The Chain of Infection and Epidemiology

Kathleen McMullen, MPH CIC

Kathleen McMullen, MPH CIC

Kathleen started her career in the field Infection Control as an Intern for the St. Louis County Department of Health, Communicable Disease Control Services in 2002 while working on gaining her Masters degree in Public Health with concentrations on Epidemiology and Biostatistics. Kathleen has been working for the prestigious Barnes-Jewish Hospital since 2003. Kathleen is currently the hospitals Infection Prevention Specialist and also has responsible for the infection control management over the operating rooms & outpatient clinics.

Presenting: ***Chain of Infection and Epidemiology***

Objectives

- Review the Chain of Infection
- Discuss common used Epidemiology terms
- Study basic Epidemiology methods

Chain of Infection

- Causative agent
- Reservoir
- Portal of exit
- Mode of transmission
- Portal of entry
- Susceptible host

Causative Agent

- Can be biological, physical or chemical
- Some have characteristics that make them more successful at causing infection
  - Invasive enough to enter tissue
  - Virulent enough to cause disease
  - High amount of the agent present (infectious dose)
  - Ability to cause disease in more than just humans
  - Ability to adapt to challenges (antibiotic resistance, antigenic variation in Influenza)

Reservoir

- Reservoir: place where an infectious agent can survive, but may not multiply
  - Fomite: inanimate object on which organisms may exist for some period of time
- Most common: humans, animals and the environment

Portal of Exit

- Path by which the infectious agent leaves the reservoir
  - Respiratory tract
  - Genitourinary tract
  - Gastrointestinal tract
  - Skin
  - Mucous membrane
  - Blood

Mode of Transmission

- Method by which the organism reaches a susceptible host
  - Contact: either direct (person-to-person) or indirect (person to fomite)
  - Droplet and airborne transmission: infectious agent is suspended in particles in the air by the reservoir then inhaled by a healthy individual
  - Vehicles: contaminated food or water

Portal of Entry

- Means by which an infectious agent enters the susceptible host
  - Same as portals of exit

Susceptible Host

- Factors that affect agents ability to enter the host
  - Age
  - Sex
  - Medical History
  - Lifestyle
  - Heredity
  - Occupation
  - Nutritional Status

Chain of Infection Example 1: Malaria

- Causative agent
  - *Plasmodium* species
- Reservoir
  - Mosquitoes
- Portal of exit
  - Saliva of mosquito

Chain of Infection Example 1: Malaria

- Mode of Transmission
  - Bloodborne
- Portal of Entry
  - Human skin/blood
- Susceptible Host
  - HIV

Chain of Infection Example 2: Tuberculosis

- Causative agent
  - *Mycobacterium tuberculosis*
- Reservoir
  - Humans
- Portal of exit
  - Respiratory tract – coughing

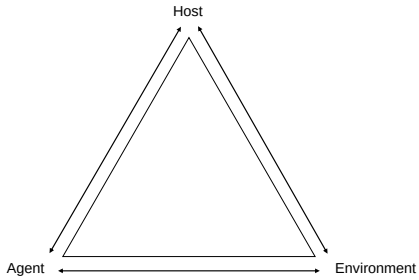
Chain of Infection Example 2: Tuberculosis

- Mode of Transmission
  - Airborne spread
- Portal of Entry
  - Respiratory Tract
- Susceptible Host
  - Immunocompromise

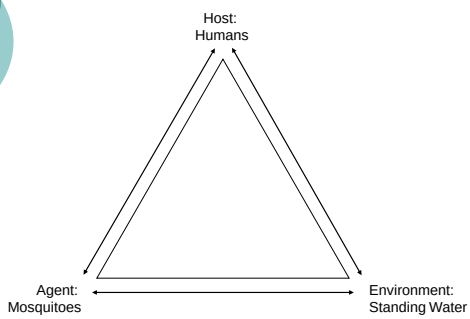
What is Epidemiology?

- Study of the distribution and determinants of health conditions or events in a specified population and the application of this study to the control of health problems
- Purpose is to aid in understanding of the cause of disease by knowing distribution, natural history and determinants in terms of person, place and time
- Both a body of knowledge and a method of study

Epidemiologic Triangle



Epidemiologic Triangle Example: West Nile Virus



Rate and SIR

- Rate
  - A measure of a part with respect to the whole (proportion)
    - Surgical Site Infection Rate measures the number of procedures with infections out of the total number of procedures
  - A quantity measured with respect to another quantity
    - UTI Rate measures the total number of patients with infections out of the total number of Foley days

Standardized Infection Ratio (SIR)

- Method to compare Rates
  - Commonly used to compare your population to that which is expected (usually equal to reported rates from the CDC or studies in the literature)
  - If >1, you have more infections than expected

Endemic, Epidemic and Pandemic

- Endemic: usual presence of a disease or condition in a specific population or geographic area
- Epidemic: the occurrence of more cases of a disease than expected in a given area or among a specific group of persons during a specific time period: synonym of an outbreak
- Pandemic: an epidemic spread over a wide geographical area, across countries or continents

Risk

- Risk: probability or likelihood of an event occurring
- Relative Risk: risk of an event, relative to an exposure
  - If relative risk = 3.2, a patient with risk factor X is 3.2 times more likely to develop disease

Association

- As one variable changes, there is a resulting change in another variable
  - Artifactual association: a false association that can be due to chance or bias in study method
  - Indirect association: mixing of effects between exposure, disease, and a third factor (i.e., confounding variable) that is associated with the exposure and independently affects the outcome
  - Causal association: when evidence indicates that one factor is clearly shown to increase the probability of the occurrence of a disease; reduction of this factor decreases the frequency of disease

Causality

- Used to determine if one factor causes disease (Caution – different from causal association)
- Requires:
  - strength of causal association
  - consistency
  - specificity
  - temporality
  - biological gradient
  - biological plausibility
  - coherence
  - associations derived from experiments

Validity and Reliability

- Reliability: Consistency of two sources of measurement
  - For example, how well two different infection preventionists "diagnose" surgical site infections
- Validity: Description of how well the measurement system compares to reality
  - For example, the comparison of the number of infections your new electronic surveillance finds infections versus your old manual method of surveillance

Sensitivity and Specificity

- Stats used to describe validity
  - Sensitivity is the proportion of true positives that are called positive by the measurement system
    - High sensitivity is used when you don't want to miss any true cases
  - Specificity is the proportion of true negatives that are called negative
    - High specificity is used when you don't want to accidently call false cases

Basic Epidemiologic Methods

- **Surveillance – disease monitoring**
- Basic Statistics
- Identifying clusters or outbreaks
- Study Design

Surveillance for Infections

- Involves review of individual patients to determine disease presence/absence
- Most common types
  - Surgical site infections
  - Organism-specific infections
- Use a standardized definition (CDC NHSN)
- Use a standard process, ideally the same person performing surveillance in the same methods each time
- Generally end up with a number of infected and non-infected patients

Defining the At-risk Population

- When defining the population for surveillance:
  - Each case must have been part of the greater population prior to developing the disease or infection
  - Each non-case must be at risk for developing the disease or infection

Case Definition vs. Clinical Diagnosis

Case Definition	Clinical Diagnosis
Aimed at finding the cause of disease or infection	Aimed at choosing appropriate treatment
Must contain characteristics of members included (e.g., all patients have VTE)	May focus on individual characteristics (e.g., patient has right leg VTE)
Must contain information that distinguishes cases from others (e.g., must have a specific strain of E.coli)	May not focus as specifically as necessary (e.g., has E.coli, but strain is unimportant)

Surveillance for Process Measures

- Factors known to be related to infections
  - Dress code
  - Pre-operative prophylaxis
    - Antibiotic choice and timing
  - Hand Hygiene
  - Skin Prep
- Generally reported as a percentage of compliance with the measure

Basic Epidemiologic Methods

- Surveillance – disease monitoring
- **Basic Statistics**
- Identifying clusters or outbreaks
- Study Design

Types of Data

- Continuous
  - Measured on a scale, values have meaning
  - Weight, age
- Categorical (Discrete)
  - Grouped into a set of values or choices
  - Yes/no, gender

Descriptive Statistics Continuous Variables

- Defines the center or middle of the sample
  - Mean
  - Median
  - Mode
- Analyzes the variability of the sample
  - Range
  - Standard Deviation

Descriptive Statistics Categorical Variables

- Show number of patients that fall into each variable and percentage
- In a sample of 10 infections:
  - Male 3 (30%)
  - Female 7 (70%)

Prevalence

- The number of existing cases of disease in a population during a defined period
- Is a function of both incidence patterns and duration of disease
  - Long diseases or colonizers (MRSA) can have high prevalence
  - Quick and common diseases (common cold) will have moderate or low prevalence

Incidence

- The number of new cases of disease that develop in a population at risk during a defined period
  - Cumulative incidence
  - Incidence density

Cumulative Incidence

- Proportion of individuals in a population who develop the disease within a defined period
- Provides a measure of the risk of developing disease within a defined period for an average individual in the population

Cumulative Incidence

- For example, an SSI rate:

$$= \frac{\text{number of new cases of disease}}{\text{total population at risk}}$$

$$= \frac{\text{10 craniotomy SSI}}{\text{123 craniotomy procedures}}$$

Incidence Density

- Cumulative incidence assumes all people at risk have been followed for the same amount of time
- Incidence Density measure the rate at which new cases of disease occur in the population at risk during a defined period

Incidence Density

- For example, a MRSA rate:
  = # of new cases of disease X 1000
  total person-time at risk
  = 11 patients with MRSA X 1000
  2441 patient days

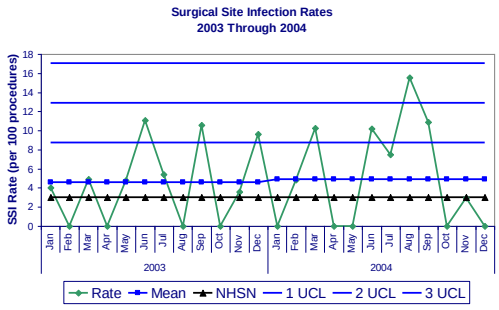
Basic Epidemiologic Methods

- Surveillance – disease monitoring
- Basic Statistics
- **Identifying clusters or outbreaks**
- Study Design

Clusters and Outbreaks

- There is no definitive answer
- These terms are dependent on hospitals and their "normal" patterns
- Run charts commonly used

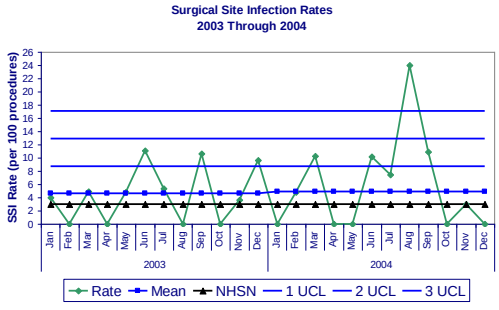
Run (Control) Chart



Run (Control) Chart Rules

- Early Warning of Process Shift
  - Rule 1- 1 point above or below the third control limit (may also be a freak value)

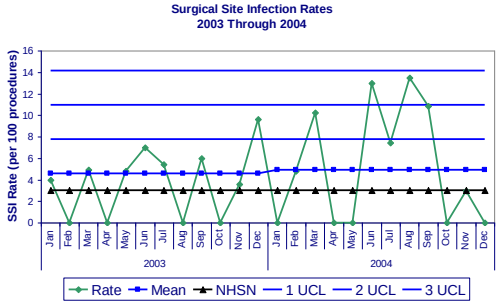
Run (Control) Chart



Run (Control) Chart Rules

- Early Warning of Process Shift
  - Rule 1- 1 point above or below the third control limit (may also be a freak value)
  - Rule 2- 2 out of 3 points above the second control limit

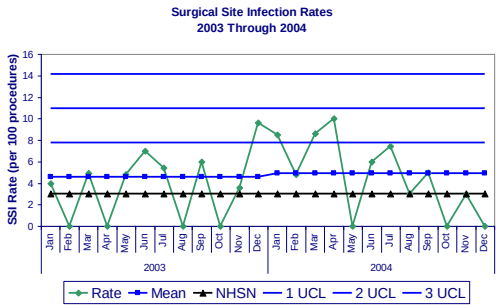
Run (Control) Chart



Run (Control) Chart Rules

- Early Warning of Process Shift
  - Rule 1- 1 point above or below the third control limit (may also be a freak value)
  - Rule 2- 2 out of 3 points above the second control limit
  - Rule 3- 4 out of 5 points above the first control limit

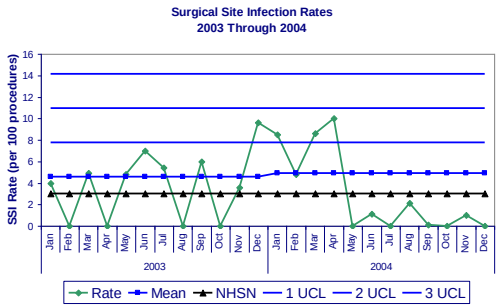
Run (Control) Chart



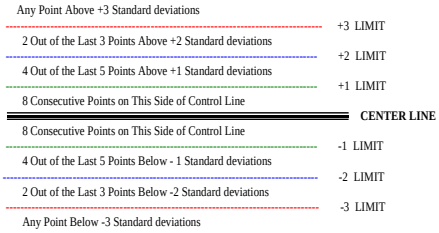
Run (Control) Chart Rules

- Early Warning of Process Shift
  - Rule 1- 1 point above or below the third control limit (may also be a freak value)
  - Rule 2- 2 out of 3 points above the second control limit
  - Rule 3- 4 out of 5 points above the first control limit
- Process Shift
  - Rule 4- 8 consecutive points above or below the center line
  - Indicates the need for new control limits

Run (Control) Chart



Run (Control) Chart Rules



Basic Epidemiologic Methods

- Surveillance – disease monitoring
- Basic Statistics
- Identifying clusters or outbreaks
- **Study Design**

Study Design

- Two basic categories of study design
  - Descriptive study
  - Analytical study
    - Experimental
    - Case-control
    - Cohort
    - Cross-sectional

Study Design

- Descriptive studies
  - Undertaken to describe patients presenting with disease or infection
  - Usually, no specific hypothesis has been identified

Descriptive Study Designs

- Case report describes newsworthy occurrence of unsuspected relationships
- Case series reports several occurrences of similar case reports
- Rate based descriptive study combines data on a set of cases with a denominator

Study Design

- Analytical studies
  - Undertaken to test a specific hypothesis or objective- typically whether an exposure causes a certain outcome

Analytic Study Designs

- Randomized trials assign participants to either receive an intervention or not based solely on chance- provides excellent control of confounding
- Non-randomized trials (cohort, case-control, cross sectional) do not assign exposure status. Because the exposure is naturally occurring, there is a high possibility of introducing confounding

Analytic Study Designs

- Case-control studies compare the frequency of past exposure between cases and controls
  - Start with all cases, select 3-4 controls from the population of un-infected patients
  - Then collect presence/absence of lots of risk factors, looks for higher proportion of risk factors in the case population, rather than the controls

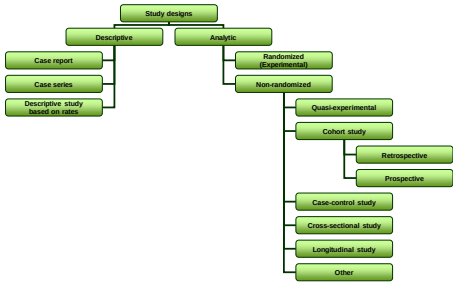
Analytic Study Designs

- Cohort studies compares disease incidence over time between groups that are found to differ in their exposure, can be retrospective or prospective.

Analytic Study Designs

- Cross-sectional studies compare exposure and outcomes that are identified at the same point in time, does not designate which came first- considered prevalent cases instead of incident cases

Study Design Tree



Koepsell T., Weiss N. Epidemiologic Methods: Studying the Occurrence of Illness. Oxford University Press, 2003. p. 94.