The mathematics of overdiagnosis

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Slides: biostatistics.dk/talks/
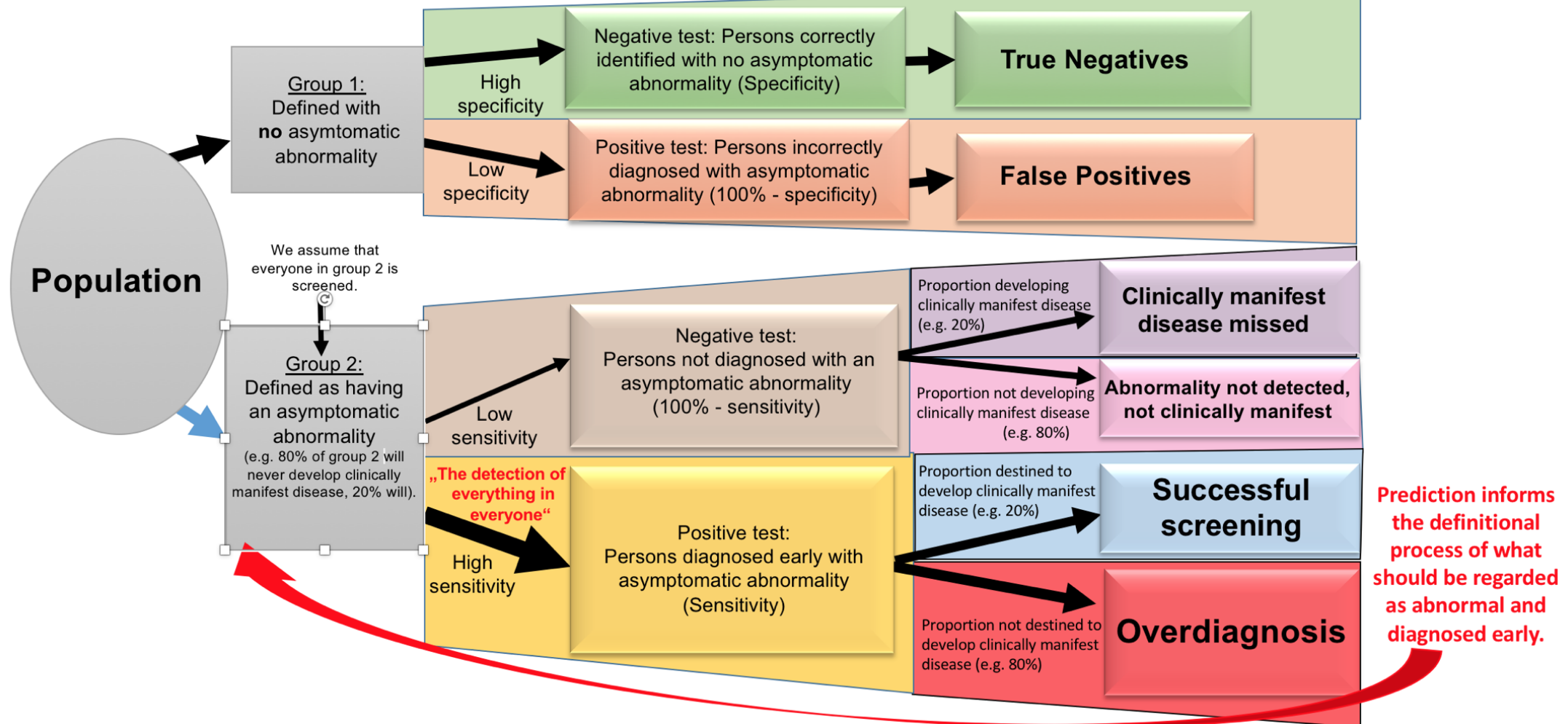
The impact of screening on patients

"If screening positive do I have the disease?"

"If screening positive do I have a disease that can be treated?"

"If screening positive do I have a disease that will give me problems?"

Step A: Definitional process	Step B: Screening	Step C: Observation	Step D
Medicine defines the proportion of the population who is regarded as having an asymptomatic abnormality to be screened for.	Screening test determines how many are diagnosed early with the asymptomatic abnormality.	Time, observation, and further testing show which of the asymptomatic abnormalities are actually destined to become clinically manifest disease (symptoms or death).	Prediction of precisely which abnormalities will become clinically manifest disease

Population

Group 1: Defined with **no** asymtomatic abnormality

High specificity → Negative test: Persons correctly identified with no asymptomatic abnormality (Specificity) → **True Negatives**

Low specificity → Positive test: Persons incorrectly diagnosed with asymptomatic abnormality (100% - specificity) → **False Positives**

We assume that everyone in group 2 is screened.

Group 2: Defined as having an asymptomatic abnormality (e.g. 80% of group 2 will never develop clinically manifest disease, 20% will).

Low sensitivity → Negative test: Persons not diagnosed with an asymptomatic abnormality (100% - sensitivity)

Proportion developing clinically manifest disease (e.g. 20%) → **Clinically manifest disease missed**

Proportion not developing clinically manifest disease (e.g. 80%) → **Abnormality not detected, not clinically manifest**

„The detection of everything in everyone"

High sensitivity → Positive test: Persons diagnosed early with asymptomatic abnormality (Sensitivity)

Proportion destined to develop clinically manifest disease (e.g. 20%) → **Successful screening**

Proportion not destined to develop clinically manifest disease (e.g. 80%) → **Overdiagnosis**

Prediction informs the definitional process of what should be regarded as abnormal and diagnosed early.

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Shiny

```
shiny::runGitHub("ekstroem/overdiagnosis")
```

More precise diagnoses

"If screening positive do I have the disease?"

Positive predictive value:

$$
\begin{aligned}
PPV &= P(\text{disease}|\text{screen positive}) \\
&= \frac{P(\text{screen positive}|\text{disease}) \cdot P(\text{disease})}{P(\text{screen positive})} \\
&= \frac{\text{sensitivity} \cdot P(\text{disease})}{\text{sens.} \cdot P(\text{disease}) + (1 - \text{spec.}) \cdot P(\text{no disease})}
\end{aligned}
$$

Honest PPV

"If screening positive do I have a disease that will give me problems?"

$$hPPV = P(\text{problematic disease}|\text{screen pos.})$$

$$= \underbrace{P(\text{prob. dis.}|\text{scr pos., disease})}_{(1-OD)} \cdot \underbrace{P(\text{dis.}|\text{scr pos.})}_{PPV}$$

$$+ \underbrace{P(\text{prob. dis.}|\text{scr pos., no dis.})}_{0} \cdot \underbrace{P(\text{no dis.}|\text{scr pos.})}_{}$$

$$= (1 - OD) \cdot PPV$$