13, Table 14, Table 15 and Table 16.

Number imported/y		100	1 000	10 000
Vaccinated and tested	Group 1	0	0	0
	Group 2	0	0	0
	Group 3	0	0	0.0002
	Group 4	0.0002	0.002	0.03
Unvaccinated youngs	Group 1	0	0	0
	Group 2	0	0	0
	Group 3	0	0	0.0004
	Group 4	0.0008	0.005	0.05

Table 13. Mean number of infected pets imported per year

Table 14 illustrates the major increase in probability which occurs between group 1 to 3 countries on one side, and group 4 countries on the other side. Using group 1 countries as a reference, the probability of importing unvaccinated pets increases by a factor of two if the pets are imported from group 2 countries, a factor of ten if they're imported from group 3 countries, and a factor of 1000 if they're imported from group 4 countries. For vaccinated adults, the probability increases by a factor of three if the pets are imported from group 2 countries, a factor of thirteen if they're imported from group 3 countries, and a factor of 3000 if they're imported from group 4 countries.

Number imported/y		100	1 000	10 000
Vaccinated and tested	Group 1	0.000009%	0.00009%	0.0009%
	Group 2	0.000026%	0.00026%	0.0026%
	Group 3	0.00012%	0.0012%	0.012%
	Group 4	0.026%	0.26%	2.6%
Unvaccinated youngs	Group 1	0.00005%	0.0005%	0.005%
	Group 2	0.00011%	0.0011%	0.011%
	Group 3	0.0005%	0.005%	0.05%
	Group 4	0.052%	0.52%	5.1%

Table 14. Mean probability of importing >0 infected pets (P1)

Number imported /y		100	1 000	10 000
Vaccinated and tested	Group 1	0.00009%	0.0009%	0.009%
	Group 2	0.0026%	0.0026%	0.026%
	Group 3	0.0012%	0.012%	0.12%
	Group 4	0.26%	2.6%	22.2%
Unvaccinated youngs	Group 1	0.0005%	0.005%	0.05%
	Group 2	0.0011%	0.011%	0.11%
	Group 3	0.005%	0.05%	0.5%
	Group 4	0.52%	5.1%	39.9%

Table 15. Mean probability of importing at least one infected pet per ten years (P10)

Number imported/y		100	1 000	10 000
Vaccinated and tested	Group 1	15 486 757	1 548 676	154 868
	Group 2	5 612 991	561 299	56 130
	Group 3	1 169 204	116 920	11 692
	Group 4	5 766	577	58
Unvaccinated youngs	Group 1	2 000 000	200 000	20 000
	Group 2	960 014	96 001	9 600
	Group 3	200 000	20 000	2 000
	Group 4	2 119	212	21

Table 16. Mean number of years between the importation of infected pets

5. DISCUSSION

The probability of importing rabies through the legal importation of pets depends on the prevalence of rabies in the exporting countries, and must therefore be related to the country of origin. The countries of interest are therefore grouped into four risk groups based on their prevalence of rabies, increasing from risk group 1 to risk group 4.

The present model estimates that the yearly probability of introducing rabies through young unvaccinated cats and dogs (hereafter called “pets”) is lower than 0.05 %, when importing up to 10,000 pets from countries with a very low or zero incidence of rabies (risk groups 1 to 3). The number of years between the importation of an infected pet from countries with a few registered cases, such as Germany, Austria and Slovenia (risk group 3), was estimated to 2,000 years, if 10,000 unvaccinated young pets were imported each year from these countries. The probability of importing rabies from these countries was approximately ten times higher than from countries such as the UK, Sweden, Denmark, and Iceland (risk group 1).

The yearly probability of introducing rabies from EEA countries with a significant number of reported cases, such as Lithuania, Latvia, Estonia, Hungary, Poland and The Slovak Republic, was estimated to be a thousand times higher than for risk group 1, reaching 5% when importing 10,000 unvaccinated young pets. Importing 10,000 vaccinated and tested pets from these countries was associated with a yearly probability of introducing rabies of 2.6%, based on the assumptions related to the number of vaccinated pets in the exporting country (50-100%) and the true protection of imported pets (on average 81%).

The probability increased approximately linearly with the number of pets imported, i.e. the risk from importing 10,000 pets/y was ten times higher than from importing 1000 pets/y and 100 times higher than from importing 100 pets per year. Limiting the number of imported pets is therefore a major means of reducing the probability of introducing rabies. It is however less important than selecting exporting countries free from or with a very low prevalence of rabies.

The level of protection provided by requiring vaccination and testing of imported pets was estimated to be on average 81%. The major factor responsible for this result was the estimated fraction of imported pets that are actually vaccinated, which in the model was assumed to be most likely 89%, ranging from 56% to 100%.

The total probability for Norway will be the sum of the probabilities from each of the country groups. This will be possible to monitor if the origin of the pets is recorded. The number of pets imported from group 4 countries has clearly the strongest impact on the total probability, and therefore emphasis should be put on recording the number of pets originating from these countries. The protection provided by requiring vaccination and testing might be moderate as long as the true level of vaccination is uncertain. Therefore, the importation of both vaccinated adults and unvaccinated pets younger than 3 months would be useful to monitor.

The uncertainty included in the model led to a moderate uncertainty about the results. For the importation of 10,000 vaccinated pets from group 4 countries, the 95% CI for the probability of importing rabies was 0.5-6% for a year, and 5-46% for a ten years period. Although there is a clear variation related to uncertain variables, it still remains within the same order of magnitude.

Both the uncertainty about the true prevalence of rabies in the exporting country and the proportion of imported pets that are actually vaccinated had a strong impact on the estimated probability. Although rabies leads to clear symptoms and death, and is under strict international surveillance, including mandatory reporting in most countries, it is almost inevitable that underreporting occurs, even in pets. For group 4 countries, which have the highest prevalence of rabies, the average probability of importing rabies increased by a factor of ten when the true number of rabies cases was considered to be ten times higher than the reported level, compared to a scenario with no underreporting. The fraction of vaccinated pets among the imported pets had a strong effect on the results. Despite mandatory vaccination and testing, some pets are likely to be introduced without being actually vaccinated. When the estimated fraction of vaccinated pets changed from 50% to 100%, the probability decreased by a factor of almost 30, due to the high effect of rabies vaccines.

In a quantitative risk assessment, a number of simplifications of reality are made in order to be able to predict some future event occurring. When the reality modelled is complex, as is the case for many biological events, there is either a need for building complex models based on a large amount of data, or a need for making assumptions in order to simplify the real situation. The results are often highly sensitive to the assumptions made, and therefore these should always be kept in mind when interpreting the results. The main assumptions made in the present model are listed under section 2.3 and the most significant will be discussed below.

First of all, it has been assumed that the probability of importing rabies from a given country, or group of countries, is stable within the time-frame considered. The estimates are based on reported cases in dogs and cats in 2003 and 2004. A significant change in the prevalence of rabies in exporting countries will result in a change in probability. Therefore, the rabies situation needs to be carefully monitored, in order to re-estimate the probability when major changes in prevalence occur.

The detection limit (DL) for rabies was based on the number of reported cases and the estimated pet population. This level was used as the minimum prevalence for the given group of countries during simulation, i.e. whenever the model yielded a lower prevalence, the DL was substituted. Therefore, when number of cases was low, the DL was used in most iterations. For group 2 and 3 countries, where only a few cases in pets are reported, the detection level for rabies was considered to be close to the reported level, i.e. approximately 1-5 infected pets per 100,000,000 pets. In group 1 countries, where no cases have been reported (except bats), a prevalence of five infected pets per 1,000,000,000 was assumed. The results are of course sensitive to the choice of the DL, which is indeed difficult to approach with more certainty. The underreporting was considered to vary between one and five, with a most likely value of 1.5 (i.e. the true incidence is 50% higher than the reported incidence). It could be significantly higher than five in some areas. When it was changed to ten, the probability increased by a factor of ten compared to a situation with 100% reporting.

The main uncertainty factor influencing the result was the fraction of imported pets that were actually vaccinated. This is difficult to estimate, although customs' data on the compliance with vaccination could be helpful. In the model, it was estimate that this could vary from 56% to 100%, with a most likely value of 89%. This was based on values previously used by Jones et al.(2002) for pets imported from North America to Great Britain. The effect of increasing this fraction was strong, as reported above, and indicates that a strict control policy at the border could effectively reduce the probability.

The number of pets imported was fixed following three different scenarios, with respectively 100, 1000 or 10 000 pets imported yearly. This approach was preferred to a stochastic approach within a given distribution for two reasons. Firstly, an adequate probability distribution was difficult to estimate, since the precise data on the origin of imported dogs and cats was unavailable and the response of the public to a change in importation policy was unknown. Secondly, threshold values are often easier to handle than uncertainty and variability distributions. Monitoring of importations can allow the government to adapt the importation policy in order to ensure that the probability remains beneath the threshold chosen as acceptable, particularly if the origin of imported dogs is registered in a centralised database.

It was assumed that importation of dogs and cats occurred independently from each other, which excludes the impact of importing a group of siblings. It's reasonable to assume that if a young pet is bit by a rabid animal, its siblings have an increased probability of being infected too. This would lead to a higher possibility that more than one infected animal is imported. However, the importation of siblings is most probably a minor phenomenon, and the origin of such siblings is most probably highly protected professional breeders, with lower probability for contracting rabies.

6. ACKNOWLEDGMENTS

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7. REFERENCES

Jones,R., Kelly,L., Fooks,T., Wooldridge,M., 2002. Quantitative risk assessment to compare the risk of rabies entering Great Britain from North America via quarantine and PETS. 47 pp.

McDiarmid,S.C., Corrin,K.C., (undated internet communicatione). Case study; the risk of introducing rabies through the importation of dogs. Internet communication <http://freespace.virgin.net/simon.green/riskman.htm> accessed on 30 June 2005.

OIE, 2005. Rabies outbreaks and control in Europe. Internet communication <http://www.oie.int/hs2/sit_mald_cont.asp?c_mald=26&c_cont=4> accessed on 3 Jun 2005.

Vose,D., 2000. Risk Analysis. A quantitative guide. 2nd ed. John Wiley & Sons Ltd, England, 418 pp.

Appendix 1- Rational for risk categories, vaccination status and pet population in EEA countries as used in the model

Country Name	Human population (/1000) (Eurostat)	2003+2004 Cases dogs and cats (Pötzsch)	2003+2004 Prevalence registered in dogs and cats (per 1 000 000)	2003+2004 Prevalence registered * 5 (per 1 000 000)	2003+2004 Cases wild animals (Pötzsch)	Vaccination Dog Compulsory (Pötzsch)	Dog Vaccination in 2003 (OIE)	Cat Vaccination in 2003 (OIE)	Risk group	Group rational (special details)
CYPRUS	721	0	0	0	0	1	1	1	1	
DENMARK	5391	0	0	0	0		0	0	1	Far from rabies-zones in Germany
ICELAND	290	0	0	0	0		0	0	1	
IRELAND	3994	0	0	0	0		0	0	1	
NORWAY	4564	0	0	0	0		0	0	1	
SWEDEN	8958	0	0	0	0		0	0	1	
UNITED KINGDOM	59423	0	0	0	0		0	0	1	
BELGIUM	10376	0	0	0	0		0	0	2	Border with Germany
FINLAND	5213	0	0	0	0		0	0	2	Border with Russia
GREECE	11033	0	0	0	0		0	0	2	Border with Bulgaria, Makedonia,..
ITALY	57401	0	0	0	0	0	0	0	2	Close to N.Afr., tourism
LIECHTENSTEIN	34	0	0	0	0		0	0	2	Border with Germany, Austria
LUXEMBOURG	450	0	0	0	0		0	0	2	Border with Germany
MALTA	398	0	0	0	0		0	0	2	Close to N.Afr., tourism
NETHERLANDS	16225	0	0	0	0		0	0	2	Border with Germany
PORTUGAL	10444	0	0	0	0		1	1	2	Close to N.Afr.
SPAIN (-Melilla)	40830	0	0	0	0		1	0	2	Close to N.Afr. (* 1 case in Melilla)
FRANCE	59762	3	0.0126	0.0629	0		1	1	2	3 cases were imported dogs
AUSTRIA	8079	0	0	0	1	0	0	0	3	
CZECH REPUBLIC	10207	0	0	0	0	1	?(0 in 2002)	?(0 in 2002)	3	Borders with group4 countries and political situation
SLOVENIA	1996	0	0	0	10		0	0	3	
GERMANY	82541	1	0.0030	0.0152	57		1	0	3	
POLAND	38206	60	0.393	1.967	413	1	1	1	4	
HUNGARY	10129	34	0.841	4.203	240	1	1	1	4	
SLOVAK REPUBLIC	5380	43	2.002	10.009	336	1	1	1	4	
LITHUANIA	3455	210	15.223	76.113	1204	1	1	1	4	
LATVIA	2325	182	19.605	98.025	1178	1	1	1	4	
ESTONIA	1353	106	19.621	98.106	951	1	1	1	4	
			Average						**Count**	
Group 1	83341	0	0		0	1	1	1	7	
Group 2	212166	3	0.00114		0	0	3	2	11	
Group 3	102823	1	0.00076		68	1	1	0	4	
Group 4	60848	635	9.61409		4322	6	6	6	6	

Sources: Eurostat, OIE, WHO Collaborating Centre for Rabies Surveillance and Research (Pötzsch pers. commun.)

Appendix 2. Summary of results

		Group 1			Group 2			Group 3			Group 4		
Number imported per year		100	1000	10000	100	1000	10000	100	1000	10000	100	1000	10000
Unvaccinated youngs	Number of infected Imported per year	0	0	0	0	0	0	0	0	0.0004	0.0008	0.005	0.05
	Probability of importing >0 infected dogs and cats	0.00005%	0.0005%	0.005%	0.00011%	0.0011%	0.011%	0.0005%	0.005%	0.05%	0.05%	0.5%	5.1%
	Probability of importing >0 infected dogs and cats in 10 years	0.0005%	0.005%	0.05%	0.0011%	0.011%	0.11%	0.005%	0.05%	0.5%	0.5%	5.1%	39.9%
	Years between import of infected dogs and cats	2000000	200000	20000	960014	96001	9600	200000	20000	2000	2119	212	21
Vaccinated and tested adults	Number of infected Imported per year	0	0	0	0	0	0	0	0	0.0002	0.0002	0.002	0.03
	Probability of importing >0 infected dogs and cats	0.000009%	0.00009%	0.001%	0.00003%	0.0003%	0.003%	0.0001%	0.001%	0.01%	0.03%	0.3%	2.6%
	Probability of importing >0 infected dogs and cats in 10 years	0.00009%	0.0009%	0.009%	0.0003%	0.003%	0.026%	0.001%	0.012%	0.12%	0.3%	2.6%	22.2%
	Years between import of infected dogs and cats	15486757	1548676	154868	5612991	561299	56130	1169204	116920	11692	5766	577	58