VSC114 Notes
TOPIC 1: Introduction to Applied Veterinary Epidemiology

Learning Objectives

- Be able to define and appropriately use the basic concepts and terminology used in the subject of epidemiology
- Be able to determine and apply different methods to measure disease frequency, dynamics and associations
- Be able to define, select and explore differing and appropriate sampling methods and conduct calculations of sample size
- Be able to interpret and make appropriate inference from epidemiological and statistical outcomes
- Be able to explore and understand the importance of the hierarchy of evidence, and define and be able to critically appraise each level of evidence.
- Be able to calculate, interpret and compare measures of diagnostic test accuracy
- Know and be able to apply the steps of an outbreak investigation
- Demonstrate knowledge of and be able to appropriately apply principles of study design
- Demonstrate knowledge of and be able to appropriately apply statistical theory and methods

Epidemiology

- Population focussed
- "deals with the investigation of ... determinants of disease distribution in animal populations" (Pfeiffer, 2010)
- Uses a range of methods
- Main Principal of Epidemiology: disease does not occur randomly in populations!
- Epidemiology is
    - Being a disease detective
    - Knowing how much disease there is
    - Identifying risk factors for diseases
    - Suggesting hypotheses for new causal mechanisms
    - Working to find the best means to minimise risks and control diseases

History

- John Snow (1813 – 1858)
    - Cholera epidemic 1854
    - Rejected 'miasma' theory
    - No germ theory at this time
    - Mapped infected households
    - Located source of disease and intervened

Veterinary Epidemiology

- May be related to human public health
    - For example: *Salmonella, Hendra virus, Zika virus*
- Or may refer to animal populations

- For example: foot and mouth disease, canine parvovirus

Tools

- Estimates of population measures
- Graphs
- Statistics
- Special measures of disease dynamics
- Maps

Measuring a disease

Objectives

- Understand different ways of measuring disease frequency
  - Counts, proportions, percentages, ratios and rates
- Define and understand the difference between incidence and prevalence
  - Be able to identify when each should be used

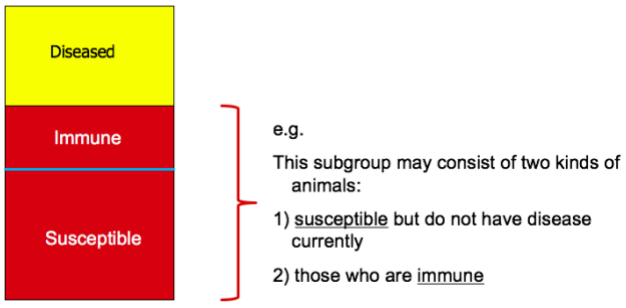
Epidemiology

- Disease does not occur randomly
- Aim is often to elaborate on causes that can explain patterns of disease occurrence
- Translate an, often qualitative, hypothesis into a quantitative one

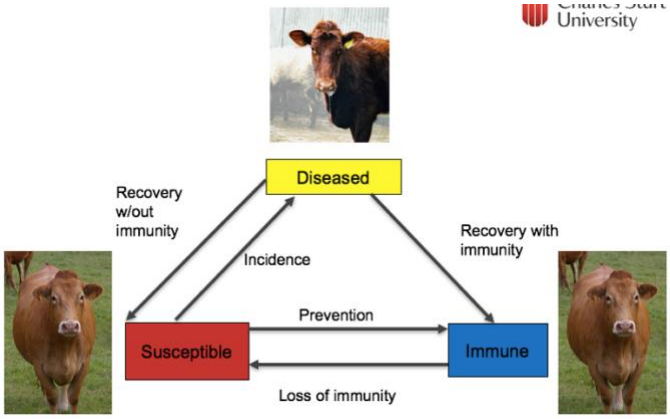
  ⇒ measure occurrence of disease

Quantification of disease occurrence

- How important is the disease?
- How quickly does the disease spread in the population?
- What are the most important causal factors for the disease?
- Summarises a population's disease status at a particular time
- We often want to know:
  - How many animals have the disease?
  - What proportion of the population has the disease?
  - What proportion of the population could still get the disease?
- Knowledge of the disease and the population is needed



- As a population is observed over time, animals in it can change from one state to another



How do we paint a picture of what is going on in a population at any one time?

- Incidence
- Prevalence
- Mortality rate
- Sex-ratio
- Attack rate
- Odds of disease
- Case-fatality
- Crude rates
- Incidence density
- Susceptible fraction
- Neonatal mortality rate
- Crude birth rate
- Postnatal mortality
- Crude death rate
- Cumulative incidence

Measures of disease frequency

- Tools that describe how common an illness is
    - With reference to the size of the population
    - Used to quantify (count) cases, in relation to the population and a measure of time
- Events of interest may be disease, infection, death, recovery, presence of antibodies, visits to the vet
- Include
    - Counts
        - Number of cases in a given population
        - Must know:
            - the size of the population from which the affected individuals come
            - the time period the information was collected
    - Percentages
        - In the equation:
            - Numerator
                - Cases

        - Denominator
            - Population at Risk
            - Or Time at Risk
        - Time frame
            - Period of time we are measuring the disease
    - Proportions
        - = number in which numerator is a subset of the denominator
        - = a / (a + b)
        - Synonyms are: a *percentage* (if expressed per 100)
            - Some well-known proportions in epidemiology
                - Proportional Mortality = $\frac{\text{\# of Deaths from disease X in year Y}}{\text{Total Deaths from all causes in Y}}$
                - Case Fatality = $\frac{\text{\# of Deaths due to disease X}}{\text{\# of New Cases of disease X}}$
                - This is a measure of the propensity of a disease to cause death of the affected individual
    - Ratios
        - = fraction in which numerator is not a subset of the denominator
        - = a / b (or a:b)
        - Values range from 0 to infinity
        - Cannot be expressed as a percentage
    - Rates
        - = number in which denominator is number of animal-time units at risk
        - Incorporates the concept of time or change over time
        - describes the change in one type of quantity relative to the change in another type (e.g. speed = distance per unit time)
        - Describes average speed at which event occurs per unit of animal-time at risk
        - Ideally, a proportion in which change over time is considered, but often (wrongly) used interchangeably with proportion, without reference to time
        - Three common forms of rates
            - Crude Death Rates
            - Specific rates
            - Adjusted rates

Measuring disease frequency in a population

Two main types

- Prevalence
    - Quantifies existing cases
    - Counts the number of existing cases at a certain time point
    - Expressed as proportion
    - The proportion of a population affected by a disease at a given point in time
    - $0 \leq$ prevalence ≤ 1
    - = P(randomly selected individual has the disease at a certain point in time)

$$\text{Prevalence} = \frac{\text{Number of prevalent cases}}{\text{Population present at a given point in time}}$$

  - Issues with using prevalence
    - A measure of existing cases – includes old and new cases
    - Diseases of long duration = high prevalence
    - Diseases of short duration = low prevalence
- Incidence
  - Quantifies the occurrence of new cases
  - Counts the number of new cases over a period of time
  - Expressed as risk or rate
  - A measure of <u>new</u> cases that occur within a given time period
  - Most often expressed as a relative measure with respect to the population at risk

Population 'at risk'

- Animals that:
  - can get the disease
  - can be diagnosed to have the disease
- can be open or closed
  - Closed population
    - No additions during the study
    - Few to no losses during the study
    - Only disease-free animals at the beginning of the study are considered 'at risk'
    - Withdrawals: animals lost to follow-up
      - To deal with this: subtract half the number withdrawals from the population at risk
      - Assumes that, on average, animals are removed from the middle of the study period
  - Open population
    - Animals enter and leave throughout the study period
    - Considered stable if the rate of additions and withdrawals are relatively constant over time

Incidence

- Two measures of incidence
  - Incidence risk
    - relates the number of new cases to the size of the population at risk in the beginning of the period studied
      $\Rightarrow$ probability for a disease (cumulative incidence)
    - The proportion of disease-free individuals developing disease over a specified time
    - $\frac{\text{\# new cases between T=0 and T=1}}{\text{\# disease-free animals at T=0}}$
    - Has no unit – a probability estimate
    - Animals have to be disease free at the beginning of the time period
    - Interpreted as an individual's risk of developing disease within the period in question

        - Where animals may develop the disease several times during the period in question, only the first occurrence is counted
        - Assumes a closed population
    - Incidence rate
        - relates the number of new cases to the animal-time at risk (a change that takes into account changes to the size of the population at risk during the follow-up period)
          $\Rightarrow$ rapidity of disease occurrence
        - Quantifies the number of cases per animal unit of time
        - Does not have an interpretation at the individual level
        - Is an instantaneous concept – the rate at which cases occur at a given instant
        - $\frac{\text{\# new cases between T=0 and T=1}}{\text{sum of periods 'at risk' of the animals}}$
- Calculating incidence rates
    - Exact calculation
        - requires exact number of animal-time contributions
        - Can become >1
        - Unit is 1/time
        - Value depends on denominator
            - Choose a denominator which a reader can understand
        - Period 'at risk'
            - determined per animal 'at risk'
            - first or all occurrences of disease?
            - immunology, resistance?
            - closed or open population? Steady state?
            - animals leaving the population?
            - immune after occurrence? For how long?
    - Approximate calculation = $\frac{\text{cases}}{\text{(start} - \frac{1}{2}\text{ sick} - \frac{1}{2}\text{ withdr.} - \frac{1}{2}\text{ add) x time}}$
        - Works well in large populations
- Incidence Rate - Speed
    - Incidence rate is the momentary rate at which cases are occurring within a group of individuals
    - To measure an incidence rate takes a finite amount of time, just as it does to measure speed
    - Can be thought of as applying at a given instant
    - Time in the denominator is arbitrary and has no implication for any period of time over which the rate is measured or applies
    - This is an average measure and may hide temporal patterns

Incidence Vs Prevalence

- Prevalence vs Incidence risk
    - Only Incidence risk includes a temporal (time-based) sequence
    - Prevalence includes new and old cases
    - Incidence risk includes only new cases - can predict what will happen in the

future

- Incidence rate does not express a risk or probability (rather, number of cases expected per time period)
- Incidence is generally used for acutely acquired diseases, prevalence for states, conditions or attributes
- Incidence is more important when thinking of aetiology of the disorder (associations), prevalence when thinking of burden of the disorder including the costs and resources consumed as a result of the disorder
- Incidence always requires a duration, prevalence may or may not (period prevalence)
- In incidence, the unit of analysis is the event, in prevalence, it is the animal. Thus, incidence may exceed 100% (e.g. annual incidence of clinical mastitis) unless a convention is adopted to count only first episodes of an illness that can occur more than once
- Prevalence can never exceed 100%
- Incidence generally requires an initial disease-free interval before counting starts, because incidence is measured in those at-risk of disease

Other specific measures of disease

- Attack rate = # new cases / initial population at risk
    - Same as incidence risk
    - short time interval
    - used in outbreak investigations
    - Calculated for different exposures and compared
- Secondary attack rate = $\frac{\text{\# cases – initial case(s)}}{\text{initial population 'at risk'}}$
    - used to described the 'infectiousness', contact with known cases
    - difficult to distinguish between primary cases and secondary cases when the latent period is long

Factors affecting interpretation

- Temporal sequences
    - Prevalence studies used to obtain a static picture at a fixed point in time
        - Can be used to examine possible causal relationships (associations) between risk factors and population health status
        - But not studied over time
        - Therefore, cannot infer which came first: factor or outcome
- Disease duration
    - Prevalence study may miss cases where disease is of short duration (or fatal)
        - Results in higher incidence than prevalence
    - Chronic diseases detected for long periods are more likely to be detected in prevalence study
        - Results in higher prevalence than incidence
    - Anything that increases duration of disease will increase prevalence
        - E.g. therapy that delays or prevents mortality
    - To convert prevalence to incidence (when P is small)

        - P = I * D
- Real vs. apparent prevalence
    - Real prevalence assumes that disease testing results are based on tests that are 100% correct
    - Most tests are not 100% correct
    - Can calculate true prevalence by knowing test characteristics and test results
    - Test results are considered the apparent prevalence
        - More on this in diagnostic test interpretation section
- Case definition
    - In many instances, it is difficult to define a set of disease signs that will include all true cases of disease
        - And exclude similar but unrelated conditions
        - As number of clinical signs required to diagnose CRD increases, definition becomes more restrictive but may misclassify some cases
- Dangling numerators
    - Absolute numbers (i.e. counts) without taking into consideration the population at risk (in some disease older animals not at risk)
        - Does not tell us anything about risk of becoming a case (incidence) or being a case (prevalence)
- Population at risk
    - Must interpret with context of PAR
        - Similar to patients that you are diagnosing
        - Eg. Free-ranging cats are not same as home-cats or *all* cats
- Adjusting rates
    - Crude disease rates include population compositions that may interfere with interpretation
    - Necessary to disentangle two factors before meaningful comparisons can be made between comparison groups

Summary

- Prevalence = snapshot in time
    - Probability that an individual has the disease
- Incidence = development of new cases over time
    - Probability that an individual will get the disease (incidence risk)
    - Speed disease is occurring (incidence rate)
- Important to define the denominator