STOC free

A Surveillance analysis Tool for Outcome-based Comparison of the confidence of freedom generated by control or eradication programmes

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Introduction

Input-based approaches

- *A focus on what needs to be done*
- *Prescriptive with respect to the actions to be taken*

Output-based approaches

- *A focus on what has been achieved*
- *Not prescriptive with respect to the approach taken*

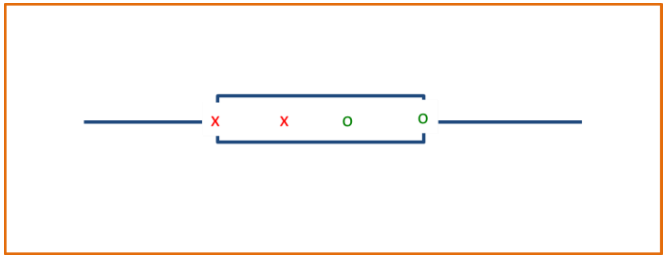
Input-based approaches

Strengths

- *Clear, straightforward, unambiguous*
- *Uniform application*
- *Ease of communication and verification*

Challenges

- *It does not acknowledge biological complexity*
- *It can become dated*

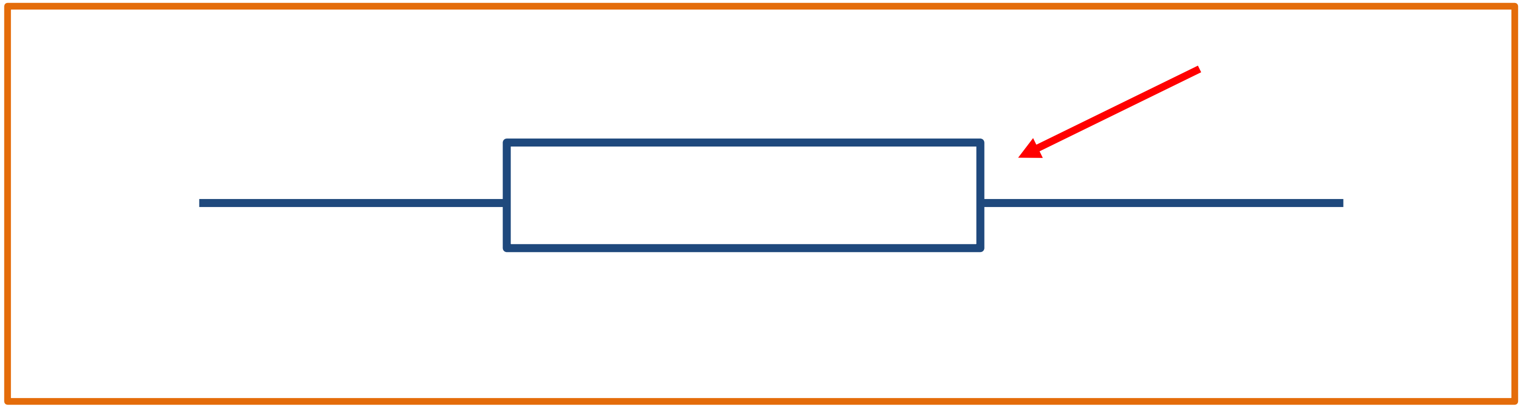


Output-based approaches

Potential advantages

- *Multiple routes*
- *The issue of risk*

The context, including known risk factors …



Output-based approaches

TABLE 1 | Comparison of BVD control programmes and BVD status in six European countries in 2017.

Elements	**Countries**					
	DE	**FR (Brittany)**	**IE**	**NL**	**SE**	**UK (Scotland)**
Herd level prevalence (breeding herds)	0.08%	unknown	2%	9%	0%–free	10%
Type of programme	Mandatory	Voluntary	Mandatory	Voluntary	Mandatory	Mandatory
Type of testing–screening/case finding	Ear notch, blood/serum	Bulk milk, ear notch, blood/serum	Ear notch	Bulk milk, ear notch, blood/serum	–	Ear notch, blood/serum
Type of testing - monitoring freedom of disease	Ear notch, blood/serum	Bulk milk, ear notch, blood/serum	Ear notch	Ear notch, blood/serum	Bulk milk, blood/serum	Blood/serum
Vaccines licensed for use	Yes	Yes	Yes	Yes	No	Yes
Funding	Private and public	Private	Private and public	Private	Private and public	Private
Most important herd level risk factors for introduction:						
1	Introduction of imported cattle	Boundary contact with neighboring cattle herds	Boundary contact with neighboring cattle herds	High cattle density	Introduction of imported cattle	Delayed removal of known PI animal(s)
2	Introduction of TI cattle	Introduction of cattle	Introduction of pregnant cattle	Introduction of pregnant cattle	–	Introduction of cattle with unknown status
3	Introduction of pregnant cattle	Presence of fattening unit	Indirect transmission through personnel	Indirect transmission through professional visitors	–	Boundary contact with neighboring cattle herds

DE, Germany; FR, France; IE, Ireland; NL, Netherlands; SE, Sweden; UK, United Kingdom.

van Roon et al., 2021. Frontiers Vet Sci 6, 133

Output-based approaches

Regulatory perspectives

CHAPTER 2

Member State or zone free from bovine viral diarrhoea

Section 1

Granting of the status

The status free from BVD as regards kept bovine animals may only be granted to a Member State or a zone if:

(a) vaccination against BVD has been prohibited for kept bovine animals;

(b) no case of BVD has been confirmed in a kept bovine animal for at least the previous 18 months; and

(c) at least 99,8 % of the establishments representing at least 99,9 % of the bovine population are free from BVD.

Commission Delegated Regulation (EU) 2020/689

Output-based approaches

Scientific perspectives

The animal
The herd
The sector
The zone
The country

Definitely infected ⟷ Definitely not infected

Output-based approaches

practical perspectives

- Heterogeneity in control/eradication programmes occurs when:
  - Diseases are not regulated by EU
  - Diseases are listed with **output-based** definitions of “free” status
- **We need:** standardized measures to be able to compare the degree of certainty about freedom of infection.
  - To optimize control programmes (and comply with regulations)
  - To reduce the risk of trade (when not yet regulated)

Aim of the project

Develop and validate a **practical** tool:

STOC free

that enables a **transparent and standardized comparison of confidence of freedom** for disease control programmes.

Outcome: framework

STOC free DATA

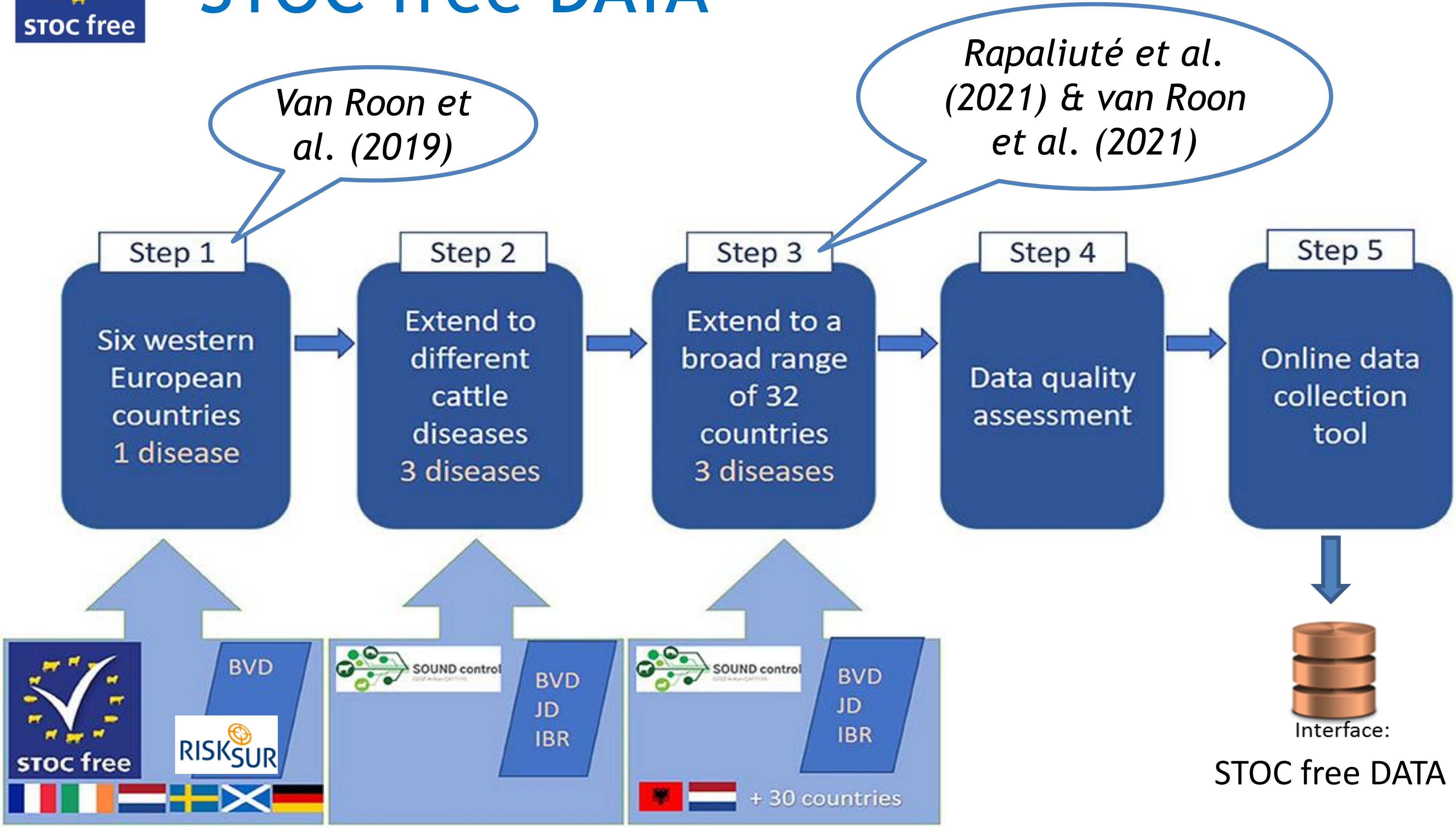
STOC free MODEL

OUTPUT

Initial ambitions:

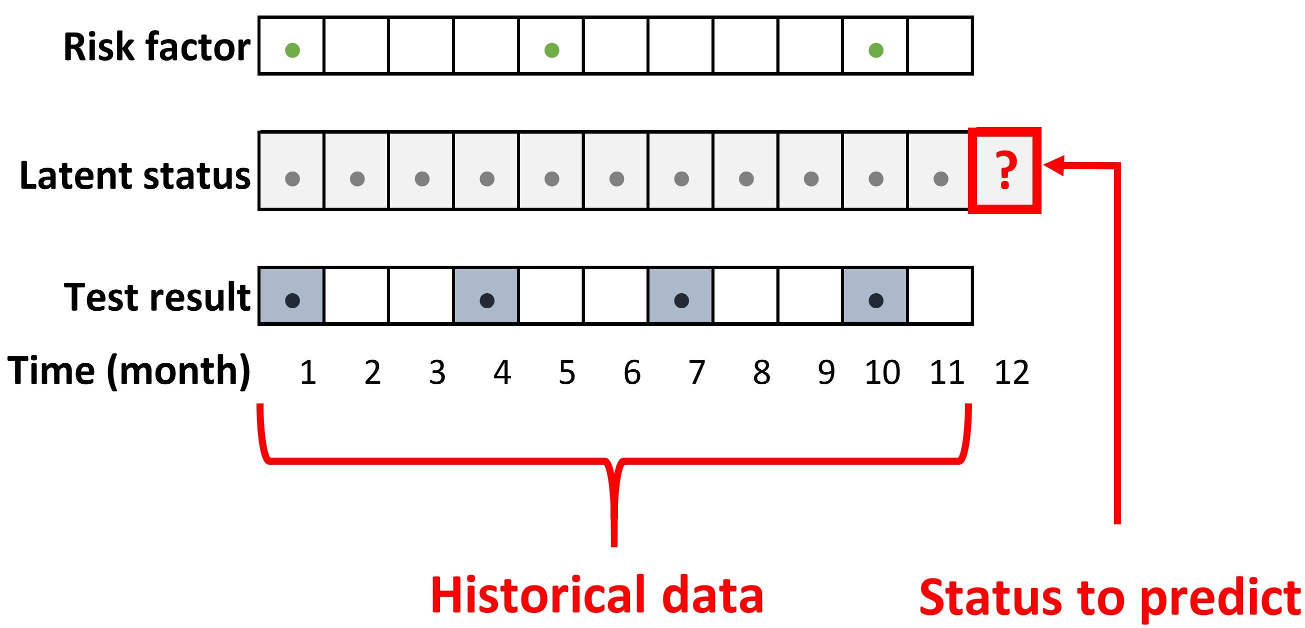
- Easy to use by stakeholders
- Heterogeneous inputs, uniform output
- Output on different levels of aggregation
- BVDV as (in 2017) non-EU regulated case disease but adaptable to multiple diseases in multiple species

STOC free DATA



STOC free MODEL

- Bayesian Hidden Markov model that requires prior knowledge about test characteristics, incidence and prevalence of the disease.
- Freely available with default values for BVDV, that are adaptable to country specific values: *Madouasse A, et al. (2021)*



Case studies 1.0

Several scenarios:

- All test types in 1 model: antibody and virus testing in serum, bulk milk and ear notch (NL)

  Contradictory results of different tests and lack of frequent testing

- Quarterly bulk milk testing to monitor free status (F, NL)

  Change in test strategy after a positive result (NL)

- Bulk milk testing in Sweden

  Sweden is free of infection and the STOC free model cannot handle such situation -> Scenario Tree Model

Case studies 2.0

- BVDV CP based on earnotch sampling of all newborn calves in a herd.
- Animal-level test results aggregated to monthly **herd-level** test results.
- One year (2019) of testing to determine the probability of freedom from BVDV in December 2019.
- Different definitions of BVDV-freedom in the earnotch route:
  - In NL: participation for 24 months, no virus detection in previous 10 months
  - In IE: participation for 36 months, no virus detection in previous 12 months
  - In DE and UK: only official animal level free status (for case study EU regulation of 18 months)

Input for case study on BVDV

	NL	DE (Paderborn)	IE	UK (Scotland)
Herd type	Dairy	Dairy and beef combined	Dairy (and beef)	Dairy (and beef)
Number of herds included in the model	1,642	361	16,097	559
Herds with 1 or more positive test result(s) in 2019	161	11	231	64
Number of observations (test months) in dataset	12,566	2,475	78,884	3,724
Number of positive test months	270	25	316	111
Number of herds free according to CP on 1 December 2019	486	319	14,743	332

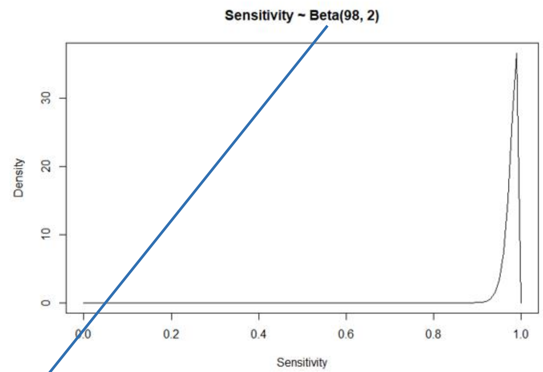
Prior information for model parameters

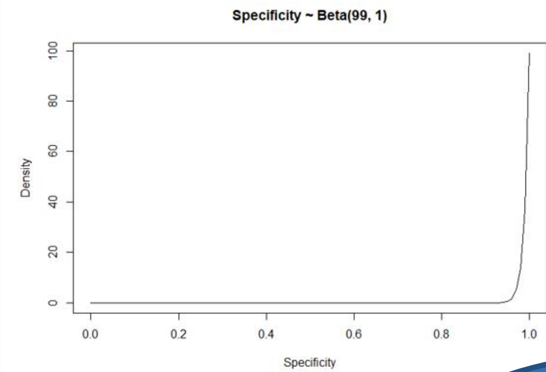
Default priors & country specific priors

5 parameters:

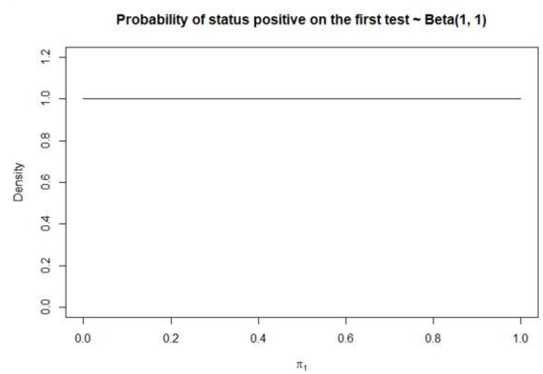
- Sensitivity
- Specificity
- Herd level prevalence at first time step
- Probability of becoming infected
- Probability of remaining infected

Default priors

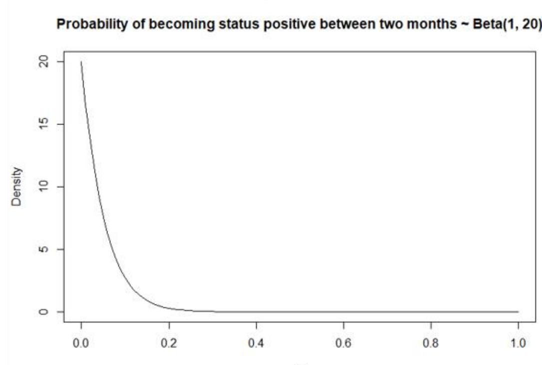


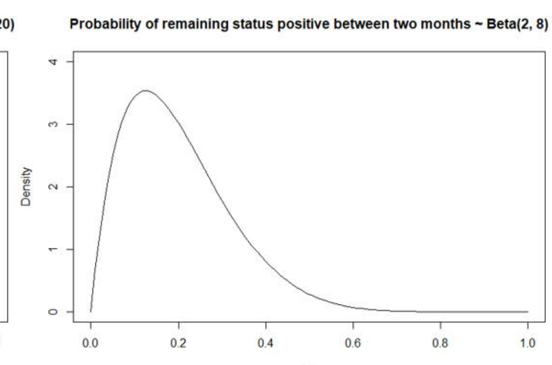


Out of 100 tests, 2 herds test negative while they are infected

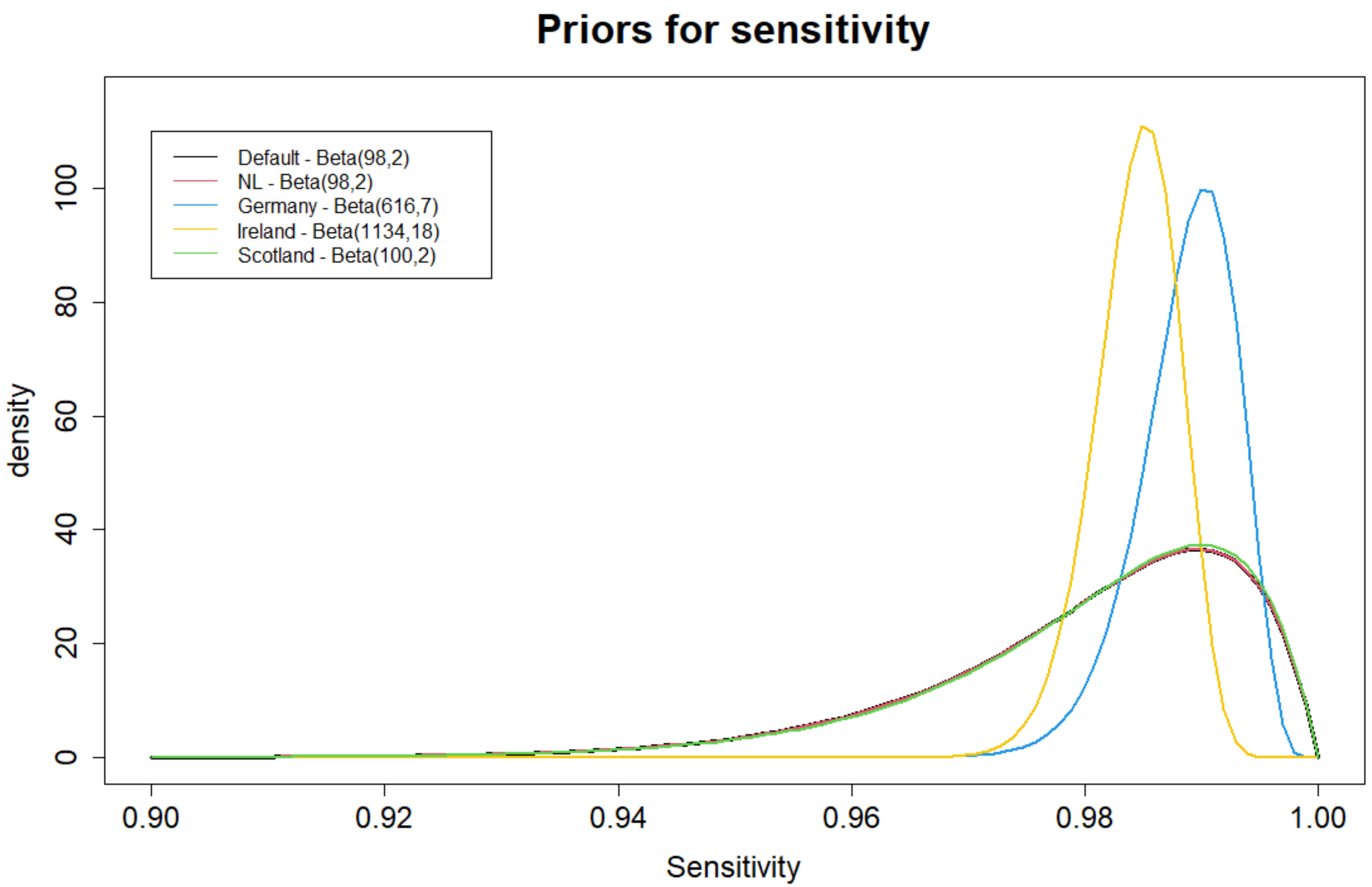


From every 10 infected herds, two herds remain positive in the next month





Country specific priors



Parameter estimations

Models with default priors:

Model parameters (median)	The Netherlands	Germany (Paderborn)*	Ireland	Scotland
Sensitivity	0.886	0.977	0.904	0.821
Specificity	0.994	0.998	0.998	0.984
T1 (becoming infected)	0.008	0.003	0.001	0.010
T2 (remaining infected)	0.511	0.454	0.624	0.627

These are herd level sensitivities and specificities

OUTPUT

Predicted probability of BVDV infection

Model outcome for free herds	NL	DE (Paderborn)	IE	UK (Scotland)
Default priors	0.002 (0.000-0.019)	0.002 (0.000-0.008)	0.001 (0.000-0.002)	0.013 (0.000-0.033)
Country specific priors	0.000 (0.000-0.009)	0.001 (0.000-0.006)	0.001 (0.000-0.001)	0.018 (0.000-0.026)

Probability of freedom: ≥99.8%

More missing results lead to higher probability of infection than negative results

OUTPUT

	herd	sq	X2.5.	median	X97.5.
1	1995	000101000000	0.000	0.000	0.000
2	3069	0-0-0-000000	0.000	0.000	0.000
3	13288	-----0-0000-	0.004	0.005	0.006

Predicted probability of BVDV infection

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Little difference between default and country-specific priors

A bit more uncertainty in country with higher incidence (NL)

OUTPUT

Remaining challenges

- Computational intensive
- Basic knowledge of R and disease modelling
- Need for prior knowledge on test validity and disease incidence/prevalence
- For BVDV it was difficult to compare CPs based on different diagnostics (i.e. antibody or virus tests).
- Generalisability to other diseases
- Not enough information in the data in regions that are almost or completely free from infection → scenario tree models

Impact

The use of the STOC free framework will stimulate:

- Compliance with output-based EU regulations for diseases
- Improved control programmes and better biosecurity on farms
- Economic benefits due to reduced risk in a flexible trade context

STOC free DATA

STOC free MODEL

OUTPUT

Thank you for your attention, questions?

http://www.stocfree.eu/

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DECIDE

Data-driven control and prioritisation of non-EU-regulated contagious animal diseases

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