340.721 Epidemiologic Inference in Public Health I

PRE-Activity Questions:
Validity & Reliability

The Activities provide experience in applying epidemiologic methods, interpreting findings, and drawing inferences. Activities will be discussed during the LiveTalks. Students are expected to work with their assigned Course Group prior to the start of each LiveTalk.

Prior to each Activity, students are to complete the corresponding set of PRE-Activity Questions. Each set of PRE-Activity Questions consists of 10 graded multiple choice questions. The graded multiple choice questions are to be completed via CoursePlus by the date and time listed in CoursePlus. PRE-Activity Questions prepare you for a productive and collaborative experience during the Activities.

Expectations for the PRE-Activity Questions

1. *Individually, read and attempt to answer all PRE-Activity Questions.*

2. *"Meet" or communicate with fellow students discuss challenging concepts, questions and compare answers. You may refer to their course materials and are strongly encouraged to collaborate with fellow students to complete the PRE-Activity Questions.*

3. *PRE-Activity Questions are due to Courseplus by the date listed on the syllabus. Although group collaboration is encouraged to complete the PRE-Activity Questions, each student must individually submit the PRE-Activity Questions.* ***Without exception, no credit will be given for submitting the PRE-Activity Questions after the due date****. The lowest PRE-Activity grade will be dropped when calculating the overall course grade.*

Motivation
In this course, you have learned about validity and reliability. In this assignment, you will apply these concepts to the use of diagnostic and screening tests. Some motivating questions to think about are: How do you know how "good" a test is? Is there a difference between a test that identifies more people with the disease and a test where more people that test positive have the disease? When would you want one over the other? What about negative tests and people without the disease? If you want to identify more people that possibly have the disease, how could you do this? What if you want to rule out more people without the disease?

This assignment corresponds to:
Lectures: Validity; Reliability
Readings: Gordis text (5th ed.) Chapter 5

Introduction
In this assignment, you will calculate sensitivity, specificity, positive predictive value, and negative predictive value of diagnostic and screening tests.

Concepts Covered:
- Validity (Sensitivity and Specificity)
- Predictive value (Positive and Negative Predictive Value)
- Determining cut-off points for defining positive and negative tests
- Reliability

Learning Objectives:
1. Define screening
2. Calculate sensitivity and specificity, positive predictive value and negative predictive value
3. Calculate net sensitivity for two tests that are administered one after the other (i.e., sequential testing)
4. Calculate overall percent agreement and percent positive agreement

Diagnostic tests are used to identify disease, based on clinical complaints, abnormal physical signs, and laboratory findings presented by patients. Diagnostic tests include interviews, physical examination, and laboratory measurements.

The purpose of screening is to identify, in an apparently healthy and asymptomatic population, individuals who have sub-clinical disease or are at increased risk for a disease or condition. As with diagnostic tests, screening tests may be interviews or questionnaires, clinical examinations (e.g., school-based hearing examinations or a blood pressure measurement), or laboratory assessments (e.g., measurement of blood lead levels). Persons found to have abnormal results on screening need follow-up diagnostic testing to determine if they have the condition in question; if so, appropriate treatment should be initiated.

No diagnostic or screening test is completely accurate (valid). The accuracy of a test is characterized by two properties: **Sensitivity** and **Specificity**. Sensitivity measures the probability that an individual with the disease will be correctly identified as having the disease. Specificity represents the probability that an individual without the disease will be correctly identified as *not* having the disease.

A. Validity and Predictive Value of a Screening Test for Heart Disease in School Children

A school nurse examined a population of 2,000 school children in an attempt to detect (preclinical) heart disease. Assume that the prevalence of heart disease in this school-age population is known to be 10%. The sensitivity of the nurse's examination is 80% and specificity is 80%.

Fill in the 2x2 table based on the information provided above:

		Heart Disease		Total
		Yes	No	
Nurse's Diagnosis	Yes			
	No			
	Total			2000

(HINT: Multiply the prevalence provided by the total population to determine how many children have heart disease. Then use the sensitivity and specificity to calculate how many children the nurse classifies as 'positive' and 'negative' for having heart disease.)

Question 1

Based on the information provided in this assignment how many children were labeled "positive" by the school nurse?

a. 360
b. 520
c. 1480
d. 1800

All school children who are labeled as "positive" (i.e., suspected of having heart disease) by the school nurse are later sent for examination by a physician. The sensitivity of the physician's examination is 90% and its specificity is also 90%.

Fill in the 2x2 table based on the information provided above.

		Heart Disease		Total
		Yes	No	
Physician's Diagnosis	Yes			
	No			
	Total			

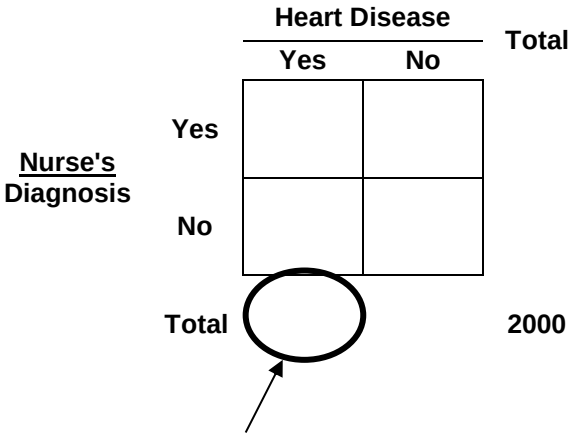
Question 2

Based on the information provided in this assignment, how many children were examined by the physician (after they were examined by the school nurse)? How many children were labeled "positive" by the physician?

a. 520 examined by the physician; 160 labeled positive by physician
b. 160 examined by the physician; 144 labeled positive by physician
c. 200 examined by the physician; 160 labeled positive by physician
d. 520 examined by the physician; 180 labeled positive by physician

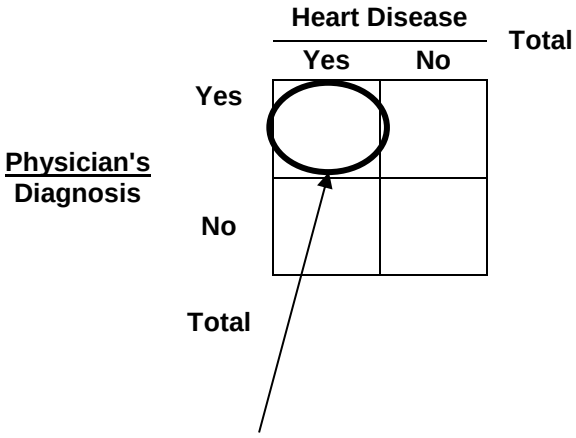
Divide the total number of children who had heart disease and were labeled as "positive" by the physician by the total number of children *with heart disease* who were screened and multiply your answer by 100%. This number is the *net sensitivity* when two tests are administered one after the other (this method of screening is referred to as 'sequential' screening in your textbook.)
(HINT: It may help to copy the information from the 2x2 tables for Questions 1 and 2 to the 2x2 tables below.)

First, all children are screened by the nurse:



Total number of children with heart disease who were screened

Then, children who test positive on the nurse's test are screened by the physician:



Total number of children with heart disease who are labeled "positive" by the physician

Another way to calculate net sensitivity when tests are administered one after the other is by using the following formula:

$$(Sensitivity\ of\ Test\ 1)\ \times (Sensitivity\ of\ Test\ 2)$$

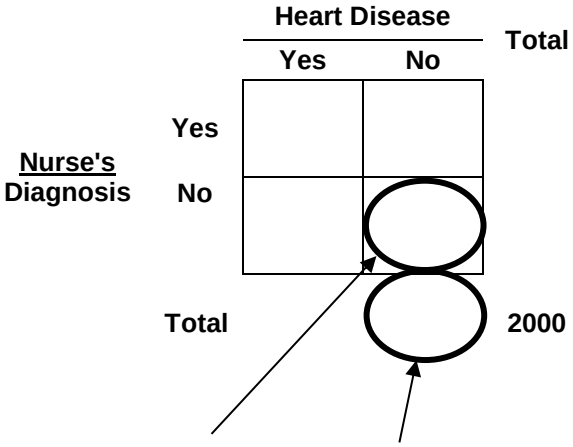
Question 3

What is the *net sensitivity* of the two tests when the all children are first screened by the nurse and the children who test 'positive' are then screened by the physician?

a. 28%
b. 72%
c. 80%
d. 90%

Now add the total number of children who did not have heart disease and were labeled as "negative" by the nurse to the total number of children who did not have heart disease and were labeled as "negative" by the physician. Divide that number by the total number of children *without heart disease* and multiply your answer by 100%. This number is the *net specificity* when two tests are administered one after the other (i.e., in 'sequential' screening).

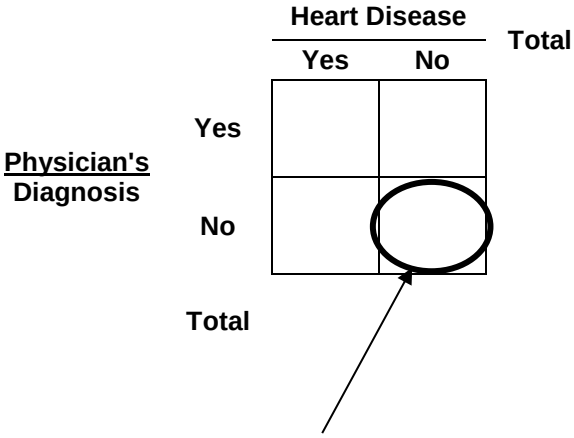
(1) First, all children are screened by the Nurse:



Number of children without heart disease labeled 'negative' by the nurse

Total number of children without heart disease

(2) Then, children who test positive on the Nurse's test are screened by the Physician:



Number of children without heart disease labeled 'negative' by the physician

Another way to calculate net specificity when tests are administered one after the other is by using the following formula:

$$(Specificity\ of\ Test\ 1 + Specificity\ of\ Test\ 2) - (Specificity\ of\ Test\ 1\ \times Specificity\ of\ Test\ 2)$$

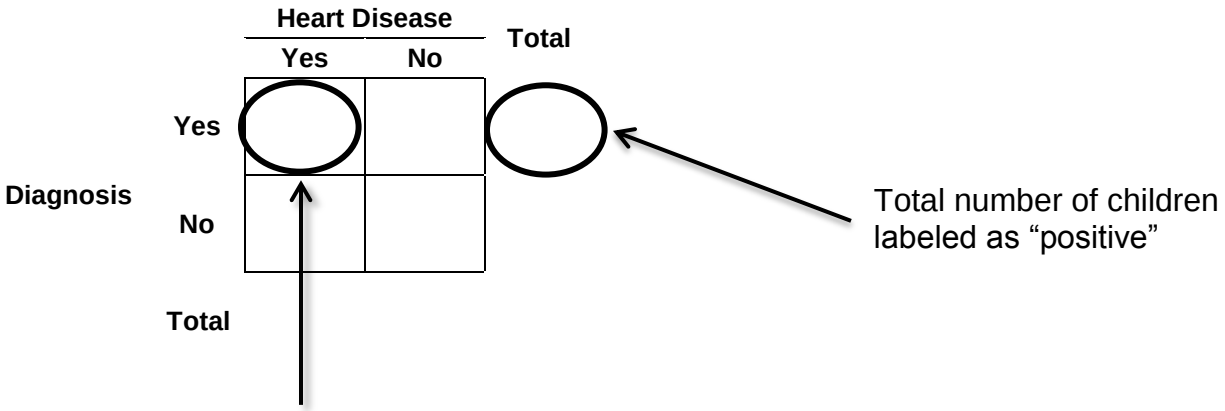
Question 4

What is the *net specificity* of the two tests when all the children are first screened by the Nurse and the children who test 'positive' are then screened by the physician?

a. 18%
b. 80%
c. 88%
d. 98%

When interpreting the results of a particular diagnostic or screening test for a given individual, it is important to know the likelihood that a *positive* or *negative* test result corresponds with actual presence or absence of disease. The **positive predictive value (PPV)** is the probability that an individual with a positive result has the specified disease. The **negative predictive value (NPV)** is the probability that an individual with a negative test does not have the disease. The two measures depend on the sensitivity of the test, the specificity of the test, and the prevalence of the condition or disease in the population of interest.

The **POSITIVE PREDICTIVE VALUE (PPV)** can be calculated as follows:



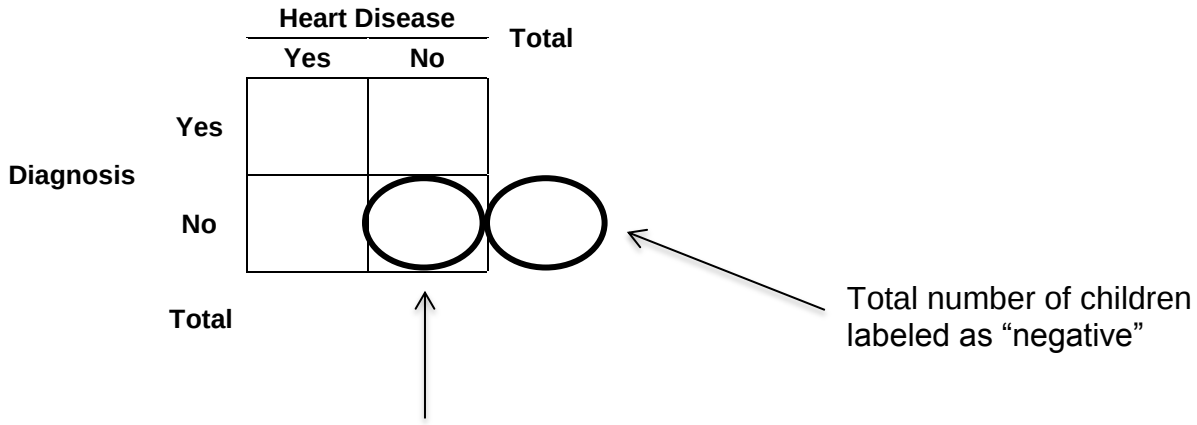
$$\textbf{\textit{PPV}} = \frac{\text{Number of Children Correctly Labeled Positive}}{\text{Total Number Labeled Positive}} \times 100$$

$$\textbf{\textit{PPV}} = \frac{\text{Number of True Positives}}{\text{Number of True Positives + False Positives}} \times 100$$

Alternatively, you can calculate the PPV using the following formula:

$$PPV = \frac{(sensitivity)\times(prevalence)}{[(sensitivity)\times(prevalence)]+[(1-specificity)\times(1-prevalence)]}$$

The **NEGATIVE PREDICTIVE VALUE (NPV)** can be calculated as follows:



$$\textit{NPV} = \frac{\text{Number of Children Correctly Labeled Negative}}{\text{Total Number Labeled Negative}} \times 100$$

$$\textit{NPV} = \frac{\text{Number of True Negatives}}{\text{Number of True Negatives + False Negatives}} \times 100$$

Alternatively, you can calculate the NPV using the following formula:

$$NPV = \frac{(specificity)\times(1-prevalence)}{[(specificity)\times(1-prevalence)]+[(1-sensitivity)\times(prevalence)]}$$

Question 5

Based on the information provided in this assignment, what is the *positive predictive value* (PPV) of the school nurse's examination? (The PPV can be calculated from the completed 2x2 table below or using the formula above.)

		Heart Disease		Total
		Yes	No	
Nurse's Diagnosis	Yes			
	No			
	Total			2000

a. 31%

b. 35%

c. 52%

d. 98%

Question 6

Based on the information provided in this assignment, what is the *positive predictive value* (PPV) of the physician's examination?

		Heart Disease		Total
		Yes	No	
Physician's Diagnosis	Yes			
	No			
	Total			

a. 80%

b. 88%

c. 90%

d. 98%

Complete the following table summarizing the results of this assignment thus far:

	Nurse's test	**Physician's test**
Sensitivity		
Specificity		
Positive Predictive Value		
Net sensitivity*		
Net specificity*		

* Of the nurse's test and the physician's test combined when the nurse's test is administered first and all children who are labeled 'positive' are then tested by the physician

Note: You will need to refer to a copy of this completed table for the Activity.

Question 7

How does the *net specificity* of both tests combined compare to the specificity of the nurse's test and the specificity of the physician's test?

a. Net specificity is *less than* the specificity of the nurse's tests and *less than* the specificity of the physician's test
b. Net specificity is *less than* the specificity of the nurse's tests and *greater than* the specificity of the physician's test
c. Net specificity is *greater than* the specificity of the nurse's test and *less than* the specificity of the physician's test
d. Net specificity is *greater than* the specificity of the nurse's test and *greater than* the specificity of the physician's test

B. Effect of Choosing Different Cutpoints for a Screening Test

Many clinical and/or laboratory tests (e.g. blood pressure, serum cholesterol) yield a quantitative measure rather than a discrete indicator of the presence/absence of abnormality. For these continuous tests, cut-off levels are designated to define disease status. The selection of a specific cut-off level may depend on disease characteristics, treatment availability, and other factors.

A screening test for diabetes was carried out on 580 men using a single blood glucose determination. Subsequently, presence or absence of diabetes was determined independently in all members of the population using a glucose tolerance test. The results are shown in the following table. In this table, a positive test is defined as a blood glucose level above the specified value and a negative test as a blood glucose level below the specified level. For example, for a cut-off blood glucose value of 100 mg %, 68 of the diabetics had blood glucose values above 100 mg % and 2 of the diabetics had blood glucose values below 100 mg %.

Number of Positive and Negative Tests for Diabetes at Specified Blood Glucose Levels (mg %)

Blood Glucose	Diabetes (N=70)		No diabetes (N=510)	
	Test +	Test –	Test +	Test –
80	70	0	504	6
90	69	1	473	37
100	68	2	381	129
110	65	5	263	247
120	62	8	162	348
130	60	10	90	420
140	52	18	45	465
150	45	25	20	490
160	39	31	7	503
170	37	33	2	508
180	35	35	1	509
190	31	39	1	509
200	26	44	0	510

Examine the preceding table and calculate the sensitivity and specificity for diabetes of the blood glucose determination for the 80, 140, and 200 mg levels of blood glucose, using 2 x 2 tables. (Hint: The cells in the table for 80 mg% are filled in for you as an example.)

80 mg%

	Diabetes+	Diabetes-
Test+	70	504
Test-	0	6
Total	70	510

140 mg%

	Diabetes+	Diabetes-
Test+		
Test-		
Total	70	510

200 mg%

	Diabetes+	Diabetes-
Test+		
Test-		
Total	70	510

Question 8

What is the sensitivity for diabetes using a cutpoint of 80 mg %, a cutpoint of 140 mg % and a cutpoint of 200 mg %?

a. 80 mg%: 100%; 140 mg%: 74%; 200 mg%: 37%
b. 80 mg%: 74%; 140 mg%: 37%; 200 mg%: 100%
c. 80 mg%: 100%; 140 mg%: 37%; 200 mg%: 91%
d. 80 mg%: 1%; 140 mg%: 91%; 200 mg%: 100%

C. Reliability

Reliability of a screening or diagnostic test refers to the degree to which the results from a test can be replicated in the same individual under similar conditions. Percent agreement is a measure of reliability that can be used to compare how 2 individuals interpret the same result (i.e., inter-observer reliability).

Use the following information to answer Questions 9 and 10:
Two physicians were asked to evaluate and independently categorize 250 patients using the Beck Depression Inventory.

Classification of 250 Adults' Depression Status by Two Psychiatrists

		Psychiatrist 1			
Psychiatrist 2		Normal	Mild	Moderate	Severe
	Normal	62	5	4	1
	Mild	9	44	6	4
	Moderate	2	13	45	1
	Severe	0	10	16	28

Question 9
Calculate the *overall percent agreement* between the two psychiatrists.

a. 47%
b. 62%
c. 72%
d. 95%

Question 10
Calculate the percent positive agreement between the two psychiatrists excluding patients that both psychiatrists classify as "Normal" (i.e., the *percent positive agreement*).

a. 47%
b. 62%
c. 72%
d. 95