

Screening for Disease Part I

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(most slides courtesy of Laura Beebe, PhD)

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Welcome to this four-part series focused on epidemiologic and biostatistical methods related to disease screening. In this first segment, we will discuss essential components for effective screening programs.

Learning Objectives

- Identify the criteria for an effective screening program

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After viewing this module, you will be able to identify the criteria for an effective screening program.

Definition of Screening

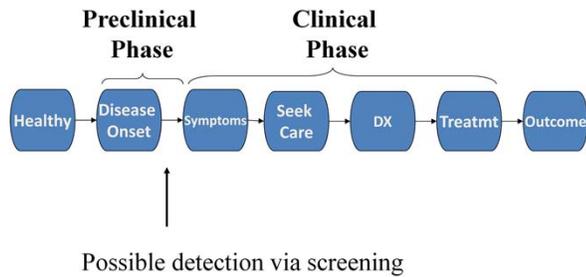
- The identification of disease in asymptomatic individuals by application of rapid tests to separate persons who probably have the disease from those who probably do not have the disease
- Not intended to be diagnostic
- Positive or suspicious findings must be referred for diagnosis and treatment

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Let's first begin with a definition of screening and distinguish a screening program from a diagnostic testing program.

A screening program is one in which we identify disease in asymptomatic individuals by application of rapid tests. Our objective is to distinguish persons who probably have the disease from those who probably do not have the disease. Note that screening programs are not intended to be diagnostic; instead, positive or suspicious findings from a screening test are referred for diagnostic testing and based on the diagnostic testing results, are referred for subsequent treatment as appropriate. An example of a screening test would be mammography, which if found to be positive, is followed by more definitive testing using imaging and biopsy, and if found to be positive, the patient receives treatment for breast cancer.

Natural History of Disease - the course of disease from its beginning to its final clinical end points



To better understand the timing of screening programs, let's consider the natural history of disease. Patients begin in a healthy state and then progress through a preclinical phase where the disease process begins but symptoms have not yet become apparent. The preclinical phase is followed by the clinical phase where the patient experiences symptoms, seeks care, receives a diagnosis and subsequent treatment, and is followed for an outcome. To be effective, the disease screening process will be implemented after the onset of disease but before the patient experiences symptoms.

Reason for Screening

- Goal: To improve prognosis and reduce mortality
- Assumption: Early detection will lead to decreased morbidity and mortality
- Secondary prevention => early diagnosis and intervention

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Screening programs are initiated early in the natural history of disease as an approach to identify disease cases early to improve prognosis and to reduce morbidity and mortality. This is based on the assumption that early detection will lead to decreased morbidity and mortality and is the principle of secondary prevention. Meaning, with early diagnosis of a disease, we can intervene in order to reduce morbidity and mortality.

The following definitions are helpful to keep in mind relative to screening and diagnostic testing programs:

Primary Prevention: programs that aim to prevent disease or injury before it occurs

Secondary Prevention: programs that aim to reduce morbidity and mortality from the disease by detecting and treating the disease at its earliest stage

Tertiary Prevention: programs that aim to reduce the impact of ongoing or chronic diseases

WHO Criteria for Effective Screening:
Criterion 1

1. The condition being screened for must be serious.

Example: Most states require newborn screening for congenital hypothyroidism. If untreated, this rare condition leads to mental retardation which is severe and costly to society

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Now, we will review the World Health Organization's criteria for Effective Screening programs. These are criteria that should be considered when developing a screening program.

First, the condition being screened for must be serious. For example, most states require newborn screening for congenital anomalies including congenital hypothyroidism. If untreated, this rare condition leads to mental retardation, which is severe and costly to society.

WHO Criteria for Effective Screening
Criterion 2

2. The condition being screened for must be treatable.

Example: All newborns are screened for PKU because it is treatable by withholding foods with phenylalanine.

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Second, the condition being screened for must be treatable. Once the patient screens positive and is positive for subsequent diagnostic tests, there needs to be an effective treatment that can be used to treat the disease.

For example, all newborns are screened for phenylketonuria (PKU) which is a birth defect that causes an amino acid called phenylalanine to build up in the body. The condition is treatable by withholding foods that contain phenylalanine.

WHO Criteria for Effective Screening
Criterion 3

3. The condition must be detectable while asymptomatic and timely treatment must reduce morbidity and mortality more effectively than treatment after the appearance of symptoms.

Ex: Cervical cancer can be detected an average of 8 to 9 years before it becomes symptomatic. If caught early by Pap smear, these cancers can be treated successfully. If disease is diagnosed through symptoms, treatment is less effective and prognosis is poor.

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The third criterion relates to the timing of the screening process. The condition must be detectable while asymptomatic and timely treatment must reduce morbidity and mortality more effectively than treatment after the appearance of symptoms.

For example, cervical cancer can be detected an average of 8 to 9 years before it becomes symptomatic. If caught early by a Pap test, cervical cancer can be treated successfully. If cervical cancer is diagnosed later, after symptoms have developed, treatment is less effective and the prognosis is poor.

WHO Criteria for Effective Screening
Criterion 4

4. The screening test must be accurate.

Example: Testing for fecal occult blood to detect colon cancer among asymptomatic, low-risk populations is an example of a screen with low accuracy. The sensitivity is only 50% and the positive predictive value is 5%. Thus, for every 20 people who initially screen positive and suffer the cost and anxiety of follow-up tests, only one will have colorectal cancer.

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Fourth, the screening test must be accurate in distinguishing disease cases from non-cases.

As an example, testing for fecal occult blood to detect colon cancer among asymptomatic, low-risk populations is an example of screening test with low accuracy. The sensitivity (which is the probability of having a positive test among those who have colon cancer) is only 50% and the positive predictive value is only 5% (which is the probability of having colon cancer among those who test positive based on the presence of fecal occult blood).

This means that for every 20 people who initially screen positive for fecal occult blood and suffer the cost and anxiety of follow-up tests, only one will have colorectal cancer.

WHO Criteria for Effective Screening
Criterion 5

5. The screening test must be acceptable to the patient and inexpensive.

Example: Sigmoidoscopy is more sensitive than testing stools for occult blood and is highly specific. Its value as an effective screening test for colorectal cancer has been questioned since patients and physicians avoid it, and the cost is high.

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Fifth, the screening test must be acceptable to the patient and inexpensive.

For example, sigmoidoscopy is more sensitive than testing stools for occult blood and is highly specific; however, its value as an effective screening test is questionable given the invasive nature of the test. Patients and physicians avoid using sigmoidoscopy and the cost is also high.

WHO Criteria for Effective Screening
Criterion 6

6. The condition must be sufficiently prevalent to warrant screening.

Example: 50 million Americans have high blood pressure. Most would benefit from monitoring or intervention. Screening is warranted because the prevalence is high.

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The final criterion is that the condition must be sufficiently prevalent to warrant screening.

For example, 50 million Americans have high blood pressure. Most patients would benefit from monitoring and treatment of their high blood pressure. Screening is warranted for hypertension because the prevalence is high, and the other conditions previously discussed would be met.

Universal Screening vs. Targeted Screening

- **Universal screening:** Screening everyone in the population.

Example: Newborn hearing tests,
Pap test for cervical cancer, blood
pressure

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To conclude this segment, let's now discuss universal versus targeted screening.

A universal screening program is one that is applied to all members of a given population. For example, newborn hearing tests are applied to all newborns. Pap tests are recommended for all women above a certain age. As a final example, blood pressure is checked for all patients visiting a primary care physician's office. These screening tests are applied universally to everyone in a defined population.

Universal Screening vs.
Targeted Screening

- **Targeted screening:** Screening populations identified as being high risk.

Example: Mammography screening for women under age 40 with a family history of breast cancer

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Targeted screening, on the other hand, is applied in populations who are at particularly high risk for developing the disease of interest.

For example, mammography screening is recommended for younger women only when the woman has a family history of breast cancer (high-risk subgroup). In addition, mammography screening is recommended more broadly when considering women who are older; however, among younger women, screening is focused on particular, high-risk subgroups.

Summary

- Definition of a screening test
- Criteria for an effective screening program

In summary, we have learned about the features of a screening program that distinguish screening from diagnostic testing programs. We have also discussed six criteria for defining an effective screening program.

In the next segment, we will define and learn how to compute quantitative measures of accuracy, including sensitivity, specificity, and likelihood ratios.