Measuring Burden of Disease

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In this lecture, I will talk about the burden of disease using two terms, prevalence and incidence.

Prevalence

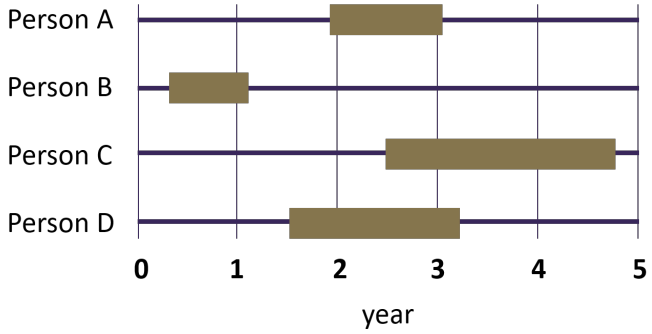
Let's start with prevalence. **Prevalence** is the frequency of disease in a defined population at a specific time. In other words, how common is the disease at a specific time? Prevalence is also called point prevalence because it determines the disease occurrence in a snapshot of time. Time is considered to be frozen in prevalence, and we can think of time as calendar time or some other timescale.

In this figure, the gold people represent diseased individuals and the purple people represent non-diseased individuals. At a specific time point, the prevalence can be calculated as the number of people with disease divided by the size of the population. Here the prevalence is 2 divided by 6, which equals 0.33, when multiplied by 100, equals 33%.

In this example, we have 100 individuals who were evaluated on January 1, 2021. 10 people met the case definition for rheumatic fever. So, for calculating the prevalence, we would look at the number of persons with disease at a specified time. These are the number of prevalent cases, which is the numerator. The size of the population is the denominator. Therefore, the

prevalence would be 10/100 or 0.10 (multiplied by 100 gives us 10%). We can interpret this result as "the prevalence of rheumatic fever on January 1, 2021, in this study population as being 10%." Note that for the prevalence we must specify the time point. Prevalence is a proportion, and so it has no mathematical unit. It is not a prevalence rate; it's a proportion.

Think about this graph for a moment. Each line represents a person in a population, and the x-axis represents time in year. If we are interested in calculating the prevalence, what would the prevalence be in this particular population at year 1? Pause the video while you write down your answer. When you're ready to continue with the lecture, press the play button.



The answer is 25%. At year 2, it is 50% because two individuals are in the disease state at that specified point in time out of a population of four total individuals. So 2/4 equals 0.5 (multiplied by 100 gives us 50%).

The prevalence and duration of disease are very tightly linked because the probability of being in a diseased state is proportional to the duration of that disease. If the diseased state lasts longer, there's a much higher chance that when we measure prevalence, we will find a person in that diseased state. So, prevalence in fact may be biased toward cases that are more chronic. This is an important factor to remember.

Screening is very similar to a prevalence survey because cases with a longer duration are more likely to be detected. However, cases that are detected, because they have a longer duration, may also be those same cases that develop more slowly and end up with a better prognosis. As a result, if we use screening to detect a particular disease, the number of cases may appear to be low. This is an important characteristic of prevalence that we need to take into consideration.

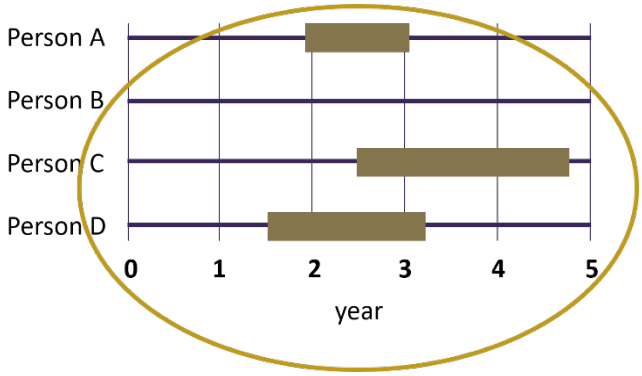
Incidence

Now let's talk about incidence. In contrast to prevalence, which measures the frequency of existing cases, **incidence** measures the frequency of disease events or new cases over a specific

period of time. How rapidly do people develop the disease over time? For incidence, time is not frozen. There are two types of incidence: the incidence proportion, or cumulative incidence, and the incidence rate. Incidence rate is more commonly used since it's applicable to open and closed populations whereas a cumulative incidence requires a closed population. Recall that this is a less common occurrence in most cases.

For a closed population, all members of the population are initially at risk and all of them are followed for the same time. The **cumulative incidence** is defined as the number of people who develop the disease among the number of people who were initially at risk. It is also called the incidence proportion. Cumulative incidence doesn't consider when the disease occurred within the time period of interest. We need a closed population in which all individuals who are initially at risk are followed for the same period of time in order to directly calculate the cumulative incidence.

In this example, all the individuals are initially at risk and followed for 5 years. The cumulative incidence over the 5 years in this population is 3 divided by 4 because person B did not develop the disease. The cumulative incidence has no mathematical unit, and, since it is a proportion, it ranges from 0 to 1.



Let's look at an example of calculating cumulative incidence where 100 people were observed in a refugee camp for a two-year period. Seventeen develop pneumonia during this time. What is the two-year cumulative incidence of pneumonia in this population? Pause the video while you calculate the answer. Then press play to continue with the lecture.

The two-year cumulative incidence of pneumonia in this study population is 17/100, or 0.17.

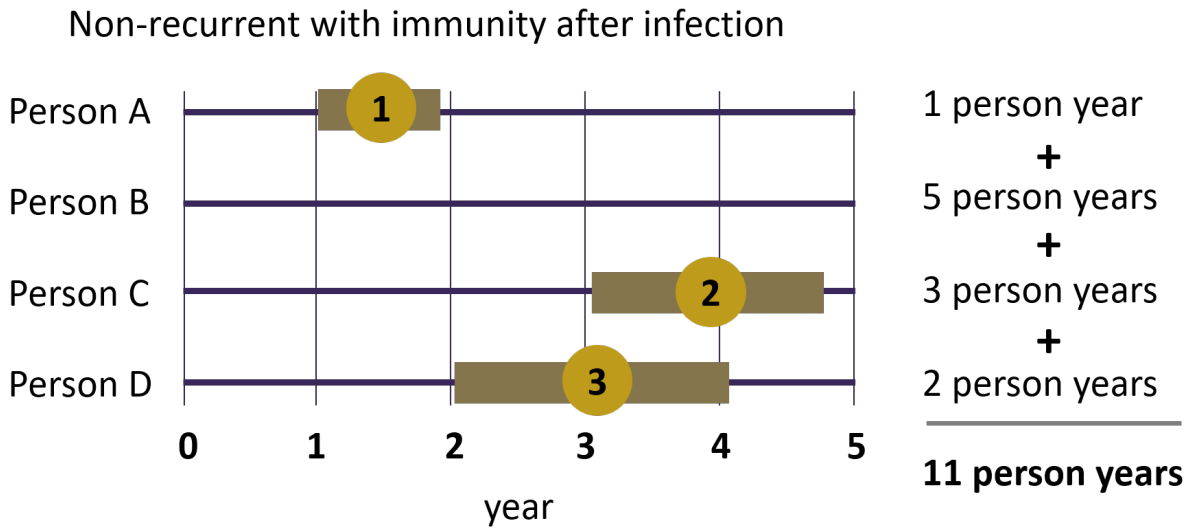
For a specified population who are initially at risk for the disease, for a specified population of people at risk of disease who may be followed for different amounts of time for the onset of disease, we can calculate the **incidence rate**. This is also known as the incidence density or the person-time incidence rate. To calculate the incidence rate, we use the number of incident events as the numerator and divide this by the amount of person-time at risk for the disease or the condition as the denominator.

If we don't know the exact amount of time at risk for each person in the population, we can estimate person-time at risk as the average, or mean, number of individuals at risk multiplied by the duration of the study period. It could be person days, person years, or any other unit of

time measurement. **At risk** really means susceptible. So, we would include only individuals who are susceptible in that at-risk population.

Incidence rate is more commonly used as it is applicable in both open or closed populations and applies to a broader range of questions. So, let's have an example.

In this closed population, we can see that the number of incident events is 3. Let's say this event is non-recurrent and people develop immunity after the infection. Remember, we calculate events and not individuals. Person A developed the disease after one year of enrollment.



Person A contributed one person-year at risk. After year 1, person A can no longer contribute person-time at risk. Person B has not developed the disease at the end of year 5 and so contributed 5 person-years at risk. Person C contributed 3 person-years at risk, and Person D contributed 2 person-years at risk. We can add up the at-risk time for each individual before they develop the disease. In this case, it is 11 person-years.

The numerator is the number of incident events, and the denominator is the total person time at risk. So, the incidence rate is 0.27 person-years as shown here, which translates into 270 per 1000 person-years. And that's how the incidence would be reported. Incidence rate is expressed as a rate; the units include time, and the range is 0 to infinity.

So, calculating the incidence rate with this example, there are 110 new injuries from car accidents detected in 2020 in community X. In June, the population of the community is 2,200 people. So, what is the incidence rate of car accident injuries in 100 person-years? Pause the video while you calculate the answer. Once you are ready to continue the lecture, press play.

The incidence rate of car accident injuries is 110/2200 person-years times 1 year, which equals 1/20 person-years, or 5 per 100 person-years.

There are other types of incidence; for example, **case fatality**, which measures the risk that if a person gets a disease, they will die of that disease. The numerator is the number of deaths from the disease, and the denominator is the number of cases people who are initially at risk of dying of that disease.

Proportional mortality is the burden of mortality due to a specific disease out of all causes of death. Again, the numerator is the number of deaths from a certain disease, and the denominator is the total number of deaths.

In this lecture, you learned the definition of some measures of disease frequency including prevalence, cumulative incidence, and incidence rate. You also learned how to calculate these proportions and rates.