Screening

❖ Learning Objectives:

At the end of lecture the students will be able to :

- ✓ Define screening and mention its purpose.

- ✓ List WHO criteria for effective screening

- ✓ Calculate and interpret measures of the validity of a screening test:

    - o   ---   Sensitivity
    - o   ---   Specificity

- ✓ Calculate and interpret measures of the performance (yield) of a screening test:

    - o   ---   Predictive value positive (PV+)
    - o   --- Predictive value negative (PV-)

❖ Definition of screening:

- o Disease screening is the application of a test or procedure to asymptomatic, apparently well individuals, to separate those with a high probability of having or developing a given disease from those with a low probability of having or developing the disease.
- o Screening tests do **not usually establish a diagnosis**, but rather the presence or absence of an identified risk factor, and thus require individual follow-up and treatment.

❖ Screening objective:

- ▪ To lower morbidity and mortality of the disease in a population
- ▪ Screening provides access to the medical care system which is not an actual goal of screening, but is a benefit.
- ▪ To identify high exposure to risk factors. For instance, children's blood samples can be screened for lead in areas of high use

Purpose: To classify individuals with respect to their likelihood of having a particular disease.

❖ Tests screening vs. diagnosis:

➢ The purpose of screening is to segregate those who may have the condition. It is an initial step, as it needs further confirmation.

➢ On the other hand, diagnosis is a procedure to confirm or disprove the existence of a disease or abnormality.

➢ Both screening and diagnosis can be achieved by obtaining medical history, performing physical examination and the application of laboratory or non-laboratory test.

Comparison between screening and diagnostic tests:

Screening tests	Diagnostic tests
Done to those who are apparently healthy or asymptomatic	Done to those with suggestive signs or symptoms
Applied to a group of individuals	Applied to a single person
Results are based on one criterion	Results are based on the evaluation of a number of symptoms, signs and investigations
Results are not conclusive	Results are conclusive and final
Less accurate	More accurate
Less expensive	More expensive
Not a basis for treatment	Basis for treatment

❖ Types of screening programs:

➢ Mass screening

Application of the screening program to the whole population or population subgroups as adults, school children, industrial workers.

➢ High risk or selective screening

The screening program will be applied to a selective group of population who are at a high risk e.g. cancer cervix in low social class.

➢ case-finding or opportunistic screening
 is aimed at patients who consult a health practitioner for some other purpose.
➢ multiple or multiphasic screening
uses several screening tests at the same time

Examples:

Screening finds people that are likely to have a disease or it looks for factors that are precursors to disease. Mammography, a special X-ray of the breasts, can detect breast cancers early in their development, when they can be easier to treat.

Pap smears detect changes in the cervix that can be precursors to cancer.

Screening tests can also be used to identify people that are at greater risk of having a disease, for example, cholesterol tests can identify people who are more likely to develop heart disease.

In recent years, advances in molecular genetics have resulted in the ability to identify people who are susceptible to developing certain diseases; this will lead to the development of many new kinds of screening tests.

## ❖ WHO criteria for effective screening:

1. The disease should be important public health problem.
2. There should be an effective and acceptable treatment for the condition if identified in an early stage.
3. Facilities for the confirmation of the diagnosis and treatment should be available.
4. There should be a latent stage of the disease (long and detectable pre-symptomatic stage).
5. There should be a suitable screening test or examination that can detect the condition.
6. The test should be acceptable to the population.
7. Natural history of disease should be adequately understood.
8. There should be an agreed upon policy on whom to treat.
9. The total cost of finding a case should be economically balanced in relation to medical expenditure as a whole.
10. Case finding should be a continuous process, not just a "once and for all" project.

❖ Uses of screening programs

- **Case detection:** Identification of unrecognized disease or pathological conditions, which doesn't arise from patients' request.

- **Control of diseases:** to prevent the transmission of the disease to healthy community members.

- **Research purposes:** Screening may be conducted to estimate the prevalence of a disease and subsequent screening will provide data on the incidence.

Diseases for which screening has been recommended

- Cervical cancer
- Breast cancer
- Ovarian cancer
- Colorectal cancer
- Skin cancer
- Diabetes
- Hypertension
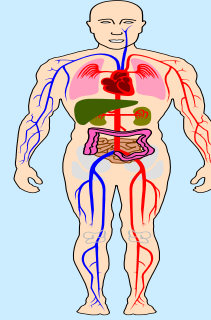
❖ **Characteristics of ideal screening test**

A) Reliability:

Does the test give the same result when repeated applications are made on the same individual?

B) Acceptability and applicability.

C) Risks vs. benefits.

D) Costs. The costs of a screening programmed must be balanced against the number of cases detected and the consequences of not screening.

1. Costs of applying the test itself.

2. Costs of performing additional tests on people with false positives, in order to correct mistakes.

E) Validity (accuracy) evaluated by sensitivity and specificity

Characteristics of a screening test:

- Validity (Sensitivity, Specificity)
- Reliability (repeatability/precision)
- Yield (performance): Predictive values of the test.

Validity of Screening Tests
How good is the screening test compared with the confirmatory diagnostic test (Gold Standard test)?

- The test will correctly classify a diseased person as likely to have the condition ("sensitivity").
- The test will correctly classify a non-diseased person as unlikely to have the condition ("specificity").

- **Sensitivity** is the proportion of people with the disease in the screened population who are identified as ill by the screening test. (When the disease I is present, how often does the test detect it?)
- **Specificity** is the proportion of disease-free people who are so identified by the screening test. (When the disease is absent, how often does the test provide a negative result?)

$$Sensitivity = \frac{True\ positives\ (TP)}{True positives\ (TP) + False\ negatives\ (FN)} \times 100$$
$$= \frac{a}{a + c} \times 100$$

$$Specificity = \frac{True\ negatives\ (TN)}{True\ negatives\ (TN) + False\ positive\ (FP)} X100$$

$$= \frac{d}{d + b} X100$$

❖ **Prevalence of disease =**

$$= \frac{a+c}{a+b+c+d} X100$$

Validity of Screening Tests

True Disease Status

Results of Screening Test	+	-
+	a	b
-	c	d

a = true positive
b = false positive
c = false negative
d = true negative

Format for comparison of results of a diagnostic test against "true" disease status

Screening test results	Gold standard "Truth"		Total
	Disease	No Disease	
Positive	a True-positive	b False-positive	a +b
Negative	c False-negative	d True-negative	c+d
Total	a+c	b+d	a+b+c+d

Validity of Screening Tests

True Disease Status

Results of Screening Test

Sensitivity: The probability of testing positive if the disease is truly present

Sensitivity = $a / (a + c)$

❖ **Positive and negative predictive values**

Two measures that directly address the probability of disease are the positive predictive value (PV+) and the negative predictive value (PV -).

❖ **Positive predictive value (PV+)**

- is defined as the % of persons with positive test results who actually have the disease of interest.
- The PV+ therefore, allows one to estimate how likely the disease is present if the test is positive. PV+ is calculated as follows:

$$Positive\ predictive\ value = \frac{True\ positive\ (TP)}{True\ Positives\ (TP) + False\ positives\ (FP)} \times 100$$

Negative predictive value (PV-)

- is defined as the % of persons with negative test results who actually don't have the disease of interest.
- The PV- therefore, allows one to estimate how likely the disease is absent if the test is negative. PV- is calculated as follows:

$$Negative\ predictive\ value = \frac{True\ negatives\ (TN)}{True\ negatives\ (TN) + False\ negatives\ (FN)}\ X\ 100$$

Results of screening 100 men for prostate cancer using (PSA)

Screening test (PSA)	Gold standard (Prostatic biopsy)		Total
	Cancer	No cancer	
Positive	3 (TP)	7 (FP)	10
Negative	2 (FN)	88 (TN)	90
Total	5	95	100

Validity of Screening Tests

True Disease Status

Results of Screening Test

	+	-
+	a	b
-	c	d

Specificity: The probability of screening negative if the disease is truly absent

Specificity = d / (b + d)

❖ **Adverse effects of screening:**

➢ Stress and anxiety caused by a false positive screening results.

- Unnecessary investigation and treatment of false positive results

- Prolonging knowledge of an illness if nothing can be done about it.

- A false sense of security caused by false negatives, which may even delay final diagnosis.

- Overuse/waste of medical resources.

Disease

Test		D	no D	
+		90	5	95
−		10	95	105
		100	100	200

Sensitivity: $a / (a + c)$
        Sensitivity = 90%
Specificity: $d / (b + d)$
        Specificity = 95%
Prevalence of disease = $(a+c)/(a+b+c+d)$
        =100/200=50%

- Number of false positives=b

- False Positive Rate=b/b+d

- Number of false negatives=c

- False Positive Rate=c/a+c

Sensitivity: **a / (a + c) = 90%**

Specificity: **d / (b + d) 95%**

False Positive Rate=b/b+d=5/100=5%

False negative Rate=c/a+c=10/100=10%

Prevalence of disease = (a+c)/ (a+b+c+d) 100/200= 50%

Reliability of Screening Tests

RELIABILITY (*Reproducibility*) *Precision*:

The extent to which the screening test will produce the same or very similar results each time it is administered (repeated).

•It can be assessed by repeating the test using the same or different observers.

--- A test must be reliable before it can be valid.

Validity vs. Reliability:

f you measure blood pressure in an obese patient and use a cuff that is too small you are likely to get a falsely high reading.

The reading maybe reliable (you get the same blood pressure if you do it again) but it lacks validity.

Reliability of Screening Tests

Sources of variability that can affect the reproducibility of results of a screening test:

1. Biological variation (e.g. blood pressure)
2. Reliability of the instrument itself
3. Intra-observer variability (differences in repeated measurement by the same screener)
4. Inter-observer variability (inconsistency in the way different screeners apply or interpret test results)

Exercise:

Validity of Screening Tests

Breast Cancer

Physical Exam and Mammography	+	-
+	132	983
-	45	63650

Sensitivity: a / (a + c)

    Sensitivity =

Specificity: d / (b + d)

    Specificity =

Answer:

Calculate sensitivity & specificity of mamography, prevalence of breast cancer.

Screening test (Mammo graphy)	Gold standard (Surgical biopsy)		Total
	Cancer	No cancer	
Positive	14	8	22
Negative	1	91	92
Total	15	99	114

Answer:

$$\text{Sensitivity} = \frac{\text{True positives (TP)}}{\text{True positives (TP)} + \text{False negatives (FN)}} \times 100$$

$$= \frac{a}{a+c} \times 100$$

= 14\ 14+1 X100 = 93.3%

$$\text{Specificit y} = \frac{\text{True negatives (TN)}}{\text{True negatives (TN)} + \text{False positive (FP)}} \times 100$$

$$= \frac{d}{d+b} \times 100$$

= 91\ 8+91 X100 = 91.9%

❖ Prevalence of disease =

$$= \frac{a+c}{a+b+c+d} X100$$

= 15\ 114 X100 = 13.2%