

Introduction to Bayesian Latent Class Models for diagnostic test evaluation

8 – 10 June 2022
Uppsala, Sweden



Practicalities



- SVA – room *Lånskeppet*
- Coffee breaks at 10:00 and at 14:30
- Lunch 12:00 – 13:00



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- **Arianna Comin** (Swedish National Veterinary Institute)
- **Maj Beldring Henningsen** (University of Copenhagen)

Practicalities



All of the material is on the **GitHub repository**

- We may tweak material as we go along
- Remember to pull changes at the start of each day!
- And click refresh in your browser . . !



Attendance registration is necessary for COST meetings

Harmony

COST action CA18208: <https://harmony-net.eu/about/>



October 2019 - October 2023



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Goals are to encourage the use of latent class models/methods for:

- Diagnostic test evaluation
- Determination of true prevalence
- Certification of disease freedom



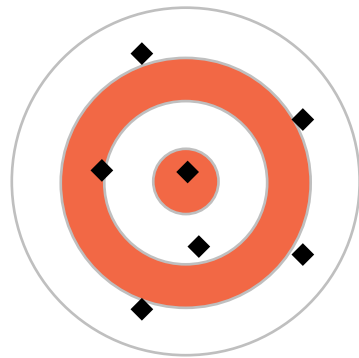
Background

Diagnostic test evaluation

Measuring test performance

Accuracy = ability to give the true measure of the substance being measured

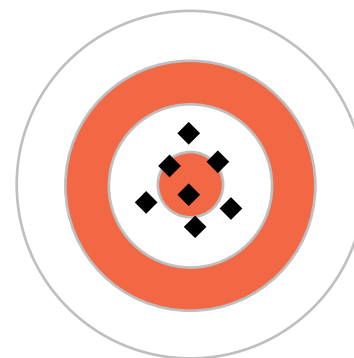
Precision = how consistent the results from the test are



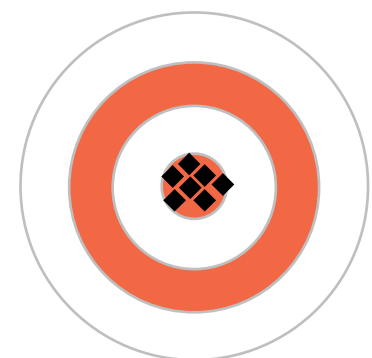
Low accuracy
Low precision



Low accuracy
High precision



High accuracy
Low precision



High accuracy
High precision

Diagnostic test evaluation

Precision



- Coefficient of variation
- Pearson's correlation coefficient
- Concordance correlation coefficient
- Cohen's kappa

Accuracy



- Sensitivity
- Specificity

Sensitivity & Specificity

Analytic Sensitivity = lowest concentration of the chemical compound that the assay can detect

Analytic Specificity = ability of the test to react only to one chemical compound

Diagnostic Sensitivity = probability of a positive test result given that the subject is diseased

Diagnostic Specificity = probability of a negative test result given that the subject is not diseased

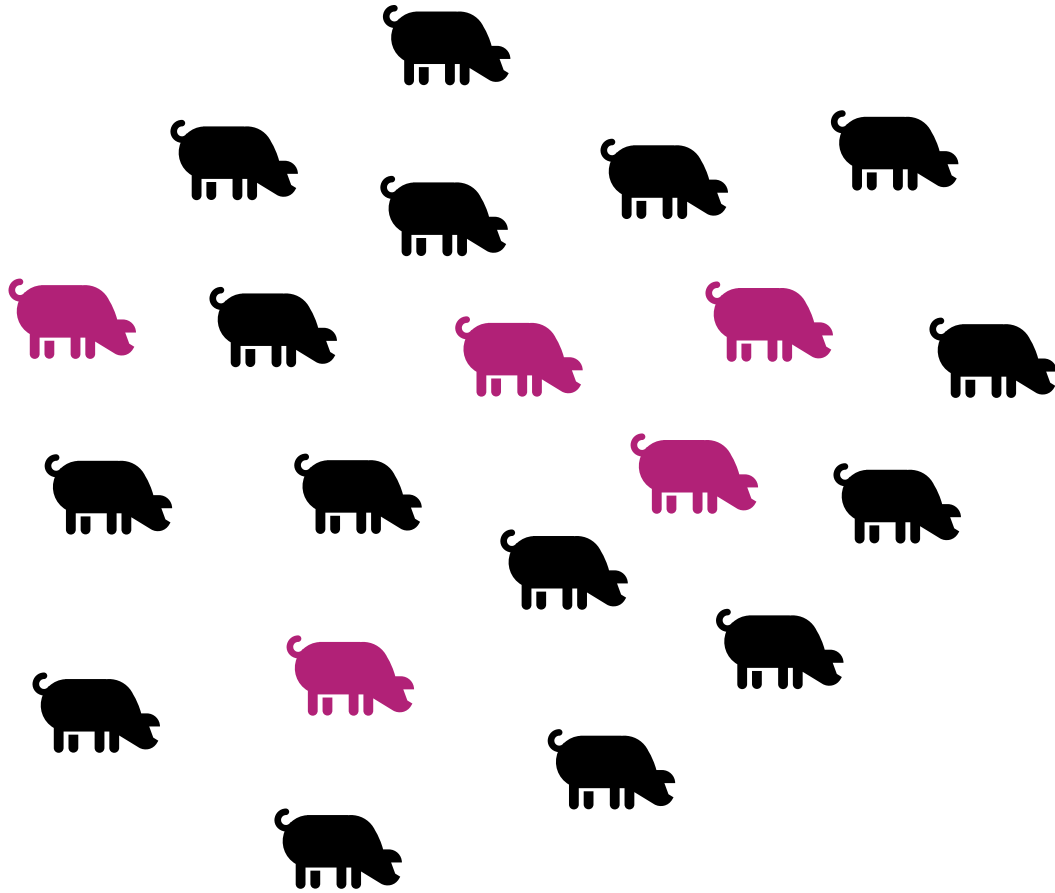
Why knowing diagnostic Se and Sp?

A quantification of the accuracy of a test allows to:

- ↳ calculate **predictive values** for a specific population (prevalence)
- ↳ calculate the accuracy of a **testing strategy** (serial/parallel testing)
- ↳ calculate the **true prevalence** of a sample/population
- ↳ estimate the **probability of freedom** from disease in a population



Estimating Se & Sp



20 animals



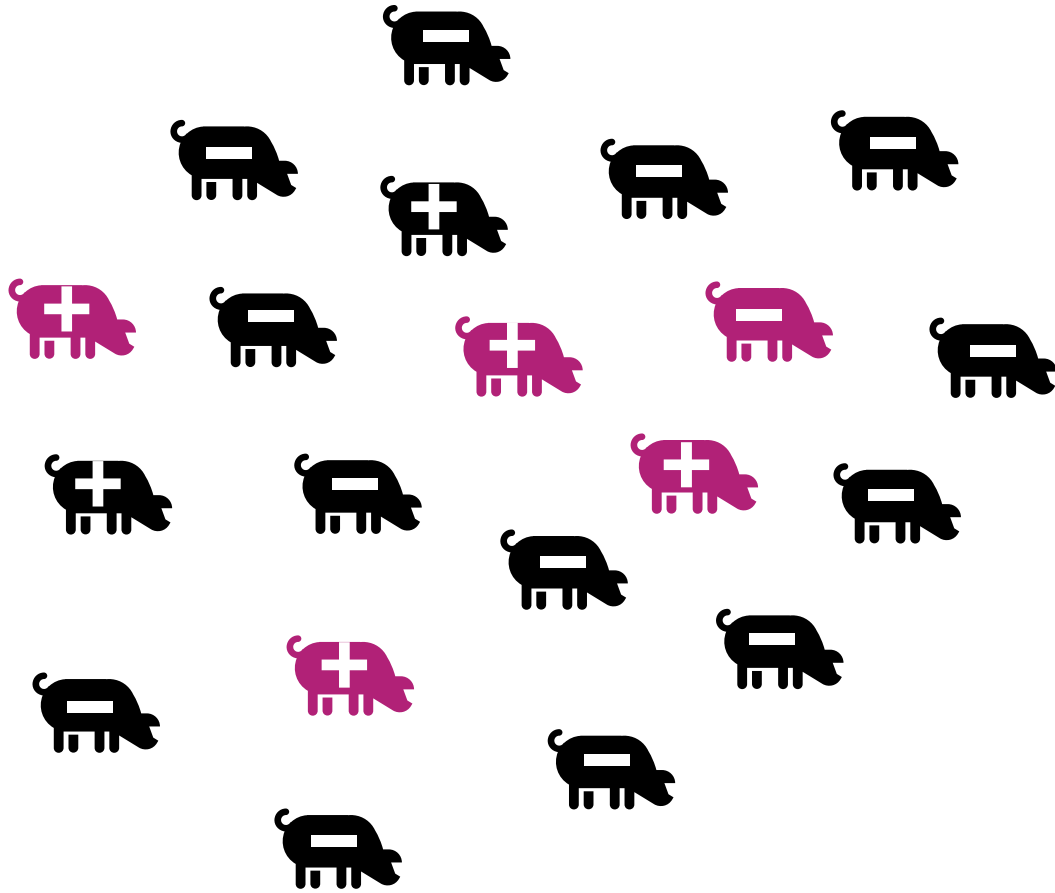
Disease

+

-

5	15
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Estimating Se & Sp



20 animals



Disease

+ -

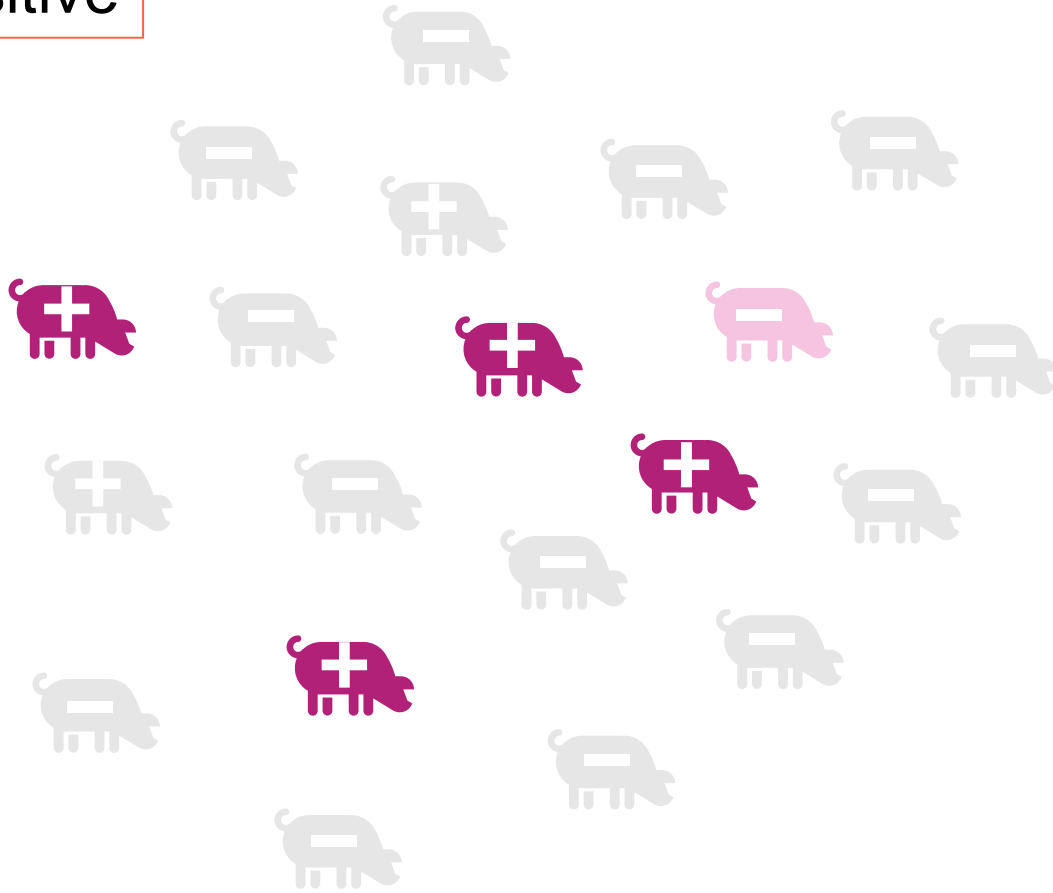
Test
+
-

5

15

Estimating Se & Sp

True Positive



20 animals



Disease

+ -

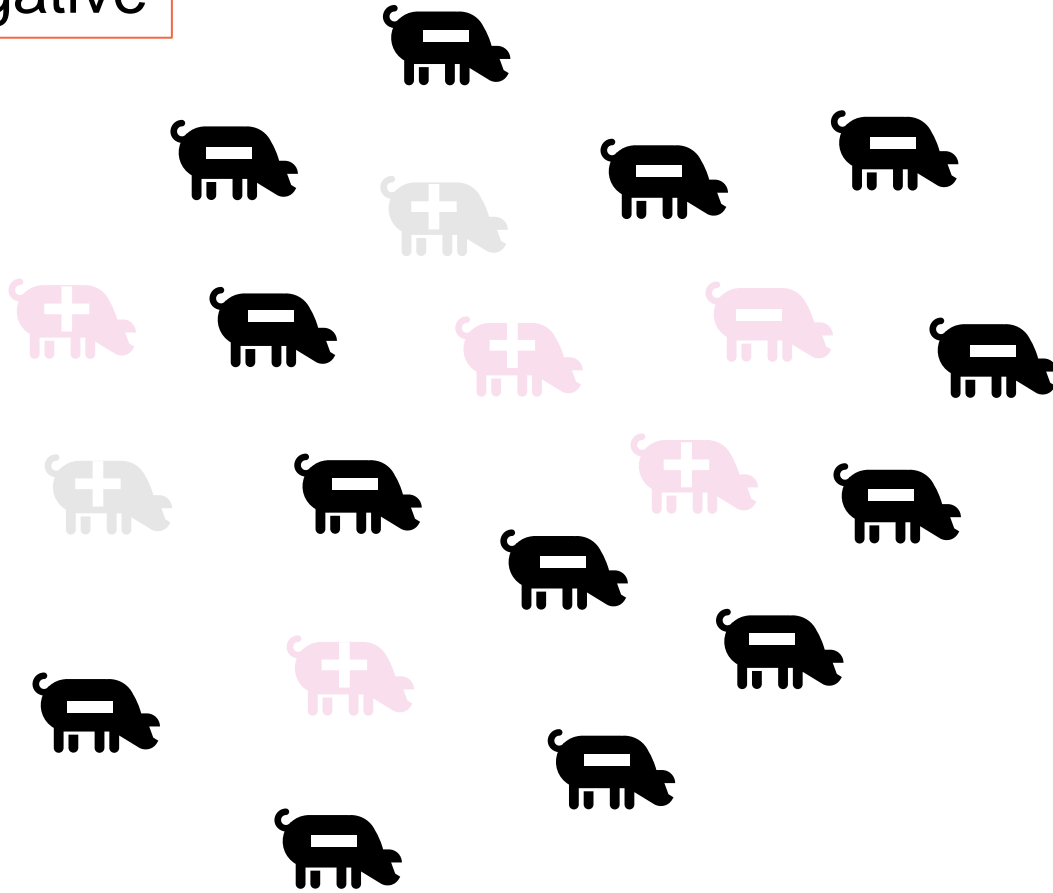
Test

+
-

	+	-
+	4 _{TP}	
-		
	5	15

Estimating Se & Sp

True Negative



20 animals



Disease

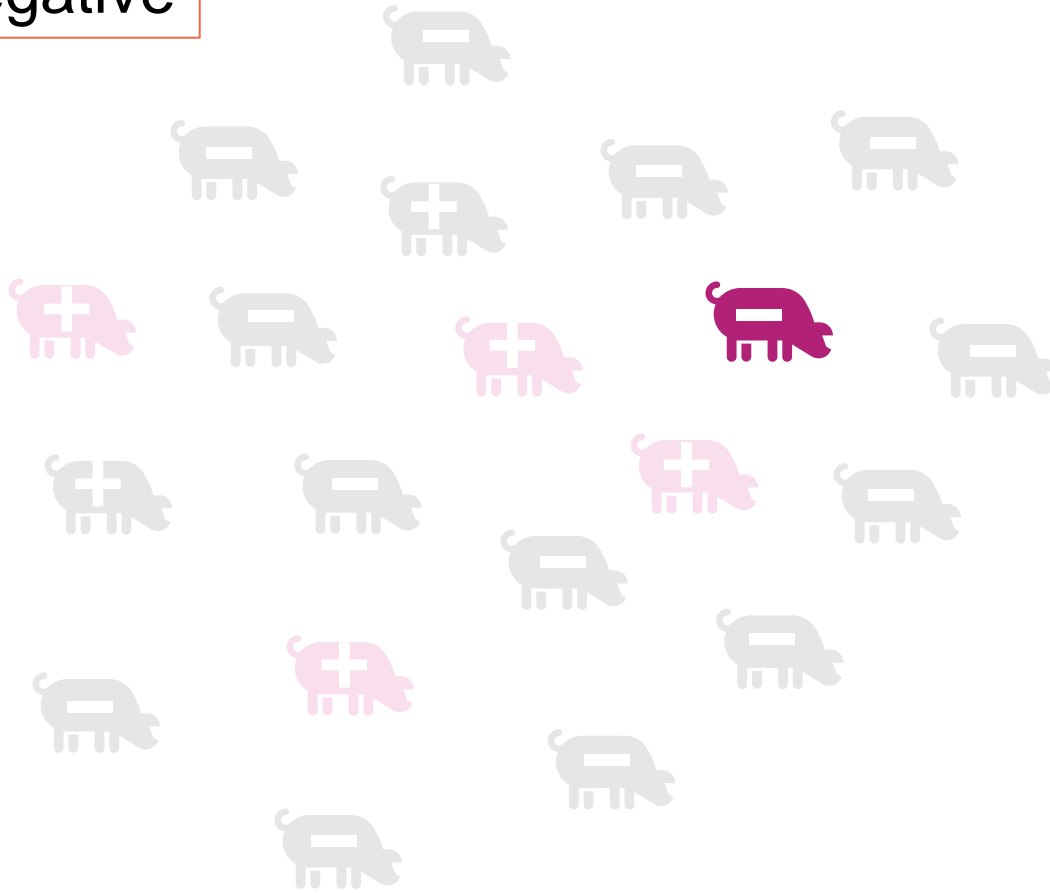
+ -

Test
+
-

	4 _{TP}	
		13 _{TN}
	5	15

Estimating Se & Sp

False Negative



20 animals



Disease

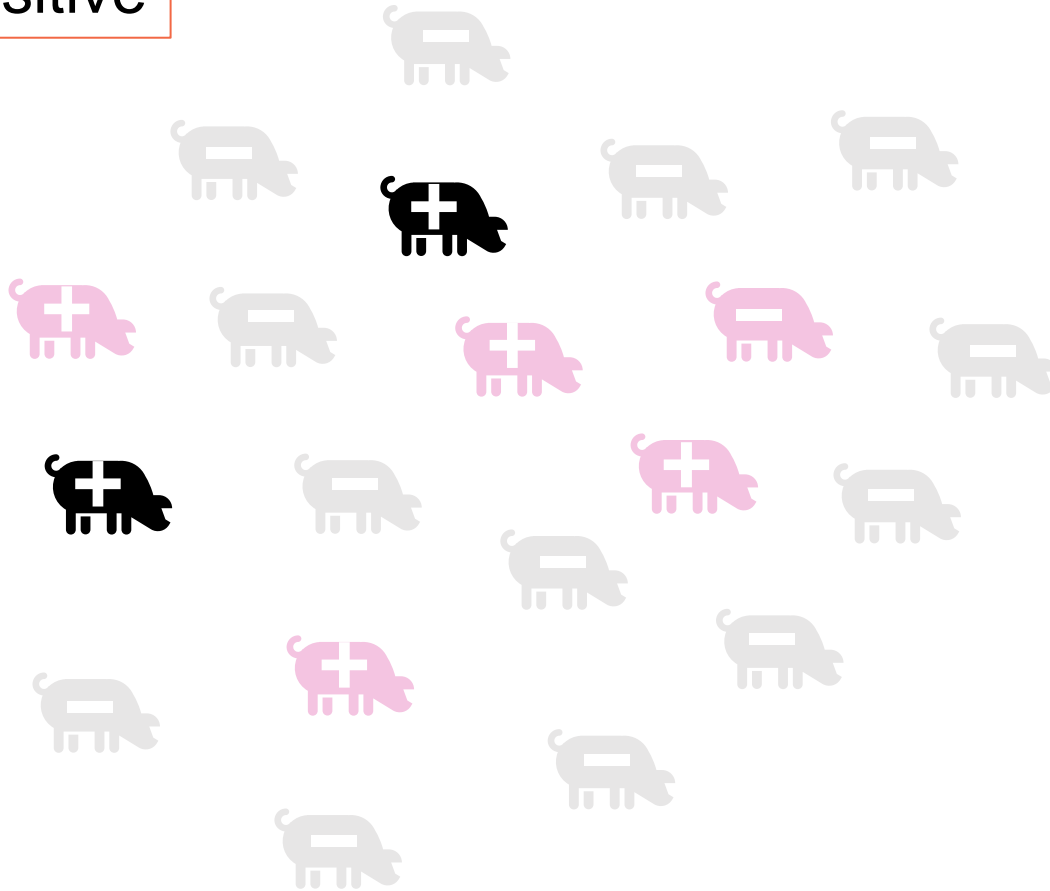
+ -

Test
+
-

4 _{TP}	
1 _{FN}	13 _{TN}
5	15

Estimating Se & Sp

False Positive



20 animals



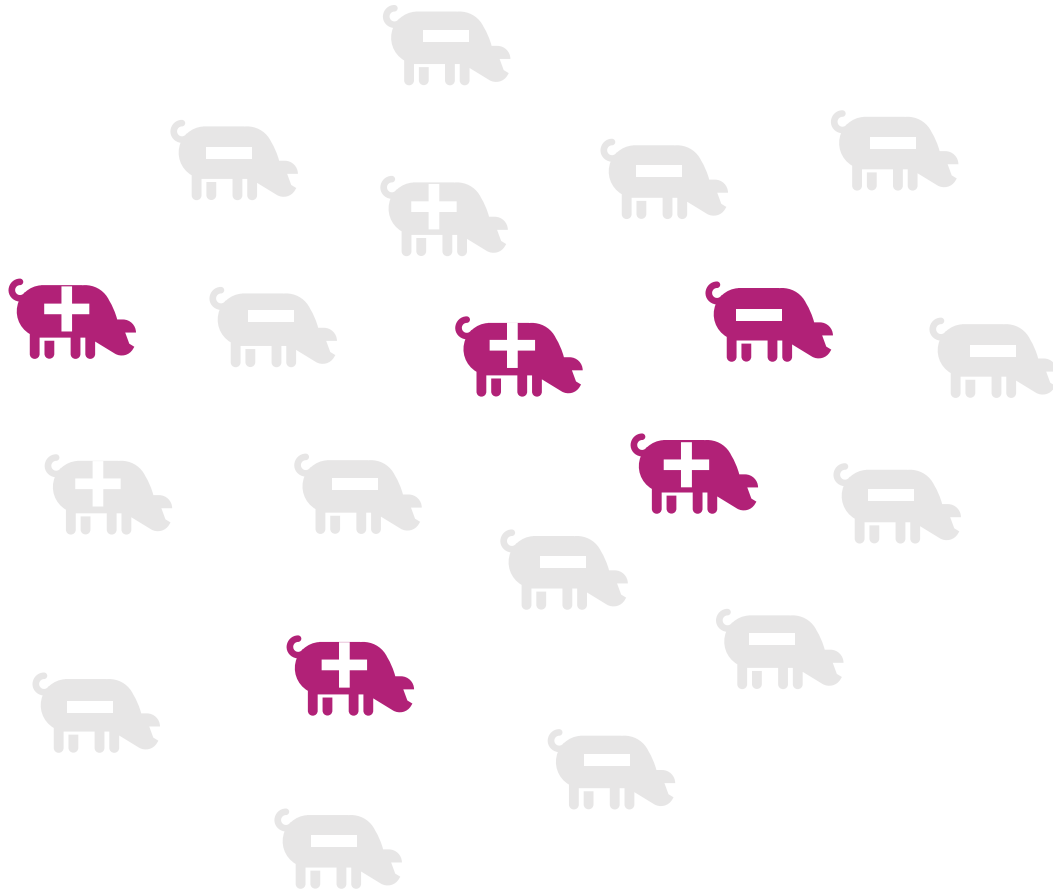
Disease

+ -

Test
+
-

4 _{TP}	2 _{FP}
1 _{FN}	13 _{TN}
5	15

Estimating Se & Sp



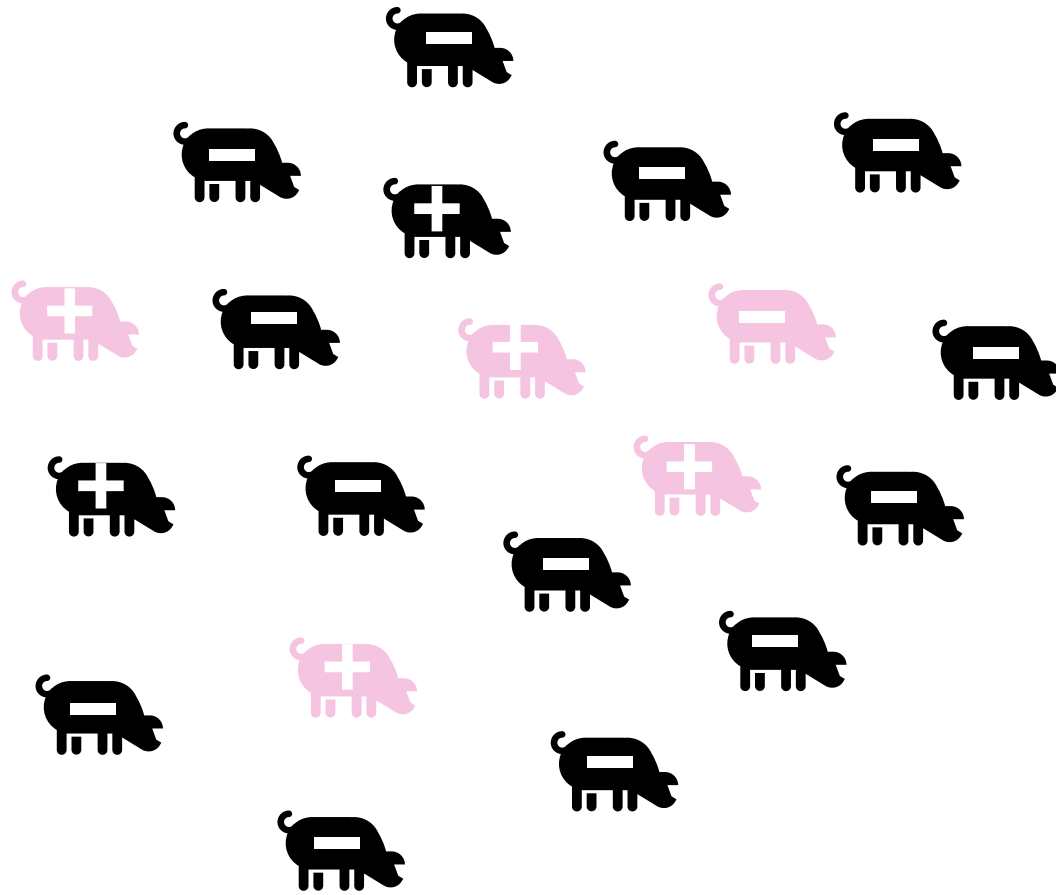
$$Se = TP / (TP + FN) = 4 / 5 = 0.80$$

Sensitivity

$$p(T+|D+)$$

		Disease	
		+	-
Test	+	4 _{TP}	2 _{FP}
	-	1 _{FN}	13 _{TN}
		5	15

Estimating Se & Sp



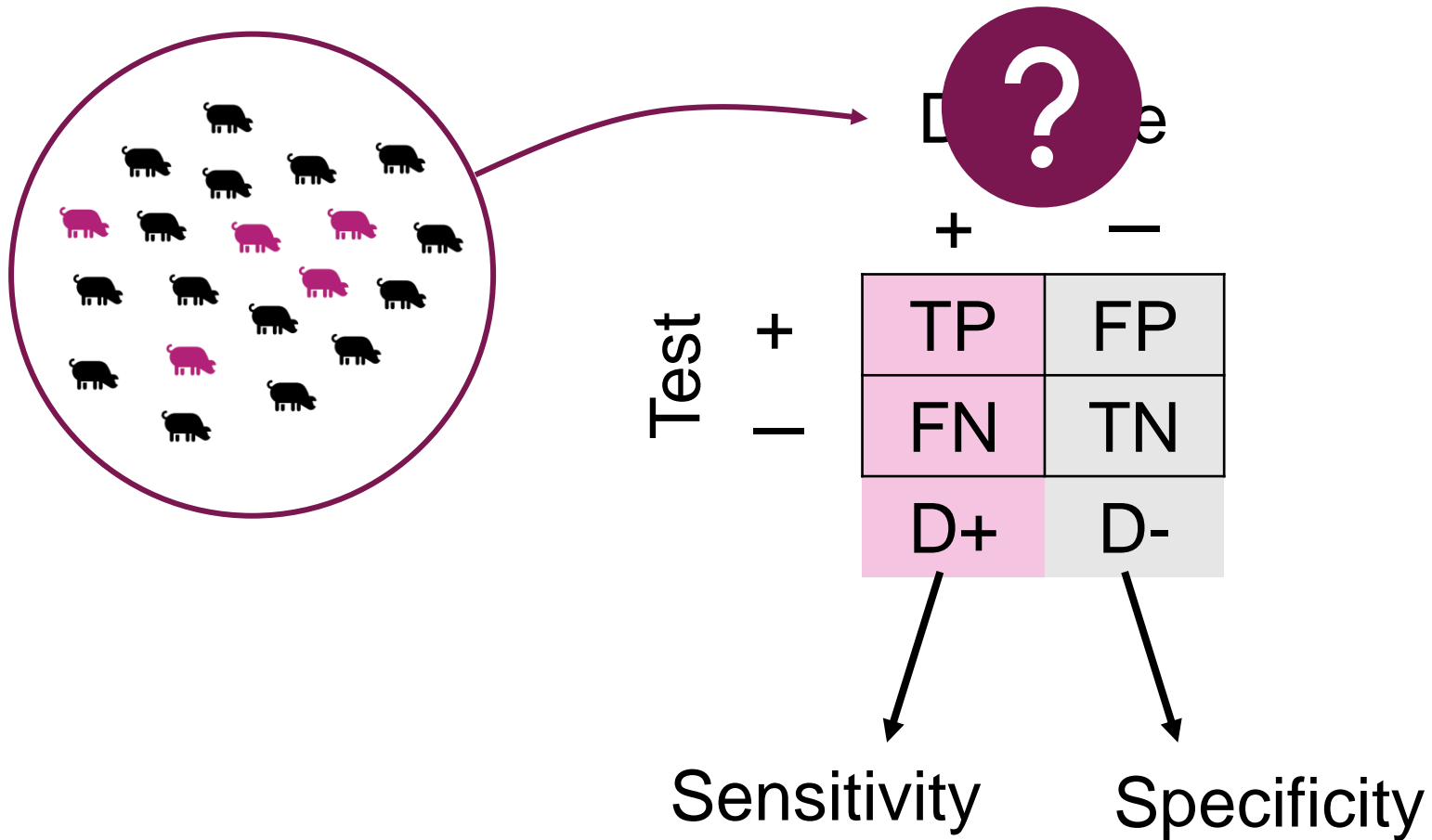
$$Sp = TN / (TN + FP) = 13 / 15 = 0.87$$

Specificity

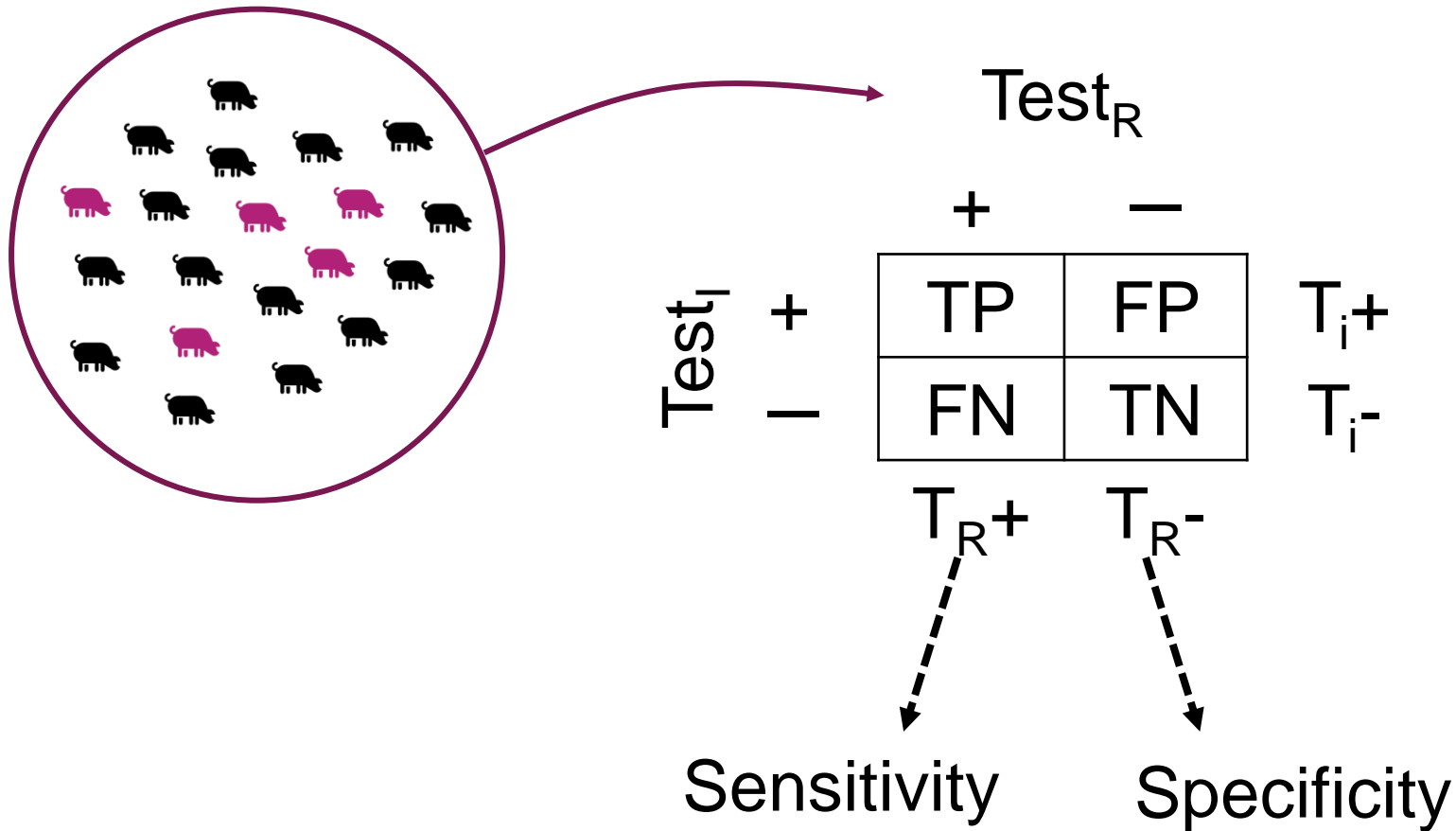
$$p(T-|D-)$$

		Disease	
		+	-
Test	+	4 _{TP}	2 _{FP}
	-	1 _{FN}	13 _{TN}
		5	15

Estimating Se & Sp

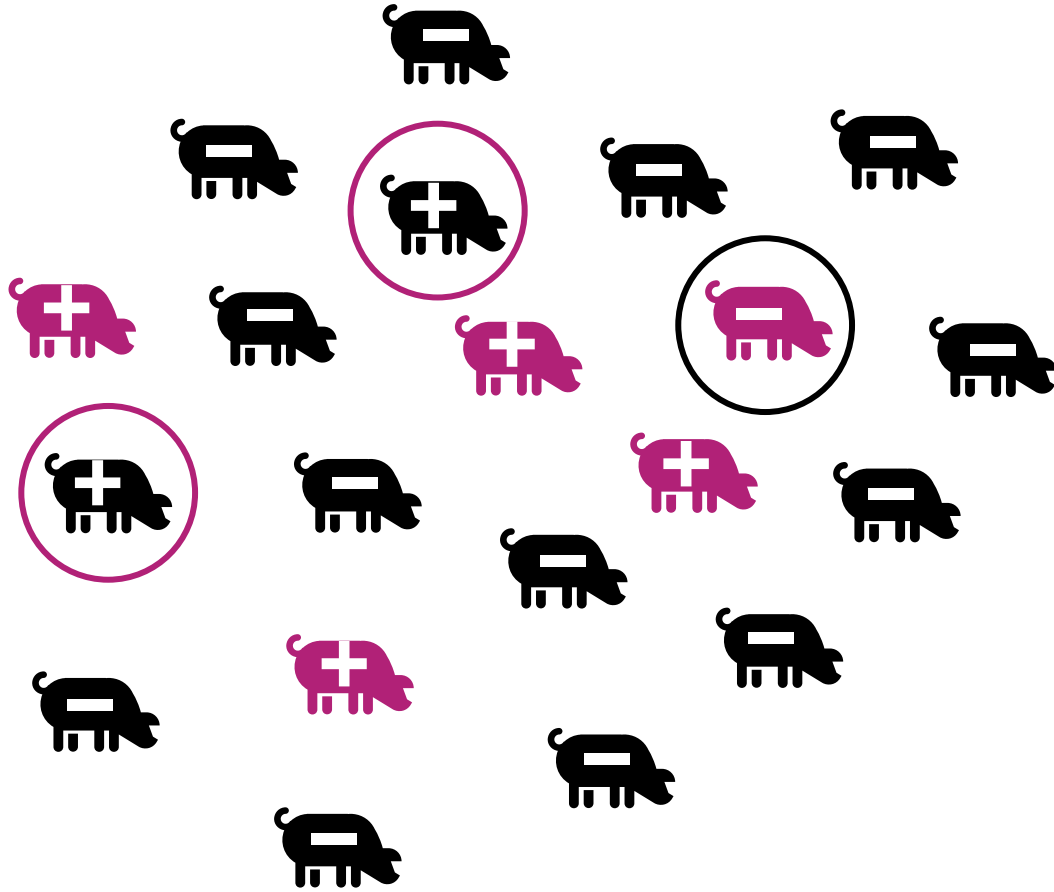


Estimating Se & Sp



Gold standard

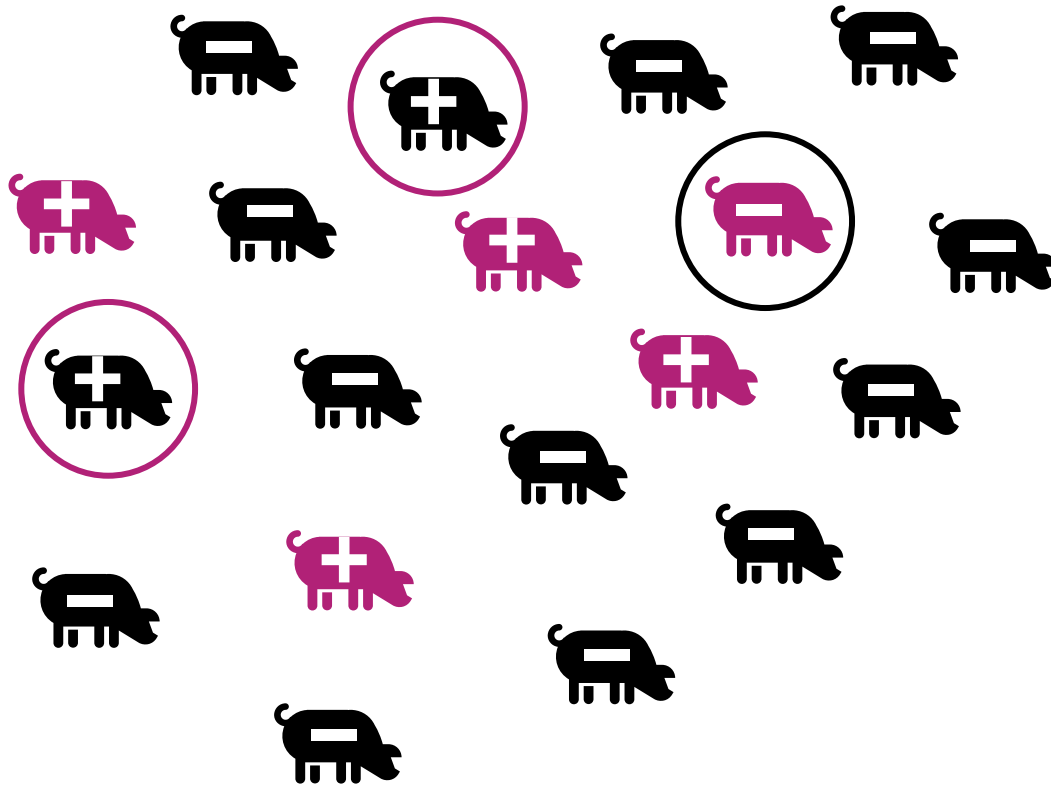
What if the reference test is not a GS?



Test _R	
+	-
6	14

What if the reference test is not a GS?

Biased estimates of the index test



		Test _R		
		+	-	
Test _I	+	4	1	5
	-	2	13	15
		6	14	

$$Se = 4 / 6 = 0.67$$

$$Sp = 13 / 14 = 0.93$$

What if the reference test is not a GS?

Alternatives:

- ↳ Ignore the bias (not recommended!)
- ↳ Correct for the imperfect reference standard (▲ need to know its Se/Sp)
- ↳ Use a composite reference standard (use multiple tests to infer the true disease status)
- ↳ Latent class models
 - Provide estimate of Se/Sp of the reference test as well
 - Allows for the index test to potentially perform better than the reference test