College of Nursing

University of Central Florida

Measures of Risk

- Frequency Measures
- Morbidity Measures
- Mortality Measures
- Natality Measures
- Measures of Association
- Measures of Public Health Impact

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Frequency Measures

- A frequency measure characterizes only *part* of the distribution of data
- Compares one part of a distribution to another or to the entire distribution
- Consist primarily of ratios, proportions, and rates with the same basic form:

$$\frac{\text{numerator}}{\text{denominator}} \times 10^n \qquad n = \text{Some type of sample \#}$$

- Ratio:
  - A comparison of any two values
  - Often written as a comparison to ":1"
  - Numerator and denominator can be completely unrelated
  - Descriptively describe males:females; controls:cases
  - Analytically measures occurrence of illness, injury, or death between 2 groups

Frequency Measures

– measured by:

<u># of events, items, persons, etc. in one group</u>
# of events, items, persons, etc. in another group

– **EXAMPLE: Calculating a Ratio — Different Categories of Same Variable:**

Between 1971 and 1975, as part of the National Health and Nutrition Examination Survey (NHANES), 7,381 persons ages 40–77 years were enrolled in a follow-up study.1 At the time of enrollment, each study participant was classified as having or not having diabetes. During 1982–1984, enrollees were documented either to have died or were still alive. The results are summarized as follows:

	Original Enrollment (1971–1975)	Dead at Follow-Up (1982–1984)
Diabetic men	189	100
Nondiabetic men	3,151	811
Diabetic women	218	72
Nondiabetic women	3,823	511

Of the men enrolled in the NHANES follow-up study, 3,151 were nondiabetic and 189 were diabetic. Calculate the ratio of non-diabetic to diabetic men:

– **Ratio = 3,151 / 189 x 1 = 16.7:1**

Frequency Measures

– **EXAMPLES: Calculating Ratios for Different Variables**

- **Example A:** A city of 4,000,000 persons has 500 clinics. Calculate the ratio of clinics per person.

$$500 / 4{,}000{,}000 \times 10^n = 0.000125 \text{ clinics per person}$$

To get a more easily understood result, you could set $10^n = 10^4 = 10{,}000$. Then the ratio becomes:

$$0.000125 \times 10{,}000 = 1.25 \text{ clinics per } 10{,}000 \text{ persons}$$

You could also divide each value by 1.25, and express this ratio as 1 clinic for every 8,000 persons.

- **Example B:** Delaware's infant mortality rate in 2001 was 10.7 per 1,000 live births.2 New Hampshire's infant mortality rate in 2001 was 3.8 per 1,000 live births. Calculate the ratio of the infant mortality rate in Delaware to that in New Hampshire.

$$10.7 / 3.8 \times 1 = 2.8{:}1$$

Thus, Delaware's infant mortality rate was 2.8 times as high as New Hampshire's infant mortality rate in 2001.

Frequency Measures

- Death:Case Ratio:
  - # of deaths attributed to a certain disease during a specified period of time divided by # of new cases of that disease in the same time period:
  - 15,075 new cases of TB reported in US in 2002; 802 died that year of TB:
    - 15,075/802 = 18.8

    (For every death from TB in 2002, there were 18.8 new cases of it)
- Proportion:
  - Comparison of a part to the whole
  - Expressed as decimal, fraction, or percentage
  - As a %, usually expressed in terms of per 100 ($10^n = 10^2$)
  - Useful at describing samples or characteristics (# of passengers on a cruise ship who become ill; # of children vaccinated at a school, etc.)
  - Show powerful relationships between behaviors and disease etiologies: 90% of all lung CA caused by smoking cigarettes
  - Numerator must be included in denominator (denominator displays ALL potential cases)
  - Can change ratios to proportions by subtract the numerator from the denominator:
    - 540 women attended a conference with 1222 total persons in attendance
    - 1222-540 = 682 men at conference; 682:540 = 1.2 males per every female at conference

Frequency Measures

- To calculate proportion:

  # of persons or events w/ particular characteristic   x 10^n

Total # of persons or events, of which numerator is subset

- **EXAMPLE: Calculating a Proportion**
  - **Example A:** Calculate the proportion of men in the NHANES follow-up study who were diabetics.

Numerator = 189 diabetic men; Denominator = Total number of men = 189 + 3,151 = 3,340

Proportion = (189 / 3,340)= .0566 = 5.66% (NOTE: To turn a decimal into a %, move the 2 places to the right)

- **Example B:** Calculate the proportion of deaths among men:

Numerator = deaths in men = 100 deaths in diabetic men + 811 deaths in nondiabetic men = 911 deaths in men

Notice that the numerator (911 deaths in men) is a subset of the denominator.

Denominator = all deaths = 911 deaths in men + 72 deaths in diabetic women + 511 deaths in nondiabetic Women = 1,494 deaths

Proportion = 911 / 1,494 = .6098 = 61%

- **Your Turn:** What proportion of all study participants were men? (Answer = 45.25%)

Frequency Measures

- Proportionate Mortality:
  - Proportion of deaths in a specified population during a period of time attributable to different causes
  - Each death represents a percentage of all deaths
  - Table 3.1 indicates Proportionate Mortality in the US (2003)
- Rate:
  - Measure of the frequency with which an event occurs in a defined population over a specified period of time
  - Very useful at comparing disease frequency in different locations, times, or among different populations
  - Incidence Rate= New Dx of specific Dz per population per year
  - Attack Rate = Proportion of a population that develops illness during an outbreak
  - Prevalence Rate = Proportion the population with a health condition at a certain point of time
  - Case-Fatality Rate = Proportion of persons with a disease who die from it

Frequency Measures

- **Table 3.2 Epidemiologic Measures Categorized as Ratio, Proportion, or Rate**

Condition	Ratio	Proportion	Rate
Morbidity (Disease)	Risk ratio (Relative risk) Rate ratio Odds ratio Period prevalence	Attack rate (Incidence proportion) Secondary attack rate Point prevalence Attributable proportion	Person-time incidence rate
Mortality (Death)	Death-to-case ratio	Proportionate mortality	Crude mortality rate Case-fatality rate Cause-specific mortality rate Age-specific mortality rate Maternal mortality rate Infant mortality rate
Natality (Birth)			Crude birth rate Crude fertility rate

Morbidity Frequency Measures

- Morbidity: Any departure, subjective or objective, from a state of physiological or psychological well-being (disease, injury, disability)
- Also defines the # of persons ill, periods of illness these persons experienced, duration of illness
- Incidence: Occurrence of new cases of a disease or injury over a specified period of time
- Incidence Proportion (Attack Rate, Risk, Probability of Developing Disease, Cumulative Incidence):
  - Proportion of an initially disease-free population that develops disease, becomes injured, or dies during a specified period of time
  - Probability of members of a population developing a disease during the specified period (includes only new cases)
  - The numerator (those w/ disease) also expressed in denominator (total persons in a given population); to calculate:

$$\frac{\text{\# of new cases of disease/injury during specified period}}{\text{Size of the population at start of same time period}}$$

Morbidity Frequency Measures

- **EXAMPLES: Calculating Incidence Proportion (Risk)**

  – **Example A:** In the study of diabetics, 100 of the 189 diabetic men died during the 13-year follow-up period. Calculate the risk of death for these men:

Numerator = 100 deaths among the diabetic men

Denominator = 189 diabetic men

Risk = (100 / 189)= .529 = 52.9%

  – **Example B:** In an outbreak of gastroenteritis among attendees of a corporate picnic, 99 persons ate potato salad, 30 of whom developed gastroenteritis. Calculate the risk of illness among persons who ate potato salad:

Numerator = 30 persons who ate potato salad and developed gastroenteritis

Denominator = 99 persons who ate potato salad

Risk = “Food-specific attack rate” = (30 / 99)= .303= 30.3%

Morbidity Frequency Measures

- More About Denominators:
  - The denominator of an incidence proportion is the number of persons at the start of the observation period
  - The denominator should be limited to the "population at risk" for developing disease, i.e., persons who have the potential to get the disease and be included in the numerator:
    - For example, if the numerator represents new cases of cancer of the ovaries, the denominator should be restricted to women, because men do not have ovaries
    - This is easily accomplished because census data by sex are readily available. In fact, ideally the denominator should be restricted to women with ovaries, excluding women who have had their ovaries removed surgically (often done in conjunction with a hysterectomy), **but this is not usually practical**
    - Epidemiologists do the best they can with the data they have

Morbidity Frequency Measures

– Secondary Attack Rate often used to calculate differences between transmission rates between groups (family affected by a particular illness with that of the general population, etc.):

$$\frac{\text{\# of cases among contacts of primary cases}}{\text{(Total \# in population - \# primary cases)}} \times 10^n$$

– **EXAMPLE: Calculating Secondary Attack Rates**

- Consider an outbreak of shigellosis in which 18 persons in 18 different households all became ill. If the population of the community was 1,000, then the overall attack rate was 18 / 1,000 x 100% = 1.8%. One incubation period later, 17 persons in the same households as these "primary" cases developed shigellosis. If the 18 households included 86 persons, calculate the secondary attack rate:

Secondary Attack Rate = (17 / (86 - 18)) = (17 / 68) .25 = 25%

Morbidity Frequency Measures

- Incidence Rate (Person-Time Rate):
  - Measure of incidence that incorporates time directly into denominator
  - Usually, new cases are compared to old cases being followed in cohort studies at 4 times:
    - Onset of disease; death; migration out of study; or end of study
  - Describes how quickly a disease occurs within a population
  - Allows participants to come and go during the study period
  - Sensitive to age because risk of developing many diseases accelerates with age
  - Often not longitudinally studied but based on cases reported/mid-year pop.
  - Calculated by:

$$\frac{\text{\# of new cases of disease/injury during specified period}}{\text{Total time of all persons observed}}$$

  - Describe "Person Years" as "Persons per Year"—This makes a lot more sense:
    - 2.5 new cases of heart disease per 1,000 person years = 2.5 new cases per 1,000 persons
  - One person followed for 5 years without developing disease contributes 5 person-years of follow-up
  - Those who migrate out or become diagnosed contribute ½ of the time of that year:
    - Drop/Dx sometime during 2nd year = 1.5 person-years of follow-up

Morbidity Frequency Measures

EXAMPLES: Calculating Incidence Rates

Example A: Investigators enrolled 2,100 women in a study and followed them annually for four years to determine the incidence rate of heart disease. After one year, none had a new diagnosis of heart disease, but 100 had been lost to follow-up. After two years, one had a new diagnosis of heart disease, and another 99 had been lost to follow-up. After three years, another seven had new diagnoses of heart disease, and 793 had been lost to follow-up. After four years, another 8 had new diagnoses with heart disease, and 392 more had been lost to follow-up.

The study results could also be described as follows: No heart disease was diagnosed at the first year. Heart disease was diagnosed in one woman at the second year, in seven women at the third year, and in eight women at the fourth year of follow-up. One hundred women were lost to follow-up by the first year, another 99 were lost to followup after two years, another 793 were lost to follow-up after three years, and another 392 women were lost to followup after 4 years, leaving 700 women who were followed for four years and remained disease free. Calculate the incidence rate of heart disease among this cohort. Assume that persons with new diagnoses of heart disease and those lost to follow-up were disease-free for half the year, and thus contribute ½ year to the denominator.

Morbidity Frequency Measures

Numerator = number of new cases of heart disease = 0 + 1 + 7 + 8 = 16

Denominator = person-years of observation =

	1^{st} year study complete	1^{st} year Dx	1^{st} year drop outs
Year One:	(2,000 +	0 +	.5 x 100) +
	2^{nd} year study complete	2^{nd} year Dx	2^{nd} year drop outs
Year Two:	(1,900 +	.5 x 1 +	.5 x 99) +
	3^{rd} year study complete	3^{rd} year Dx	3^{rd} year drop outs
Year Three:	(1,100 +	.5 x 7 +	.5 x 793) +
	4^{th} year study complete	4^{th} year Dx	4^{th} year drop outs
Year Four:	(700 +	.5 x 8 +	.5 x 392) =
			6,400 person-years of follow-up

Person-time rate = <u>Number of new cases of disease or injury during specified period</u>
Time each person was observed, totaled for all persons

= 16 / 6,400
= .0025 cases per person-year (x 1,000)
= 2.5 cases per 1,000 person-years

- IMPORTANT POINT:
  - In contrast, the incidence proportion can be calculated as 16 / 2,100 = 7.6 cases per 1,000 population during the four-year period, or an average of 1.9 cases per 1,000 per year (7.6 divided by 4 years).
  - The incidence proportion underestimates the true rate because it ignores persons lost to follow-up, and assumes that they remained disease free for all four years.

Morbidity Frequency Measures

- **Example B:** The diabetes follow-up study included 218 diabetic women and 3,823 nondiabetic women. By the end of the study, 72 of the diabetic women and 511 of the nondiabetic women had died. The diabetic women were observed for a total of 1,862 person-years; the nondiabetic women were observed for a total of 36,653 person-years. Calculate the incidence rates of death for the diabetic and non-diabetic women:

For diabetic women, numerator = 72 and denominator = 1,862

Person-time rate = 72 / 1,862 = 0.0386 deaths per person-year (x 1,000)
= 38.6 deaths per 1,000 person-years

For nondiabetic women, numerator = 511 and denominator = 36,653

Person-time rate = 511 / 36,653 = 0.0139 deaths per person-year (x 1,000)
= 13.9 deaths per 1,000 person-years

Morbidity Frequency Measures

- **Example C:** In 2003, 44,232 new cases of acquired immunodeficiency syndrome (AIDS) were reported in the United States. The estimated mid-year population of the U.S. in 2003 was approximately 290,809,777. Calculate the incidence rate of AIDS in 2003:

Numerator = 44,232 new cases of AIDS

Denominator = 290,809,777 estimated mid-year population

10^n = 100,000 (you want to express the rate in-terms of per 100,000 individuals)

Incidence rate = (44,232 / 290,809,777) x 100,000

= 15.21 new cases of AIDS per 100,000 population

Morbidity Frequency Measures

- Prevalence:
  - Proportion of persons in a population who have a particular disease or attribute at a specified point in time or over a specified period of time
  - Differs from incidence in that it includes all cases, both new and preexisting, in the population at the specified time (recall incidence is *new* cases only)
  - Point prevalence: Prevalence measured at a particular point in time
  - Period prevalence: Prevalence measures over an interval of time
  - Prevalence looks more at the number of persons with a certain condition at a given period of time (chronic diseases, for example) whereas incidence looks more at who's *developing* the condition at a given period of time
  - High prevalence in a population might indicate high incidence or prolonged survival time without a cure (or both)
  - Low prevalence might indicate low incidence, a rapidly fatal process, or rapid recovery

Morbidity Frequency Measures

- Calculating Prevalence:

$$\frac{\text{All new and preexisting cases during a given time period}}{\text{Population during the same time period}} \times 10^n$$

- Calculating Prevalence of an Attribute:

$$\frac{\text{Persons having a particular attribute during a given time period}}{\text{Population during the same time period}} \times 10^n$$

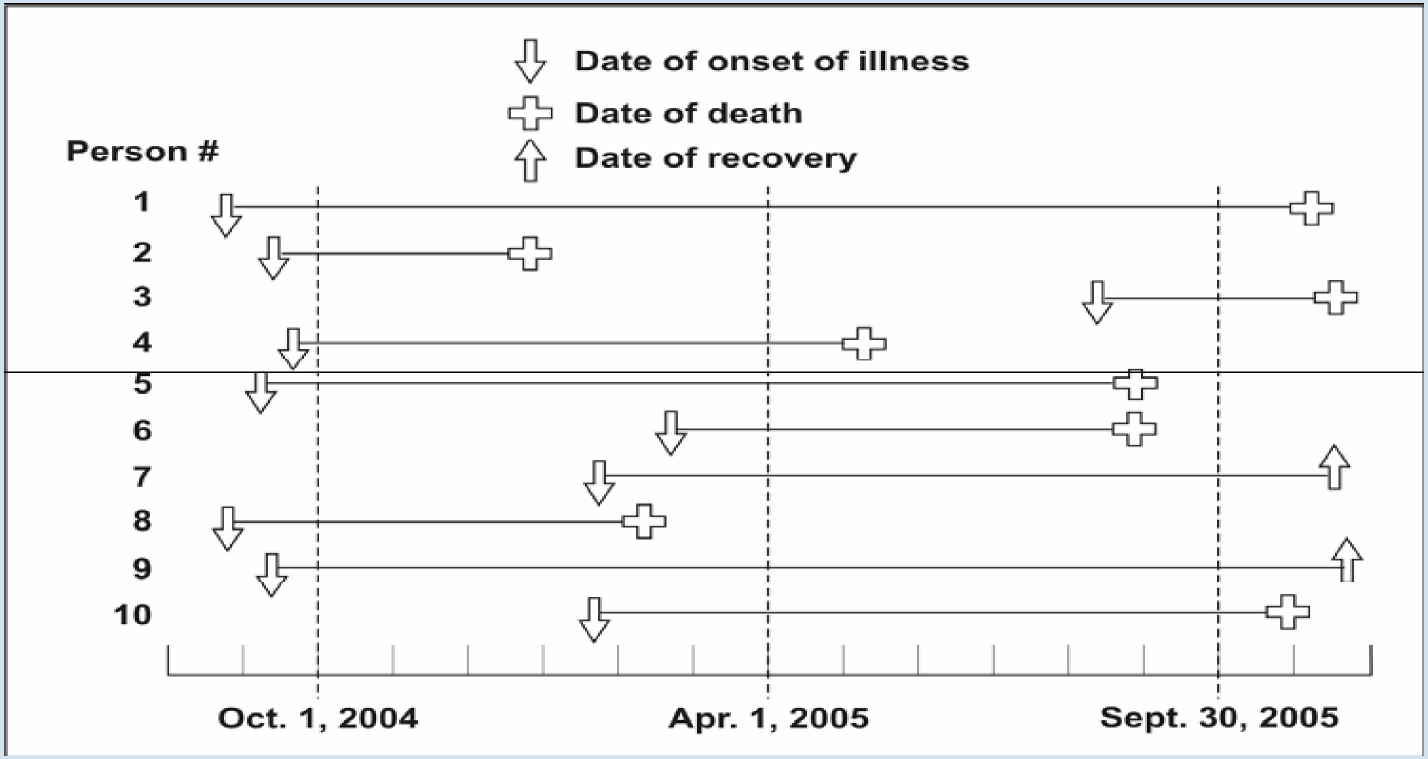
- In a survey of 1,500 women who gave birth in Main in 2000, a total of 468 reported taking a MVN at least 4x/week during the month before becoming pregnant. What is the prevalence of those who took a MVN in this group?

Numerator = <u>468</u> (those who took the MVN)

Denominator = 1,150 (total who gave birth)

Morbidity Frequency Measures

- Incidence vs. Prevalence:
- Figure 3.1 represents 10 new cases of illness over about 15 months in a population of 20 persons. Each horizontal line represents one person. The down arrow indicates the date of onset of illness. The solid line represents the duration of illness. The up arrow and the cross represent the date of recovery and date of death, respectively.



Morbidity Frequency Measures

- **Example A:** Calculate the incidence rate from October 1, 2004, to September 30, 2005, using the midpoint population (population alive on April 1, 2005) as the denominator. Express the rate per 100 population:

  Numerator = 4 (note that 6 had s/s before 10/1)
  Denominator = 18 (total pop. is 20 but 2 died before 4/1)
  (4/18) x 100 = 22 new cases per 100 persons

- **Example B:** Calculate the point prevalence on April 1, 2005. Point prevalence is the number of persons ill on the date divided by the population on that date. On April 1, seven persons (persons 1, 4, 5, 7, 9, and 10) were ill:

  Numerator = 7 (number of ill individuals living on 4/1—dead NOT counted)
  Denominator = 18 (total population living—dead is subtracted)
  (7/18) x 100 = 38.9% (39% currently ill in this pop.)

- **Example C:** Calculate the period prevalence from October 1, 2004, to September 30, 2005. The numerator of period prevalence includes anyone who was ill any time during the period. In Figure 3.1, the first 10 persons were all ill at some time during the period.

  Numerator = 10 (number of ALL ill individuals no matter when s/s started)
  Denominator = 20 (total population living or dead during the same time period)
  (10/20) x 100 = 50% (Total of 50% of this pop. was ill during this period)

Mortality Frequency Measures

- Mortality Rate:
  - Measure of frequency of occurrence of death in a defined population during a specified interval
  - Calculated as:

$$\frac{\text{Deaths occurring during a given time period}}{\text{Size of the population among which the deaths occurred}} \times 10^n$$

  - The denominator is usually the size of the population at the midpoint of the time period
  - Crude Mortality (Death) Rate:
    - Mortality rate from all causes of death for a pop.
    - There were 2,419,921 deaths in the US in 2003; the total pop. was 290, 809,777. Therefore the crude death rate was:
      (2,419,921/ 290, 809,777) x 100,000 = 832.1
      (832 deaths per 100,000 in the pop.)
  - Cause-Specific Mortality Rate:
    - Mortality rate from a specific cause
    - There were 108,256 deaths from accident in 2003:
      (108,256/290,809,777) x 100,000 = 37.2 (37 deaths from accident per 100,000 in the pop.)

Mortality Frequency Measures

- Age-Specific Mortality Rate:
  - Mortality rate limited to a particular age range:
  - Numerator is total deaths in the age range and denominator is total of the population of that age range
  - In 2003, there were 130,761 deaths in those 25-44:

  (130,761/total pop. of those 25-44) x 100,000 = 153

  153 per 100,000 persons died in 2003
- Infant Mortality Rate:
  - Reflects the health of mother (access to prenatal care, maternal behaviors—ETOH, smoke, nutrition, etc.) and baby (proper nurtition, immunizations, etc.) during preg. and the year following
  - Often used to compare health status among nations:

$$\frac{\text{\# of deaths among children < 1 yr of age during a given time period}}{\text{\# of live births reported during the same time period}} \times 1{,}000$$

  - Note the numerator probably includes those children who were also born in the previous year but the denominator only those who were born that year
  - This is similar but not precisely equal to age-specific death rate of infants <1 because the total number of <1 living in the US exceeds total births
  - In 2003, there were 4,089,950 births in the US; 28,025 of these died:

  (28,025/4,089,950) x 1,000 = 6.85 deaths per every 1,000 births

Mortality Frequency Measures

- Neonatal Mortality Rate:
  - Number of deaths among children <28 days during a given time period (this is the numerator—the denominator is the total number of live births during the same time period)
  - Expressed per 1,000 births
- Postneonatal Mortality Rate:
  - Number of deaths among children aged 28-364 days during a given time period (this is the numerator—the denominator is the total number of live births during the same time period)
  - Expressed per 1,000 births
- Maternal Mortality Rate:
  - Ratio used to measure mortality associated with preg.
  - Number of deaths among preg. women during a given time period resulting from preg. or its management (this is the numerator—the denominator is the total number of live births during the same time period)
  - Expressed per 100,000 births
- Sex-Specific Mortality Rate:
  - Number of deaths in either ♀ or ♂ in a time period; denominator only ♀ or ♂
- Race-Specific Mortality Rate:
  - Number of deaths in a particular race in a time period; denominator only that race

Mortality Frequency Measures

- Let's practice calculating mortality rates:
  - Table 3.5 provides the number of deaths from all causes and from accidents (unintentional injuries) by age group in the United States in 2002. Review the following rates. Determine what to call each one, then calculate it using the data provided in Table 3.5:
  - a. Unintentional-injury-specific mortality rate for the entire population:
    - This is a cause-specific mortality rate.
    - Rate = $\frac{\text{number of unintentional injury deaths in the entire population}}{\text{estimated midyear population}} \times 100{,}000$

$$= (106{,}742 / 288{,}357{,}000) \times 100{,}000$$
$$= 37.0$$

(37 unintentional-injury-related deaths per 100,000 population)

Mortality Frequency Measures

- Let's practice calculating mortality rates:
  - Table 3.5 provides the number of deaths from all causes and from accidents (unintentional injuries) by age group in the United States in 2002. Review the following rates. Determine what to call each one, then calculate it using the data provided in Table 3.5:
  - b. All-cause mortality rate for 25–34 year olds:
    - This is an age-specific mortality rate.
    - Rate = $\dfrac{\text{number of deaths from all causes among 25–34 year olds}}{\text{estimated midyear population of 25–34 year olds}} \times 100{,}000$
    - = (41,355 / 39,928,000) x 100,000
    - = 103.6 deaths per 100,000 25–34 year olds

Mortality Frequency Measures

- Let's practice calculating mortality rates:
  - Table 3.5 provides the number of deaths from all causes and from accidents (unintentional injuries) by age group in the United States in 2002. Review the following rates. Determine what to call each one, then calculate it using the data provided in Table 3.5:
  - c. All-cause mortality among males:
    - This is a sex-specific mortality rate.
    - Rate = $\frac{\text{number of deaths from all causes among males}}{\text{estimated midyear population of males}} \times 100{,}000$
    - = (1,199,264 / 141,656,000) x 100,000
    - = 846.6 deaths per 100,000 males

Mortality Frequency Measures

- Let's practice calculating mortality rates:
  - Table 3.5 provides the number of deaths from all causes and from accidents (unintentional injuries) by age group in the United States in 2002. Review the following rates. Determine what to call each one, then calculate it using the data provided in Table 3.5:
  - d. Unintentional-injury-specific mortality among 25- to 34-year-old males
    - This is a cause-specific, age-specific, and sex-specific mortality rate
    - Rate = $\frac{\text{number of unintentional injury deaths among 25–34 year old males}}{\text{estimated midyear population of 25–34 year old males}} \times 100{,}000$
    - = (9,635 / 20,203,000) x 100,000
    - = 47.7 unintentional-injury-related deaths per 100,000 25–34 year old males

Mortality Frequency Measures

– Age-Adjusted Mortality Rates:
  - Comparison between mortality rates between ages might not yield rich data since we know mortality increases with age anyway
  - For these types of calculations, we need age-adjusted mortality rates
  - These take a weighted average of the ages of the population to eliminate the effects of different age groups among the population

– Death-to-Case Ratios:
  - # of deaths attributed to a particular disease during a specified time period divided by the # of new cases of that disease identified during the same time period
  - Not necessarily a proportion because the # of deaths (numerator) might include those not part of the new cases during that time period (denominator):

$$\frac{\text{\# of deaths attributed to a particular disease during a specified time period}}{\text{\# of new cases of the disease ID during the specified time period}} \times 10^n$$

  - Example: Between 1930-1940, a total of 143,497 cases of diphtheria were reported. During that same decade, 11,228 deaths were caused by diphtheria. Calculate the death-to-case ratio:

11,228/143,497 (x 100) = 7.82 deaths per 100 cases.

Mortality Frequency Measures

- Case-Fatality Rate:
  - Proportion of persons with a particular disease (cases) who die from that condition
  - Measure of the severity of that condition

$$\frac{\text{\# of cause-specific deaths among the incident cases}}{\text{\# of incident cases}} \times 10^n$$

  - This is a proportion; numerator is restricted to deaths among people included in the denominator but the numerator doesn't have to be one time point (for example, the numerator could be deaths among those diagnosed with HIV in 1990 to the present while the denominator could be the number diagnosed with HIV in 1990)
  - Similar to death-to-case ratio; but here, deaths included in the numerator are limited to the number of cases in the denominator; whereas in death-to-case ratios, the deaths could include those diagnosed years earlier
  - Example: In an epidemic of Hep. A traced to green onions from a diner, 555 cases were ID. 3 of the patients died from their infections. Calculate the Case-Fatality Rate: 3/555 = .005 = .5%

Mortality Frequency Measures

- Proportionate Mortality:
  - Proportion of deaths in a specified pop. over a period of time attributable to different causes
  - Each cause expressed as a % of all deaths (sum to 100%)

$$\frac{\text{Deaths caused by a particular cause}}{\text{Deaths from all causes}} \times 100$$

  - Each cause expressed as a % of all deaths (sum to 100%)
  - This value is particularly useful in looking at occupational epidemiology (are cause-specific mortality rates higher in specific occupations compared to the general pop?)
  - Comparison between 2 proportionate mortalities is termed Proportionate Morality Ratio (PMR):
    - PMR > 1 = a particular cause accounts for a greater proportion of deaths in the population of interest
  - The PMR can be misleading because it does not take into account those people too unhealthy to be part of the workforce (healthy worker effect)

Mortality Frequency Measures

- Years of Potential Life Lost (YPLL):
  - Measure of impact of premature mortality on a pop
  - Sum of differences between a predetermined end point and the ages of death of those who did not meet that end point
  - Usually 65 is considered that end point ($YPLL_{65}$) but this devalues life after 65
  - Years of Potential Life Lost based on remaining life expectancy ($YPLL_{LE}$) is more accurate since < 30% of all deaths occur among those 65+
  - YPLL usually age-adjusted to eliminate the effect of differing age distributions when comparing two populations
  - To Calculate YPLL from a line listing:

1. Decide on an end point (65 is a good one for application)
2. Exclude all records of those dying at or beyond the end point
3. Subtract the age of death for each case of death below the end point from the end point: $YPLL_{individual}$ = end point – age at death
4. Sum the individual YPLLs: $YPLL = \sum YPLL_{individual}$

Mortality Frequency Measures

- To calculate YPLL from a Frequency:

1. Ensure groups break at the ID end point; eliminate all groups beyond the end point
2. For each group younger than the end point, ID the midpoint of the age group, where midpoint =

$$\frac{\text{Age group's youngest age in years} + \text{oldest age} + 1}{2}$$

3. For each group younger than the end point, ID that age group's YPLL by subtracting the midpoint from the end point
4. Calculate age-specific YPLL by multiplying the age group's YPLL x the # of persons in the age group
5. Sum the age-specific YPLL's

- YPLL Rate represents years of potential life lost per 1,000 pop below the end-point; should be used to compare premature mortality in different populations because differences in population size not a factor:

$$\frac{\text{Years of potential life lost}}{\text{Population under age 65 yrs}} \times 10^n$$

Mortality Frequency Measures

- **EXAMPLE: Calculating YPLL and YPLL Rates:**
- Use the data in Tables 3.9 and 3.10 to calculate the leukemia-related mortality rate for all ages, mortality rate for persons under age 65 years, YPLL, and YPLL rate:
  - 1. Leukemia-related mortality rate, all ages

    = (21,498 / 288,357,000) x 100,000

    = 7.5 leukemia deaths per 100,000 population
  - 2. Leukemia-related mortality rate for persons under age 65 years

    = <u>125 + 316 + 472 + 471 + 767 + 1,459 + 2,611</u> = x 100,000

(19,597 + 41,037 + 40,590 +39,928 + 44,917 + 40,084 + 26,602)

    = 6,221 / 252,755,000 = x 100,000

    = 2.5 leukemia deaths per 100,000 persons under age 65 years

Mortality Frequency Measures

- **EXAMPLE: Calculating YPLL and YPLL Rates:**
- Use the data in Tables 3.9 and 3.10 to calculate the leukemia-related mortality rate for all ages, mortality rate for persons under age 65 years, YPLL, and YPLL rate:
  - 3. Leukemia-related YPLL:

a. Calculate the midpoint of each age interval: Using the previously shown formula (Youngest Age + Oldest Age) / 2:

0-4 = (0+4+1)/2 = 2.5
5-14: (5+14+1)/2= 10
15-24: (15+24+1)/2 = 20
25-34: (25+34+1)/2 = 30
35-44: (35+44+1)/2 = 40
45-54: (45+54+1)/2 = 50
55-64: (55+64+1)/2 = 60

b. Subtract the midpoint from the end point to determine the years of potential life lost for each particular age group:

0-4: 65- 2.5 = 62.5
5-14: 65- 10 = 55
15-24: 65- 20 = 45
25-34: 65-30 = 35
35-44: 65- 40 = 25
45-54: 65- 50 = 15
55-64: 65- 60 = 5

c. Calculate age-specific years of potential life lost by multiplying the number of deaths in a given age group by its years of potential life lost::

0-4: 62.5 x 125 = 7,813
5-14: 55 x 316 = 17,380
15-24: 45 x 472 = 21,240
25-34: 35 x 471 = 16,485
35-44: 25 x 767 = 19,175
45-54: 15 x 1,459 = 21,885
55-64: 5 x 2,611 = 13,055

d. Total the age-specific YPLL: : 7,813 + 17,380 + 21.240 + 16,485 + 19,175 + 21, 885 + 13,055 = 117,033

Mortality Frequency Measures

- **EXAMPLE: Calculating YPLL and YPLL Rates:**
- Use the data in Tables 3.9 and 3.10 to calculate the leukemia-related mortality rate for all ages, mortality rate for persons under age 65 years, YPLL, and YPLL rate:
  – 4. Leukemia-related YPLL rate:
    - = $YPLL_{65}$ rate
    - = YPLL divided by population to age 65
    - = (117,033 / 252,755,000) x 1,000
    - = 0.5 YPLL per 1,000 population under age 65

Natality Frequency Measures

- Natality Measures:
  - Population-based measures of birth
  - Useful for those working in maternal/child health
  - **Table 3.11 Frequently Used Measures of Natality:**

Measure	Numerator	Denominator	10^n
Crude birth rate	Number of live births during a specified time interval	Mid-interval population	1,000
Crude fertility rate	Number of live births during a specified time interval	Number of women 15-44 at mid-interval	1,000
Crude rate of natural increase	Number of live births minus number of deaths during a specified time interval	Mid-interval population	1,000
Low-birth weight ratio	Number of live births <2,500 grams during a specified time interval	Number of live births during the same time interval	100

Measures of Association

- Measures of Association:
  - Comparison is essential in epidemiology
  - It allows us to determine if true relationships between variables exist and if one population is at greater risk or incidence than another
  - Measure of association quantifies the relationship between exposure (foods, mosquitoes, partner w/ STI, age, race, sex, biologic characteristics, activities, or living conditions) and disease among two groups
    - Risk Ratio (RR):
      - Compares the risk of a health event (disease, injury, risk factor, death) among 1 group with that of another
      - Divides the risk (incidence proportion, attack rate) in group 1 by the risk (incidence proportion, attack rate) in group 2
      - The 2 groups usually differentiates through demographics (male/female) or exposure to suspected risk factor (did/did not eat Taco Bell® green onions)

Measures of Association

- RR =

Risk of disease (incidence proportion, attack rate) in a group of primary interest
Risk of disease (incidence proportion, attack rate) in comparison group

- A risk ratio of 1.0 = identical risk among the 2 groups
- Risk ratio > 1.0 = ↑ risk for the group in the numerator (usually the exposed group)
- Risk ratio < 1.0 = ↓ risk for the exposed (exposure might actually protect the group)

Measures of Association

- **EXAMPLES: Calculating Risk Ratios**
  - **Example A: In an outbreak of tuberculosis among prison inmates in South Carolina in 1999, 28 of 157 inmates residing on the East wing of the dormitory developed tuberculosis, compared with 4 of 137 inmates residing on the West wing.11 These data are summarized in the two-by-two table so called because it has two rows for the exposure and two columns for the outcome. Here is the general format and notation:**
  - **Table 3.12A General Format and Notation for a Two-by-Two Table**

	Ill	**Well**	**Total**
Exposed	a	b	**$a + b = H_1$**
Unexposed	c	d	**$c + d = H_0$**
Total	$a + c = V_1$	$b + d = V_0$	T

Measures of Association

- **EXAMPLES: Calculating Risk Ratios**
  - In this example, the exposure is the dormitory wing and the outcome is tuberculosis illustrated in Table 3.12B. Calculate the risk ratio.

Table 3.12B Incidence of Mycobacterium Tuberculosis Infection Among Congregated, HIV-Infected Prison Inmates by Dormitory Wing, South Carolina, 1999

Developed tuberculosis?

	Yes	**No**	**Total**
East wing	a = 28	b = 129	$H_1 = 157$
West wing	c = 4	d = 133	$H_0=137$
Total 32 262			T=294

Measures of Association

- To calculate the risk ratio, first calculate the risk or attack rate for each group. Here are the formulas:

Attack Rate (Risk)

Attack rate for exposed = a / a+b

Attack rate for unexposed = c / c+d

- For this example:
  - Risk of tuberculosis among East wing residents = 28 / 157 = 0.178 = 17.8%
  - Risk of tuberculosis among West wing residents = 4 / 137 = 0.029 = 2.9%
- The risk ratio is simply the ratio of these two risks:
  - Risk ratio = 17.8 / 2.9 = 6.1
- Thus, inmates who resided in the East wing of the dormitory were 6.1 times as likely to develop tuberculosis as those who resided in the West wing.

Measures of Association

- **EXAMPLES: Calculating Risk Ratios**
  - **Example B:** In an outbreak of varicella (chickenpox) in Oregon in 2002, varicella was diagnosed in 18 of 152 vaccinated children compared with 3 of 7 unvaccinated children. Calculate the risk ratio.
- **Table 3.13 Incidence of Varicella Among Schoolchildren in 9 Affected Classrooms, Oregon, 2002**

	Varicella	Non-case	Total
Vaccinated	a = 18	b = 134	152
Unvaccinated	c = 3	d = 4	7
Total 21			159

- Risk of varicella among vaccinated children = 18 / 152 = 0.118 = 11.8%
- Risk of varicella among unvaccinated children = 3 / 7 = 0.429 = 42.9%
- Risk ratio = 0.118 / 0.429 = 0.28
- The risk ratio is less than 1.0, indicating a decreased risk or protective effect for the exposed (vaccinated) children.
- The risk ratio of 0.28 indicates that vaccinated children were only approximately one-fourth as likely (28%, actually) to develop varicella as were unvaccinated children.

Measures of Association

- Rate Ratios:
  - Compares the incidence rates, person-time rates, or mortality rates of two groups
  - These 2 groups typically differentiated by demographic or exposure characteristics; Calculated as:

$$\text{Rate Ratio} = \frac{\text{Rate for group of primary interest}}{\text{Rate for comparison group}}$$

- A Rate Ratio = 1. 0 = Equal rates in the two groups;
- A Rate Ratio > 1. 0 = ↑ risk for group in numerator;
- A Rate Ratio < 1. 0 = ↓ risk for group in numerator

Measures of Association

- **EXAMPLE: Calculating Rate Ratios**
  - Public health officials were called to investigate a perceived increase in visits to ships' infirmaries for acute respiratory illness (ARI) by passengers of cruise ships in Alaska in 1998.13 The officials compared passenger visits to ship infirmaries for ARI during May–August 1998 with the same period in 1997. They recorded 11.6 visits for ARI per 1,000 tourists per week in 1998, compared with 5.3 visits per 1,000 tourists per week in 1997. Calculate the rate ratio:

Rate ratio = 11.6 / 5.3 = 2.2

- Passengers on cruise ships in Alaska during May–August 1998 were more than twice as likely to visit their ships' infirmaries for ARI than were passengers in 1997. (Note: Of 58 viral isolates identified from nasal cultures from passengers, most were influenza A, making this the largest summertime influenza outbreak in North America.)

Measures of Association

- Odds Ratio:
  - Measurement of choice for a case-control study
  - Group of persons with disease (case patients) and a comparable group without disease (controls) enrolled
  - Risks, rates, risk/rate ratios can't be calculated since size of the case patient population is unknown
  - Instead, Odds Ratio provides an approximation of the risk ratio
  - *Odds ratio* $= \left(\frac{a}{b}\right)\left(\frac{c}{d}\right) = ad / bc$
  - Where:
    - a = number of persons exposed and with disease
    - b = number of persons exposed but without disease
    - c = number of persons unexposed but with disease
    - d = number of persons unexposed: and without disease
    - a+c = total number of persons with disease (case-patients)
    - b+d = total number of persons without disease (controls)

Measures of Association

- Odds ratio is sometimes called the **cross-product ratio** because:
  - the numerator is based on multiplying the value in cell "a" times the value in cell "d," whereas the denominator is the product of cell "b" and cell "c"
  - A line from cell "a" to cell "d" (for the numerator) and another from cell "b" to cell "c" (for the denominator) creates an x or cross on the two-by-two table:
  - **Table 3.15 Exposure and Disease in a Hypothetical Population of 10,000 Persons:**

	Disease	No Disease	Total	Risk
Exposed	a = 100	b = 1,900	2,000	5.0%
Not Exposed	c = 80	d = 7,920	8,000	1.0%
Total	180	9,820	10,000	

Measures of Association

- **EXAMPLE: Calculating Odds Ratios:**
  - Use the data in Table 3.15 to calculate the risk and odds ratios.
    - 1. Risk ratio:
      - 5.0 / 1.0 = 5.0 (note these are expressed in percents)
    - 2. Odds ratio:
      - (100 x 7,920) / (1,900 x 80) = 5.2
- Notice that the odds ratio of 5.2 is close to the risk ratio of 5.0. That is one of the attractive features of the odds ratio — when the health outcome is uncommon, the odds ratio provides a reasonable approximation of the risk ratio
- Another attractive feature is that the odds ratio can be calculated with data from a case-control study, whereas neither a risk ratio nor a rate ratio can be calculated.

Measures of Public Health Impact

- Used to place the association between an exposure and an outcome into a meaningful public health context
- Reflects the burden that an exposure contributes to the frequency of disease in the population
- Attributable proportion:
  - Measure of the public health impact of a causative factor
  - Assumes the occurrence of disease in the unexposed group represents the baseline or expected risk for that disease
  - Assumes if the risk of disease is > than the risk in the unexposed group, the difference can be attributed to the exposure
  - Represents the expected reduction in disease is the exposure could be removed or never existed
  - Appropriate only for SINGLE risk factor being etiology, not multiple ones

$$\frac{\text{Risk for exposed group} - \text{risk for unexposed group}}{\text{Risk for exposed group}} \times 100\%$$

Measures of Public Health Impact

- **EXAMPLE: Calculating Attributable Proportion:**
  - In another study of smoking and lung cancer, the lung cancer mortality rate among nonsmokers was 0.07 per 1,000 persons per year.14 The lung cancer mortality rate among persons who smoked 1–14 cigarettes per day was 0.57 lung cancer deaths per 1,000 persons per year. Calculate the attributable proportion:

Attributable proportion = (0.57 – 0.07) / 0.57 x 100% = 87.7%

  - Given the proven causal relationship between cigarette smoking and lung cancer, and assuming that the groups are comparable in all other ways, one could say that about 88% of the lung cancer among smokers of 1-14 cigarettes per day might be attributable to their smoking. The remaining 12% of the lung cancer cases in this group would have occurred anyway

Measures of Public Health Impact

- Vaccine Efficacy or Effectiveness:
  - Measures the proportionate reduction in cases among vaccinated persons
  - Efficacy used in ideal (clinical) studies; Effectiveness used in less than ideal situations (non-controlled); VE =

    $$\frac{\text{Risk among unvaccinated group} - \text{risk among vaccinated group}}{\text{Risk among unvaccinated group}}$$

    Or

    1 – Risk Ratio
  - Interpretation: 90% = There is a 90% reduction of the disease among the vaccinated group
  - **EXAMPLE: Calculating Vaccine Effectiveness**
    - Calculate the vaccine effectiveness from the varicella data in Table 3.13.

      VE = (42.9 – 11.8) / 42.9 = 31.1 / 42.9 = 72%

      Alternatively, VE = 1 – RR = 1 – 0.28 = 72%
  - So, the vaccinated group experienced 72% fewer varicella cases than they would have if they had not been vaccinated.

Summary

- Because many of the variables encountered in field epidemiology are nominal-scale variables, frequency measures are used quite commonly in epidemiology
- Frequency measures include ratios, proportions, and rates. Ratios and proportions are useful for describing the characteristics of populations. Proportions and rates are used for quantifying morbidity and mortality
- These measures allow epidemiologists to infer risk among different groups, detect groups at high risk, and develop hypotheses about causes — that is, why these groups might be at increased risk.
- The two primary measures of morbidity are incidence and prevalence.
    - **Incidence** rates reflect the occurrence of new disease in a population.
    - **Prevalence** reflects the presence of disease in a population.
- A variety of **mortality** rates describe deaths among specific groups, particularly by age or sex or by cause
- The hallmark of epidemiologic analysis is comparison, such as comparison of observed amount of disease in a population with the expected amount of disease.
- The comparisons can be quantified by using such measures of association as risk ratios, rate ratios, and odds ratios
- These measures provide evidence regarding causal relationships between exposures and disease
- Measures of public health impact place the association between an exposure and a disease in a public health context. Two such measures are the attributable proportion and vaccine efficacy