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Textbook of Diploma for Health Inspectors



Editor-in-Chief
Purushottam Giri

Editors
Medha Mathur
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Foreword
Sanjay Zodpey

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CHAPTER

7

Screening for Diseases

Animesh Gupta

Learning Objectives

After completing this chapter, the readers will be able to comprehend:

- Define screening.
- Discuss the purpose of screening.
- Enumerate different types of screening method.
- Enumerate the criteria for screening test.
- Describe the concept of lead time.
- Define sensitivity and specificity.
- Calculate the sensitivity, specificity and predictive accuracy in the given set of problem.

INTRODUCTION

The concept of a screening process that can identify individuals in the early stages of disease or before the symptoms appears has been discussed for some years.

Screening is defined as "the presumptive identification of unrecognized disease or defect by the application of tests or procedures or examinations, which can be applied rapidly on a apparently healthy person". Screening tests sort out the apparently well persons who probably have a disease from those who probably do not have a disease. A screening test is done to detect potential health disorders or diseases in people who do not have any symptoms of disease.

PURPOSE OF SCREENING

- To identify those people who have early stage of disease
- To reduce the risk of disease
- To save lives by early detection and treating the disease in early stage
- To prevent the development or progression of disease
- To improve the quality of life of a patient through early identification.
- To reduce the incidence of a disease or condition by identifying early and treating its precursors.

Screening and Diagnostic Test (Table 7.1)

Although screening tests are not considered as diagnostic test, but are used to identify a subgroup of the population that needs further testing to determine whether the disease is present or not. The major difference between screening and diagnostic test are as follows:

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Table 7.1: Differences between screening and diagnostic test.

	Screening test	***Diagnostic test***
Purpose	To detect potential disease	To establish presence or absence of disease
Target population	Apparently healthy or asymptomatic people	Sick or symptomatic people
Test application	Applied to groups	Applied to single patients
Test method	Simple, rapid and acceptable to people	May be invasive and time taking, but justified for diagnosis
Test result	Test results are arbitrary and final	Diagnosis may not be final
Test basis	Based on one criterion or cut-off point	Based on test finding, symptoms, signs
Accuracy	Less accurate	More accurate
Cost	Relatively inexpensive	Expensive
Test outcome	Used for further evaluation, if test come positive	Used for treatment
Example	PSA test in prostate cancer	MRI in prostate cancer

Source: World Health Organization (WHO). (2020). Screening programmes: A short guide. Increase effectiveness, maximize benefits and minimize harm.

Principles of Screening (Wilson and Junger)

- The condition should be an important health problem.
- There should be an accepted and effective treatment for recognized disease.
- Facilities for diagnosis and treatment should be available.
- There should be a recognizable latent or early symptomatic phase.
- There should be a suitable test or examination.
- The test should be acceptable to the population.
- The natural history of the condition, including development from latent to declared disease, should be adequately understood.
- There should be an agreed policy regarding who should treated as patients.
- The cost of case-finding, which includes diagnosing and treating patients, should be economically balanced with the potential cost of overall medical care.
- Case-finding should be a continuous process and not a "once and for all" project.

Concept of Lead Time (Flowchart 7.1)

It is a time between the detection of disease by screening (early detection) and its usual time of diagnosis by other means based on signs or symptoms.

In the above figure, disease is early detected by screening test, which further enhances the survival period by early initiation of treatment. Lead time is denoted in the above picture, which is the time period by early diagnosis by screening test and usual time of diagnosis after the clinical presentation.

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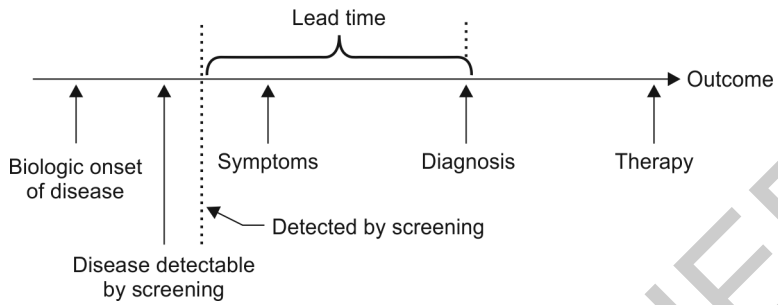
Flowchart 7.1: Flowchart of disease progression with the importance of lead time.



Source: Gordis L. Epidemiology, 5th edition. Philadelphia: Elsevier Saunders; 2014. Chapter 4, The validity and reliability of screening tests.

Uses or Implication of Screening

- **Prescriptive screening or case identification**
  - It is a presumptive identification of disease for their own benefit
  - It is applied to individuals to detect pre-symptomatic or established disease or who have specific risk factors or symptoms.
  - Example: Neonatal screening, cancer screening
- **Prospective screening or disease control**
  - People are screening for other's benefit.
  - Its goal is to detect conditions or diseases early to reduce overall prevalence of a disease in the community.
  - Example: Screening of immigrants from infectious diseases like COVID, Ebola, Tb and Syphilis to protect the home population.
- **Educational purpose**
  - It provides opportunities for creating public awareness.
  - It can also be used for educating health professionals.
  - Examples: Screening for hypertension.
- **Research purpose:** It helps in obtaining knowledge regarding natural history of disease

Types of Screening

- **Mass screening:** When the screening is applied to mass or whole population irrespective of particular risk individuals. For example, screening of all adult females for breast cancer.
- **High risk/selective screening:** It is applied to the selective group or high-risk people. For examples, screening of diabetes among adults aged more than 40 years.
- **Multiphasic screening:** When two or more screening tests are applied together to the large group of people at one time for identification of particular disease. For example, anthropometric measurement or physical examination and blood investigation at same time can be done to assessed the nutritional status of children.
- **Opportunistic screening:** People are recruited for screening when they use healthcare resources like doctors, hospitals. For example, identification of high blood pressure as a routine examination in a case of fever/malaria.

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Criteria for Screening Test

The screening test should satisfy the following criteria:

- **Acceptability:** The test should be acceptable to the targeted people. Generally, it should be comfortable, less expensive and nonembarrassing (like per rectal examination).
- **Repeatability/reliability/consistency:** This is the ability of a test to give same results after repetition. It measures whether the test gives consistent result at its outcome. The repeatability of the test depends on three factors namely:
  1. **Observer variation:** It is the error caused by observer, like same observer observes two different observation on same subject at same time, is known as intra observer variation. Whereas different observer observes different observation on same subject at same time is known as inter-observer variation. For example, different readings of blood pressure on same patient at same time by one observer is intra observer variation, and by different observers is inter-observer variation.
  2. **Biological variation:** This variation is due to physiological changes like blood pressure reading on different time (morning and night), variation in the way of perception of patient's symptoms and their way of presentation to the doctors.
  3. **Errors due to technical methods:** This variation is due to instruments or tools used for test, which can be defective, noncalibrated.
- **Validity (Fig. 7.1):** It is the ability of test to accurately measures what it is supposed to measure. It measures whether the extent to which the test claims to measure is achieved.

In the above figure, 'a' denotes that the target are consistently on the outer side, but not in the target area (center part) so, it was reliable but not valid. In 'b', the target was achieved sometimes, but consistency was not maintained, so it was valid but not reliable. In 'c' neither the consistency was maintained nor the target was achieved, so it was neither reliable nor valid. In 'd', the all the attempt are in the center and consistency also maintained, so it was valid as well reliable also.

The validity of a test is measured by three essential components namely sensitivity, specificity and predictive accuracy.

To understand sensitivity, specificity and predictive accuracy, lets us take an example.

A screening test was done to detect certain diseases and after the screening, the result was shown in the below **Table 7.2**.

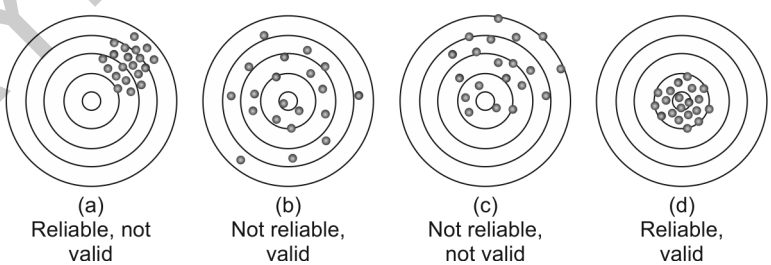

Fig. 7.1: Concept of reliability and validity in four possible situation.

Source: Gordis L. Epidemiology, 5th edition. Philadelphia: Elsevier Saunders; 2014. Chapter 4, The validity and reliability of screening tests.

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Table 7.2: Example of screening test result by diagnosis.

Screening test	***Diagnosis***		***Total***
	Diseased	***Nondiseased***	
Positive	A True positive (TP)	B False positive (FP)	A + B (TP + FP)
Negative	C False negative (FN)	D True negative (TN)	C + D (FN + TN)
Total	A + C (TP + FN)	B + D (FP + TN)	A + B + C + D

In the given table, 'A' denoted the one who have the disease and screening test also came positive, that means positive test is true. Whereas 'B' denotes the one who do not have disease, but test came positive, which means that positive test is false. C denotes the one who have the disease but test came negatives, which means that negative result is false. Lastly, 'D' denotes the one who do not have disease and test also came negative, that means negative test is true.

Now, we will understand the following indicators of screening test:

- **Sensitivity**
  - The ability of a test to identify correctly all those who have the disease, that is 'true positive'
  - A highly sensitive test means that there are less false negative results
  - It is calculated as $TP/(TP + FN) \times 100 = A/(A + C) \times 100$
- **Specificity**
  - The ability of a test to identify correctly those who do not have the disease, that is 'true negative'
  - A highly specific test means that there are less false positive results
  - It is calculated as $TN/(FP + TN) \times 100 = D/(B + D) \times 100$
- **Predictive accuracy**
  - It reflects the diagnostic power of screening test and it represent as predictive value of positive test and predictive value of negative test.
  - The positive predicted value (PPV) is the probability or likelihood that a subject with a positive (abnormal) test truly have the disease. It is calculated as $TP/(TP + FP) \times 100$
  - The negative predicted value (NPV) is the probability or likelihood that the subject with a negative test truly does not have a disease. It is calculated as $TN/(FN + TN) \times 100$
- **Percentage of false negatives and false positives**
  - The false negative means the people have the disease, but test came negative and false positive means the people do not have a disease, but the test came positive.
  - Percentage of false negative is calculated as $FN/(TP + FN) \times 100$
  - Percentage of false positive is calculated by $FP/(FP + TN) \times 100$

Common Screening Test (Table 7.3)

Some of the example of common screening test are:

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Table 7.3: Example of common screening test.

Screening test	*Disease*
PAP smear	Cervical cancer
Prostate specific antigen (PSA)	Prostate cancer
Mammography	Breast cancer
Fecal occult test	Bowel cancer
Alpha-fetoprotein (AFP)	Developmental anomalies in fetus
Urine for sugar	Diabetes mellitus

Table 7.4: Example of screening test.

Screening test	*Disease*		*Total*
	Present	*Absent*	
Positive	50 (a)	15 (b)	65 (a + b)
Negative	10 (c)	405 (d)	415 (c + d)
Total	60 (a + c)	420 (b + d)	480 (a + b + c + d)

PRACTICAL APPLICATION AND IMPLICATIONS

After gaining the knowledge of screening for diseases, now the students will be able to choose the specific screening methods for certain diseases and also will be able to evaluate the screening test in terms of sensitivity, specificity, predictive accuracy.

For practical implication, a scenario based example is provided below:

Example: A new screening test **(Table 7.4)** or a disease is being evaluated. The test was administered to 480 persons, 60 of whom are known to have the disease. This new test was found to be positive in 50 of the 60 people with the disease as well as in 15 people who do not have the disease. Calculate the measures to evaluate the screening test.

Calculation

Firstly, a table was drawn based on the parameters mentioned above.

Now, we calculated the measures used to evaluate the screening test, i.e., sensitivity, specificity, predictive values for positive and negative test, and percentage of false negative and positive (by using the formula as discussed earlier)

- Sensitivity = $a/(a + c) \times 100 = 50/60 \times 100 = 83.33\%$
- Specificity = $d/(b + d) \times 100 = 405/420 \times 100 = 96.42\%$
- Predictive value of positive test = $a/(a + b) \times 100 = 50/65 \times 100 = 76.92\%$
- Predictive value of negative test = $d/(c + d) \times 100 = 405/415 \times 100 = 97.59\%$
- Percentage of false negative = $c/(a + c) \times 100 = 10/60 \times 100 = 16.66\%$
- Percentage of false positive = $b/(b + d) \times 100 = 15/420 \times 100 = 3.57\%$

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Screening for disease is valuable tool to detect the health issues or condition before the symptoms appears, which further can initiate the early treatment and better outcome. It is always differ from diagnostic test because of wide applicability and nonexpensive. Screening can be done by different methods like mass or high-risk screening depending upon the need. The test for screening of disease should be acceptable, consistent or reliable and valid. The validity of test depends on sensitivity (true positive), specificity (true negative) and predictive accuracy (positive and negative predictive value). Ultimately, screening plays an important role in preventing the burden of disease, preventing the complications and mortality of a disease, and reducing the financial burden of a diseased person.

Expected Questions

1. **Define screening. Enumerate the purpose or aims of screening.**
2. **Discuss the principles of screening.**
3. **Enumerate the uses and types of screening.**
4. **Mention the important criteria or principle of screening.**
5. **How screening test is different from diagnostic test?**
6. **Define sensitivity and sensitivity.**
7. **In a screening of disease, a test was used among 500 persons. The test was found positive among 300 persons, out of which 200 persons had disease. The test was found negative in 200 persons out of which 120 persons did not have the disease. Calculate the sensitivity, specificity, positive and negative predictive values, and percentage of false positive and negative.**

Suggested Reading

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Editor-in-Chief

Purushottam Giri MBBS MD (PSM) MIPHA FIAPSM CCEBDM (Diabetes) is currently working as Professor and Head, Department of Community Medicine, Indian Institute of Medical Science and Research (IIMSR) Medical College, Badnapur, Maharashtra, India. He has 18 years of teaching experience and has been an examiner for both UG and PG in more than 22 medical universities including deemed-to-be universities in various states of India. He has published more than 225 scientific papers in various national and international indexed medical journals and has received citations of 2,895 (h-index: 27, i10-index: 63) till date. He has been an Executive Editor, Associate Editor, Assistant Editor, and Editorial Board Member of more than 25 national/international indexed medical journals related to Community Medicine and Public Health. He is also a peer reviewer for more than 25 indexed medical journals.

He has written eight medical textbooks, titled: 1. Epidemiology and Programmatic Management of NCDs in India (Jaypee Brothers Medical Publishers in 2023), 2. IAPSM Case-Based Learning in Community Medicine (CBS Publishers in 2024), 3. Practical Application in Community Medicine (Jaypee Brothers Medical Publishers in 2024), 4. Essential Medical Guide for General Practitioners (Mahi Publishers in 2024), 5. IAPSM Textbook on National Health Programs and Policies of India in a Nutshell (Jaypee Brothers Medical Publishers in 2025), 6. Essentials of Geriatrics (Innovative Publications Pvt. Ltd. in 2025), 7. Comprehensive Exploration of Mental Health in India (Innovative Publications Pvt. Ltd. in 2025), and 8. Occupational & Environmental Health in India: Comprehensive Manual for Medical & Allied Health Professionals (Innovative Publications Pvt. Ltd. in 2025).

At present, he also holds the posts of President of IAPSM Maharashtra Chapter (2024–27), Secretary General of National IAPSM (2022–25), Zonal Representative (West Zone) of APCRI (2022–24 and 2024–26), Central Council Member (West Zone) at National IPHA (2023–25), Vice-President of IPHA Maharashtra Chapter (2018–21 and 2021–24), Secretary of IAPSM Maharashtra Chapter (2015–18 and 2021–24), and Accredited Faculty of Maharashtra Medical Council (MMC), Mumbai, Maharashtra, since 2014.

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