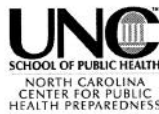
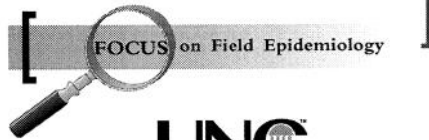


## Epidemic Curves Ahead



## Goals

- Discuss the importance of epidemic curves as a method to graphically depict outbreaks
- Define and review:
  - Outbreak patterns of spread
  - Outbreak magnitude
  - Outbreak time trend
  - Outbreak outliers
  - Period of exposure
  - Incubation period
- Describe methods to create epidemic curves



## What is an Epidemic Curve and How Can it Help in an Outbreak?

- An epidemic curve (epi curve) is a graphical depiction of the number of cases of illness by the date of illness onset



## What is an Epidemic Curve and How Can it Help in an Outbreak?

- An epi curve can provide information on the following characteristics of an outbreak:
  - Pattern of spread
  - Magnitude
  - Outliers
  - Time trend
  - Exposure and/or disease incubation period



## Outbreak Pattern of Spread

- The overall shape of the epi curve can reveal the type of outbreak
  - Common source
  - Point source
  - Propagated

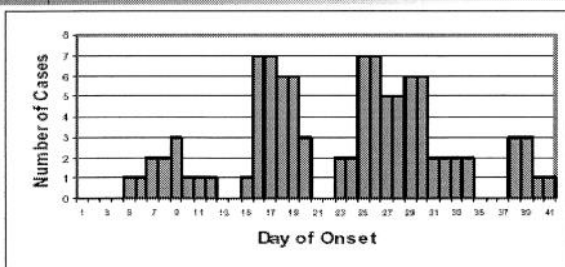
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## Outbreak Pattern of Spread- Common Source

- People are exposed continuously or intermittently to a harmful source
- Period of exposure may be brief or long
- Intermittent exposure often results in an epi curve with irregular peaks that reflect the timing and the extent of exposure

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## Example of an Epi Curve for a Common Source Outbreak with Intermittent Exposure



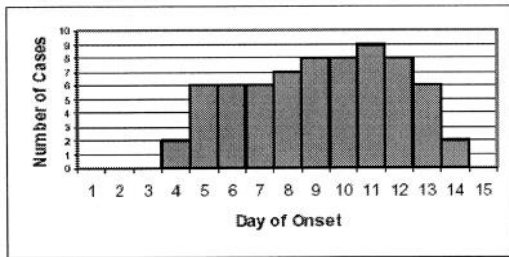
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## Outbreak Pattern of Spread- Common Source

- Continuous exposure will often cause cases to rise gradually (and possibly to plateau, rather than to peak)

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### Example of an Epi Curve for a Common Source Outbreak with Continuous Exposure

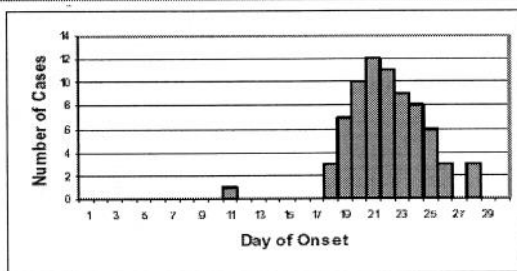


### Outbreak Pattern of Spread-Point Source

- Typically shows a sharp upward slope and a gradual downward slope
- Is a common source outbreak in which the period of exposure is brief, and all cases occur within one incubation period



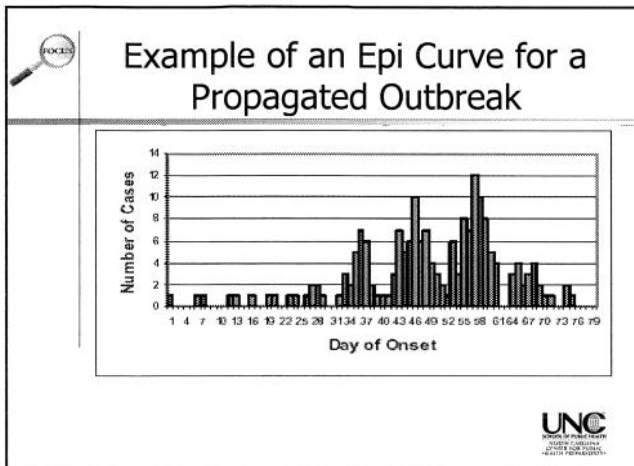
### Example of an Epi Curve for a Point Source Outbreak



### Outbreak Pattern of Spread-Propagated

- Is spread from person to person
- Can last longer than common source outbreaks
- May have multiple waves
- The classic epi curve for a propagated outbreak has progressively taller peaks, an incubation period apart





- ### Outbreak Magnitude
- Can provide a sense of the magnitude of an outbreak
  - Additional information can be obtained by stratifying the epi curve
    - Separating the sample into several subsamples according to specific criteria, e.g. age and gender
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- ### Outbreak Time Trend
- Allow information about the time trend of the outbreak to be gleaned
    - Consider:
      - Date of illness onset for the first case
      - Date when the outbreak peaked
      - Date of illness onset for the last case
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- ### Outbreak Outliers
- Outliers are cases at the very beginning and end that may not appear to be related
    - First check to make certain they are not due to a coding or data entry error
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## Outbreak Outliers

- If they are not an error, they may represent
  - Baseline level of illness
  - Outbreak source
  - A case exposed earlier than the others
  - An unrelated case
  - A case exposed later than the others
  - A case with a long incubation period



## Period of Exposure/Incubation Period for the Outbreak

- If the timing of the exposure is known, epi curves can be used to estimate the incubation period of the disease
- The time between the exposure and the peak of the epi curve represents the median incubation period



## Period of Exposure/Incubation Period for the Outbreak


- In common source outbreaks with known incubation periods, epi curves can help determine the average period of exposure
- Find the average incubation period for the organism and count backwards from the peak case on the epi curve




## Period of Exposure/Incubation Period for the Outbreak


- This can also be done to find the minimum incubation period
- Find the minimum incubation period for the organism and count backwards from the earliest case on the epi curve




 **Period of Exposure/Incubation Period for the Outbreak**


- Average and minimum incubation periods should be close and should represent the probable period of exposure
- Widen the estimated exposure period by 10% to 20%




 **How do I Make an Epi Curve?**


- Plot the number of cases of disease reported during an outbreak on the y-axis
- Plot the time or date of illness onset on the x-axis




 **How do I Make an Epi Curve?**

- Technical tips
  - Choice of time unit for x-axis depends upon the incubation period
  - Begin with a unit approximately one quarter the length of the incubation period
  - If the incubation period is not known, graph several epi curves with different time units



 **How do I Make an Epi Curve?**

- Usually the day of illness onset is the best unit for the x-axis
  - If the incubation period is very short, hour of onset may be more appropriate
  - If the incubation period is very long, week or month may be more appropriate





## How do I Make an Epi Curve?

- Epi curves are histograms
  - There should not be any space between the x-axis categories
- Label each axis
- Provide a descriptive title
- Include the pre-epidemic period to show the baseline number of cases



## Using Software Packages to Create Epi Curves

- Epi curves may be done by hand or with software such as Microsoft Excel, Microsoft PowerPoint or Epi Info
- To create an epi curve in Microsoft Excel:
  - Click the "Chart wizard" on the tool bar
  - Choose "Column" as the chart type
  - Click "Next" twice and specify the chart options
  - Click "Next"
  - Click "Finish"
  - Change the "Gap width" to "0" to get the bars to touch



## Using Software Packages to Create Epi Curves


- To create an epi curve in Microsoft PowerPoint
  - Click on the "Insert Chart" command on the tool bar
  - Clear the example data
  - Insert outbreak data
  - Format spreadsheet so that first row is the date and second row is the number of cases




## Using Software Packages to Create Epi Curves


- To create an epi curve with Epi Info
  - Click the "Analyze data" button on the main menu
  - Open or import the outbreak data
  - Click on "Graph" from the menu bar under the "Statistics" section
  - Choose "Histogram" as the "Graph Type"
  - Choose date/time of illness onset variable as the x- axis main variable




 **Using Software Packages to Create Epi Curves**


- Choose "Sum" from the "Show value of" option beneath the y-axis option
- Choose number of cases variable for the "Weight variable" beneath the y-axis option
- Type graph title where it says "Page title"
- Click "Ok"




 **Using Software Packages to Create Epi Curves**


- An epi curve may also be created in Epi Info by using the "graph" command and various graph options
  - Code to do this can be found by looking up "analysis code index" in the Epi Info help menu and choosing the "graph" option




 **Conclusion**

- Epi curves are useful in outbreaks to
  - Identify the pattern of spread
  - Assess the magnitude
  - Evaluate time trends
  - Examine Outliers
  - Estimate the exposure period



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## Epidemic Threshold

Above this a virus may spread + below this it cannot. If a birth rate of a virus is greater than its death rate, the virus has a chance to spread successfully, although it may die out before it spreads much. If the virus does manage to get a foothold, it will start to rise slowly in prevalence. The rate at which it does so is governed by a number of factors.

## Herd Immunity

When an infectious agent is introduced into a population that has never previously encountered it, all are susceptible. As the epidemic passes through successive hosts, leaving them immune, progressively higher proportions of the population become immune. When a sufficiently high proportion of the population becomes immune to the infectious agent, the epidemic subsides and eventually ceases. The proportion required to reduce susceptibility to a level where an epidemic cannot be sustained depends on many variations in the properties of the herd, the environment + the agent. A common cold virus introduced into a virgin herd infects everyone and confers transient immunity on everyone after recovery. If the herd is large, say 10,000 or more, common cold viruses may continue to circulate long enough for immunity to wear off + the same individuals can be reinfected. An epidemic begins only when there is a sufficiently large susceptible population. Eg: probability of a diphtheria epidemic is reduced to near the vanishing point when 50 to 60% of the population have been rendered resistant either by previous infection or immunization.

## Basic Reproduction Number

$R_0$  is defined as the expected number of secondary cases (new infections) produced by a single (typical) infection in a completely susceptible population.

$R_0$  is a dimensionless number + not a rate

$$R_0 = N \cdot \bar{c} \cdot d$$

$N$  = transmissibility (probability of infection given contact between susceptible + infected individual)

$\bar{c}$  = the average rate of contact between susceptible + infected individuals

$d$  = duration of infectiousness

## Effective Reproduction Number

$R$  or  $R_e$  = effective reproduction number of an infection.

- may be used to monitor the impact of a vaccination programme
- If  $R_e$  is maintained below 1, then sustained endemic transmission of the infection cannot occur.
- Not everyone in a pop will be susceptible (may have vaccine) so effective reproductive number will be less than  $R_0$  (not everyone is susceptible, not everyone is likely to have contact with index case, not everyone has same duration of infectiousness)
- $R$  = The no of secondary cases produced in a host pop not consisting entirely of susceptible individuals. Under conditions of stable endemic infection,  $R = 1$

## Generators

In epidemic models, these are the waves of secondary infection that flow from each previous infection.