Module 2: Measuring Health and Disease

Slide 1: Introduction

Hello and welcome to Module 2: Fundamentals of Epidemiology. This presentation will focus on measuring health and disease. My name is Krissy Simeonsson and I am an Assistant Professor of Public Health and Pediatrics at East Carolina University, Brody School of Medicine.

Slide 2: Acknowledgements

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Slide 3: Objectives

At the end of this presentation, students will be able to define epidemiology and recognize some of its uses, interpret the distribution of disease according to person, place, and time, and finally calculate measures of disease occurrence and severity.
Slide 4: What is Epidemiology?

So, let’s begin with the question, what is epidemiology, really? Epidemiology is the study of health and disease among populations. It is a basic science and foundation of public health and it really answers the questions for us, what causes disease, how does disease spread, how can we prevent disease, and how can we control disease?

And questions that are often asked by epidemiologists include: why is cancer on the rise, how widespread will the next flu outbreak be, why do some families seem to have more heart disease than others, and what parts of the country have the higher rates of multiple sclerosis or other diseases?

Slide 5: Use of Epidemiology

So, what are some of the uses of epidemiology? We use epidemiology to identify risk factors for disease, as well as identify the cause or etiology. We can use epidemiology to determine the extent of disease in a population. We can use it to study the natural history and prognosis of a disease or illness. We can use epidemiology to evaluate existing or new preventive and therapeutic measures. Finally, we can use epidemiology to provide a foundation for developing public policy and regulatory decisions. So, you can see from this slide that there are many uses of epidemiology and it is around us every day as we are working in healthcare.
Slide 6: Definition of Epidemiology

This is a definition for epidemiology that is from an appropriately named Dictionary of Epidemiology from the fourth edition, 2001. And it says, “epidemiology is the study of distribution and determinants of diseases or other health-related outcomes in populations and the application of this study to control health problems.” The key pieces of this definition really are the distribution of disease in a population, which we will talk about shortly, and also the determinants of diseases or other health-related outcomes in populations. There is another module in this series that focuses on determinants of health if you are interested in learning more about that.

Slide 7: Distribution of Diseases

So, let’s talk a little bit more about the first part of that definition, regarding the distribution of disease in a population. Epidemiologists spend time looking at the distribution of disease in a population and they analyze disease patterns based on these three factors: person, place, and time. In other words, they are answering the question: who is getting the disease, where is disease occurring, and how is it changing over time?

Slide 8: Acute Hepatitis B

This is an example looking at acute hepatitis B, a viral hepatitis infection, and it’s showing data for cases of acute hepatitis B distributed by person. This graph is looking at males versus females, with acute hepatitis B, in the year 2006 in the United States, and it breaks it down by age groups as well. So, along the left-hand side of the graph is age group in years, starting with the youngest children at the top, going up to adults over 60 at the bottom. We can quickly orient to person and notice that there are age groups that seem to have a higher incidence of acute hepatitis B, primarily 25-29 year olds up through 40-44 year olds. And we can also quickly see with this graph, the distribution for person, that males seem to have a higher incidence of hepatitis B overall, than females. So, this is an example of the distribution of disease in a population, the distribution of hepatitis B, by person.
Slide 9: Acute Hepatitis B

This is again data looking at acute hepatitis B, but now we are orienting to place. We’re looking at the incidence of acute hepatitis B in the United States in 2007, and we are showing the incidence, or number of new cases of hepatitis B, by county. So again, we are able to quickly see, there are hot spots in the United States where hepatitis B seems to be more of a problem than in others. You can see on this county distribution map for the United States that counties with the darkest blue shading have the highest incidence of acute hepatitis B.

Slide 10: Acute Hepatitis B

Finally, we talk about the distribution of disease in a population by time. Again, we are still looking at the same disease, acute hepatitis B, and we are looking at the incidence or number of reported cases per 100,000 population over time, from 1982 to 2008 in the United States. And so, what we are able to see here is how has the disease, hepatitis B, changed over time? You can see that there has been a steady decline occurring since the late 1980s, and now we are down to approximately 2 to 3 cases per 100,000 population in 2008.

Slide 11: Measures of Morbidity & Mortality

So, now that we have talked a little bit about the background, in terms of what is epidemiology, and how do we describe cases, in terms of person, place, and time, let’s move on to the real meat of this lecture, which is talking about how we measure morbidity and mortality, or how we measure health and disease in a population. The remainder of this talk is going to focus on different measures of morbidity and mortality. We are going to talk about counts of disease, then we are going to spend some time talking about prevalence, which is actually a proportion, so, prevalence of disease. And finally we are going to talk about some rates at the end, and specifically we are going to talk about incidence rates, attack rates, mortality rates, case fatality rates, and infant mortality rates. There are many more types of rates and proportions that we could talk about, but it goes beyond the scope of this lecture, so these are the ones that I would like to highlight for you today.
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Slide 12: Counts

So, let’s start first with talking about counts. This is the most basic tool that epidemiologists have. It is a measure of disease frequency and it is simply just the number of cases or other health outcomes being studied.

Slide 13: Cholera

One example of counts that we can look at every year is from the CDC, or Centers for Disease Control *Morbidity and Mortality Weekly Report Summary of Notifiable Diseases*. The CDC puts this report out every year and it gives us an idea of how many cases of diseases are reported in the United States. There is a list of over 80 or 90 diseases that can be reported by states to the Centers for Disease Control and then they put out this list and report every year. So, this is just one example of one of the diseases that’s on the list: cholera, not a disease that we see very commonly. It just shows you, the count, or number of reported cases of cholera, that we had in the United States, in 2008. You can see that there were not very many cases at all, there was approximately 5 cases total and you can quickly see what states reported cholera. And again, it’s not possible to make comparisons between states looking at this, because we don’t have denominator data, all we have is the counts. But counts are important, to help us to be able to plan for public health response. So, knowing the actual number of cases can help us plan for what types of healthcare services we need in certain places, based on the number of cases they are reporting.
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Slide 14: Eastern Hemisphere

Another example of counts is shown here, and this is a map of the Eastern Hemisphere, and it is from the World Health Organization’s website, where they are tracking the avian influenza epidemic of H5N1 that has been going on since 2003. This is looking at the number of human cases that have been confirmed. So, these are counts. We don’t have rates, there is not denominator data here, we are not doing it over a set interval of time per year, these are just purely the raw numbers or counts. Again, hard to make a comparison between countries, because we don’t have rates, but the counts themselves are important, because it gives us a quick measure of the number of cases that are occurring and also can help with health service planning, in terms of responding to the avian influenza outbreak.

Slide 15: Prevalence

So, that was counts, and now we are going to turn to prevalence, which is actually a proportion. And prevalence, you have probably heard the term before in the literature, or just people talking about the prevalence of obesity in your community, or the prevalence of this or that. Prevalence really answers the question of how common is this disease, what is the burden of disease in a population? And it really gives us a slice through the population at a set point in time, where you basically are determining who has the disease and who doesn’t. And it is often stated as the percentage, i.e. per 100 people, so you often see prevalence reported as 60% or 15%. We will go through some examples coming up.
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Slide 16: Prevalence Formula

Here is the actual equation or formula for prevalence. Prevalence is the number of cases of a disease present in the population at a specified time divided by the number of persons in the population at that same time. So again, it’s a slice through a population at a given time looking at how many people have this disease at this moment divided by the total number of people in that population.

Slide 17: Prevalence

Looking in a little more detail on prevalence, it’s important to realize that prevalence doesn’t really tell us when disease developed or how long someone’s had it. It basically just tells us, they have the disease or they don’t. So, the numerator is a mix of people with different durations of disease. This is important to realize, because you can’t measure risk (your risk of developing a disease, or your risk of having a disease, with prevalence data). This will make more sense as we talk about incidence, which is coming up next. Prevalence is really a good measure of the burden of disease in a population if it is relatively stable, and it’s a chronic condition. Good examples of this include obesity, diabetes, and hypertension. Prevalence is a good measure of disease for us when we are talking about allocating health resources. If we know that 20% of our community has obesity or is obese, then we can allocate health resources accordingly, to maybe improve physical activity programs and nutrition education programs for example.
Slide 18: Obesity Trends

This slide is showing obesity trends among US adults, over time in the United States, between the period of 1990 and 2009. This is the percentage of adults, US adults, who were obese, divided by the total population in each state. What we can see here with prevalence, again we don’t know when people developed obesity or became obese, we just know in 1990, for example, in North Carolina, approximately 10 to 14% of adult North Carolinians were obese. Compare that to California in 1990, where it was less than 10%, (they had a lighter shade of blue). Follow that to the map representing 1999, where there is now darker colors, you can see that a lot of states with dark shading of blue. You can tell that prevalence in those states of obesity among adults is now 15 to 19%. And then finally, the map in the bottom center for 2009 is showing that obesity epidemic is continuing to increase across the United States. Colorado is the only state now, still in blue, with a prevalence of obesity of 15 to 19%. All other states are reporting obesity of at least 20% or more, in their adult population. So again, this gives us prevalence, and we can quickly get a snapshot of how common obesity is in the different states.

Slide 19: Adults Diagnosed with Diabetes

These are maps that are also talking about prevalence that show us the adults who have been diagnosed with diabetes over time. Again, looking at three different time periods, from 1994 to 2009. This is similar to the maps I showed for obesity in the United States, this is now looking at adults diagnosed with diabetes and again, you get a quick snapshot. If you look in the top left, for 1994, about half of the states had a prevalence of about 5% of adults that were diagnosed with diabetes and the other half were running about 4 to 6% for diabetes for prevalence. Compare that to the US map on the right for 1999 and you can now see that Mississippi has a higher prevalence for diabetes than any other state, with about 7.5 to 9% prevalence among adults for diabetes and then looking at 2009, you can now see that there are many states with that darkest red shading, the prevalence of greater than or equal to 9% for diabetes. So again, a quick snapshot looking at different states and it tells you the burden of diabetes in these different states.
Slide 20: Incidence

So, now we are actually moving on to rates, and, this is important, because if we really want to make comparisons between groups, we want to have rates. Incidence is one of the ones we hear about most commonly and incidence is a measure of the change from non-disease to disease. So, not only do we know who is diseased, but we are actually measuring that change from when you did not have disease to when you suddenly developed it. Therefore, incidence can help us provide a measure of risk. What is someone’s risk for diabetes? What is their risk of acute hepatitis B? When we are talking about risk, we are talking about the probability that an individual will develop a disease over a specified time. And incidence is a measure of risk. It is also known as the incidence rate because again, it is a rate, and it is often stated per 100,000 population per year.

Slide 21: Incidence Formula

So, what is the difference between prevalence and incidence? Well, it’s all right here in this formula. Incidence is the number of new cases of a disease during a specified period of time divided by the total number of people at risk during that period of time. So, circled here in red is the word new, because that is the most important distinction between prevalence and incidence. Prevalence looks at all people with disease in the numerator. Incidence just wants to know about the number of new cases, who is newly diagnosed with disease. So, in other words, people who have had diabetes for five or more years would not be included in an incidence rate for 1999, if they have had diabetes since 1990. They would be counted in the prevalence calculation, but not in incidence.
Slide 22: Incidence

This is one example of where you will often see incidence data. This is data from the Department of Health and Human Services and the National Cancer Institute, looking at lung cancer incidence rates, by gender, comparing males to females. You can make a comparison that the number of new cases of lung cancer was 82.7 per 100,000 men, compared to 55 new cases of lung cancer per 100,000 women. So, you are able to make that comparison right away using incidence rates.

Slide 23: Incidence

This is one more example of incidence rates from the National Cancer Institute. This graph shows how many people out of 100,000 got lung cancer in 2006. The lung cancer incidence rates are grouped by race and ethnicity, as well as gender. As you can see by having the incidence rates here, we are able to compare the rates between the different genders as well as races and different ethnicities.

Slide 24: Incidence Rates

Incidence rates are used in epidemiology to monitor changes over time in disease. Again, make comparisons between groups and you will often see age-specific rates as well as gender or sex-specific rates. And finally, incidence can be used for goal setting. So, we have Healthy People 2020 objectives, where we try to reduce the risk of disease, we try to reduce the number of new cases of diseases being diagnosed, and so incidence helps us with looking at have we met the target objective. We set a goal and have we met it? Let’s look at some examples of these in the coming slides.
Slide 25: Incidence of Acute Hepatitis A

This first graph is looking at incidence of acute hepatitis A, by year, from 1982 to 2006 in the United States. And what you can see is the number of new cases of hepatitis A started to decline in 1995, and this coincided with the availability of a hepatitis A vaccine in the United States. So, it’s able to show us the change over time in the incidence of acute hepatitis A.

Slide 26: Incidence of Gonorrhea

This next graph is showing us the incidence of gonorrhea in 2006 in the United States. So, gonorrhea is a sexually transmitted infection, and we can see that there are differences between men and women in terms of cases of gonorrhea. In 2006, for the 15-19 year old age group for females, there were 647.9 cases of gonorrhea per 100,000 women. Compare that to the male side and there were 279.1 new cases of gonorrhea per 100,000 males. You can make age and sex-specific comparisons by using incidence rates. So, again, if you want to make comparisons and talk about the risk, for a teenage female developing gonorrhea, you can use incidence rates like this.

Slide 27: Incidence Used for Goal Setting

Finally, we talked a little about incidence rates being used for goal setting. So, this is a Healthy People 2010 target, looking at the goal for gonorrhea, where we want our rates to be. So, we want them to be around 20 cases per 100,000 population. Actually, specifically, 19 cases per 100,000 population. So, we have set that goal, and that is shown here on this graph as the little dotted white line going along the bottom. The goal for 2010 was 19 cases per 100,000 population. The yellow line above that is the true number of new cases of gonorrhea diagnosed each year, or the incidence of gonorrhea, each year per 100,000 population. And we can clearly see that we have made some progress when we compare the late 70s to the most current year, 2006, but we still have a way to go in terms of meeting that Healthy People 2010 goal.
Slide 28: Attack Rate

I wanted to take a brief moment to talk about an attack rate, and this is very similar to an incidence rate, and it is used often in outbreak settings, when the nature of the disease is such that the population is being observed for a very short period of time. And it is often when you know there has been a specific exposure. This is very common in foodborne outbreaks, when a lot of people have all attended the same event and everyone seems to get food poisoning afterwards. Rather than talking about diarrheal illness or some other foodborne illness, epidemiologists will talk about the attack rate. And you can use attack rates to compare the risk of disease in groups with different exposures. We will also be talking more about attack rates in an outbreak setting in another module as part of this education material.

Slide 29: Attack Rate Formula

So, this is the formula for an attack rate. If you had a church picnic where everybody brought potluck and you had a lot of people get sick, not long after that picnic, you could calculate an attack rate for each food item that was brought. For example, if people really thought it was the potato salad that made them sick, you could calculate the attack rate for potato salad. And that formula would be the number of people that ate potato salad that developed whatever illness that it was gastroenteritis, food poisoning, whatever you have defined as your illness, and that’s divided by the total number of people who ate potato salad. So, that gives you an attack rate.
So, I have already hinted that there is a relationship between incidence and prevalence, but they are distinct entities. So, prevalence is really just incidence times the duration of disease. Prevalence really depends on the duration of the disease—how long do people survive once they have been diagnosed, can they live a long time with that disease in a chronic state, is it a disease that is very fatal, where they die very quickly? So, there are some diseases for example, chronic hepatitis B, you can live with for a lifetime. You can imagine that although the incidence of hepatitis B might be a certain rate or number per year, the prevalence would probably be more than that, because you can live with it. So, once you become a case, then always a case. The flip side of that is a disease, which is highly fatal. One example would be pancreatic cancer. Most people diagnosed with pancreatic cancer in a year will die within a year or two, so you can imagine that the incidence and prevalence are very similar, because people don’t live for a very long time with pancreatic cancer. Any time there is an increase in prevalence in a population, you have to stop and ask yourself why. It can certainly mean that there is an increased risk of disease, that there is an increased incidence that more people are coming down with this disease, more people are being diagnosed with this disease. So, it could truly reflect an increased risk of disease, if your prevalence is increasing.

However, there is a silver lining to increased prevalence. It may be that people are living longer with the disease, after diagnosis, so fewer people may be dying from the disease, based on new therapy, new technology, etc., so you can have an increased survival. You also may have people who are not responding as well to treatment, meaning they are not being cured, so they are continuing to have their disease for a longer period of time, and that’s obviously not a positive side of it, but certainly is another way to look at it when your prevalence is increasing. Is it because my incidence has increased or is it because the duration of illness has increased? That it could be either people are surviving longer with it, and that is a good thing, or more people are living with it, because we are not able to treat it effectively. So there’s different ways to look at it, and certainly some of it can be good news for increased prevalence and some of it can be bad news. The following slides are going to look at these figures to drive home the point that we are trying to make here between prevalence and incidence.
So, this is a diagram out of Epidemiology, a textbook by Gordis, which is a wonderful book for epidemiology for people that want to read more. This is showing a flask of beads and each bead in the flask is representing a case of disease in a population. And so the level of those beads, where the arrow is pointing, is your prevalence, or the number of cases in this population.

If we add more cases into our population this represents. More cases coming in increases our baseline prevalence. So, whereas we had a certain amount before, adding new cases in, increasing the incidence, also increases the prevalence.
Slide 34: Incidence V. Prevalence

The next slide though, shows how you can actually have a decrease in prevalence by cases no longer being counted. That can happen because people are cured and they no longer have disease or people can die from the disease, so they are no longer counted. So, again, that’s how you can certainly have a decrease in your prevalence for the population, so it could be a positive thing in that people are cured and no longer have disease, or it could be a bad thing in that you have a lot of people that are dying from the disease and so they are not being counted in the prevalence data.

Slide 35: Incidence V. Prevalence

This final slide is just looking at that balance. You always have new cases coming in, representing your incidence, and then you have people that are no longer counted as cases either because they have died or because they have been cured of their disease. So, realize that there really is a relationship between incidence and prevalence, but keep in mind that there are distinctions between the two.

Slide 36: AIDS Incidence, Deaths, and Prevalence

Before we move on to mortality rate, case fatality rate, etc., I did want to look at incidence and prevalence with a disease that we are all familiar with, which is AIDS. This is a graph that is looking at AIDS incidence, so the number of new cases each year, the number of deaths from AIDS, and also the prevalence, so the number of people living with AIDS in a certain year in the United States. And this is great data; it is at almost 20 years of data looking at AIDS cases. What you can see here, is that the mortality from AIDS, or the number of deaths from AIDS, that’s represented in the blue line, increased dramatically in the 1980s, as well as the number of cases of AIDS, and that’s represented in the black line. In the early 80s all the way up to the early 90s, you had a rapid increase in the number of deaths as well as the number of cases being diagnosed. Then in the early 90s, you have a decrease in the
number of deaths, people dying from AIDS, as well as the number of new cases of AIDS being diagnosed. So, the incidence, as well as, the deaths showed some decline. The reason for the decreased number of deaths is certainly due a lot in part to advances with antiretroviral therapy for AIDS, medications for people that were diagnosed with HIV. Certainly the decrease incidence in AIDS, a lot of that can be credited to public health education campaigns, making people aware of lifestyle issues and how to protect themselves from contracting HIV. With the drop in mortality, which is represented in blue, and the lengthening of the lifespan of people living with AIDS, you can see the prevalence, which is in the green line, continuing to go up. So, we had more people living longer, surviving longer with AIDS. The prevalence continued to climb, even though the number of new cases of AIDS had dropped. A lot of this again had to do with that increased survival from the medications that were available as well as the continuing addition of some, new diagnoses of AIDS every year.

**Slide 37: Measures of Mortality**

Let’s turn now to measures of mortality, and the three that I am going to highlight here are mortality rates, case fatality rates, and infant mortality rates. Measuring mortality is important because it gives us an index of the severity of disease. Certainly a mortality rate for a disease can approximate an incidence rate, but we will talk about that in the coming slides.

**Slide 38: Mortality Rate Formula**

Let’s now talk about mortality rate. Mortality rate, , is the number of all deaths in one year divided by the number of people in that population at midyear. And you can have your annual mortality rate, which looks at all deaths in one year or you can actually have your cause-specific mortality rate, so if you want to look specifically at a certain disease, you can have the number of deaths from a specific disease in one year, divided by the number of people in the population at that year. If you are looking at cause-specific mortality rates, so the number of people that died from lung cancer for example, in the numerator would be the number of lung cancer deaths in one year and your denominator would be the number of people in the population at risk of dying from lung cancer in that year. It would include both people that have lung cancer as well as people that don’t. So, that’s the important distinction there for mortality rate. We’ll talk a little bit about how that’s different from case fatality rate in the coming slides, but again mortality rate just looks at the number of deaths in a year over the total number of people in a population.
Slide 39: Leading Causes of Death for All ages in the U.S.

This slide is showing the leading causes of death for all ages in the United States, from the period of 1950 through to 2004. The top green line is showing all causes of death, so basically looking at the number of deaths in one year in the United States divided by 100,000 population. But the other lines below that for heart disease in red, cancer in blue, stroke in brown, unintentional injuries in a lighter green, you can see the different cause-specific mortality rates and the nice thing is again, when we use rates we can make comparisons between the different causes of death. So, we can see that heart disease is the leading cause of death over this period of time. But that cancer, in the 21st century, 2000-2004, is starting to approach the mortality rate for heart disease. So, again making those comparisons, we want to see these rates, so you can have your annual mortality rate, which is that top dark green line, but then you can look at cause-specific mortality rates and those are depicted below that dark green line in the various colors.

Slide 40: Leading Causes of Death in Adults

This is another example, a very bright colorful slide, looking at death rates or mortality rates from leading causes of death in adults 25-44 years of age in the United States, looking at about 12 years of data from 1982 to 1994. What we are seeing is the number of deaths or the mortality rate per 100,000 population, and we can see for young adults to middle aged adults, unintentional injuries, up at the top in pink, are one of the leading causes of death, the rates are highest, but we also see again HIV infection, starting in the early 80s quickly outpaced the other causes of death in this age group. So, you can again look at cause specific mortality rates and make some comparisons about what are the leading causes of death. Public health officials use this type of data to target different interventions. So, you can look at this at a national level like this graph is showing, but you can also look at it for your own community or county and compare it to Healthy People objectives to see if your rates are lower or higher. It can certainly help you decide what type of health services planning you need to do in your community.
Slide 41: Case Fatality Rate Formula

So, I have been talking about mortality rate and I hinted that there was another type of rate that would be similar sounding but would be different, and that’s a case fatality rate. This is the formula here for case fatality rate, this is the number of people dying during a specified period of time after diagnosis of their disease divided by the total number of people with that disease. So, this is different from mortality rate because if you’ll remember the denominator in mortality rate was all people in the population, whether they had disease or not, just people at risk of dying from the disease, so it could be people with the disease or people without who still have the possibility to develop it. Case fatality rate, the denominator is looking specifically at people who have the disease, people who have been diagnosed. And so the case fatality rate is just looking at how deadly the disease really is. If you develop Ebola virus infection, what is the likelihood that you will die? So, certainly there are diseases with very high case fatality rates, some strains of Ebola certainly qualify, rabies infection certainly qualifies, and some strains of flu viruses have very high case fatality rates. But there are also many diseases with low case fatality rates, tuberculosis is an example, other strains of influenza can certainly be an example, etc. So, we’ll talk about this a little more in the next few slides, but again, just remember that the denominator is really the big difference. For case fatality rate, your denominator is the total number of people with the disease already, contrast that to mortality rate where your denominator is all people in the population, whether they have disease or not.

Slide 42: Case Fatality Rate for Avian Influenza A/H5N1

So, I have mentioned already the outbreak of Avian Influenza/H5N1 that is still ongoing in the eastern hemisphere, fortunately has not developed into a pandemic as of 2011, springtime, but continued to be monitored closely by the World Health Organization. Avian Influenza/H5N1 has a high case fatality rate. As of February 25, 2011, according to the WHO, there were 309 deaths out of a total of 522 cases of H5N1, so that means there were 522 cases diagnosed and of those, 309 had died. So, the case fatality rate is approaching 60%. So, again, more than a 50/50 chance of dying if you develop infection with H5N1. Now certainly there is some bias here because probably the number of cases in that denominator are only severe cases that are being reported to public health officials, so the case fatality rate may not be as high as 60%, but certainly this is a disease of high severity, with a lot of cases dying from the disease or developing severe complications.
Slide 43: Mortality Rate Versus Case Fatality Rate

This slide is going to show us the difference between mortality rate and case fatality rate. This is looking at three diseases that we have probably all heard of: rabies, measles, and tuberculosis. Rabies is along the top, mostly in green, showing that the vast majority of cases, almost 100% will die. There has been one case report of a teenage girl who survived her rabies infection, so, that’s why there is some severe case in the green hatch mark, but for the most part, rabies is uniformly fatal. So, the case fatality rate for rabies approaches 100%.

Measles, on the other hand, has a broader spectrum of disease. You can have in yellow, inapparent infection, which means no symptoms, although people can still be infected and transmit measles virus to others. Then you have a lot of mild to moderate disease, which is shown in blue and the blue diagonal bars. These are people that have symptoms, but still not life threatening. Then some cases of measles are severe and can be fatal. Children can die from pneumonia or other complications, such as encephalitis. So, measles case fatality rate is probably 10-15%. Contrast that to the very bottom which is tuberculosis, you can see that the vast majority of cases are inapparent, meaning most people infected with tuberculosis don’t even realize they have symptoms, don’t realize they are infected. The case fatality rate for tuberculosis is very, very low. It’s not likely that if you develop tuberculosis that you are going to die from your infection. It’s much more likely that you are going to have very mild symptoms or no symptoms at all. So the case fatality rate from this bar graph you can see is clearly the highest for rabies, almost 100%, case fatality rate for measles is slightly higher than for tuberculosis, but still for neither one of those is the case fatality rate that high.

However, when we talk about mortality rate, the number of people who die from a disease divided by the total number of people in a population, we get a different story. There are so many cases of tuberculosis worldwide, there are so many cases of tuberculosis diagnosed in the United States, that even with just a few people dying from tuberculosis, the mortality rate from tuberculosis is still higher than it is for rabies.
**Slide 44: Pancreatic Cancer**

This slide is looking at pancreatic cancer data from 1987-2007, and it’s looking at two different measures of disease severity. One is disease incidence, how many new cases of pancreatic cancer are diagnosed every year. That’s shown in the top graph. The bottom graph is showing the mortality associated with pancreatic cancer, so the number of pancreatic deaths per 100,000 population. The reason I put this slide in is again to show that there can be some interplay between incidence and mortality. A mortality rate can give a good indication of incidence if two criteria are met: one, if the case fatality rate is high, meaning most people that develop the disease die quickly and also if survival is low, and the duration of the disease is short. If people are diagnosed and then die fairly quickly, incidence rate and mortality rate are very similar. Pancreatic cancer is a good example of this, most people once they are diagnosed, live on average a year or less. So, the top graph here is showing the incidence rate for pancreatic cancer from the years 1987-2007 and overall rate is shown in that salmon colored line, so it’s basically about 12 cases of pancreatic cancer per 100,000 population. Look now at the bottom graph that’s showing the mortality rate from pancreatic cancer, that’s the number of deaths from pancreatic cancer per 100,000 population. Again, the overall mortality rate bottom graph is shown by that salmon line, and it’s about 11 deaths from pancreatic cancer per 100,000 population. So, again following mortality data for pancreatic cancer is a good proxy for incidence rates for pancreatic cancer. We can look at the number of deaths from pancreatic cancer and use that as an estimate of the number of new cases diagnosed every year. The reason for that is the case fatality rate for pancreatic cancer is very high and survival duration is very short.

**Slide 45: Infant Mortality Rate**

The last mortality rate that I want to discuss is infant mortality rate. This is an important rate to be familiar with because this is used a lot to look at maternal and child health in different states as well as different countries. It is a good indicator of overall health. The formula is shown here. It is the number of deaths under one year of age, during a specified time interval, usually a year, divided by the number of live births reported during the same time period. So, again, numerator is the number of deaths in infants, those less than one year of age, divided by the total number of live births during that same time period. It’s usually expressed as per 1,000 live births and I will show you on the next graph how we use it to make comparisons.
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Slide 46: Infant Mortality Rates in Different Countries

This is data, looking at the infant mortality rates in different countries in 2005. Again because we are using rates, we can compare different groups, in this case countries. You can see that Singapore leads the way with 2.1 infant deaths per 1,000 live births. A lot of Scandinavian countries are also near the top of the list with infant mortality rates of 3 deaths per 1,000 live births. Near the bottom of the list, unfortunately is the United States, with almost 7 infant deaths per 1,000 live births. So, this is certainly something that the United States is working to continue to decrease. This is a rate that we want to continue to decrease. Healthy People 2020 objectives have set a goal for us to work towards. Beyond just this infant mortality rate for the United States of 6.9, there is a lot of disparity within this rate, in that African American infants have a much higher infant mortality rate when compared to white infants. So not only does the United States in general have some improvements to make with infant mortality rates compared to some of our other counterparts in the developed world, but reducing the disparities between racial groups is a goal that we need to continue to work towards as well.

Slide 47: Summary

In summary today, I want to reiterate that epidemiology, which we have talked a little bit about, is really a basic science of public health. It forms the foundation of all we do, in terms of identifying the causes of disease, the risk factors for disease, etc. I hope you have learned through this presentation that these bread and butter of epidemiology is to be able to do these basic verbs: to count, to describe, to divide, and to compare. So, we count cases, we describe them by person, place, and time, we divide them so that we can begin to make comparisons. We may use proportions, as is the case with prevalence, or we may use rates where we include the time component, and this helps us compare. We can be able to compare different groups, we can compare males to females, we can compare different age groups, and we can compare different countries. If you want to assess risk, then you have to use rates. When we talk about disease occurrence, how it occurs, what is morbidity for this disease, how often does it occur, we are really talking about two different measures, we are talking about incidence, which is again our rate, and also prevalence; I hope from this presentation you will be able to remember the distinction between the two. Remember incidence, that numerator is going to be number of new cases diagnosed over the total number of people in the population. Prevalence, on the other
hand, is at a given moment, how many people have the disease, divided by the total number of people in the population. So, prevalence is different from incidence because prevalence includes new and old cases. Finally, if you want the measure of disease severity, the primary measure for that is going to be a case fatality rate. If a disease has a very high case fatality rate, such as pancreatic cancer, then your mortality rate certainly is also a good indication of disease severity and can also be a good estimate of disease incidence.