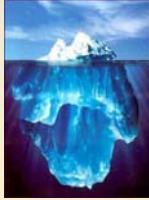


May 1, 2007
POPH 5160: Infectious Diseases
Epidemiology of Disease



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The Bottom Line

"Veterinarians are often called on to diagnose and treat disease in populations...As veterinarians, we are expected to know how diseases are introduced, spread, and persist in animal populations. We must determine the cause of disease and also devise a plan to reduce disease frequency to an 'acceptable' level."

Smith, 1991

Overview of this Session...

- Describe in general terms basic principles of infectious disease epidemiology, including how these principles are evident in the context of common diseases of large animals.



Acknowledgements (Slides)

- Dana Cole, DVM, PhD, DACVIM
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 - <http://www.vetmed.wsu.edu/courses-jmgay/documents/GroupEpidemiologyConcepts.pdf>
- M. Tefvik Dorak, MD, PhD
 - <http://www.dorak.info/epi>

Epidemiology

- The study of the cause, occurrence, distribution, and control of health and disease in a defined population
- Most diseases do not occur randomly, but are related to environmental and personal characteristics that vary by place, time, and subgroup of the population

Epidemiology = Study of Dz in Populations

- An epidemiologist tries to:
 - Describe the amount of disease in a population
 - Determine/ describe risk of disease
 - Who is at higher risk?
 - Where is risk of disease highest?
 - When is disease most likely to occur?
 - What common exposures are present?
 - Modify exposure to these issues to help control dz



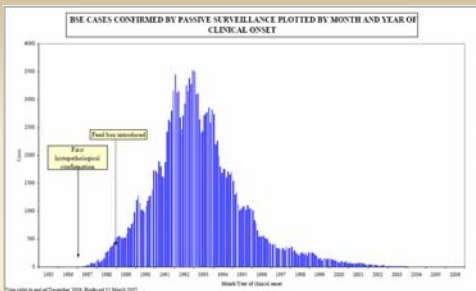
What's the Relevance to a Veterinarian?

- Prevention of disease = investment
- Services provided by veterinarians should be regarded more as an investment, less as a cost
- Application of epidemiological principles to clinical practice → a preventive approach
- More established paradigm in food animal medicine, but also important in companion animal practice

An epidemiological approach works well for diseases where etiology is known, but also for diseases where the cause is not known ...

- Example
 - November 1986: BSE first diagnosed in Great Britain
 - As of March 1, 2007, ~181,000 confirmed cases
 - After 1st 200 cases, epidemiological investigations identified that meat and bone meal was the vehicle of transmission
 - The [relatively] prompt ban (July 1988) on feeding meat and bone meal prevented an even larger epidemic than the one observed





So...if We Can Manage **Risk**, We Can Manage Dz, Even if We Don't Know the Exact Cause

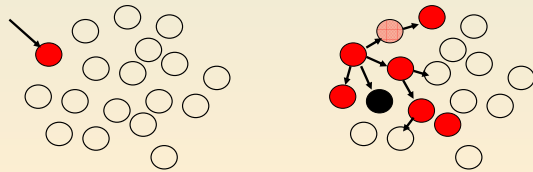
Department for Environment, Food and Rural Affairs (<http://www.defra.gov.uk/>)

Infection vs Disease

- Presence or absence of the etiological agent is the main determining factor in the epidemiology of infectious disease
 - Infectious disease cannot occur without a causative agent
 - BUT, disease need not always result from the presence of the agent
- Critical epidemiological distinction between infection and disease
 - **Infection** - invasion of a living organism (host) by another living organism (agent)
 - **Disease** - derangement in a part (or whole body) of host

Infectious Disease Transmission

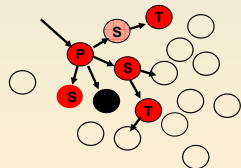
- A case is a risk factor ...
- ❖ Infection in one animal can be transmitted to others



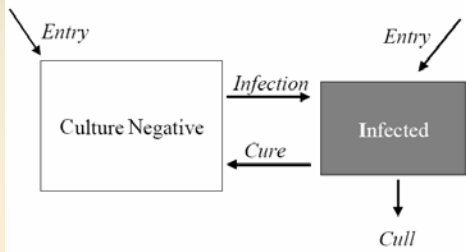
Infectious Disease Transmission

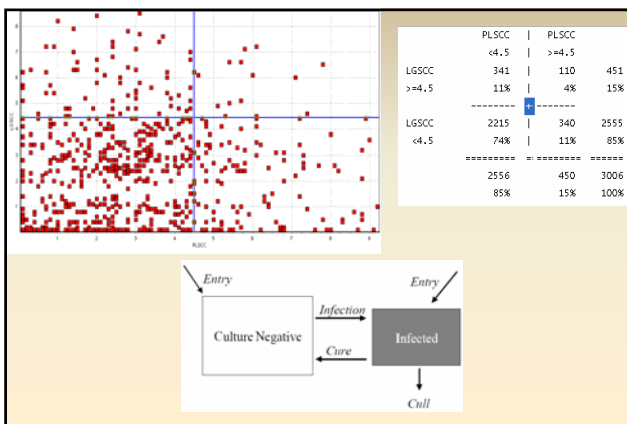
- Cases
- Index - the first case identified
 - Primary - the case that brings the infection into a population
 - Secondary - infected by a primary case
 - Tertiary - infected by a secondary case

- Susceptible
- Immune
- ◐ Sub-clinical
- Clinical



Dynamics of Intramammary Infections (Mastitis) in a Dairy Herd





Disease in Individuals and Populations

□ 'Time' factors that influence patterns of disease:

□ Calendar time

- Ex: influenza outbreaks in people

□ Subject-referent time

- Ex: milk fever in dairy cattle
- gestational diabetes in humans

Temporal Patterns of Disease

- Pattern of new disease cases over time within a defined population:
 - Sporadic
 - Single case or cluster of cases
 - Ex: Mycoplasma mastitis in a "clean" dairy herd
 - Endemic
 - Disease occurs at expected frequency
 - Ex: Environmental strep mastitis in dairy cows
 - Epidemic
 - Disease occurs at greater than expected frequency
 - Ex: Faulty milking equipment leads to "outbreak" of mastitis
 - Pandemic
 - Huge epidemic (international)

Temporal patterns of disease

- Endemic
 - Disease that repeatedly appears in small numbers in a population while most are unaffected
 - Disease occurs at expected frequency
 - Disease present in population or region at all times
 - Level of disease usually low and predictable
 - Examples:
 - Mastitis in dairy cattle
 - Coccidiosis in young cattle

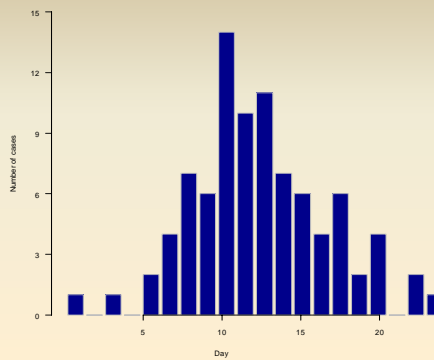
Temporal patterns of disease

- Epidemic
 - Disease occurs at greater than expected frequency
- Can use temporal patterns of onset to provide insight into nature of epidemic (epidemic curves)
 - Common source
 - Propagated

Temporal Patterns of Disease

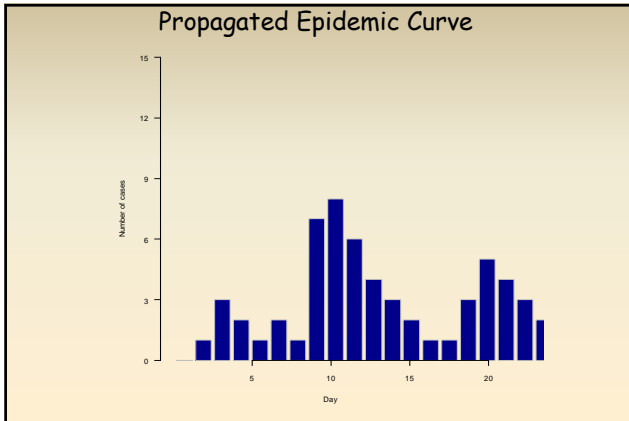
- Common source epidemics
 - Disease arises from a single source of exposure to a causal agent
 - Epidemic curve shows a steep initial rise in case numbers and then a rapid falling off in the tail
 - Examples:
 - Batch of contaminated feed causing an outbreak of salmonellosis in feedlot cattle
 - Milk vacuum problem causing an outbreak of clinical mastitis in a herd of dairy cows
 - Foodborne disease outbreaks

Common Source Epidemic Curve



Temporal Patterns of Disease

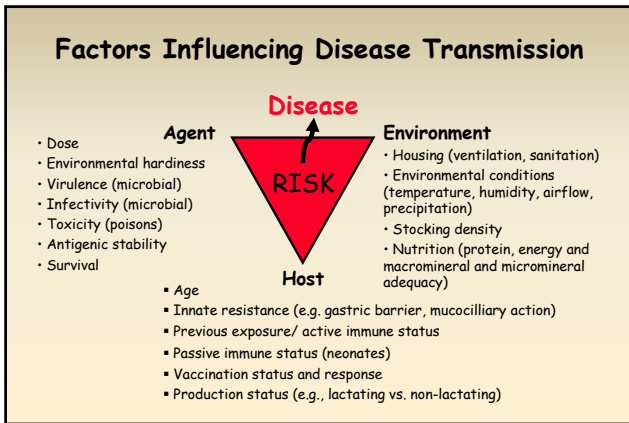
- Propagated epidemics
 - Classic infectious disease outbreak
 - Occurs when an agent is transmitted through the population from host to host (typically infectious conditions)
 - Nature of epidemic depends on
 - Characteristics of agent (virulence) and host (susceptibility)
 - Contact rate (likelihood of contact occurring between infectious and susceptible hosts)
 - Population density
 - Examples:
 - Influenza spread in people (plane trips, day care facilities)
 - Contagious mastitis in dairy cattle



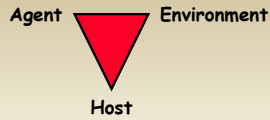
Disease in Individuals and Populations

- Whether or not disease occurs in an individual depends on an interplay of three factors:
 - The host
 - The agent
 - The environment

- Useful concept when explaining to clients why some animals become sick and others do not

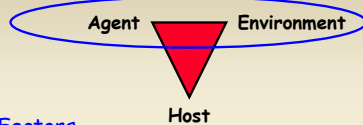


Epidemiologic Triad



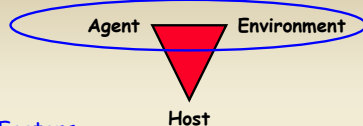
- Recognizing the components of the triad is critical to control infectious disease
 - A variety of opportunities to reduce disease at multiple points in the transmission cycle
 - A common mistake is to focus on only one area for disease control or prevention and to overlook the others

Factors Influencing Disease Transmission



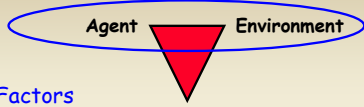
- **Agent-Environment Factors**
 - Hardiness - how long can it survive in the environment?
 - Agent structure, temperature, sunlight, moisture content, pH all impact survivability
 - Enveloped viruses (BVDV) tend to be less stable than non-enveloped (FMD)
 - Spores (Clostridia) very stable in soil for many years

Factors Influencing Disease Transmission



- **Agent-Environment Factors**
 - Survival/ Amplification in environment
 - Salmonella does not seem to multiply significantly outside of GI, but can survive several weeks in water and several years in soil if conditions of temperature, humidity, and pH are favorable.
 - Listeria can persist in soil and propagate in spoiled silage

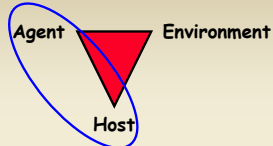
Factors Influencing Disease Transmission



Agent-Environment Factors

- Sunshine: UV harmful to microbes
 - Excellent control strategy for cryptosporidia
- pH:
 - Enteric pathogens have adapted to pH levels around 3.0
 - Most others prefer a pH of 7.2-7.4
- Moisture:
 - Bacteria and fungi prefer higher relative humidity
 - Remember - 3 basic needs of bacteria:
 - warmth, moisture, food

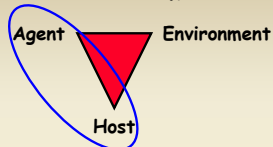
Factors Influencing Disease Transmission



Agent-Host Factors

- Age
- Innate resistance (e.g. gastric barrier, mucocilliary action)
- Previous exposure/ active immune status
- Passive immune status (neonates)
- Vaccination status and response
- Production status (e.g., lactating vs. non-lactating)

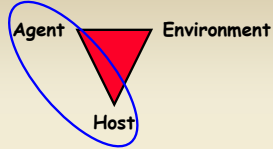
Factors Influencing Disease Transmission



Agent-Host Factors

- Susceptibility = host vulnerable to infection
 - Age
 - Vaccination status
- Infected (Infectious) = host colonized and a source of infection for others (may be clinically sick, or may not)
- Recovered = infection cleared
 - Pathogen threshold required to stimulate immune response
 - Rate of pathogen clearance by the immune system

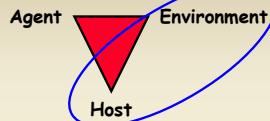
Factors Influencing Disease Transmission



□ **Agent-Host Factors**

- Infectivity = the size of the dose required to cause infection in a susceptible host
- Reproductive rate
 - Reproduction in host
 - Reproduction between hosts
- Virulence = the magnitude of the adverse effect on the host

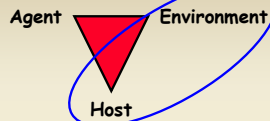
Factors Influencing Disease Transmission



□ **Host-Environment Factors**

- Nutritional factors:
 - Insufficient energy or protein - immune compromise
 - Vitamin/ micromineral deficiencies:
 - Vit A, E and Se - associated with immune system
 - Copper deficiency causes rough hair coats/fractures
- Social dynamic:
 - Impacts feed intake/ nutritional status/ ability to rest
 - Subordinates may have elevated cortisol

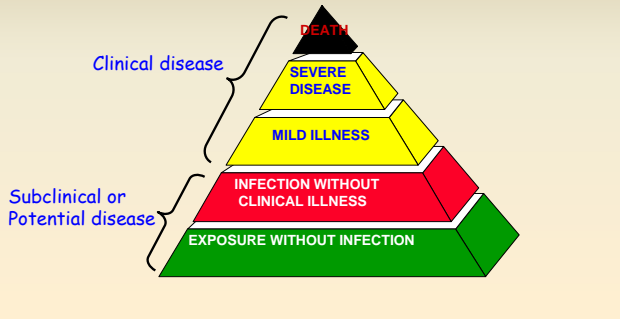
Factors Influencing Disease Transmission



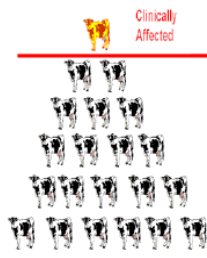
□ **Host-Environment Factors**

- Production class
 - Transition cows (late pregnancy / early lactation)
 - Baby calves
- Temperature/ Relative Humidity/ Hygiene
 - Heat stress
 - Cold stress
 - Mud stress
 - Increases amount of energy expended
 - Poor hygiene increases probability of exposure
- Ventilation
- Precipitation

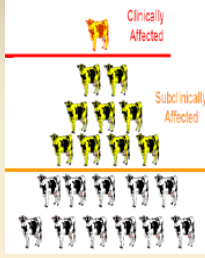
Epidemiological Triads and the "Iceberg" Principal of Disease in Populations



Clinical Perception of Problem



Actual Herd Problem



Often, the **most costly** due to loss of production

This "iceberg" effect of disease is often misunderstood and can leave to diagnostic mistakes and incorrect conclusions

Four Common but Serious Mistakes Due to Misunderstanding The "Iceberg" Phenomenon

- 1) Considering only the clinically (observably) ill animals in the midst of an outbreak
 - For example, if precautions are applied only to clinically sick animals, subclinically infected (normal appearing) but shedding animals can continue to infect other susceptible animals
 - Normal appearing animals can be infected
 - The saying that "most disease is bought and paid for"

Four Common but Serious Mistakes Due to Misunderstanding The "Iceberg" Phenomenon

- 2) Interpreting the absence of clinical cases as the absence of the disease/ infection in any form
- Many infections enter a herd by importation of a subclinical chronic carrier animal
 - May spread for weeks to years before the infection is finally diagnosed in a clinical case
 - Productivity is lost due to the subclinical form of disease, but loss may be difficult to recognize/ visualize
 - As a consequence, action *may* not be taken until the problem becomes clinical
 - EX: Johnes Dz, Staph aureus mastitis, "hairy heel warts"

Four Common but Serious Mistakes Due to Misunderstanding The "Iceberg" Phenomenon

- 3) Associating presence of infection/ agent with causation by that agent
- Evidence of the presence of infection by an agent does not necessarily indicate that the agent is the cause of the disease problem
 - Must have other corroborating evidence
 - Ex: *Neospora caninum* as a cause of abortion
 - In the midst of outbreaks, veterinarians often take samples only from the clinically affected animals

Four Common but Serious Mistakes Due to Misunderstanding The "Iceberg" Phenomenon

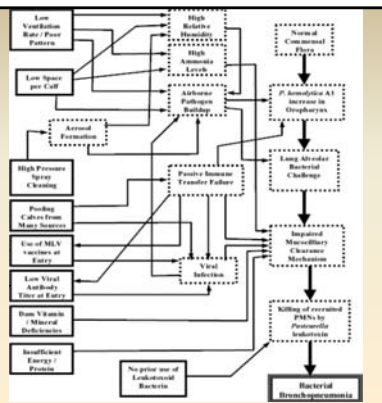
- 4) Interpreting the decline of clinical cases over time as evidence that the veterinary or management interventions applied were effective
- A decline is the "natural history" of most infectious disease outbreaks without any interventions
 - "All bleeding eventually stops"
 - Typically, the number of clinical cases declines as animals respond to the infection and the pool of susceptibles declines
 - Clinical cases may disappear altogether even though the infection is still widespread in the herd.
 - This natural decline is then mistaken as evidence of vaccine efficacy or drug efficacy if one has been used

Hazards Analysis and Critical Control Points (HACCP)

- Systematic preventative approach that addresses physical, chemical and biological hazards as a means of prevention
- HACCP is used in the food industry to identify potential food safety hazards, so that key actions, known as Critical Control Points can be taken to reduce or eliminate the risk of the hazards being realized
- Ex: dairy production system
 - Premilking hygiene (cow)
 - Milking system hygiene (equipment)
 - Rapid cooling of milk
 - Pasteurization of milk
 - Maintenance of cooling from farm to consumer

Causal Web of Risk Factors for Bronchopneumonia in Housed Calves (and CCP's)

John Gay, DVM PhD DACVPM



<http://www.vetmed.wsu.edu/courses-jmgay/documents/GroupEpidemiologyConcepts.pdf>

Conclusions

- Diseases normally do not occur randomly, but are influenced by certain risk factors
 - Clinical disease is merely the "tip of the iceberg"
 - (Don't forget about subclinical infections)
- Disease spread among groups of animals represents a dynamic process
 - Struggle between pathogen and host
 - Battlefield is environment
- Knowledge of pathogen-host-environment dynamics can help tremendously
 - Help devise differentials in case of outbreak investigation
 - Aids in disease prevention
 - Crucial to developing sound herd health programs

Thanks For Your Attention!



QUESTIONS?

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