Outline of Module

- This module will introduce the following topics:
  - Basic epidemiological principles
    - Prevalence and incidence
    - Morbidity and mortality
    - Risk and benefit
    - Risk ratios and odds ratios
Objectives of Module

Students who complete this module should be able to correctly define and apply the following terms as they pertain to evidence-based clinical practice.

- Prevalence
- Incidence
- Morbidity
- Mortality

Students who complete this module should be able to...

- Distinguish between prevalence and incidence and explain how these are mathematically and clinically related.
- Distinguish between the relative risk and the odds ratio.
- Calculate and interpret relative risk and odds ratio statistics.
Prevalence and Incidence
Incidence vs. Prevalence

- **Prevalence**
  - Number of *existing cases* in the *population* at a given time
  - Represents total disease burden in the population
  - Expressed as a proportion

- **Incidence**
  - Number of *new cases* in the *population at risk*\(^*\) per unit of time
  - Represents rate of development of disease in the population
  - Expressed as a rate

**Prevalence = Incidence \times Duration**

- In general, we often see that:
  - Acute diseases: Prevalence \sim Incidence
  - Chronic diseases: Prevalence > Incidence
- However, the exact relationship depends on many issues such as duration of the disease, seasonal patterns of disease, available treatment options and mortality rates

\(^*\)By definition, the population at risk cannot include those who already had the disease.
Incidence vs. Prevalence

Distribution of Disease in Population at Time 1

Distribution of Disease in Population at Time 2

Prevalence = 1/10 = 10%

Prevalence = 3/10 = 30%

Incidence = 2/9 = 22%
Specific Examples

- About 215,000 people younger than 20 years have diabetes (type 1 or type 2). This represents 0.26% of all people in this age group. **PREVALENCE**

- Among youth aged 10 years or older, the rate of new cases was 18.6 per 100,000 each year for type 1 diabetes and 8.5 per 100,000 for type 2 diabetes. **INCIDENCE**

- Video with example calculations: [https://www.youtube.com/watch?v=Xd0IPXsUdBc](https://www.youtube.com/watch?v=Xd0IPXsUdBc)
  - YouTube – Rahul Patwari: “Incidence and prevalence”
Relationship between Incidence & Prevalence

- Anything that tends to increase incidence or duration of disease will tend to increase prevalence; anything that decreases incidence or duration will tend to decrease prevalence (Prevalence = Incidence x disease duration)

- Consider the “epidemiologist’s bathtub”:
  - [https://www.youtube.com/watch?v=1jzZe3ORdd8](https://www.youtube.com/watch?v=1jzZe3ORdd8)
Morbidity and Mortality
**Morbidity and Mortality**

- **Morbidity** is a quantitative measurement of disease.
- **Mortality** is a quantitative measurement of death.

Do not confuse the terms morbidity and mortality with incidence and prevalence.
- Morbidity and mortality may be described with prevalence and incidence statistics.
  - For example: Both the incidence and prevalence examples on a previous slide show statistics for a morbidity, type II diabetes.

- **Co-morbidity** is a term used to refer to the simultaneous presence of multiple morbidities in the same patient or group of patients.
  - For example: Type II diabetes is a co-morbidity often associated with obesity.
Risk and Benefit
Context of Risk and Benefit in EBM

- Estimates of risk and benefit can have tremendous impacts on clinical decisions and patient outcomes.

- Estimates of risk and benefit are presented in numerous ways in the medical literature. Moreover, they vary widely with respect to accuracy, quality, and clinical value.

- It is important for clinicians to understand these EBCP concepts in order to make informed choices and offer informed opinions to their patients.
Risk and Benefit Vocabulary

- **Risk**: Probability of developing a disease* within a given time interval
  - Example: Patients with diabetes have an increased risk of complications from influenza infection.

- **Risk factor**: A variable or exposure that increases the probability of developing a disease
  - Example: Employment in a healthcare setting is a risk factor for influenza infection.

- **Protective factor**: A variable or exposure that decreases the probability of developing a disease
  - Example: Seasonal flu vaccination is a protective factor for influenza infection.

*Note: “Disease” may also refer to a complication, side-effect or other negative outcome, here and elsewhere in this section.
The relative risk (RR) is a common statistic used to measure effect size in the clinical literature. It is also sometimes called a “risk ratio.”

The RR is a ratio of incidence rates in two groups being compared.
- A group exposed to factor of interest (risk factor or protective factor)
- A group not exposed to the factor of interest (risk factor or protective factor)

\[ RR = \frac{\text{Incidence in exposed group}}{\text{Incidence in non-exposed group}} \]
- \( RR = 1 \) if there is no difference in risk between groups
- \( RR > 1 \) if the factor increases risk (i.e., a risk factor)
- \( RR < 1 \) if the factor reduces risk (i.e., protective factor)
Example

- The RR can be calculated using a 2 x 2 table in which patients in a study are classified based on whether they were exposed to the factor of interest and developed the disease of interest.

<table>
<thead>
<tr>
<th>Disease</th>
<th>No Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>a</td>
</tr>
<tr>
<td>Not Exposed</td>
<td>c</td>
</tr>
</tbody>
</table>

- Suppose that, in a clinical study, 100 patients were given a treatment drug and another 100 patients received a placebo.

- The patients were followed over time to see whether they developed a particular disease, and a similar table was prepared.
  - Note that the example study design here is an example of a “clinical trial,” an interventional design. We also could have used an observational cohort study design example.
We can calculate the RR from this table....
Step 1: Incidence in exposed group = 30/100 = 0.3
Step 2: Incidence in non-exposed group = 60/100 = 0.6
Step 3: \( RR = \frac{0.3}{0.6} = 0.5 \)
RR < 1, suggesting that the drug is a protective factor

What if this RR had been >1? We’ll return to risk factors soon.
Benefit

- Studies involving *protective factors*, like the example on the previous slide, inform clinical decisions about prevention and treatment.

- However, note that these studies estimate the benefit of a treatment or prevention method for a *group* of patients.
  - This is **not** the same as estimating the benefit for a *single patient*.

- In the previous example, **30 patients** on the treatment drug still developed the disease.

- This highlights the importance of considering risks and benefits published in medical research *in context*. Always consider how EBM applies to your *particular* patient.
Relative Risk vs. Odds Ratio

- Recall that studies in groups of patients can identify factors that:
  - Decrease the risk of disease (protective factors)
    - RR<1: The risk of disease is reduced by (1-RR)%.
      A relative risk of 0.8 means a 20% reduction in the risk of disease.
  
  - Increase the risk of disease (risk factors)
    - RR<1: The risk of disease is increased by (RR-1)%.
      A relative risk of 1.8 means an 80% increase in the risk of disease.

- Recall that the RR is a ratio of incidence rates.
  - Calculation of incidence rates requires us to follow a population at risk over a period of time.

- It is not always possible to follow a population at risk over time or to calculate incidence rates. In these cases, we can estimate risk using a different statistic—the odds ratio (OR).
Example

- Suppose we want to study a *rare disease*, and we want to know whether a particular gene leads to the development of that disease.

- If we take 100 patients with the gene and 100 without the gene and follow them over time (e.g. with a “prospective cohort” study design), we may not see any cases of this disease, due to its low incidence (it is rare, after all). **In this case, we may be unable to calculate a RR.**

- To overcome our inability to calculate the incidence of this disease, suppose that we find 20 people with the disease and 40 people without the disease and then compare these two groups to determine if they have the gene of interest.
  
  - We can still calculate the same sort of 2x2 table that we used in a previous example. However, the statistic we use to measure effect size will be different.
  
  - Note: this is a “case-control” study design (refer back to module 2)
Should we calculate incidence rates and a RR for this table? No, we did not follow a population at risk over time.

Instead, we selected a group with disease and a group without disease, and we now wish to compare them. An OR should be used in this case.

<table>
<thead>
<tr>
<th></th>
<th>Disease</th>
<th>No Disease</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>15</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Not Exposed</td>
<td>5</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Totals</td>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>
Odds Ratio Calculation

- Like RR, OR can be calculated using a 2 x 2 table in which patients are classified based on whether they were exposed to the factor of interest and developed the disease of interest.

<table>
<thead>
<tr>
<th></th>
<th>Disease</th>
<th>No Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Not Exposed</td>
<td>c</td>
<td>d</td>
</tr>
</tbody>
</table>

\[ \text{OR} = \frac{a/b}{c/d} = \frac{a \times d}{b \times c} \]

- Compare to RR: \[ \frac{a}{a+b} = \frac{a}{a+b} = \text{incidence in exposed group} \]
  \[ \frac{c}{c+d} = \text{incidence in unexposed group} \]

- For the example on the previous slide:
  \[ \text{OR} = \frac{15 \times 20}{20 \times 5} = \frac{300}{100} = 3.0 \]

*Odds are less intuitive than rates. In common language, they are sometimes used in gambling. Odds of 2:1 winning to losing indicate a 66% (2/3) chance of winning.
Odds Ratio

- ORs are interpreted much like RRs:
  - OR=1: No association of exposure and disease
  - OR>1: Exposure associated with increased odds of disease
  - OR<1: Exposure associated with decreased odds of disease

- Yet, RR and OR are **not** the same.
  - The OR does not contain any information about the *incidence* of a disease. This will be important to understand later.

- However, in cases of **rare** diseases, the OR approximates the RR.

- The OR is an alternative to the RR that is used when incidence cannot be calculated (but is harder to interpret and explain to patients).
Video: The difference between RR and OR

- YouTube – Rahul Patwari: “Odds Ratios and Risk Ratios”
  - Remember, ‘relative risk’ and ‘risk ratio’ are synonyms
  https://www.youtube.com/watch?v=hOtoV2Kjb0o

- As is explained very well in the video, there is an important relationship between study design and the appropriate use of RR vs. OR
  - RR may be used for studies with prospective designs, because we know the denominator and can calculate incidences (e.g. cohort studies & clinical trials)
  - OR (rather than RR) must be used in case-control study designs, because we cannot calculate incidence – we don’t know the denominator!
Key Points for Module 3

- Morbidity, mortality, incidence, and prevalence are epidemiology terms commonly used to characterize diseases or conditions in groups of patients or populations.

- Prevalence = Incidence x Duration

- A ‘relative risk’ or ‘risk ratio’ (RR) is a ratio of incidence rates in exposed and unexposed groups within a clinical study or population. The RR can be used to estimate the risks or benefits of exposures, treatments, or prevention methods.

- An ‘odds ratio’ (OR) is an alternative to the RR in estimating risks and benefits and is used in various situations, including when disease incidence cannot be determined.

- OR approximates RR for very rare conditions

- Clinical trials and cohort studies commonly use RR as an outcome measure; case-control studies use OR (because RR cannot be calculated)
Please complete the ICON quiz.

Thank you!

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