A Quantitative Approach to Determining Waiting Periods for FMD Freedom

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Conclusions

- Quantitative calculation of appropriate waiting periods is possible
  - Need to change standard used to assess surveillance
    - From *surveillance sensitivity* to *probability of freedom*
- Appropriate waiting periods depend on
  - Sensitivity of ongoing surveillance activities
  - Probability of introduction of infection
  - Use of vaccination

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Overview

- Waiting periods
- Surveillance standards
- Calculations
- Implications

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Waiting periods

- OIE Code for FMD
  - Periods of 3, 6, 12, 18, 24 months depending on situation
- What is the purpose?
- How were they determined?
- Are they correct?

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Purpose of waiting periods

- Allow disease to spread
  - Reach a detectable level (design prevalence)
  - Non-vaccinated non-immune population
    - Rapid spread, very short period required
  - Vaccinated population
    - Slower spread, may require more time
- Allow disease to be detected by surveillance
  - Ongoing surveillance (e.g. passive farmer reporting)
    - More time = more surveillance = more confidence

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Time and confidence in freedom

- Intuitive principles
  1. Old surveillance loses value
  2. Confidence accumulates over time
- How to describe these effects quantitatively?

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Quantifying effects of time

- Decrease of value of old surveillance

  Example:
  - Serosurvey achieving 95% surveillance sensitivity
    - No positive animals detected
  - Scenario 1:
    - Completed one month ago
    - Are we confident that the population is free now?
  - Scenario 2:
    - Same survey conducted 5 years ago
    - Are we confident that the population is free now?

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Decay in confidence with time

- Due to risk of introduction of disease
- Perfect biosecurity
  - No loss in confidence

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Accumulation in confidence

- Ongoing surveillance activities
  - Passive farmer reporting
  - Abattoir surveillance
  - Active negative clinical reporting
- Individual observations
  - Relatively low sensitivity
- Longer waiting time
  - More observations, higher surveillance sensitivity

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Surveillance standards: Traditional approach

- Surveillance sensitivity
  - Pr(S+ | D+)
  - Probability of detecting at least on positive animal given that the population is infected at the design prevalence
  - Only standard used in OIE code
  - Sometimes called 'confidence'
  - Usually set at 95%

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Surveillance sensitivity

- Contributing factors
  - Sample size
  - Individual test sensitivity
  - Design prevalence
  - Risk-based sampling
  - **Does not capture effect of time**

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Surveillance standards: Alternative approach

- Probability of freedom
  - Pr(D- | S-)
  - Probability that the population is free from disease (at the design prevalence), given that surveillance found no positive animals
  - Calculated using Bayes' Theorem
  - Intuitively easier for regulators to understand

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Probability of freedom

- Contributing factors
  - Surveillance sensitivity
    - Sample size, design prevalence, test Se, risk-based sampling
  - Multiple surveillance activities
    - e.g. serosurveillance + passive reporting + abattoir
  - Accumulation of historical evidence over **time**
  - Risk of introduction of disease over **time**

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Calculation

$$Pr(Free)_{t_{n+1}} = \frac{(1-\Pr(Intro))\times \Pr(Free)_{t_n}}{1-SSe+(\Pr(Free)_{t_n}\times SSe)}$$

$$SSe = 1 - \prod_{k=1}^{n}(1 - CSe_k)$$

$$CSe = 1 - (1 - P^* \times Se)^n$$

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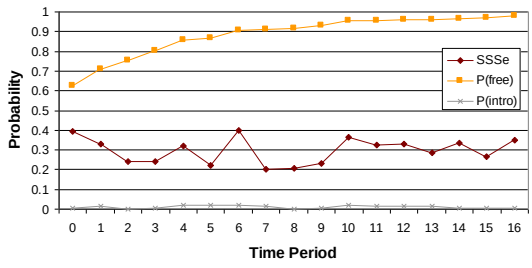

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Tools for calculation

- Free on-line tool to do calculations
  - Multiple surveillance components
  - Multiple time periods
  - Herd-level data
  - Herd- and animal-level risk based sampling
- http://epitools.ausvet.com.au
  - Access currently limited while under development
  - Will be made public on completion of project

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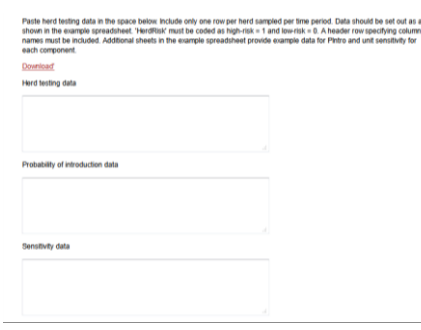

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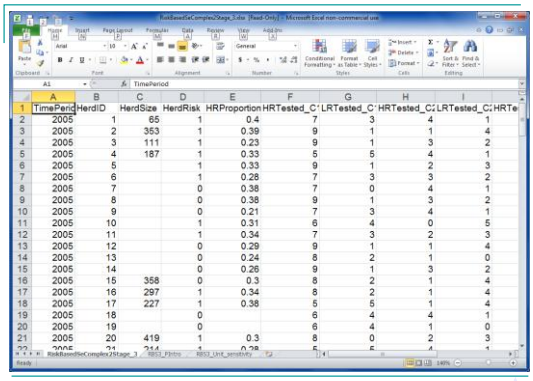

	A	B	C	D	E	F	G	H	I
1	TimePeriod	HerdID	HerdSize	HerdRisk	HRProportion	HRTested_C	LRTested_C	HRTested_C	LRTested_C
2	2005	1	65	1	0.4	7	3	4	1
3	2005	2	353	1	0.39	9	1	1	4
4	2005	3	111	1	0.23	9	1	3	2
5	2005	4	187	1	0.33	5	5	4	1
6	2005	5		1	0.33	9	1	2	3
7	2005	6		1	0.28	7	3	3	2
8	2005	7		0	0.38	7	0	4	1
9	2005	8		0	0.38	9	1	3	2
10	2005	9		0	0.21	7	3	4	1
11	2005	10		1	0.31	6	4	0	5
12	2005	11		1	0.34	7	3	2	3
13	2005	12		0	0.29	9	1	1	4
14	2005	13		0	0.24	8	2	1	0
15	2005	14		0	0.26	9	1	3	2
16	2005	15	358	0	0.3	8	2	1	4
17	2005	16	297	1	0.34	8	2	1	4
18	2005	17	227	1	0.38	5	5	1	4
19	2005	18		0		6	4	4	1
20	2005	19		0		6	4	1	0
21	2005	20	419	1	0.3	8	0	2	3
22	2005	21	214	1	0.28	5	5	4	1

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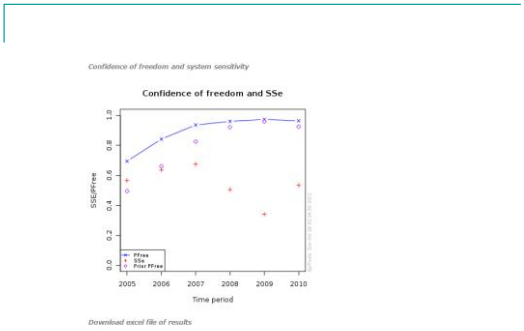

2-stage risk-based surveillance with multiple components

Analysed: Sun Oct 28, 2012 @ 02:34

Inputs

	Herd level	Animal level
Relative risk	3	2
Population proportion high-risk	0.2	0.4
Design prevalence	2%	10%
Prior confidence of freedom	0.5	
Population size	1500 herds	

Results

Summary results

	SSe (RBS)	SSe (rep)	Se ratio	Confidence of Freedom (posterior)	Prior PFree	Discounted Prior	Pintro	PFree(equ)	Prior PFree(equ)	Mean SeH	Mean EPI_H	Herds sampled
2005	0.567	0.443	1.28	0.694	0.5	0.495	0.01	0.992	0.982	0.965	0.029	30
2006	0.636	0.435	1.46	0.841	0.694	0.659	0.05	0.97	0.921	0.976	0.035	29
2007	0.675	0.491	1.37	0.935	0.841	0.825	0.02	0.99	0.97	0.982	0.033	34
2008	0.505	0.323	1.56	0.959	0.935	0.821	0.015	0.985	0.97	0.969	0.036	20
2009	0.341	0.258	1.32	0.972	0.959	0.958	0.001	0.998	0.997	0.988	0.028	15
2010	0.534	0.351	1.52	0.963	0.972	0.924	0.05	0.954	0.906	0.974	0.035	22

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Implications

- Time to target probability of freedom
  - Shorter with
    - Higher sensitivity surveillance
      - Larger sample size
      - Good risk-based sampling
      - Higher sensitivity test system
      - Higher design prevalence
    - More surveillance components
    - Lower probability of introduction

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Calculating appropriate waiting periods

1. Set target probability of freedom
2. Identify surveillance components contributing evidence of freedom
3. Estimate sensitivity of each component
4. Estimate probability of introduction
5. Calculate time to achieve target

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Freedom with vaccination

- Effects of vaccination
  - Lower within-herd design prevalence
  - Lower sensitivity of clinical surveillance
- Result
  - Lower surveillance sensitivity
  - Longer waiting period required

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