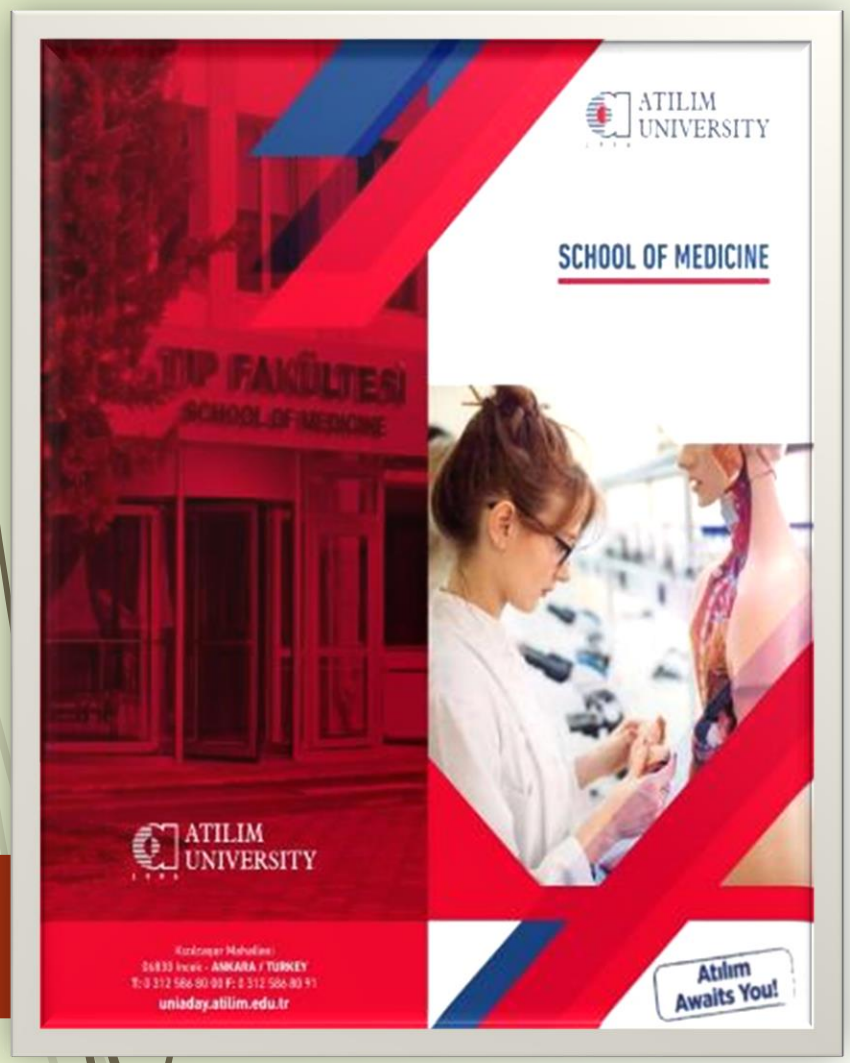

Epidemiologic Screening Technics

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LLM, in Health Law

BSc, in Public Administration & Political Sciences

Screening is the systematic application of a test or enquiry to identify individuals at risk of a specific disorder to warrant further investigation or direct ***preventive action***, amongst persons who have not sought medical attention on account of symptoms of that disorder.

Phase 1 lecture, 2023 - 2024 academic year, spring semester

03rd May 2024, Ankara - TURKIYE

www.ahmetsaltik.net

Learning objectives….

At the end of this lecture, students are expected to;

- ***describe*** Screening and its Epidemiologic rational & contribution
- ***understand*** critical function of Screening in Medicine
- ***realise*** that Screenings are not the tools for making diagnosis!
- ***count*** major types of screenings and ***define*** related key terms
- ***classify*** major screening tests for certain population groups
- ***interprete*** results of screening test and consult with the patient
- ***exhibit*** infrential skills on the performance of screening tests
- ***calculate*** sensitivity/specificity/+&- predictive value of the test

What is Epidemiologic SCREENING??

- **Epidemiologic screening** refers to the process of testing a population that does not show symptoms of a particular condition to identify individuals who have the condition, so they can receive early treatment.
- It's ***a proactive public health strategy*** aimed at early detection & intervention to reduce the incidence and/or mortality of health problems within the population.
- ***Screening is the testing of an asymptomatic population*** for a particular condition in order to identify those who have the condition so that they can be treated early.
- Common examples include ***cancer screenings*** like mammograms and pap smears, routine hypertension screening, and annual tuberculosis and HIV screening among healthcare workers.

https://open.oregonstate.education/epidemiology/chapter/screening-and-diagnostic-testing/ 3.5.24

What is Epidemiologic SCREENING??

- **The purpose of screening** is to identify people in an apparently healthy population who are at higher risk of a health problem or a condition, so that early treatment or intervention can be offered.
- *This helps reduce the incidence and/or mortality of the health problem or condition within the population.*
- **Screening is** distinct from diagnostic testing, which is performed on symptomatic patients to determine what condition they have.
- ***Screening*** *aims to find diseases before symptoms appear, allowing for earlier and potentially more effective treatment.*

https://open.oregonstate.education/epidemiology/chapter/screening-and-diagnostic-testing/ 3.5.24

SCREENING TESTS

Screening tests are widely used in medicine to assess the likelihood that members of a defined population have a particular disease.

These slides present an overview of such tests including the definitions of key technical (***sensitivity*** & ***specificity***) and population characteristics necessary to assess the benefits and limitations of such tests.

False positive :
Someone with a positive screening result who does not have the target condition.

False negative :
Someone with a negative screening result who does have the target condition.

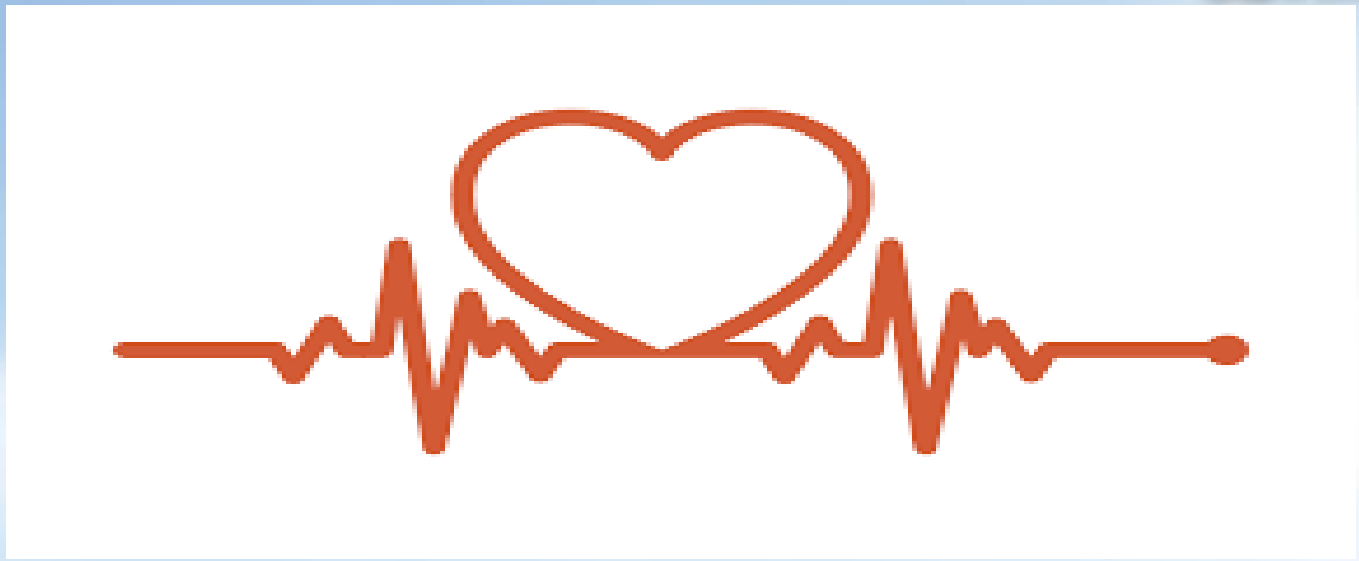
https://portal.e-lfh.org.uk/Catalogue/Index?HierarchyId=0_43382&programmeId=43382

Prevention..

Prevention Science :

A multidisciplinary field devoted to the scientific study of the theory, research, and practice related to the prevention of ***social, physical, and mental health*** *problems, including etiology, epidemiology, and intervention.**

*IOM “Preventing Mental, Emotional, and Behavioral Disorders Among Young People: Progress and Possibilities” pg x*xvii*



Public health surveillance

is the ongoing, systematic collection, analysis, and interpretation of health-related data essential to the *planning*, *implementation*, *and evaluation* of public health practice.

Public health surveillance testing..

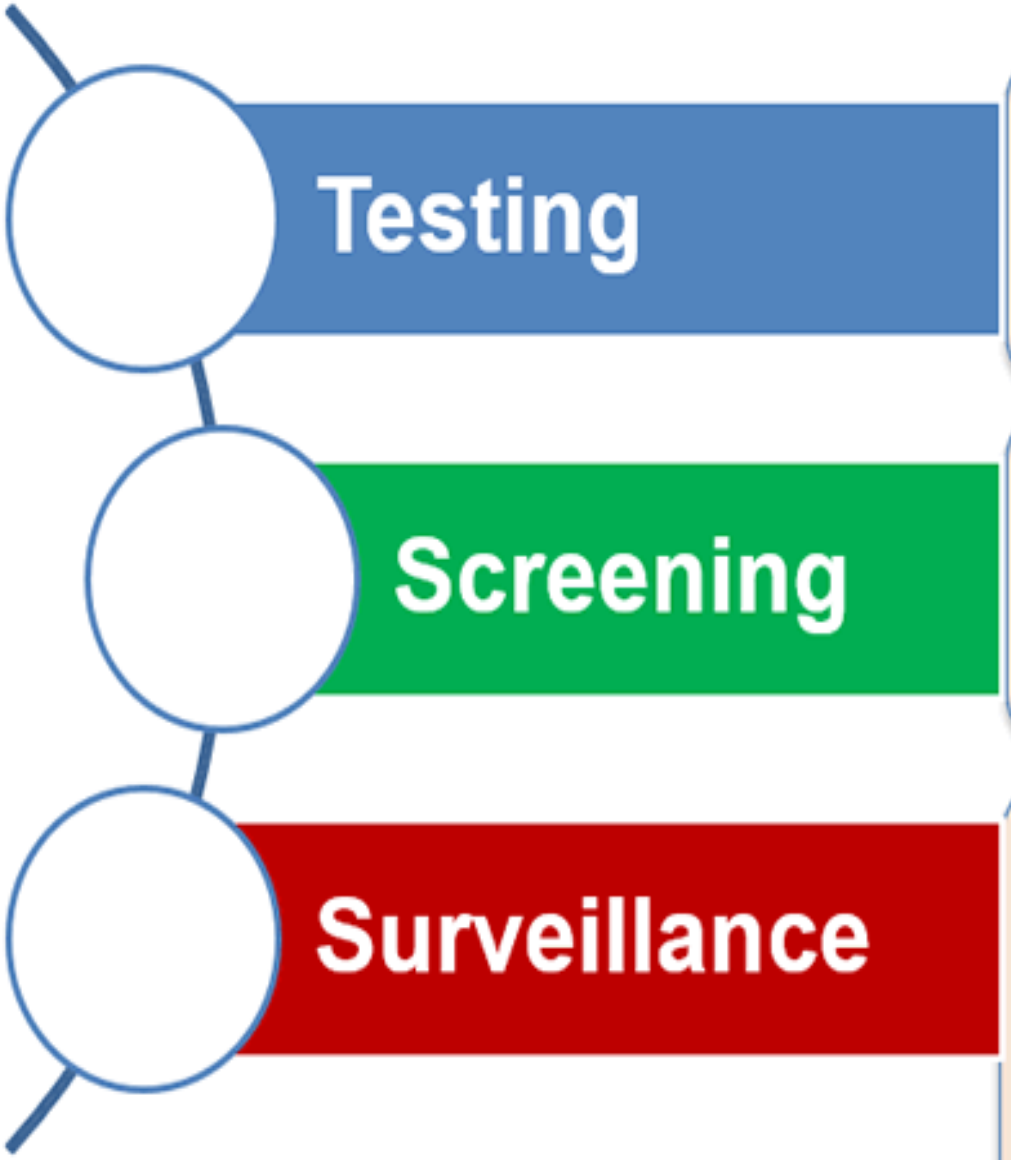
- ***Public health surveillance*** testing is intended
  - to monitor community
  - or population-level outbreaks of disease,
  - or to characterize the *incidence and prevalence* of disease.

- **Surveillance testing** is performed on de-identified specimens, and thus, results are not linked to individual people.

- Public health surveillance testing results cannot be used for individual decision-making. *Testing Strategies for SARS-CoV-2 | CDC 25.4.23*

SCREENING EXPECTATIONS

- It is important to have realistic expectations of what a screening programme does.
- **Screening can :**
- Save lives or improve quality of life through early identification of a condition
- *Reduce the chance of developing a serious condition or its complications*
- Give pregnant women informed reproductive choice
- *Screening does not guarantee protection.*
- Receiving a low chance result does not prevent the person from developing the condition at a later date.
- *In any screening programme there are **false positive** and **false negative** results.* https://www.gov.uk/guidance/population-screening-explained *18.4.23*



- Definitive diagnosis of COVID-19 with high sensitivity
- PCR-based tests, with potential refinements to specimen collecting modalities (e.g. saliva)
- Less amenable to high frequency conduct due to greater resource utilization

- Indicative of COVID-19 status, with lower sensitivity
- Typically newer, rapid technology approaches
- Amenable to higher frequency repetition and more easily scalable

- Use of traditional and non-traditional data sources to complement case data
- Wastewater surveillance complements conventional COVID-19 surveillance systems by providing:
  - efficient pooled community sample
  - data for communities where timely clinical testing is underutilized or unavailable
  - data at the local level

Criteria for screening *(based on WHO criteria)-1*

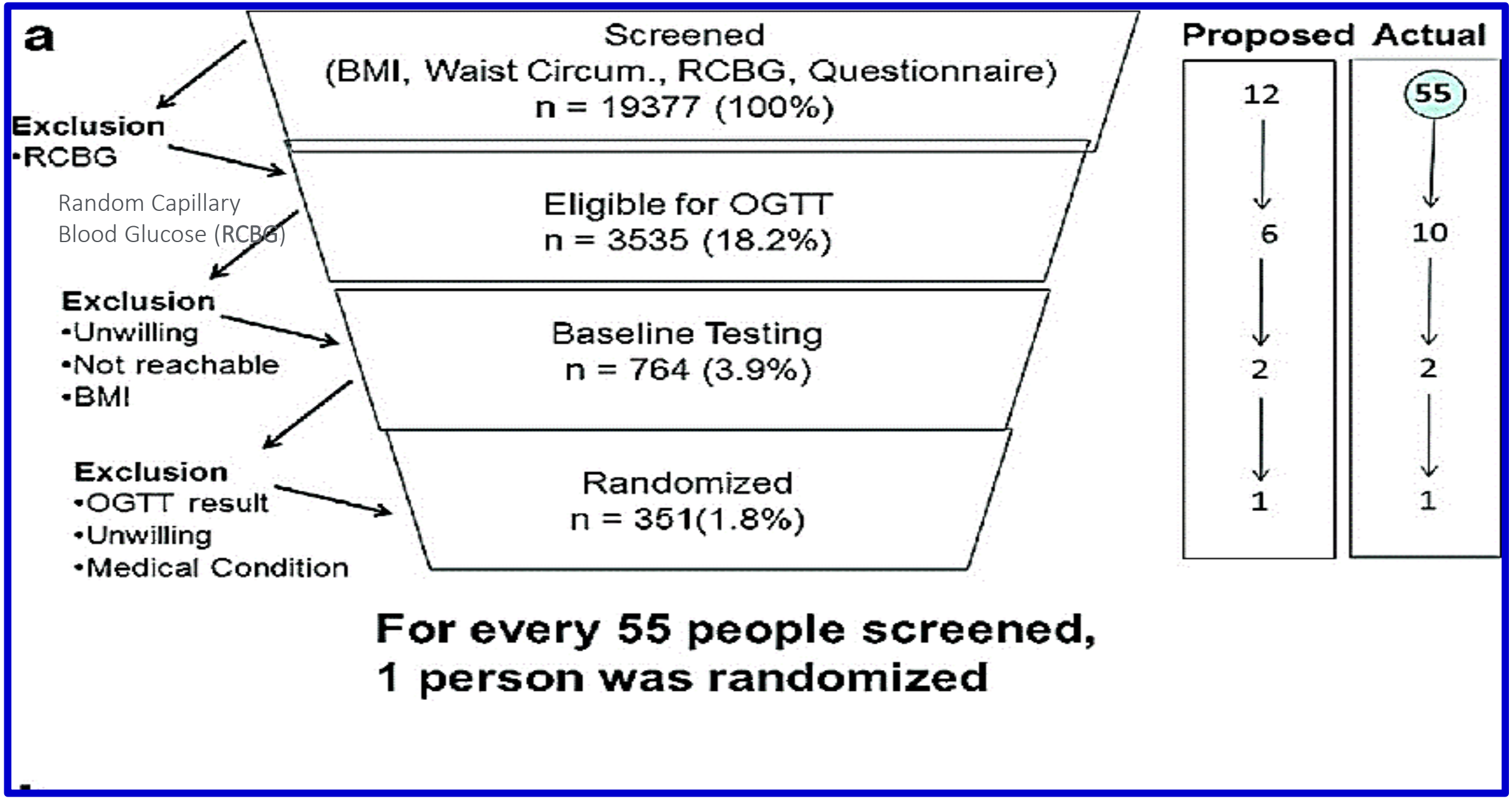
- There are **WHO guidelines** for deciding when screening is appropriate, drawn up by Wilson and Jungter in 1968:

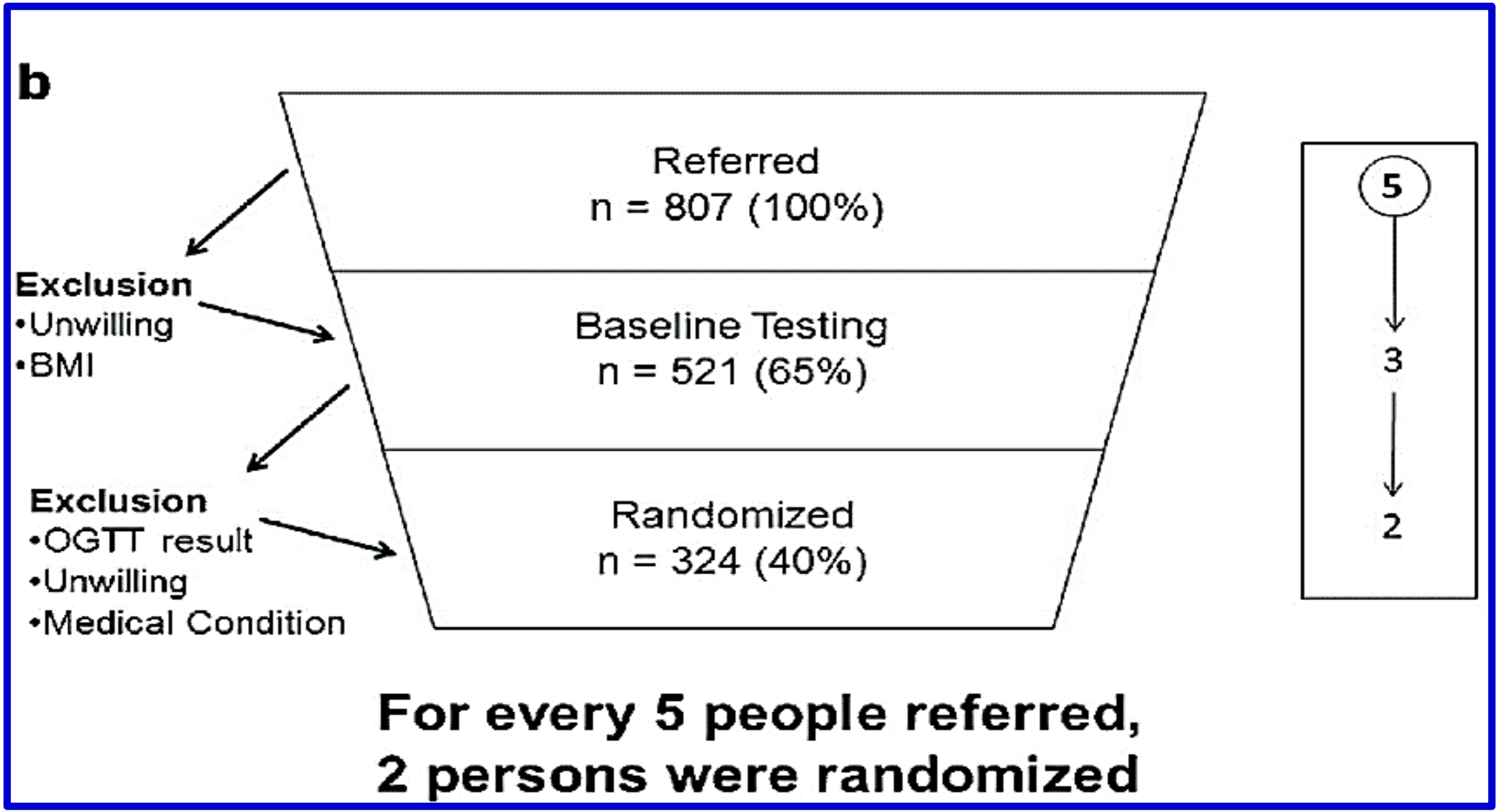
1. *The condition being screening for should be an **important health problem***
2. The natural history should be well understood
3. *There should be a detectable **early stage***
4. Treatment at an early stage should be of greater benefit than at a later stage
5. *There should be a **suitable test** for the early stage*

Criteria for screening *(based on WHO criteria)-2*

- There are **WHO guidelines** for deciding when screening is appropriate, drawn up by Wilson and Jungter in 1968:

6. *The test should be **acceptable***
7. Intervals for repeating the test should be determined
8. *There should be adequate health service provision for the extra clinical workload resulting from the screen*
9. The **risks** should be less than the **benefits**
10. *The **costs** should be balanced against the **benefits***


a
Screened
(BMI, Waist Circum., RCBG, Questionnaire)
n = 19377 (100%)
Exclusion
•RCBG
Random Capillary Blood Glucose (RCBG)
Eligible for OGTT
n = 3535 (18.2%)
Exclusion
•Unwilling
•Not reachable
•BMI
Baseline Testing
n = 764 (3.9%)
Exclusion
•OGTT result
•Unwilling
•Medical Condition
Randomized
n = 351(1.8%)
Proposed
12
6
2
1
Actual
55
10
2
1
For every 55 people screened,
1 person was randomized


b
Referred
n = 807 (100%)
Exclusion
•Unwilling
•BMI
Baseline Testing
n = 521 (65%)
Exclusion
•OGTT result
•Unwilling
•Medical Condition
Randomized
n = 324 (40%)
5
3
2
For every 5 people referred,
2 persons were randomized

SCREENING TESTS

- ✓ *Several examples are used to illustrate calculations, including the characteristics of low dose computed tomography as a lung cancer screen, choice of an optimal **PSA** (Prostate Specific Antigen) cutoff and selection of the population to undergo **mammography**.*
- ✓ The importance of careful consideration of the consequences of both ***false positives and negatives*** is highlighted.

CDC's National Breast and Cervical Cancer Early Detection Program offers free or low-cost mammograms and **Pap tests** nationwide. Find out if you qualify.

SCREENING TESTING

✓**Screening tests** are intended to identify people with COVID-19 who are *asymptomatic* and do not have known, suspected, or reported exposure to SARS-CoV-2.

✓*Screening helps to identify unknown cases so that measures can be taken to prevent further transmission.*

Examples of screening include testing :

- *Employees in a workplace setting*
- Students, faculty, and staff in a school setting
- *A person before or after travel*
- Someone at home who does not have symptoms

associated with COVID-19 and no known exposures to someone with **COVID-19**

Testing Strategies for SARS-CoV-2 | CDC *25.4.23*

SCREENING TESTS

Logical possibilities for true disease state and screening test outcome.

Test result	Subject has disease	Subject disease free	Subtotal
Positive	Correct result	False positive	Total positive test results
Negative	False Negative	Correct result	Total negative test results
Subtotal	Total subjects with disease	Total subjects disease free	Total subjects (GT: Grand total)

$$\text{Sensitivity (\%)} = \frac{A}{A+C} \times 100$$

$$\text{Specificity (\%)} = \frac{D}{B+D} \times 100$$

$$\text{Predictive value (\%)} = \frac{A}{A+B} \times 100$$

	Positive (DR present)	Negative (DR not present)
Positive screening test	A	B
Negative screening test	C	D

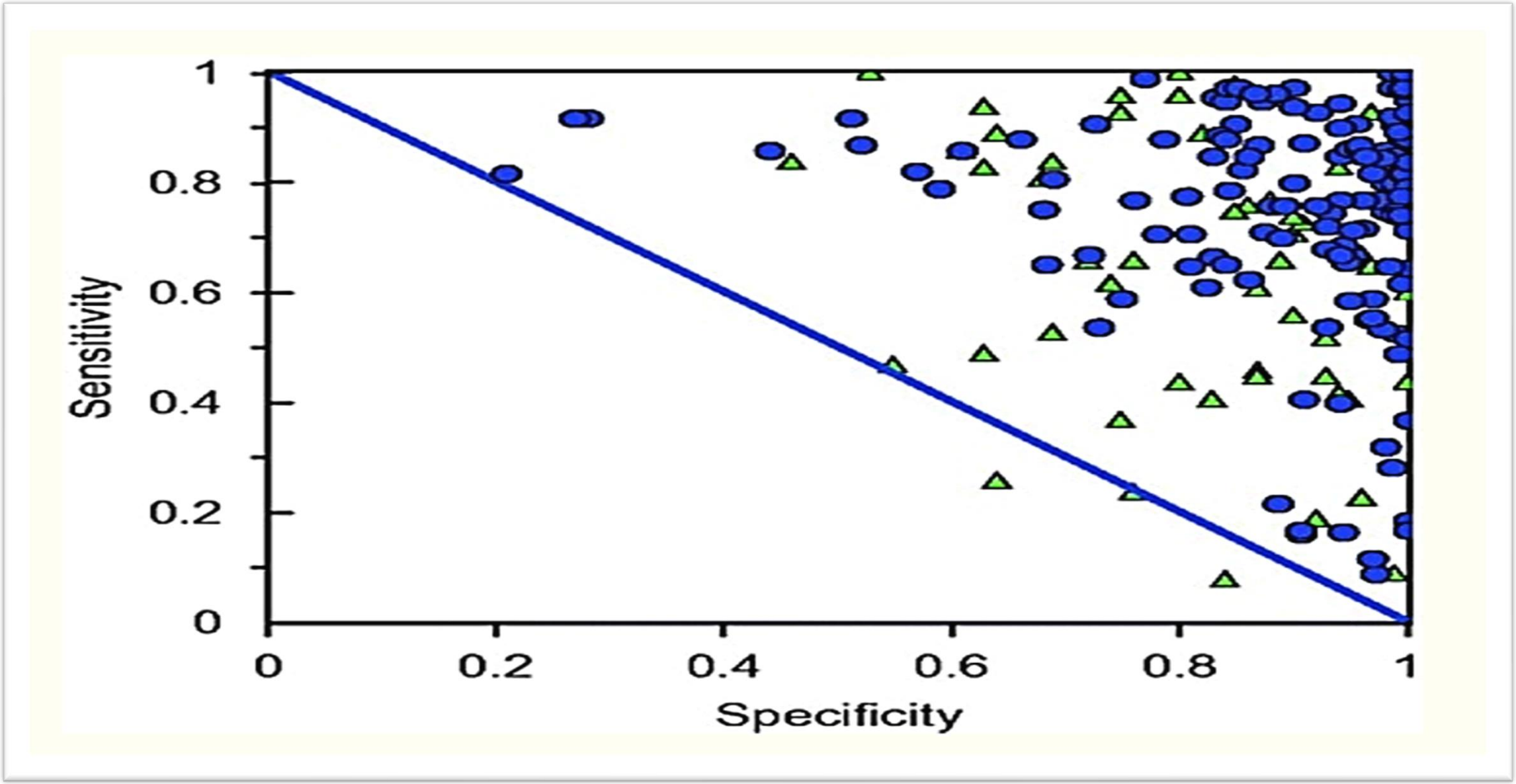
SCREENING TESTS

The ***positive predicted value*** (PPV) is the probability that a subject with a positive (abnormal) test actually has the disease ($Pr\{D^+|T^+\}$) also called the *a posteriori* probability.

Given the above notation; $PPV = \Pi S/((\Pi S + (1 - \Pi)(1 - Sp))$.

In words, the a posteriori probability that the subject has the disease given a positive test is the ratio of ***true positives*** *(the product of the prevalence and* ***sensitivity****) divided by total positives (the sum of true positives and* ***false positives****).*

Negative correlation between Sensitivity & Specifity



SCREENING TESTS

It is desirable that the screening test has a high PPV.

The ***negative predicted value*** (NPV) is the post-test probability that the subject has no disease given a negative test result ($Pr\{D^- | T^-\}$) also termed the *a posteriori* probability given a negative test. Given the above notation:

$NPV = (1 - \Pi)Sp/((1 - \Pi)Sp + \Pi(1 - S))$.

The purpose of community diagnosis is to define existing problems, determine available resources and set priorities for planning, implementing and evaluating health action, by and for the community.

Examples of screening and diagnostic tests and possible Gold Standard

Disease or condition	Screening tests	Gold Standard	References
Urinary tract infection	Urine microscopy	Urine culture	Bauman (1990)
Congenital heart disease	Exercise ECG	Coronary angiography	Bauman (1990)
		Echocardiography	Mertens & Friedberg (2009)
Hypertension	Blood pressure (Korotkoff sounds)	Intra-arterial measurement of pressures	Bauman (1990) Pickering et al. (2005)
Myocardial infarction	EEG or cardiac enzymes	Cardiac biopsy (at autopsy)	Bauman (1990)
Breast cancer	Mammography	Biopsy result	Bauman (1990)
Bowel cancer	Fecal immunochemical test (FIT) and the fecal occult blood test (FOBT)	Colonoscopy ± biopsy	Bauman (1990)
TB	Tuberculin Skin Test; Interferon Gamma Release Assays	Chest X-ray and a sample of sputum, detection of *Mycobacterium tuberculosis* (MTB) by culture or molecular methods.	CDC (2013) Achkar et al. (2011)
Chlamydia	Tissue culture from single cervical swabs	Direct immunofluorescence, enzyme immunoassay, PCR and serology, others	Thejls et al. (1994), see Watson et al. (2002) for review article
Cervical cancer	Pap smear	Colposcopy with appropriate biopsy or sentinel lymph node biopsy	Gotzak-Uzan et al. (2010)
Celiac disease	IgG- and IgA-antigliadin antibodies, IgA-endomysial antibodies, and intestinal permeability	Small bowel biopsy	Vogelsang et al. (1995)

CDC supports :

- ***screening for breast, cervical, colorectal (colon), and lung cancers***

  as recommended by the U.S. Preventive Services Task Force (USPSTF).
- ***Screening means checking your body for cancer before you have symptoms.***
- *Getting screening tests regularly may find breast, cervical, and colorectal (colon) cancers **earlly**, when treatment is likely to work best.*
- ***Lung cancer screening** is recommended for some people who are at high risk.* [*Cancer Screening Tests | CDC*](#) *25.4.23*

CDC supports :

- Screening for ovarian, pancreatic, prostate, testicular, and thyroid cancers has not been shown to reduce deaths from those cancers.
- *The USPSTF found insufficient evidence to assess the balance of benefits and harms of screening for bladder cancer and oral cancer in adults without symptoms, and of visual skin examination by a doctor to screen for skin cancer in adults.* *Cancer Screening Tests | CDC* *25.4.23*

Ethics of screening :

- *A screening test is a medical intervention that is done to a person who is not ill and usually to someone who has not initiated the request for the test.*
- For this reason the **ethics** of carrying out screening must be carefully considered.
- *For the individual the screening test can do **harm** as well as giving benefit:*
- There may be a **risk** attached to the screening test or subsequent diagnostic test
- *A false positive result can cause unnecessary anxiety*
- There may be other unplanned effects of a positive test
- *A false negative result will give false reassurance ?*

The Cost of screening programmes :

- *Resources for health care will always be scarce relative to competing demands. The relative **cost-effectiveness** of a screening programme compared with other forms of health care (including public health intervention such as primary prevention e.g. reducing the number of people smoking) should therefore be considered.*
- **Costs** relate not just to the implementation of the screening programme but also to the further diagnostic tests and the subsequent cost of treatment. On the other hand, in the absence of screening, costs will be incurred by the treatment of patients in more advances stages of disease.

Effectiveness of screening programmes :

Effectiveness is evaluated by the extent to which implementing a screening programme affects the subsequent outcomes. This is difficult to measure because of a number of **biases** that affect most of the study designs used:

- **Selection bias** *exists as people who participate in screening programmes often differ from those who do not. Found in breast screening trials. Needs 'intention to treat' analysis for **RCT** of screening*

- **Lead time bias** exists because screening identifies diseases that would otherwise be identified at a later stage. This may result in an apparent improvement in the length of ***survival*** due to screening which is really due to the earlier date of diagnosis.

10 minutes

Selecting the correct screening test

- Easy to administer
- Cause minimal discomfort
- Be reliable
- Be valid
- Be affordable

https://www.futurelearn.com/courses/diabetic-eye-disease/0/steps/47640

Identifying a good screening test: sensitivity, specificity and coverage

The screening process is like passing people through a sieve.
The holes in the screening sieve are a certain size that will catch some people and allow others to pass through.
A screening test is designed to catch people who are at risk *of a disease (it must be very **sensitive**) and allow those not at risk to pass through (it must be very **specific**).*

Ethics of population screening

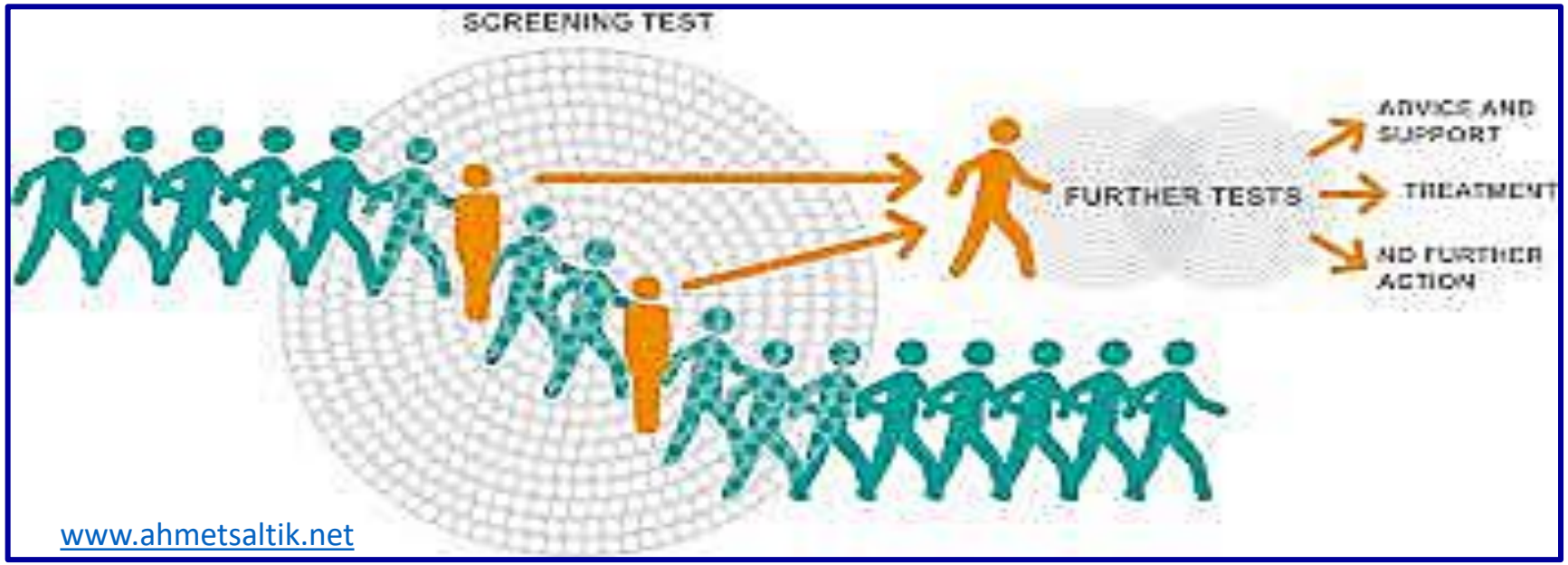
Because apparently healthy people are invited for screening, healthcare professionals have to ensure individuals receive:

- *guidance to help make informed choices*
- *support throughout the screening process*

https://www.gov.uk/guidance/population-screening-explained, 18.4.23

Identifying a good screening test: sensitivity, specificity and coverage

Sometimes people will get stuck in the **sieve**
who will turn out not to be at risk i.e. false alarms.
Others will pass through the sieve despite being at risk i.e. missed cases (false negatives).
Everyone picked up in the sieve will go on for more testing to determine if they have the disease and need treatment.



At each stage of the **screening** process, people can make their own choices about further:

- ***tests***
- ***treatment***
- ***advice***
- ***support***

https://www.gov.uk/guidance/population-screening-explained, 18.4.23

Identifying a good screening test: sensitivity, specificity and coverage

Screening is the process of identifying apparently healthy people who may have an increased chance of a disease or condition.

*The **screening** provider then offers information, further tests and treatment.*

This is to reduce associated problems or complications.

Screening should always be a personal choice.

https://www.gov.uk/guidance/population-screening-explained, 18.4.23

Identifying a good screening test: sensitivity, specificity and coverage

- The idea of a quick test to determine if a person has a disease or not is very appealing but no test can give the perfect “yes” or “no” answer.
- *It remains important that the selected screening test is accurate and appropriate for the local population.*
- **Diabetic retinopathy** (DR) screening programmes must prepare to manage each possible outcome of a screening test.

Identifying a good screening test: sensitivity, specificity and coverage

- ✓ *The **sieve** represents the screening test and most people pass through it.*
- ✓ This means they have a low chance of having the condition screened for.
- ✓ *The people left in the **sieve** have a higher chance of having the condition.*
- ✓ A further investigation is then offered to them.
- ✓ *Identification through this process can show that they have the condition screened for.*
- ✓ The person may need further confirmatory diagnostic tests.

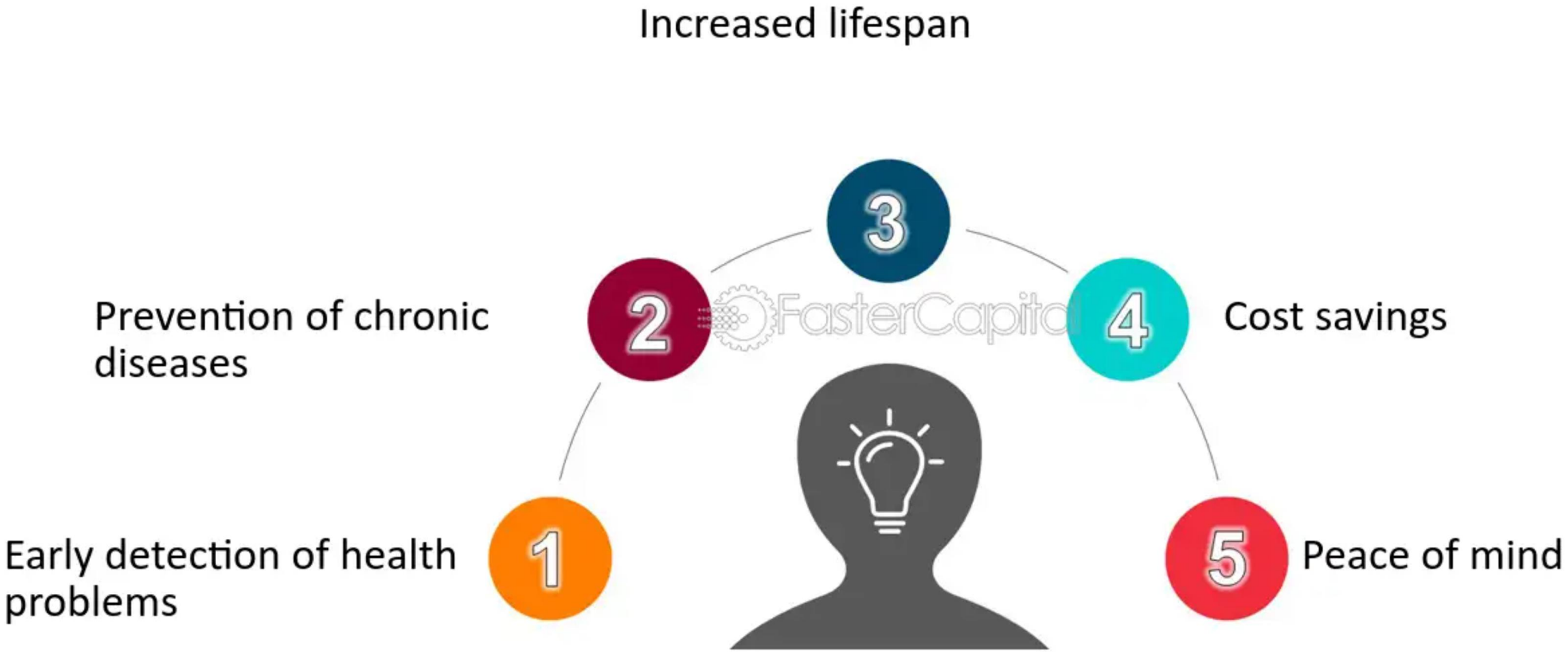
ANNEX 4 Characteristics of a screening test

Characteristics of a screening test	HIV serological testing
1. The condition should be an important health problem.	✓
2. There should be a treatment for the condition.	✓
3. Facilities for diagnosis and treatment should be available.	✓
4. There should be a latent tomatic stage oor asympf the disease.	✓
5. There should be a test for the condition.	✓
6. The test should be acceptable to the population.	✓
7. The natural history of the disease should be adequately understood.	✓
8. There should be an agreed policy on who to treat.	✓
9. The total cost of finding a case should be economically balanced in relation to medical expenditure as a whole.	To be determined
10. Case-finding should be a continuous process, not just a 'once and for all' project.	✓
11. Test used should be sensitive.	✓

BENEFITS OF SCREENINGS.

When properly integrated with a corporate wellness plan, screenings can help reduce health risks, improve health status, reduce health care costs, and improve productivity and performance of the workforce.

The Advantages of Regular Health Screenings



Updated definition of targeted screening will help clarify remit of expanded UK - National Screening Committee

- Nationally delivered ***proactive screening programme*** which aims to improve health outcomes in people with the condition being screened for, among groups of people identified as being at elevated / above average risk of a specific condition.
- *Compared to the general population, the people targeted may have* ***higher risk*** *because of lifestyle factors, genetic variants or having another health condition.*

Updated definition of targeted screening will help clarify remit of expanded UK - National Screening Committee

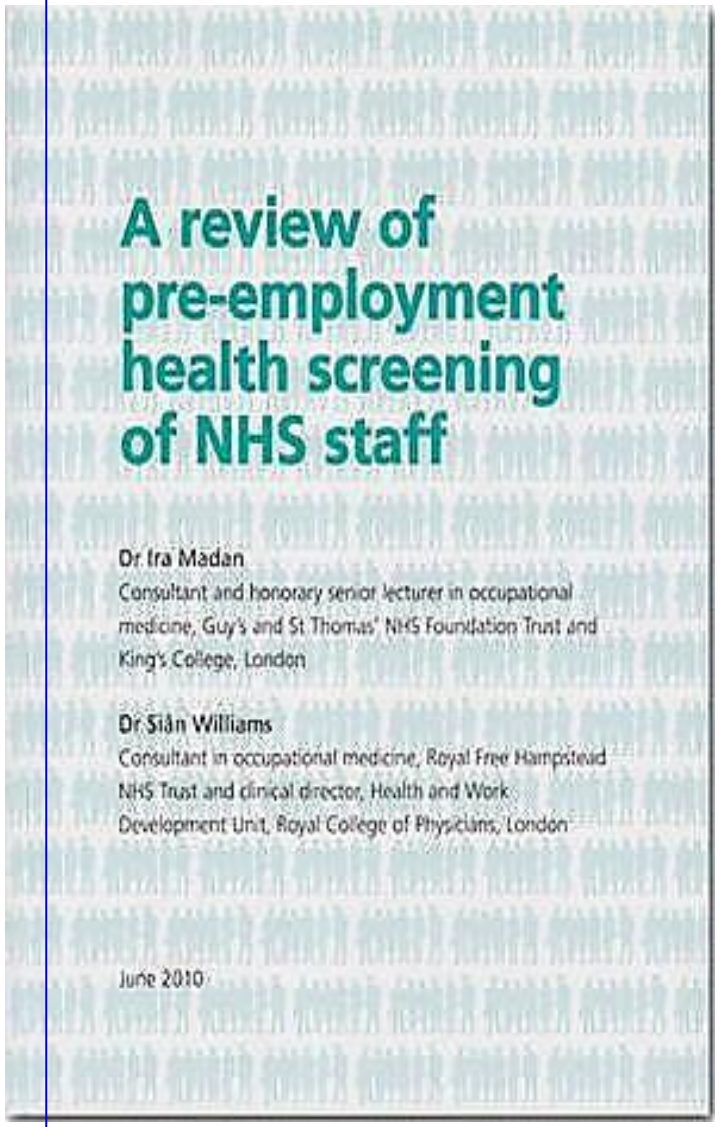
- The UK National Screening Committee (UK NSC) has been making ***evidence-based*** recommendations on population screening programmes.
  The UK NSC's can now also actively consider:

- ***Targeted screening***
  for high-risk groups

- ***Stratified screening***
  that is more tailored to individual risk

- **Community screenings**
  are a way to identify people who may have a health condition but do not know it yet.
- These screenings can help detect conditions early when they are easier to treat.

- **Test validity** is the ability of a screening test to accurately identify diseased and non-disease individuals.
- An ideal screening test is exquisitely **sensitive** *(high probability of detecting disease)* and extremely **specific** *(high probability that those without the disease will screen negative)*. However, there is rarely a clean distinction between "***normal***" and "***abnormal***."
- *The **validity** of a screening test is based on its **accuracy** in identifying diseased and non-diseased persons, and this can only be determined if the accuracy of the screening test can be compared to some "**gold standard**" that establishes the true disease status.*



- **The gold standard** might be a very accurate, but more expensive diagnostic test. Alternatively, it might be the final diagnosis based on a series of diagnostic tests.
- *If there were no definitive tests that were feasible or if the gold standard.*
- Diagnosis was invasive, such as a surgical excision, the true disease status might only be determined by following the subjects for a period of time to determine which patients ultimately developed the disease.
- *For example, the accuracy of **mammography** for **breast cancer** would have to be determined by following the subjects for several years to see whether a cancer was actually present.*

Colon Cancer Screening

- Multiple screening options
  - Colonoscopy – gold standard
  - Sigmoidoscopy
  - Virtual colonoscopy – CT colonoscopy
  - Barium enema
  - Fecal testing – occult blood, DNA test
- Recommended age, frequency vary by test and family history

Criterion validity

- Divided into concurrent (other criteria assessed simultaneously) and predictive (predicting future or past events) sub-areas
- Deals with whether the assessment scores obtained for participants are related to a criterion outcome measure
- For example for predictive, do SAT scores predict post-secondary perfomance?

Content validity

- Deals with whether the assessment content and composition is appropriate given what is being measured (e.g., does the test reflect the knowledge/skills required to do a job or demonstrate that one grasps the course material)
- For example, is there an appropriate representation of questions from each topic area on the assessment that reflect the curriculum that is being taught
- Related to but not to be confused with "face validity"

Construct validity

- Deals with whether the assessment is measuring the correct construct (trait/attribute/ability/skill)
- For example, is this human biology exam actually measuring human biology constructs

EVALUATING SCREENING PROGRAMS

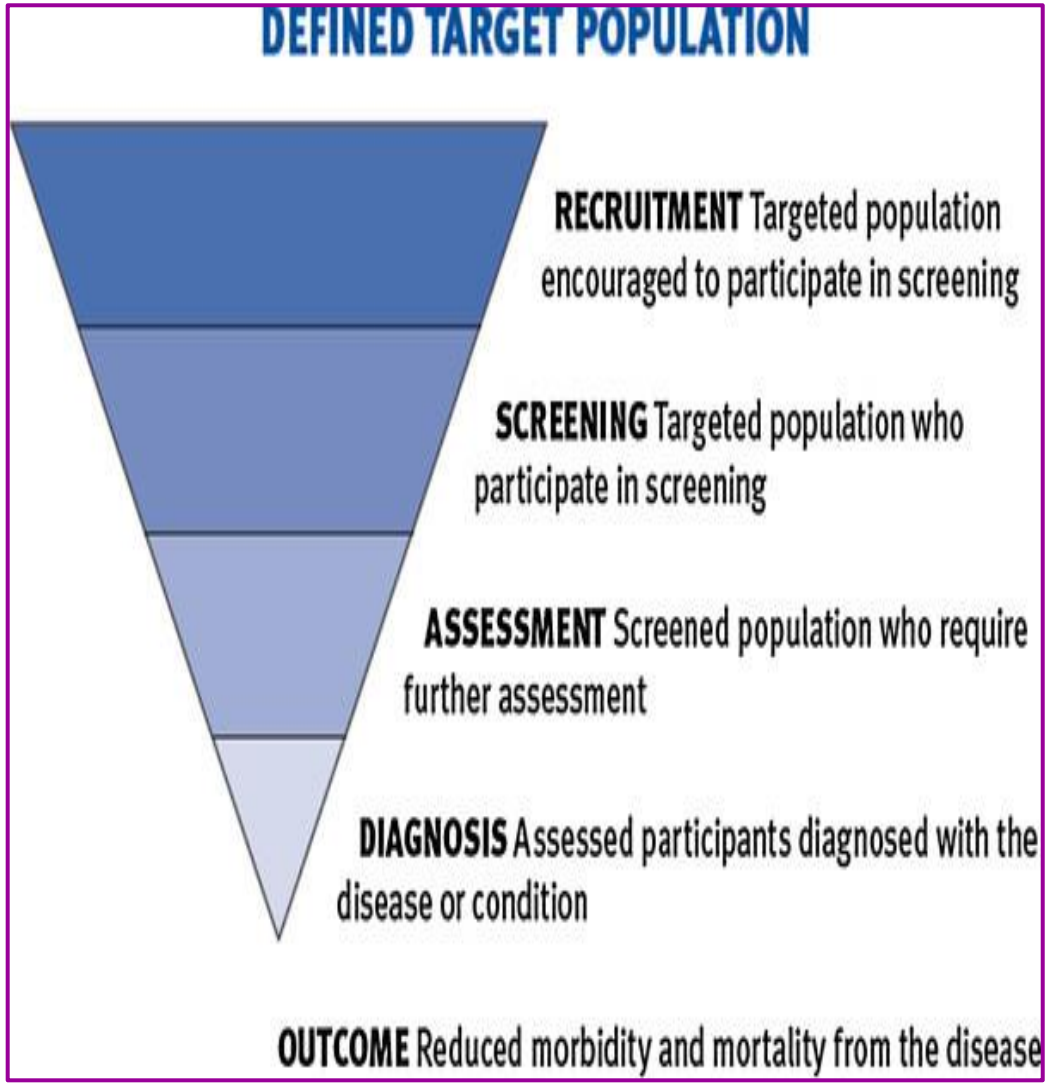
- *Even if a test accurately and efficiently identifies people with pre-clinical disease, its effectiveness is ultimately measured by its ability to reduce morbidity and mortality of the disease.*
- The most definitive measure of ***efficacy*** is the difference in cause-specific **mortality** between those diagnosed by screening versus those diagnosed by symptoms.
- *There are several study designs which can potentially be used to evaluate the efficacy of screening.*
- These include *correlational studies* that examine trends in **disease-specific mortality** over time, correlating them with the frequency of screening in a population.

However,

1) These are measures for entire populations, and cannot establish that decreased mortality is occurring among those being screened;

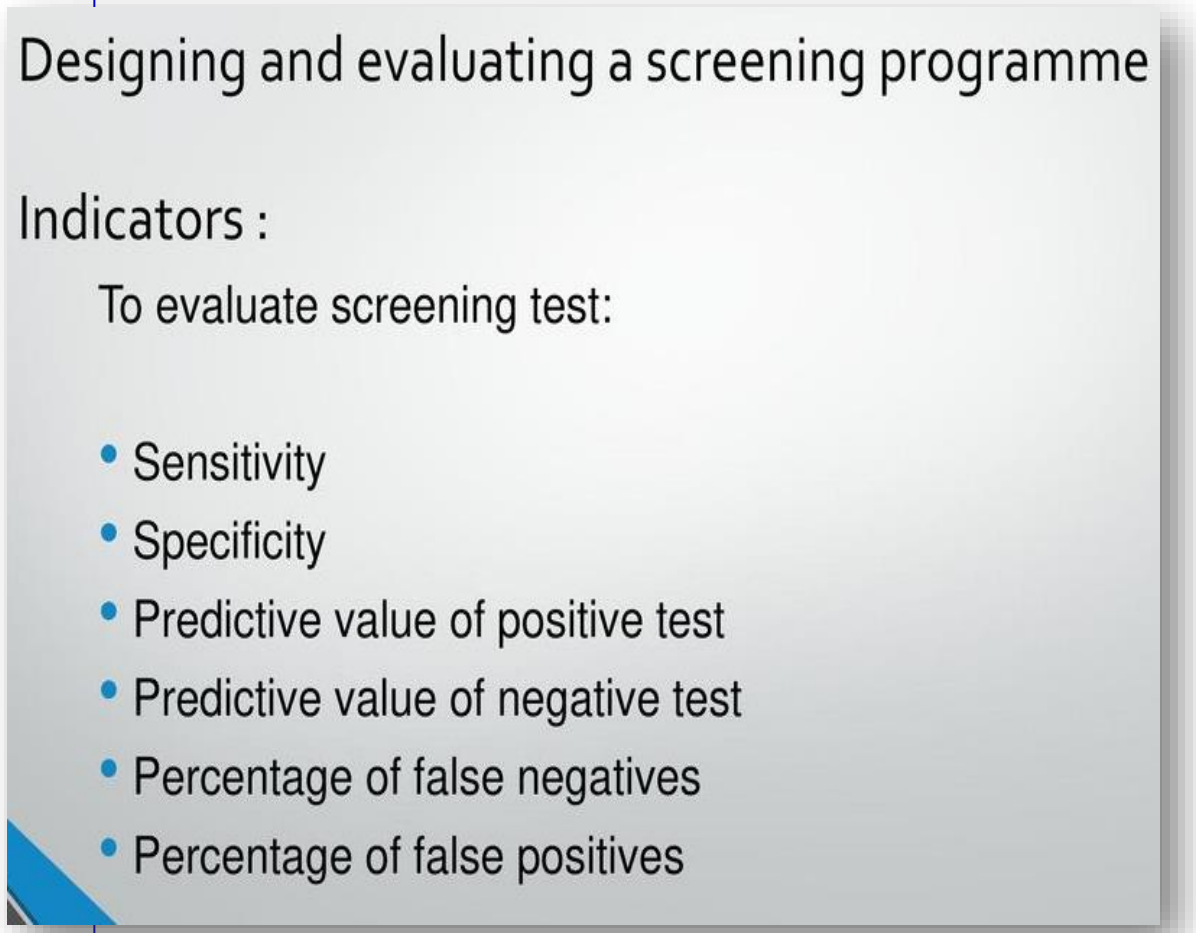
EVALUATING SCREENING PROGRAMS

- 2) one cannot adjust for confounding; and
- *3) one cannot determine optimal screening strategies for subsets of the population.*
- *Case-control and **cohort studies** are frequently used to evaluate screening, but their chief limitation is that the study groups may not be comparable because of confounders, volunteer bias, lead-time bias, and **length-time bias**.*

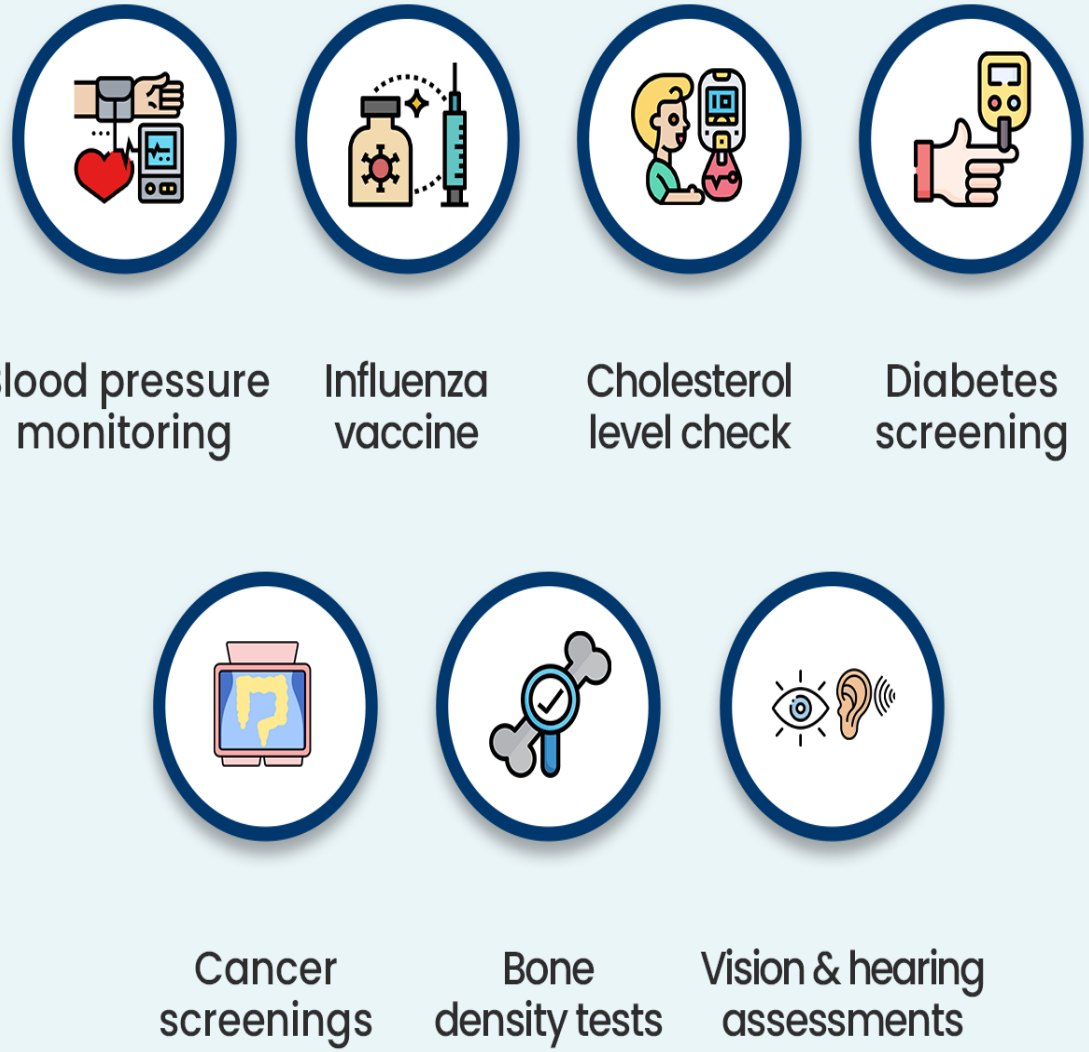


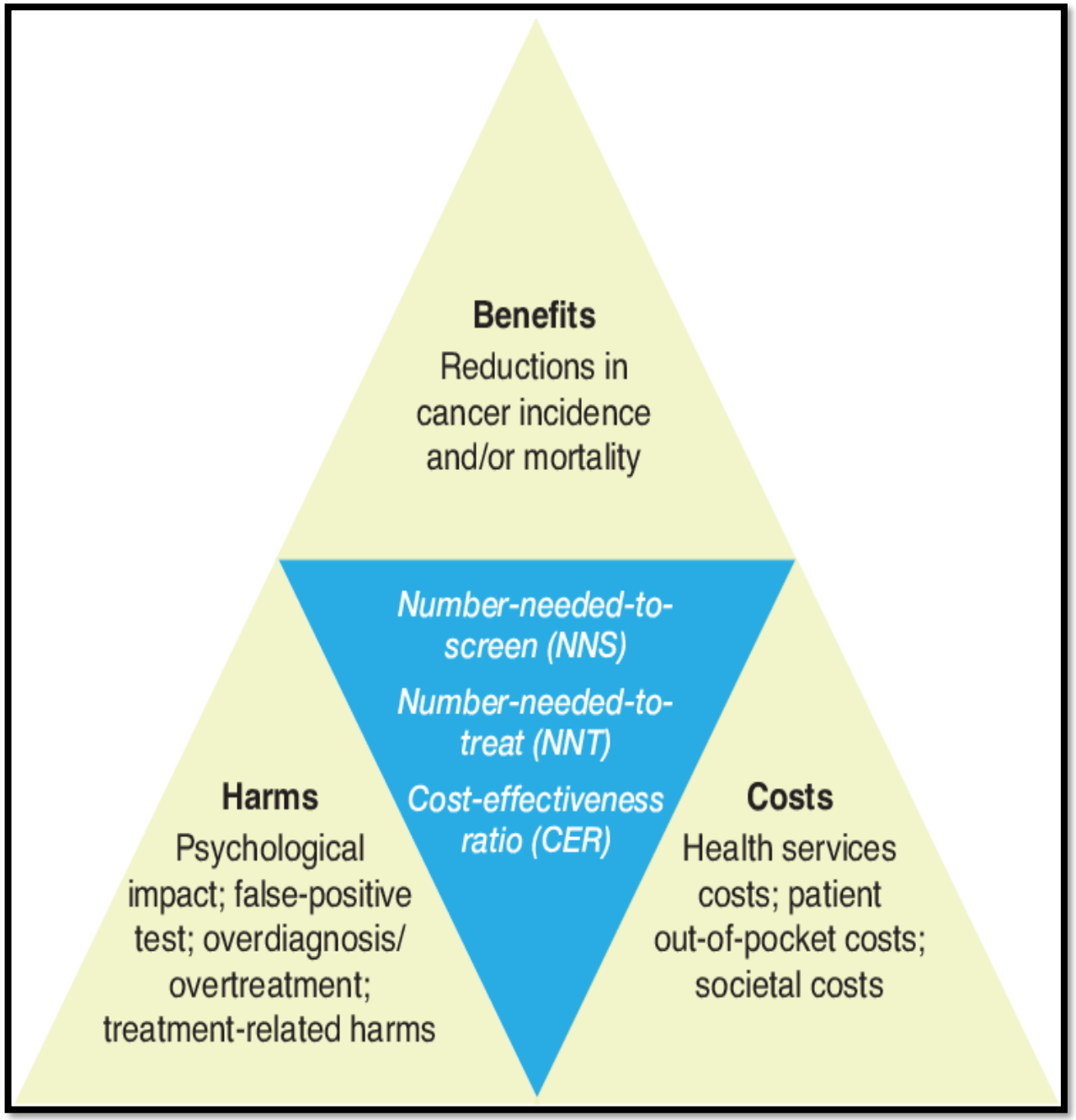
EVALUATING SCREENING PROGRAMS

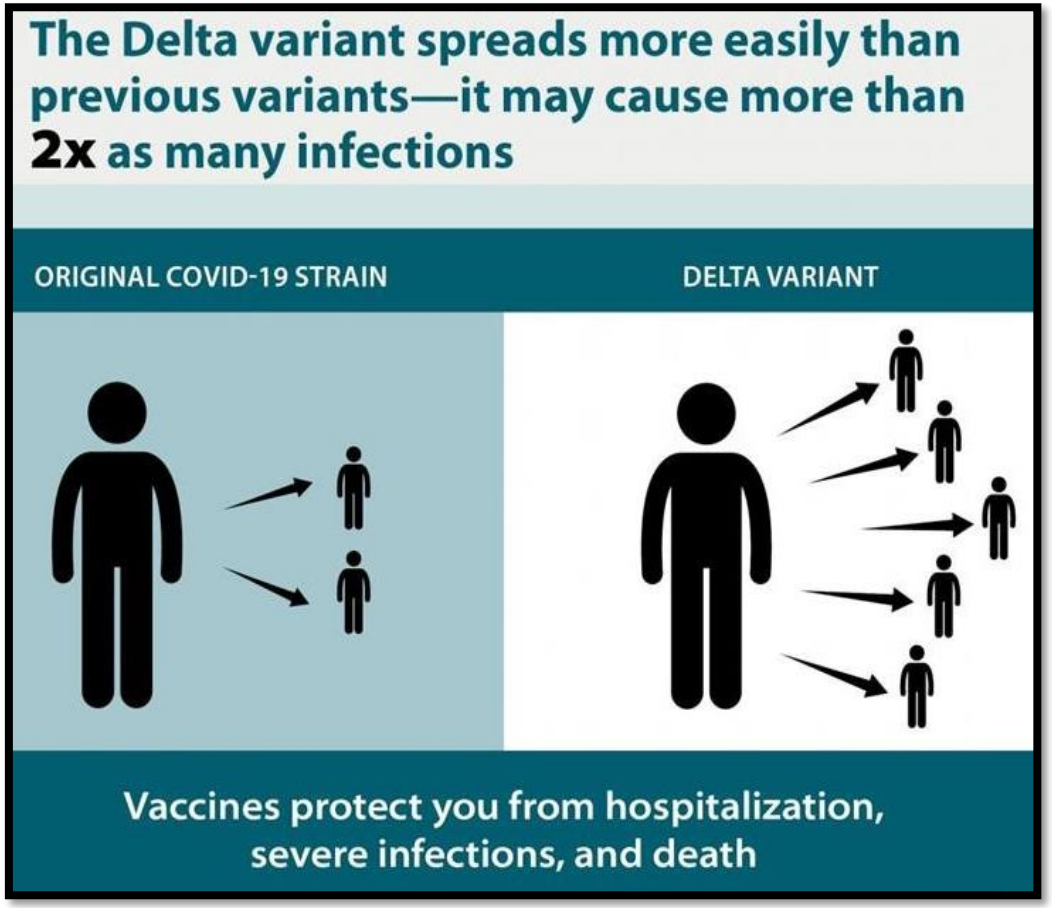
- Because of these limitations, the optimal means of evaluating efficacy of a screening program is to conduct a **randomized clinical trial (RCT)** *with a large enough sample to ensure control of potential confounding factors.*
- **However**, the costs and ***ethical problems*** associated with RCTs for screening can be substantial, and much data will continue to come from observational studies.
- *Screening programs also tend to look better than they really are because of several factors:*

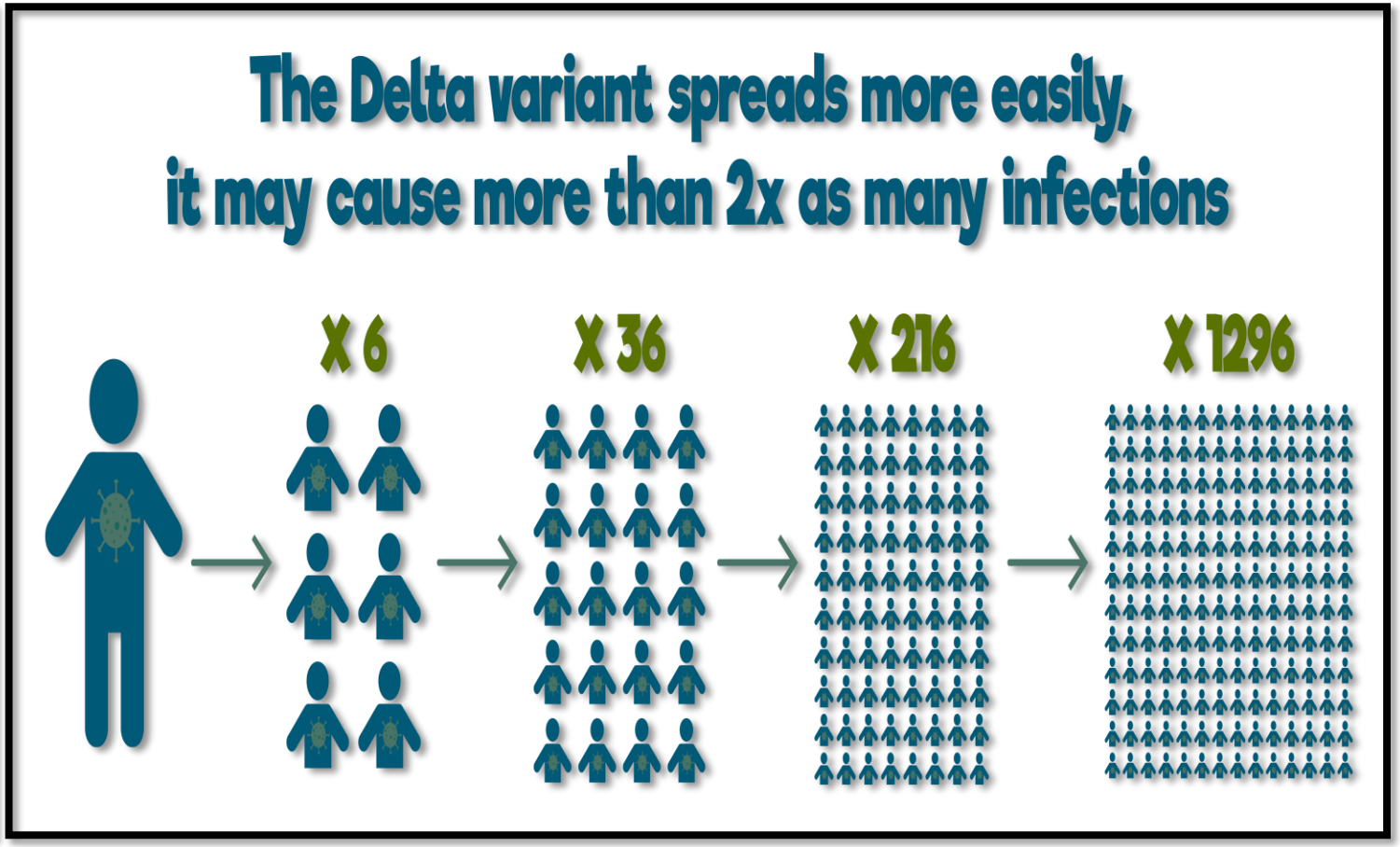


Most Common Preventive Screenings for Seniors









https://portal.ct.gov/projectcoviddetect/benefits-of-screening?language=en_US 3.5.24

- If you apply **mass screening** on ***close contacts*** of a patient infected with Delta Variant, you may catch a lot of newly infected persons at early phase that may remain secret in the population or may get late diagnosis by transmising a lot of people in the mean time then continuation of the epidemic!

SAMPLE PROBLEM

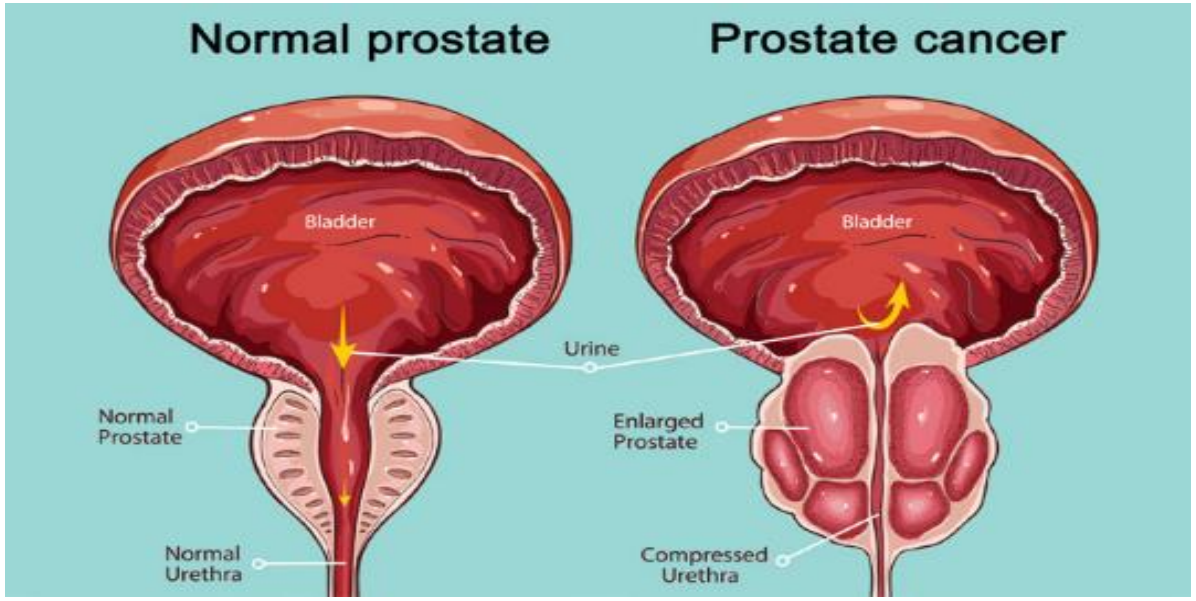
Table - Results of Screening for Prostate Cancer with Prostate-specific Antigen Test

	Biopsy-proven Cancer	No Cancer	Row Totals
PSA Screen +	800	1,132	1,932
PSA Screen -	130	558	688
Column Totals	930	1,690	2,620

Please calculate and interpretate

sensitivity =
specicifty =
positive predictive value =
negative predictive value =

of PSA test as a screening test before ***gold standard*** test prostate biopsy..



Prostate Cancer Screening by PSA

- **False negatives:**

The PSA test may be normal in 1 in 7 men who do have prostate cancer

meaning these cases would be missed

- **False positives:** There are several conditions, not related to cancer, that can cause the **PSA** to be raised e.g. age, vigorous exercise, prostatitis, urinary tract infection, some medications.

- These men would be told *wrongly* that they have cancer.

- **It does not differentiate between slow-growing and fast-growing prostate cancers.**

- Most men do not have aggressive tumours, they die *with* it, not *because* of it.

https://www.evidentlycochrane.net/screening-earlier-detection-of-disease-is-not-necessarily-better/ 3.5.24

Contingency table (2 X2)

- **A contingency table**, also known as a confusion matrix, is used in statistics to summarize the performance of a classification algorithm. Here's an example of a ***contingency table***:
- To calculate sensitivity, also known as the true positive rate or recall, you can use the following formula:
- **Sensitivity** = TP+FNTP
- Sensitivity measures the proportion of actual positives that are correctly identified as such. It's a measure of the test's ability to detect the condition when the condition is present. If you have the actual numbers for TP and FN, you can calculate the sensitivity by substituting those values into the formula.
- **Specificity** (True Negative Rate): Measures the proportion of actual negatives correctly identified. Specificity=TN+FPTN
- **Positive Predictive Value** (PPV): Measures the proportion of positive test results that are true positives. PPV=TP+FPTP
- **Negative Predictive Value** (NPV): Measures the proportion of negative test results that are true negatives. NPV=TN+FNTN
- To calculate these values, you would need the actual numbers for TP, TN, FP, and FN from your data. Once you have those, you can substitute them into the formulas to get the respective values.

	Condition Positive (True)	Condition Negative (False)
Test Positive	True Positive (TP)	False Positive (FP)
Test Negative	False Negative (FN)	True Negative (TN)

PREVENTION

Saving Lives & Money

STUDENTS WILL HAVE A HEALTH SCREENING BEFORE ENTERING

Conclusion-1

- **Screening Importance :**

We've learned that screening is a critical tool in preventive medicine.
It allows for the early detection of diseases, which can lead to better outcomes and, in some cases, can prevent the development of disease altogether.

- **Understanding Metrics :**

We've delved into the significance of understanding *sensitivity, specificity, and predictive values*.
These metrics are essential for evaluating the effectiveness of a screening test and understanding its limitations.

- **Ethical Considerations :**

We've discussed the ethical implications of screening, including the potential for *overdiagnosis* and the importance of ***informed consent***.

Conclusion-2

- **Public Health Impact** :

- We've seen how screening programs can have a profound impact on **public health**, reducing the ***burden of disease*** on a population level.

- Remember, the ***goal of screening*** is not just to find disease, but to improve health outcomes.

- As future medical professionals, you will be tasked with balancing the benefits of ***early detection*** with the risks and costs associated with screening programs.

- Always consider the **evidence base**, the patient population, and the individual patient's values and preferences when deciding on the use of screening tests.

Thank You

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