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Principles and Predictive Value of Screening

Objectives

- Discuss principles of screening
- Describe elements of screening tests
- Calculate sensitivity, specificity and positive predictive value
- Discuss how a clinician can make test results more meaningful to the patient
- Explore factors that influence clinical interpretation and explain how to individualize them for each patient

Screening

- Objective is to reduce mortality and morbidity with early detection and treatment.
- Screening is the application of a test to people.
- Assists with early identification of a disease in its early stages and intervening with a treatment which is more effective because it is being applied earlier.
- Hence reduces the consequence of the disease
- But cannot reduce the incidence.
- Secondary prevention.

Principles of Good Screening Programs

- Screen for health problems that
  - Are important to the individual and community
  - Have an acceptable form of treatment
  - Has a natural history that is adequately understood
  - Has a recognizable latent or early symptomatic stage
  - Has a suitable screening test
  - Is economically beneficial

The Screening Test

- Ideally should be inexpensive, easy to administer (low risk) and with minimal discomfort
- There should be a Gold Standard based on the evidence
- Results should be accurate/valid and reliable/reproducible/precise

Gold Standard

- In most cases, screening tests need to be benchmarked against an agreed "Gold Standard" test.
- The gold standard test is a diagnostic test that is usually regarded as definitive (e.g. by biopsy or autopsy).
- Gold standard test may be invasive (e.g. biopsy), unpleasant, too late (e.g. autopsy) to be relevant, expensive or impractical to be used widely as a screening test.

Disease	Screening	Gold Standard
Congenital Heart disease	Exercise ECG	Angiography Echocardiography
Breast cancer	Mammography	Biopsy
TB	Mantoux	Chest Xray Sputum test

Accurate/Valid

- Defined as:

  The degree to which a variable represents what it is supposed to represent.

- Best way to assess
  - Compare with a reference
- Threatened by systematic error (bias)
  - Due to observer, subject and/or instrument

Reliable/Precise

- Defined as
  - The degree to which a variable has nearly the same value when measured several times
- Best way to assess
  - Repeated measures
- Threatened by random error
  - Due to observer, subject and/or instrument

Why screen for conditions?

- To improve outcomes for individuals
  - Keep Well health checks
  - Breast mammography
- To improve outcomes for populations
  - Port health checks
  - Employment checks

When should you screen?

Based on the Wilson – Junger criteria:

- Is there an effective intervention?
- Does earlier intervention improve outcomes?
- Is there a screening test which recognises disease earlier than usual?
- Is the test available and acceptable to the target population?
- Is the disease a priority?
- Do the benefits outweigh the costs?

Different approaches of Screening

- Population-level or Mass screening
  - National level policy decision to offer mass screening to a whole sub-group of a population
    - e.g., mammography screening (women 40+)
    - e.g., Vision and hearing screening of all school children

- Individual-level or case finding screening
  - Occurs at the individual patient-physician level
  - Also refereed to case finding
    - e.g., BP screening every time during a physician visit
    - e.g., Prostrate specific antigen (PSA) screening
  - Focus is on identifying existing disease in patients who do not know they have it.

Screening – why is it different?

- Individuals may not benefit
- Involves people who are well subjecting themselves to testing – medicalisation
- Creation of a pre-disease state
- False positive tests
- False negative tests
- Initiated by health professionals not individuals
- Cost-benefit depends on prevalence within a population
- Inequalities implications

- Screening differs from treatment

Screening	Testing
Healthy non patients	Sick patients
NO diagnostic intent	Diagnostic intent
Very low to low disease intent	Low to high disease intent

Measures used in screening

- Sensitivity is the likelihood that those with disease will be picked up by the screening test
- Specificity is the likelihood that those with a negative screening test will not have the disease
- Positive predictive value is the likelihood that those with a positive test will have the disease
- Negative predictive value is the likelihood that those with a negative test will not have the disease

Predictive Value

- Is determined by Sensitivity, Specificity and the Prevalence of the disease

- Prevalence is defined as the number of patients per 100,000 population who have the disease at a given time

Sensitivity	**The fraction of those with the disease correctly identified as positive by the test.**
Specificity	**The fraction of those without the disease correctly identified as negative by the test.**

Positive predictive value (+ PV)	**The fraction of people with positive tests who actually have the condition.**
Negative predictive value (-PV)	**The fraction of people with negative tests who actually don't have the condition.**

The sensitivity and specificity are properties of the test.

The positive and negative predictive values are properties of both the test and the population you test.

If you use a test in two populations with different disease prevalence, the predictive values will be different.

A screening test is most useful if directed to a high-risk population (high prevalence and high predictive value).

Now to the Math

	Patient with the disease	Patient without the disease
Test is positive	A True Positive	B False Positive
Test is negative	C False Negative	D True Negative

Using the 2X2 table you can calculate

Sensitivity = a / (a+c)

Specificity = d / (b+d)

+ PV = a/(a+b)

- PV = d/(c+d)

Knowing the prevalence of the disease in the population is necessary for these calculations

Measures for screening

- Sensitivity and Specificity
- Positive predictive value and Negative predictive value

		Disease		**Total**
		Yes	No	
Screening test	Positive	300	30	**130**
	Negative	20	3000	**3020**
Total		**320**	**3030**	**3350**

Measures for screening

- Sensitivity and Specificity
- Positive predictive value and Negative predictive value

		Disease		**Total**
		Yes	No	
Screening test	Positive	300	30	**330**
	Negative	20	3000	**3020**
Total		**320**	**3030**	**3350**

Sensitivity = 300/320 = 94%

Specificity = 3000/3030 = 99%

PPV = 300/330 = 91%

NPV = 3000/3020 = 99%

Understanding Predictive Value

- Prevalence is defined as the number of patients per 100,000 population who have the disease at a given time.
- A high +PV indicates a strong chance that a person with a positive test has the disease whereas a low +PV is usually found in populations with low prevalence of the condition being examined. A high -PV means that a negative test in effect rules out the disease.

Effects of Prevalence
Sensitivity=95% Specificity=95%

Population's Prevalence	Predictive Value of a Positive Test
0.1%	1.9%
1.0%	16.1%
2.0%	27.9%
5.0%	50%
50%	95%

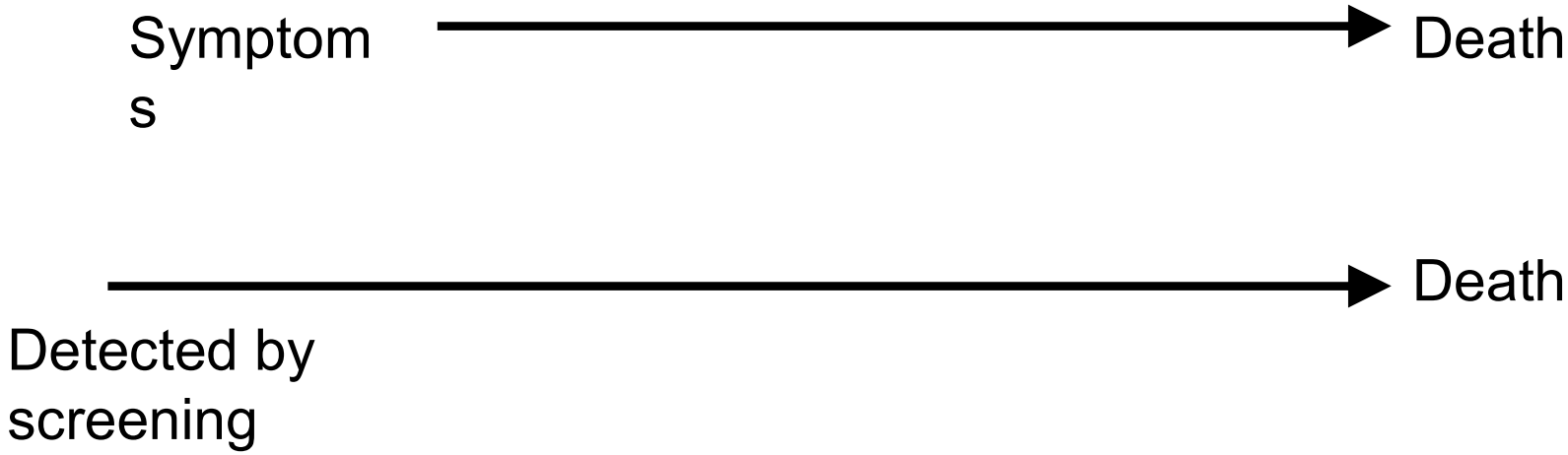
Effects of Prevalence
Sensitivity=99% Specificity=99%

Population's Prevalence	Predictive Value of a Positive Test
0.1%	9.0%
1.0%	50%
2.0%	66.9%
5.0%	83.9%
50%	99%

Particular biases

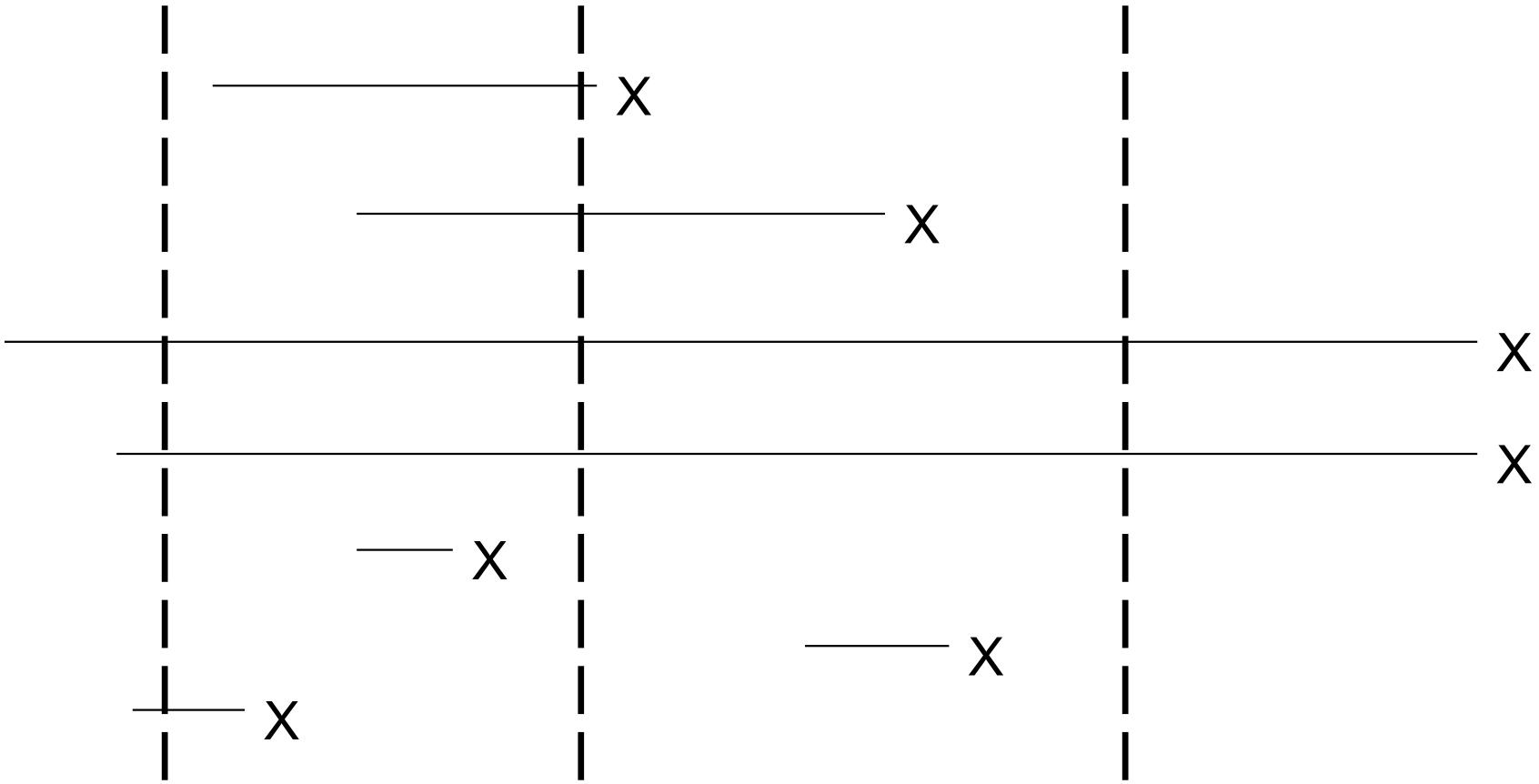
- Lead time bias

  Given that screening picks up disease at an earlier stage – the time between diagnosis and death increases without any actual increase in survival



- Length time bias

  Screening is more likely to detect less aggressive disease and therefore can give impression of improved survival



DISCUSSION