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Risk-based surveillance for human health hazards

The example of *Trichinella*

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Background

Increasing demands for cost-effectiveness in surveillance for human health hazards

Risk-based principles offers a way out

Implies targeting subpopulations with higher risk of infection compared to the whole population

But which subpopulations have higher risk?

Use of historical data

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For many infections, surveillance data are gathered continuously

Continued negative findings add to the credibility that infection is not present

But how can historical data from surveillance be used to assess risk of infection?

Aim

We demonstrate how historical data from surveillance can be used to assess risk of infection

We show how to identify high-risk subpopulation

We assess the probability that the population is free from infection in a future risk-based scenario

Trichinella spiralis infection in pigs used as example

Trichinella

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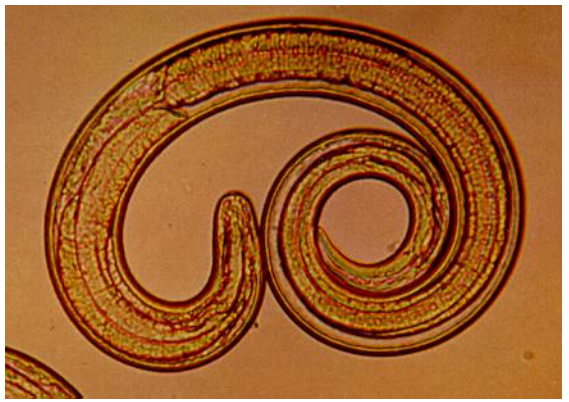
- *Trichinella* is a zoonotic parasite
- *Trichinella spiralis* infects pigs but also wild fauna (foxes, wild boar)
- Humans become infected by eating raw or undercooked meat containing *Trichinella* larvae
- Cases of human trichinellosis in EU caused by
  - Meat from outdoor pigs
  - Meat from backyard pigs
  - Horse meat
  - Game



Discounting historical evidence

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- Model developed by Angus Cameron and Tony Martin, Australia
- Depends mainly on three variables
  - The annual probability of introduction of *Trichinella* (*Pintro*)
  - The specified design prevalence (*P**)
  - The sensitivity of the system (*SSe*)
    - The surveillance system's capacity to identify ≥1 cases of *Trichinella* once the infection is present above the chosen design prevalence in the national pig herd

Simulate surveillance for 16 years

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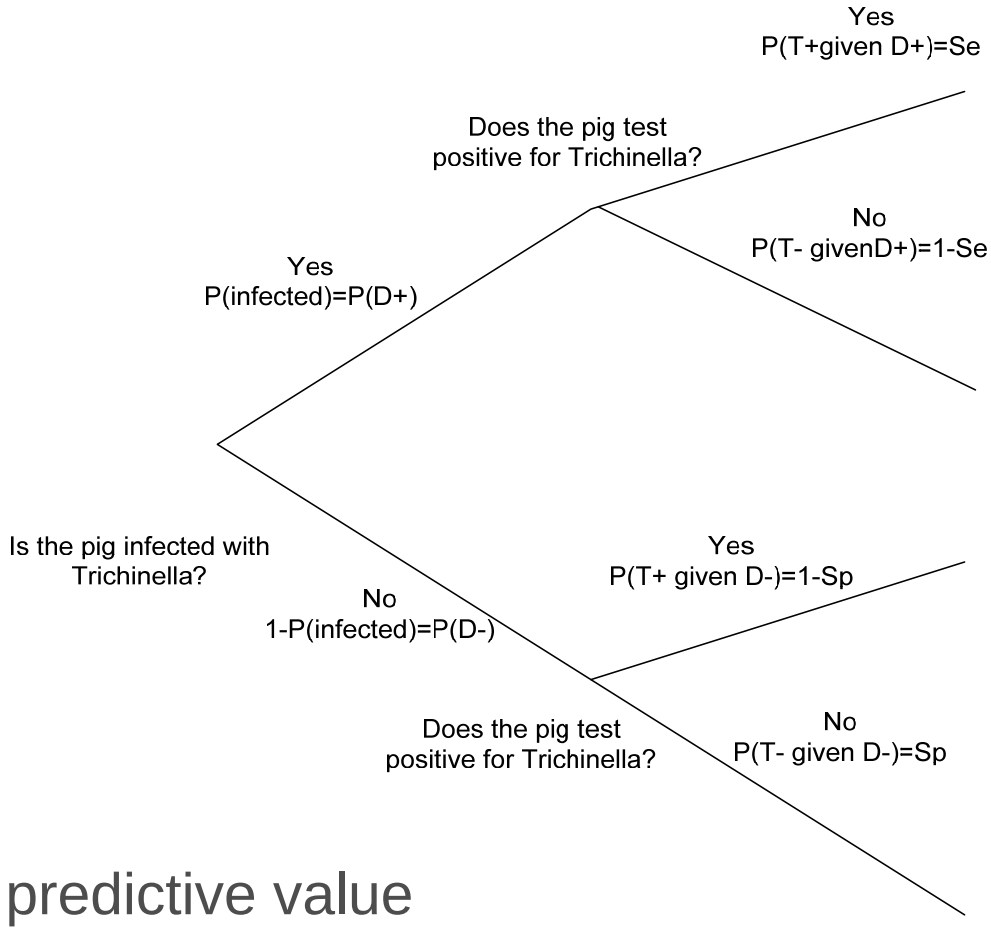
- Simulations reiterate for a number of years, in our case from 1990 to 2006

- At the end of each year, the probability that the population is free from disease at *P** is estimated as the negative predictive value of the surveillance system

Negative predictive value



No pigs have ever been found positive. Therefore, this route in not in use in the calculations

These are the dangerous - the false-negatives

No pigs have ever been found positive. Test-specificity = 100%

These are truely negative pigs

Negative predictive value

= True negative/(True negative + False negative)

= P(D-)/(P(D-)+P(D+)xP(T- given D+))

Bayes formula used

- Formula used to update prior estimate of confidence that population is not infected with new evidence provided by incorporating *SSe*, to derive a posterior estimate of the probability of freedom *PostPFree* for a given time period (*tp*)

$$PostPFree_{tp} = \frac{1 - PriorPInf_{tp}}{1 - PriorPInf_{tp} \times SSe_{tp}}$$

Risk of introduction (Pintro)

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In Denmark, pigs at slaughter are tested

- Currently 23 million per year

Despite of 76 years of sampling, no pigs have been found positive

As estimate of Pintro we use

- 1/waiting time = 1/76 = 1.3%

Surveillance system sensitivity (SSe)

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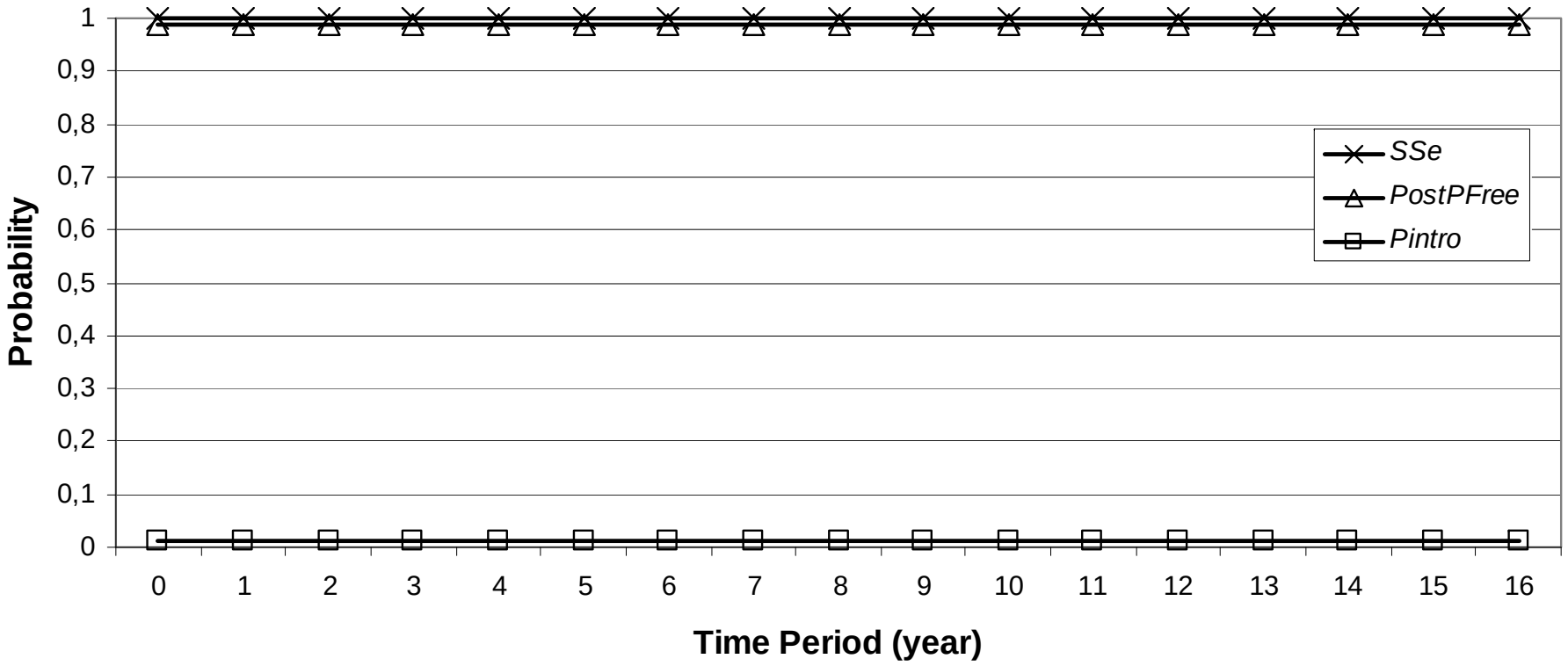
- SSe can be estimated from
  - Maximum number of infected carcasses expected under specified design prevalence
  - Sensitivity of test applied (40%)
- 1/mio used as design prevalence
  - 23 million pigs => 23 infected pigs
  - $P(x=0) = (1-0,4)^{23}$
  - $SSe = P(x>0) = 1- (1-0.4)^{23} = 0.9999 = 99.99\%$
- So, prevalence of *Trichinella* in Danish pigs is negligible (<1 case/ million)

Current surveillance



Risk-based surveillance

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If the prevalence of an infection is negligible, risk-based surveillance can be considered

Implies targeting high-risk subpopulations

High-risk subpopulations

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- Look into biology of disease
  - *Trichinella*: contact to wildlife implies increased risk

- Outdoor-reared pigs
  - Direct contact a possibility
- Sows and boars
  - Live longer than finishers
    - More chances to catch infection, if present

Implies testing 610,000 pigs per year (2005 data)

SSe in future risk-based system

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A design prevalence of 1/million used corresponding to 23 infected pigs

Again, we simulate surveillance for 16 years

Four different proportions of 23 cases being present in high-risk population assumed

- 67%, 50%, 33% and 13%

Surveillance system sensitivity

Assumption about infected pigs in high-risk population			
No.	Proportion	RR*	SSe (%)
15	0.67	69	99.95
12	0.50	40	99.78
8	0.33	20	98.32
3	0.13	5.5	78.40

*: Relative risk of infected pigs being found in the high-risk population compared to remaining population

Pintro in future risk-based system

- Red fox surveys conducted in Denmark 1970's and 1990's revealed very low (<0.1%) *Trichinella* prevalence

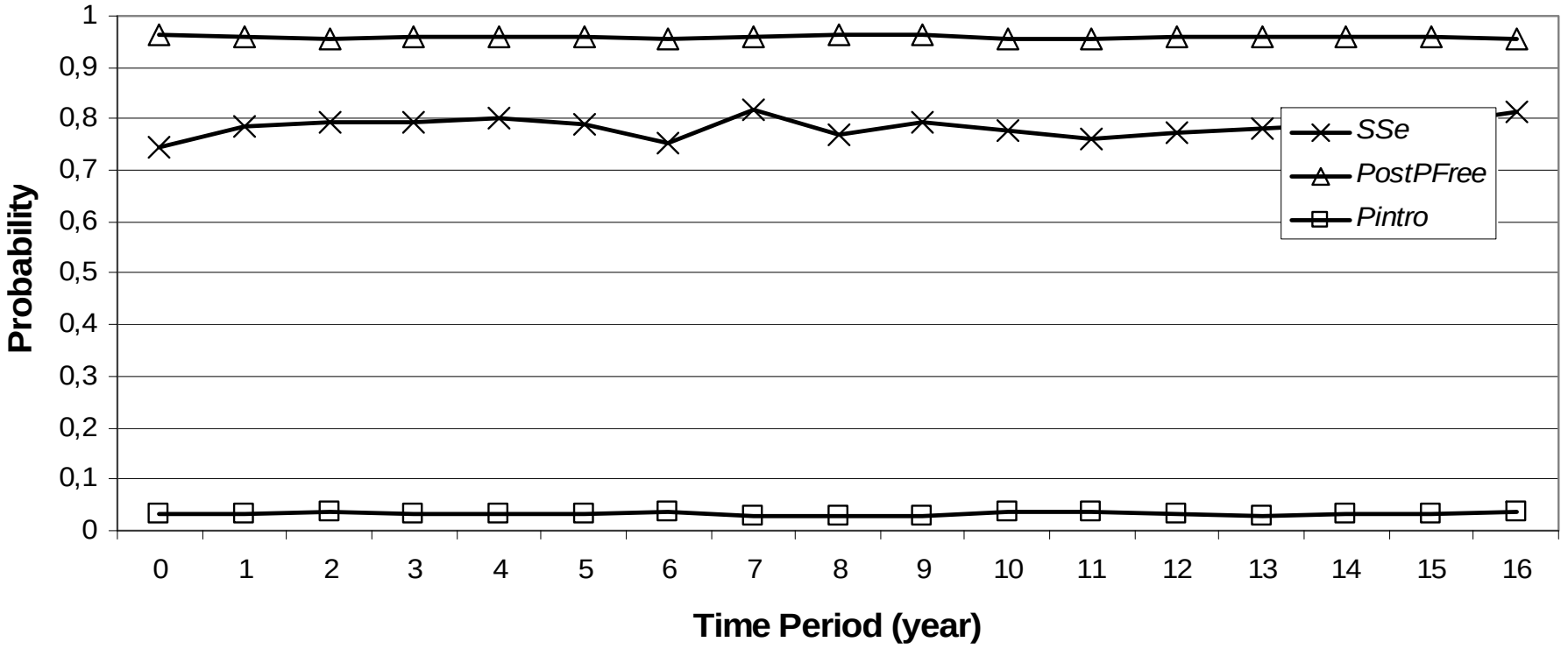
- Raccoon dogs typically show higher prevalence and larval burden of *Trichinella* than foxes
  - Currently not established as species in Denmark but expected to spread into Denmark in future

- We chose to model risk as an interval
  - Lower bound of PIntro as 2 x PIntro(inside) = 2 x 1.3% = 2.6%
    Upper bound of PIntro as 3 x PIntro(inside) = 3 x 1.3% = 3.9%

Four simulation rounds

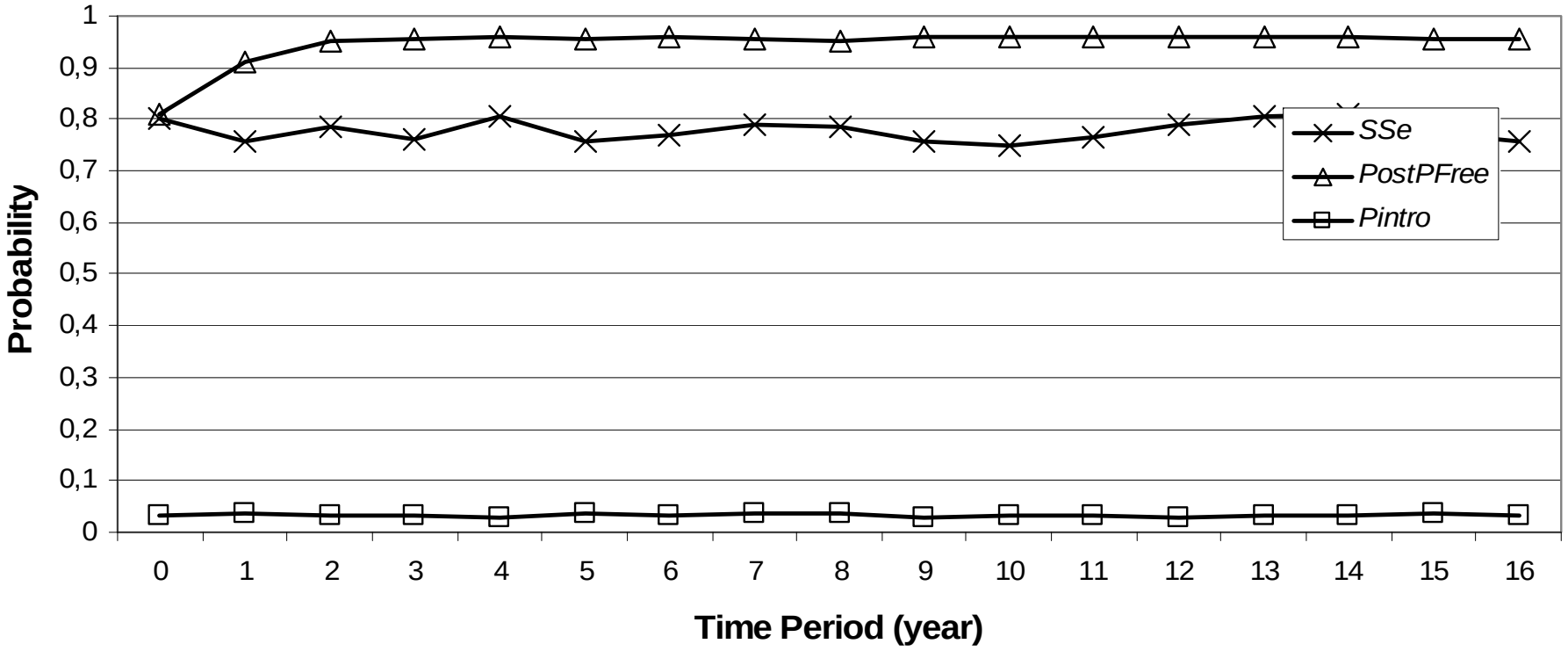
- Two different assumptions used regarding number of infected pigs present in high-risk population
  - 3 or 8 out of 23 present in high-risk population
- Two different values used for assumed probability that population is free in the begining of first year
  - 0.5 corresponding to an uninformed prior
  - 0.014 result from surveillance of entire population
- All 4 combinations simulated

Risk-based surveillance - 1



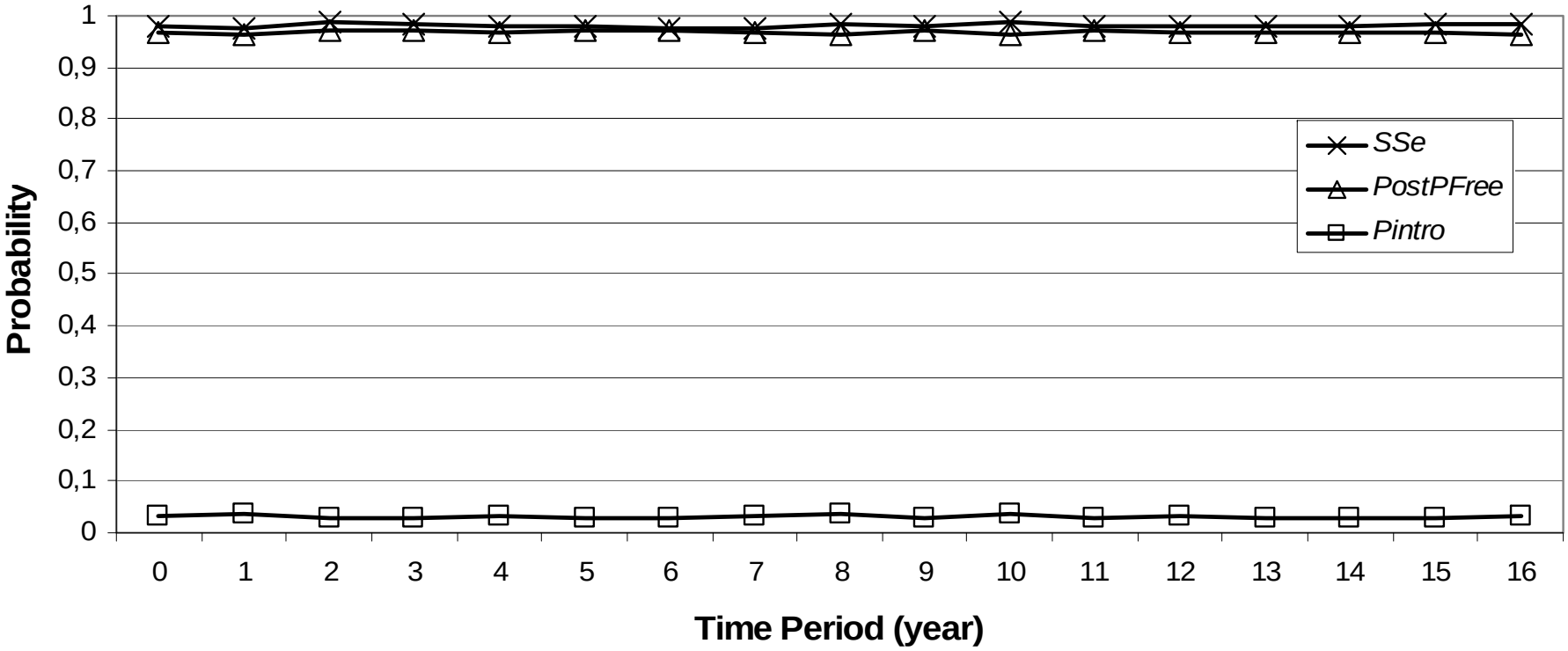
Assuming that only three out of 23 *Trichinella*-infected pigs would be present in the high-risk population. Chosen prior=0.014

Risk-based surveillance - 2



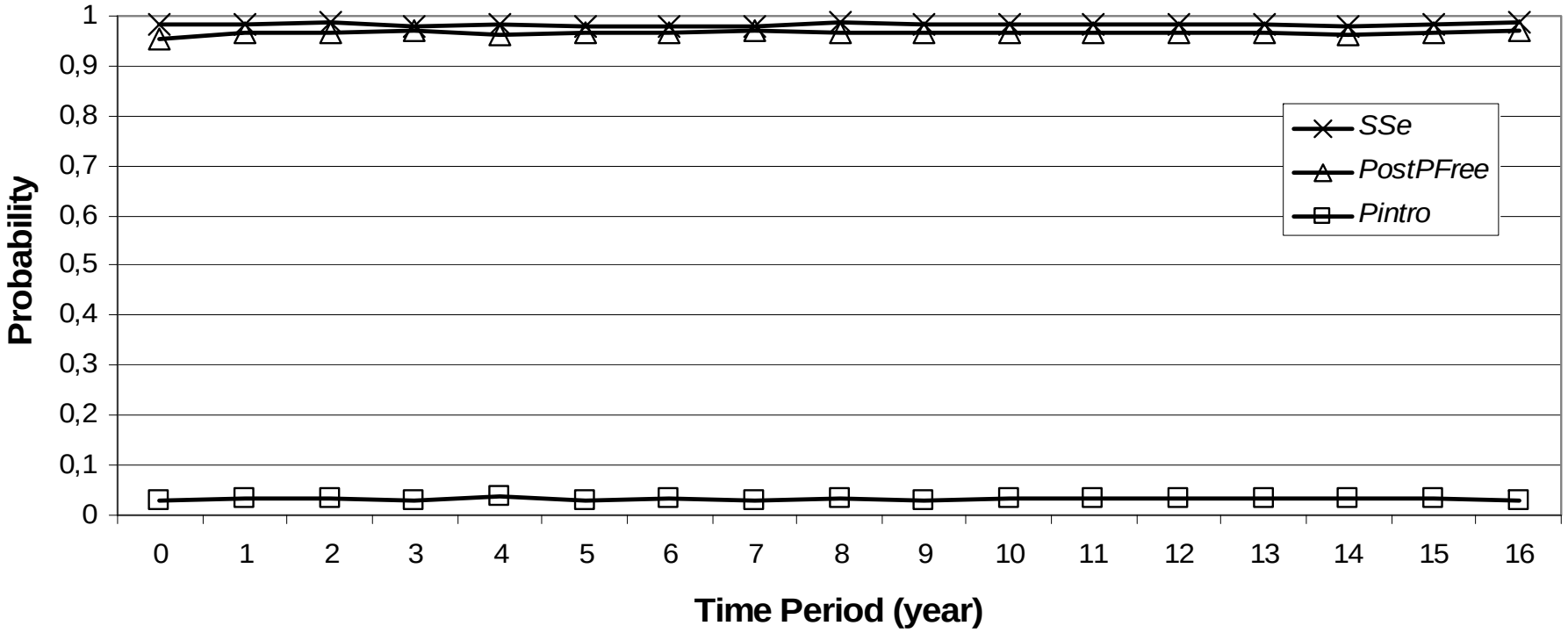
Assuming that only three out of 23 *Trichinella*-infected pigs would be present in the high-risk population. Chosen prior=0.5

Risk-based surveillance - 3



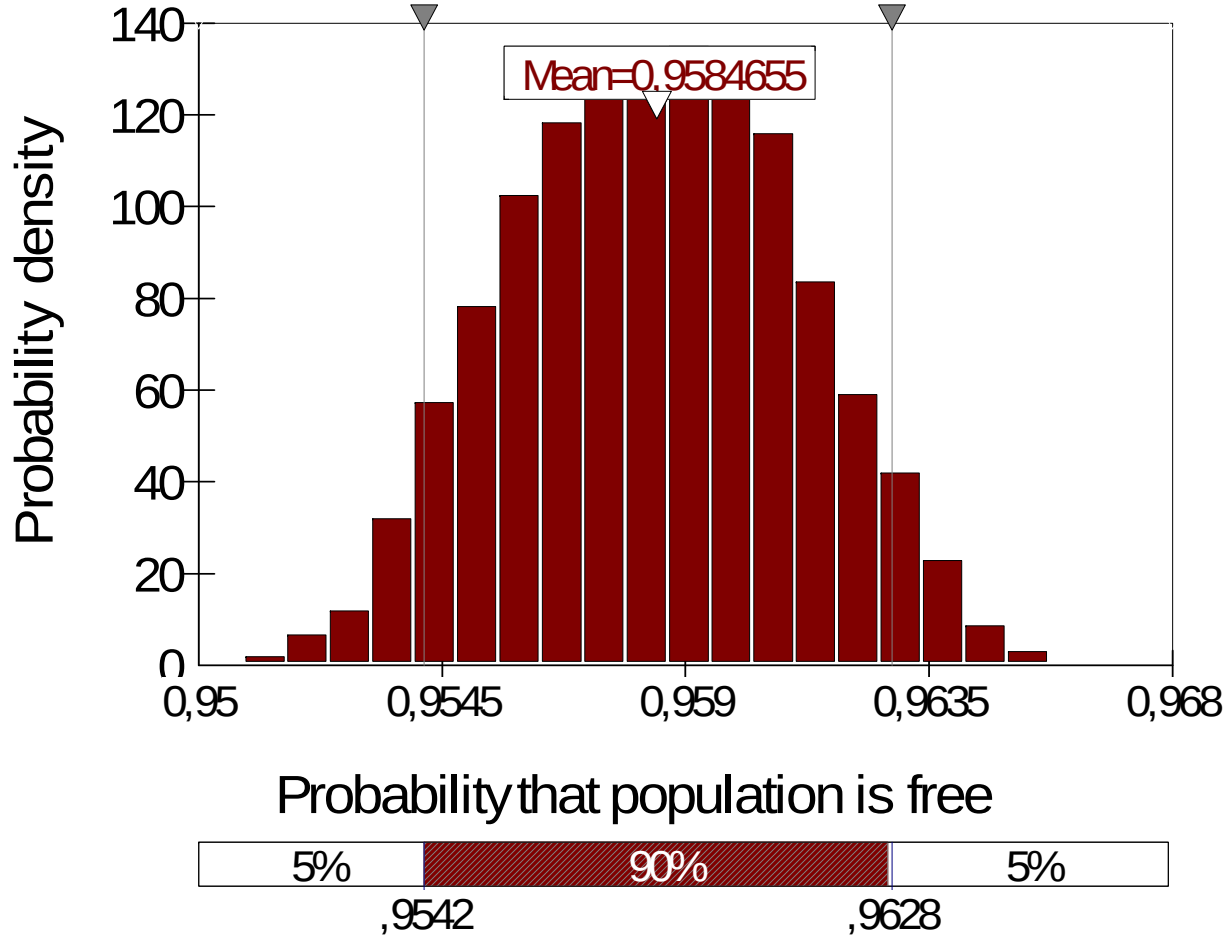
Assuming that eight out of 23 *Trichinella*-infected pigs would be present in the high-risk population. Chosen prior=0.014

Risk-based surveillance - 4



Assuming that eight out of 23 *Trichinella*-infected pigs would be present in the high-risk population. Chosen prior=0.5

Adjusted probability of freedom from *Trichinella* after 16 years



Discussion

- Existence of true *Trichinella*-free areas unlikely
  - Because even though *Trichinella* may be absent in domestic pigs it may still be present in wildlife
- However, we can conclude from our simulations
  - That prevalence in domestic pigs in Denmark negligible for years and Denmark is a low-risk area for *Trichinella* in slaughter pigs
- Therefore, risk-based sampling targeting sub-populations with higher risk justified
  - Much more expensive to certify each herd

Conclusion

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- Risk-based sampling of 610,000 pigs gives slightly lower confidence instead of sampling 23 million indoor pigs
  - Mainly due to assumed higher risk of introduction
- Negligible risk of infection among indoor-reared finishers due to strict biosecurity in Danish indoor pig herds
- Outdoor-reared pigs act as a sentinel for infection of *Trichinella* in national herd
- Sows and boars act as indicator of infection in individual herds in the event of infection in wildlife and biosecurity failing to prevent introduction of *Trichinella*

Epilogue

- The European Commission granted Denmark status as area with negligible risk of Trichinella in pigs in July 2007
  - Model results included in application to the Commission
  - Proposed risk-based surveillance programme for *Trichinella* in Denmark will include annual wildlife surveys, pig traceability, contingency plans and test quality assurance
- However, bilateral negotiations with each export country outside EU also needed

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Thank you for your attention