Carnegie Foundation
for the Advancement of Teaching

1.9-C

Percentages and Probabilities in Medical Testing

Health Care

SPECIFIC OBJECTIVES

By the end of this lesson, you should understand that

- a percent has different uses, including being used to express the likelihood (or probability) of a certain event.
- it is important to select the correct comparison value and reference value when calculating percentages.

By the end of this lesson, you should be able to

- extract relevant information from a table.
- select the appropriate values to calculate probabilities.

PROBLEM SITUATION: HIV TESTING

Lilia is a screening counselor in an HIV testing clinic called the ScreenMe Clinic. The Human Immunodeficiency Virus (HIV) is a virus that damages the body's ability to defend against sicknesses. There are effective treatments for people with HIV. But, there is no cure for HIV. This means that once you have HIV, you have it for life. HIV can, but doesn't always lead to AIDS.[1] 1.2 million people in the United States are infected with the HIV virus. 1 in 7 people with HIV are unaware of their infection.

If you think you may have been exposed, it is important to get tested for HIV. Knowing if you have HIV can help prevent spreading the virus. Unfortunately, HIV cannot be cured by medicine. But, there are medicines available to help prevent it from turning into AIDS.

As a screening counselor, Lilia gives HIV tests and counseling to clients about results. There are several HIV tests available. The ScreenMe Clinic uses the ELISA test. Often clinics use the ELISA test because it can be done using saliva or blood. It can provide quick results. This is important because sometimes people who get tested do not come back to get their results. About 30-39% of people who get tested for HIV do not return for the results. With the ELISA test, almost all clients receive their results because clinics provide the results during the testing visit.[2]

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[1] http://www.cdc.gov/hiv/basics/index.html.
[2] http://www.cdc.gov/hiv/testing/lab/clia/rtcounseling.html.

The problem is the ELISA test is not always accurate. Sometimes the test returns a positive result even though the person does not have HIV. Lilia has to share results with patients. This can be complicated and difficult. Here is an example: Imagine a person takes the ELISA test. He tests positive for HIV. Lilia has to tell him: "Your preliminary test result is positive. But, we do not know for sure if you are infected with HIV. We need to get the results from a confirmation test. In the meantime, you should take precautions to avoid passing the virus to other people."[3]

An example of a confirmation test is the Western Blot test. The patient is tested using the Western Blot test to confirm that the ELISA result is correct. Results from the Western Blot test can take over two weeks to come back, but are accurate.

Patients in this situation get very upset. Often they suffer from extreme anxiety while waiting for the results from the Western Blot test. Lilia wants the clinic to consider a different type of screening test. She needs you to analyze ELISA test data. You must help Lilia determine if ScreenME should continue to use the test, or look for a new one. Data will include information about how often the ELISA test provides results that are not accurate.

You will analyze the likelihood or chance of getting accurate or inaccurate results. You will study "probability." The probability of an event is the likelihood that the event occurs. Probabilities are often represented by percentages. For example, if a fair coin is flipped, there is a 50% chance it will land heads. This is because there are only two equally likely outcomes: heads or tails. "Heads" is one of those outcomes: 1 out of 2 = 1/2 = 0.5 = 50%.

(2) We know from the problem situation that 1 in 7 people infected with HIV in the U.S. do not know they have it. What is the probability that a person who is infected with HIV is unaware they have the virus?

(3) Lilia finds data on test results of a million people who were screened for HIV with ELISA, including the actual HIV status of those who were screened. Some of what she finds is presented below in Table 1. Fill in the empty cells in Table 1.

Table 1

	Carry HIV	No HIV	Total
Positive ELISA result	4885	73630	
Negative ELISA result	115		
Total		995,000	1,000,000

[3] Taken from the CDC counseling guidelines: http://www.cdc.gov/hiv/testing/lab/clia/rtcounseling.html.

Use the numbers in Table 1 to answer the questions below. You will use the numbers in the table to decide on the probability that this test gives correct and incorrect results. Report probabilities in percentages (%). Be careful about which numbers you use for the numerator and denominator in your calculations.

(4) If a person has HIV, what is the probability that their ELISA test will come back positive? (Answer to the nearest percent.)

(5) If a person does not have HIV, what is the probability that their ELISA test will come back negative?

(6) Based on the above answers, would you say that ELISA is an accurate screening test?

(7) (a) Given that the ELISA test is not always accurate, it is possible that the test can fail to identify HIV in someone who carries HIV. This is called a false negative. Suppose that a person carries HIV. What is the probability that this person's test will receive a negative test result? (Round your answer to the nearest one-hundredth of a percent)

(b) If a person tests negative using ELISA, should they feel confident that they don't have HIV?

(8) (a) Is there also the possibility of a false positive? Explain your answer.

(b) What is the probability that a person who does not carry HIV will receive a positive test result?

(9) After seeing the answer for 8(b), reconsider Question 7(b). Do you think ELISA is an accurate test? Write Lilia a short note explaining why you think ScreenMe should continue to use the ELISA test or replace it. Be sure to use your calculations. Write your note using complete sentences.

(10) At ScreenMe, if someone does get a positive result for HIV using the ELISA screening test, they are given the Western Blot Test. This test is 100 percent accurate in identifying HIV. However, the Western Blot test costs $200, whereas the ELISA test costs $75 and is more readily available to healthcare workers.

Do you think the ELISA screening test is a cost-effective way to identify HIV-positive status? Why or why not? Write your answer in **two or three complete sentences**.

MAKING CONNECTIONS

Record the important mathematical ideas from the discussion.

FURTHER APPLICATIONS: USING PERCENTAGES TO DESCRIBE THE ACCURACY OF MEDICAL TESTS

Some athletes use performance-enhancing drugs (PEDs) to improve their performance in sports. Schools, sports leagues, and other sports organizations usually do not allow the use of PEDs. These groups can administer or give athletes a blood or urine test to determine whether the athletes are using drugs.

Imagine a situation in which 500 athletes have undergone a test to determine if they use PEDs. A positive (+) test result indicates or shows that the athlete is using a PED. A negative (–) test result indicates the athlete is not using these drugs. However, this test is not 100% accurate. This means that some errors may have occurred in the test results. The table below shows how often the test correctly determined if athletes used PEDs.

	Athletes Using PEDs	Athletes Not Using PEDs	Total
Positive Test Result	9	5	**14**
Negative Test Result	1	485	**486**
Total	**10**	**490**	**500**

(1) **False Negatives**: The table shows that one athlete who was using PEDs received a negative test result. This means the test incorrectly identified this single athlete. What percentage of athletes who are using PEDs incorrectly test negative?

Hint: Think about the ratio of the number of incorrect negative results compared to the number of athletes who were using PEDs.

(2) **False Positives:** The test also produced false positives. This means the test gave a positive result to some athletes who had not used PEDs.

Hint: Think about a situation in which a school principal receives a positive result on a PED test for a student athlete. Answer these questions:

(a) What is the chance the result is a false positive?

(b) How should the principal think about this percentage? What should the principal do with this information?