

Sensitivity and Specificity

After completing this unit, students should be able to:

- Define sensitivity and specificity and positive predictive value.
- Use information on sensitivity, specificity, and prevalence to calculate the probability of having a condition given a positive test for it.

Definitions

Suppose a diagnostic test is performed on 550 people, with the following results.

	Disease Status		Total
	Has disease	No disease	
Test result: Positive	120	40	
Test result: Negative	30	360	
Total			

Which box represents

- true positives?
- false positives?
- true negatives?
- false negatives?

What is the sensitivity of the test?

What is the specificity of the test?

	Disease Status		Total
	Has disease	No disease	
Test result: Positive	120	40	
Test result: Negative	30	360	
Total			

What is the positive predictive value (PPV) of the test?

What is the negative predictive value (NPV) of the test?

HIV testing

The standard test for the HIV virus is the enzyme-linked immunosorbent assay (ELISA), also known as the EIA (enzyme immunoassay), that tests for the presence of HIV antibodies in the blood. According to the U.S. Preventative Services Task Force's 2005 report, "A large study of HIV testing in 752 U.S. laboratories reported a sensitivity of 99.7% and specificity of 98.5% for enzyme immunoassay."

If a person tests positive on the ELISA test, a confirmatory test, called the Western blot test, is carried out. If this is positive, the person is assumed to have the HIV virus.

We will focus on the ELISA test.

- A sensitivity of 99.7% means that for every 1000 people who...
- The specificity of 98.5% means that for every 1000 people who ...
- The Center for Disease Control estimates that 1.1 million people in the US are infected with HIV (as of 2016).

Assume that a large group of people in the US are tested using the ELISA test. If a person tests positive, what is the chance that this person has the HIV virus?

First, make a guess on PollEv.

- A. 20%
- B. 40%
- C. 60%
- D. 80%
- E. 95%

Now, diagram out what would happen in a large group of, say, 100,000 people in the US.

How can this be correct? How can the chance that you actually have the disease be so low if the test is so accurate (high sensitivity and specificity)?

What is the difference between sensitivity and PPV? For HIV testing, which one is very high and which one is very low?

Analogy: suppose you are looking through a bunch of undated photos of your Irish mom when she was a kid.

- What is the probability that your mom is wearing green, given that the photo was taken on St. Patrick's Day? (high, medium, or low)
- What is the probability that the photo was taken on St. Patrick's Day, given that your mom is wearing green? (high, medium, or low)

Covid Testing

Example. On campus covid testing uses a PCR test. An article by the College of American Pathologists gives a sensitivity for the PCR covid test of 80% and a specificity of 98 - 99%. We'll use the 99% figure, which also agrees with info on the Carolina Together Testing page.

- a) Suppose you go to get routine, asymptomatic covid testing on campus and you get a positive covid test. What is the chance that you actually have covid?
- b) Suppose you get a negative covid test? What is the chance that you actually have covid anyway ?

Note: we will need to estimate the probability that an asymptomatic UNC student actually has covid, i.e. the prevalence of asymptomatic covid.

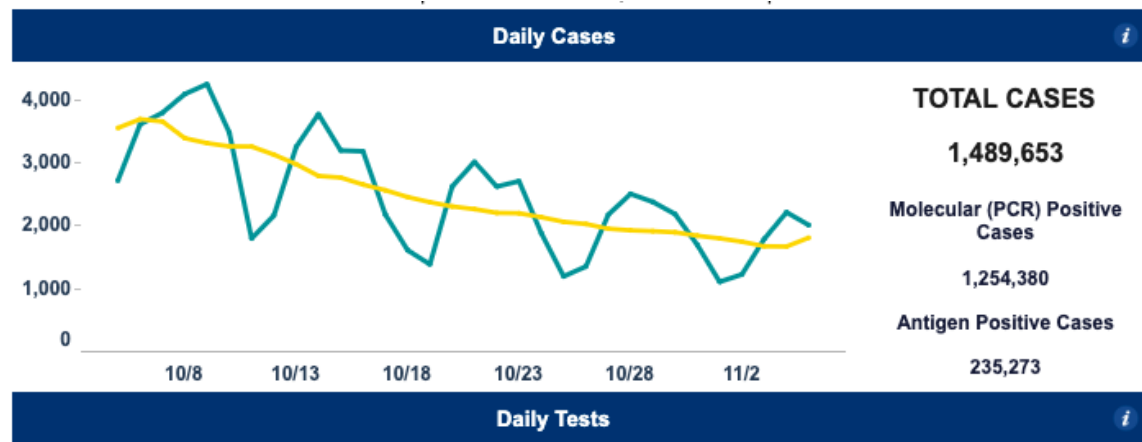
One way to estimate the prevalence of asymptomatic covid among UNC students is to look at the testing stats on the Carolina Together Dashboard. During the week of October 29 - November 4, there were 2,159 asymptomatic students who got tested and 6 tested positive.

Based on these numbers, what is the prevalence of asymptomatic covid among UNC students?

Why might this estimate not be completely accurate?

Another way to estimate the prevalence of asymptomatic covid is to use facts about covid cases in North Carolina. Here are some facts that may help.

- The CDC's Covid Disease Burden page estimates that from February 2020 to May 2022, 1 in 4.2 total covid-19 infections were reported.
- North Carolina covid 19 daily reported cases are in this chart from the North Carolina Department of Health and Human Services.



- According to a November, 2020 article in Nature, 17% of people infected with covid-19 are asymptomatic.
- The CDC page on Duration of Isolation for Adults with Covid-19 says that "replication-competent" virus is detectable for about 10 days.

Estimate the prevalence of asymptomatic covid as follows:

1. Estimate the number of new covid 19 cases reported in NC each day in early November from the chart.
2. Estimate the number of actual new covid 19 cases each day in NC, if we assume only 1 in 4.2 is reported.
3. Estimate the number of asymptomatic new covid cases each day in NC, if we assume 17% of infections are asymptomatic.
4. If we assume that every person who has asymptomatic covid has detectible levels of virus for 10 days, estimate the number of people with asymptomatic covid in NC right now.
5. Estimate the fraction of the NC population with asymptomatic covid. You will need to look up the NC population.

Now, use the sensitivity of 80% and a specificity of 99%, along with the prevalence that we just estimated, to determine

- a) the chance that you have covid, given that you test positive (and are asymptomatic)
- b) the chance that you have covid, given that you test negative (and are asymptomatic)

Syphilis Testing

Extra Example. There are two different classes of tests for syphilis - the nontreponemal tests (RPR) and the treponemal tests (antibodies). The nontreponemal tests (RPR) are used as the first step in screening because they are cheap and quick. A positive result on the nontreponemal test (RPR) is then followed by the more specific treponemal test (antibodies) for confirmation of the positive result.

According to a 2016 update to the US Preventative Services Task Force Recommendation, RPR has a sensitivity of 86% (for the initial stage of infection) and a 98% specificity.

The CDC Sexually Transmitted Disease Surveillance Report 2017 reports that in 2017, there were 9.5 cases per 100,000 people in the US.

If you get a positive test RPR test, what is the chance that you actually have syphilis? Does this probability change if you have symptoms of syphilis (e.g. rash).