Principles of Disease Management Strategies: Prevention, Control, Eradication

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R-FETPV Regional Field Epidemiology Training Program for Veterinarians

Outline

- Differences between the three terms: Prevention, Control, and Eradication.
- Conditions and limitations of these strategies
- Principles of “Herd Immunity”
- Demonstrations through existing case studies and programs
- Q & A

General Strategies for Disease Management

- Prevention
- Control
- Eradication

Disease Prevention

- **Exclusion of a disease from unaffected animals or people**
- Focus on individuals or groups
- First line of defense against disease

Disease Prevention

- Achieved by:
- Exclusion of agent from areas where it does not already occur
  - Quarantine healthy/unexposed
- Protect specific animals in areas where the disease already occurs:
  - Quarantine sick or potentially exposed
  - Hygiene
  - Immunization
  - Prophylactic Treatment

Disease Prevention

- Requires:
- Prior knowledge about the agent
  - Survivability, vectors, etc.
- Biology of the disease
  - Incubation, persistence, shedding, etc.
- Ecology of population
  - Management, in's and out's, etc.
- Example of diseases – Prevention the spread of Lumpy Skin Diseases in Thailand …

Disease Control

- **All measures used to affect the frequency or impact of disease in a population**

  (includes actions for sick and healthy individuals)
- **“Flatting the curve” – reduce the area undercurve**

Disease Eradication

- **Elimination of a necessary disease cause from populations**
- Local vs. Regional vs. Global
- Difficulty grows exponentially with:
  - Complexity of disease ecology
  - Size of population
  - Geographic area
  - Number of political boundaries

Disease Eradication

- Practical Goal of Regional Eradication
  - Eliminate parasite in expanding area until natural barriers to transmission are reached.
  - Natural Barriers do not necessarily coincide with political barriers.
- Sometimes etiologic agents can disappear naturally (influenza)
  - Changes affecting life-cycle
  - Environment for natural reservoirs, vectors, extinction of host, etc.

Directed Actions for Disease Management

- Diagnosis – Early Detection
- Mass Treatment
- Quarantine
- Sacrifice of diseased or exposed animals
- Environmental hygiene
- Mass immunization
- Applied ecology – E.g. Rotating
- Education – Awareness
- Genetic resistance – Breed modifications

Schwabe, 1984

Diagnosis

- Essential part of ALL management processes
  - Inadequate without other actions
  - For disease management:
    - Essential to detect disease/infection early
    - Allows other actions to be taken
- Clinical or laboratory diagnosis:
  - Must understand and manage limitations of diagnostic process
  - Accuracy of diagnostic process is central to assuring freedom from disease

Mass Treatment

- Treatment or Chemoprophylaxis
- Underlying Goal: decrease impact of infectious agents
  - Likelihood of infection
  - Likelihood of shedding
  - Amount of shedding
  - Duration of shedding
- Requires that effective and safe treatment is available
- Must be cost effective

Mass treatment

- Advantages:
  - Does not necessarily require identification of diseased animals
  - Can work for both clinical and subclinical cases
- Disadvantages:
  - Efficacious treatments not always available
  - May require handling of all animals
  - Potential side effects and cost
  - Not suitable for multiple disease agents
  - Can affect microbial evolution
    - Examples: Antimicrobial resistance
    - Malaria
    - TB
    - Small strongyles

Quarantine

- Restraint placed upon the movement of humans, animals, plants, or goods that are suspected of being carriers or vehicles of infectious agents.
- Underlying Goal: Reduce likelihood of effective contact
- International, regional, or local
  - Local efforts target both sick and healthy animals
  - Larger efforts routinely exclude consideration of sick individuals, and therefore only target healthy animals for quarantine

Quarantine

- Advantages:
  - Essential for preventing introduction of subclinical cases *(occult infection)*
- Disadvantages:
  - Imposing and and coercive by nature
  - Many times ineffective because it imposes on freedoms
    - Convenience
    - Frequent travel
    - Global economy

Sacrifice of Diseased or Exposed Animals

- Remove an ill minority to protect a healthy majority
- Selective vs. depopulation
- Underlying Goal: Prevent exposure and eliminate reservoirs
- Important companion to surveillance or disease diagnosis
  - e.g. Test and slaughter
- Requires confidence in a positive test result
- Examples:
  - Tuberculosis
  - Brucellosis
  - Foot and Mouth Disease

FMD Example: Action

- Because of extreme contagious nature
- Essential to act quickly and decisively!
  - Control movement
  - Depopulation
  - Vaccination

FMD Example: Eradication

- 'Stamping Out'
  - Depopulation of infected and at risk populations
  - Applied in countries which have been free from FMD
  - Also applied as the final stage in an eradication campaign to eliminate the virus once the disease has been controlled
- Essential elements in the eradication of FMD
  - Control movement of animals and sources of virus exposure
  - Removal source of infection

Slaughter of Diseased or Exposed Animals

- Advantages:
  - Efficient method of breaking transmission cycle
  - Rapid method for eradication
  - May be only way of eliminating chronic or subclinical infections
- Disadvantages:
  - IMPOSING!
  - Costly
  - Not generally applicable in all situations
    - High prevalence
    - Replacements unavailable
    - Economically or socially unacceptable

Slaughter of Diseased or Exposed Animals

- Disadvantages:
  - Cannot be applied in all species
    - e.g. wildlife or fish
  - Difficult to sell to the public
  - Sacrificing of false positive animals/premises
  - Impact on the environment
  - Animal welfare issues and social pressure

Mass Immunization

- Various methods for improving immunity to specific disease agents
  - Innate versus acquired
  - Active vs. passive
- Underlying Goal: Decrease susceptibility
- Mass immunization vs. targeted immunization

Mass Immunization

- One of the most common methods of protection
  - Our reliance is good and bad
- Vaccines should always be evaluated carefully for both safety and efficacy
- Examples:
  - Routine vaccinations
  - Brucellosis for eradication
  - FMD for eradication
  - Rinderpest

Mass Immunization

- Advantages:
  - Ability of resistant individuals to move about (carrying protection with it)
  - High appeal for consumers
  - Fewer doses required for extended protection (compared to chemoprophylaxis)
- Disadvantages:
  - Lack of proven products
  - Imperfect protection
    - Sterilizing immunity vs. protection from disease
    - Duration of immunity
  - Usually requires handling all individuals

Developing Disease Management Programs: HACCP

1. Conduct a hazard analysis.
2. Identify the critical control points (CCP).
3. Establish critical limits associated with each CCP.
4. Establish CCP monitoring requirements.
5. Establish corrective actions.
6. Establish effective record-keeping procedures.
7. Establish procedures for verifying that the HACCP system is working correctly

Practical Aspects

- Underlying Goals are Common Among Many Directed Actions:
  - Early Detection
  - Decreased contact
  - Increased resistance
  - Eliminate reservoirs

Special Consideration for Mass Immunization:

Herd Immunity vs. Host Immunity

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Host Resistance Against Infectious Agents

- Two types of resistance:
  - Biological Resistance
    - Host immunity
  - Circumstantial Resistance
    - Lack of contact
    - Herd Immunity

Herd Immunity

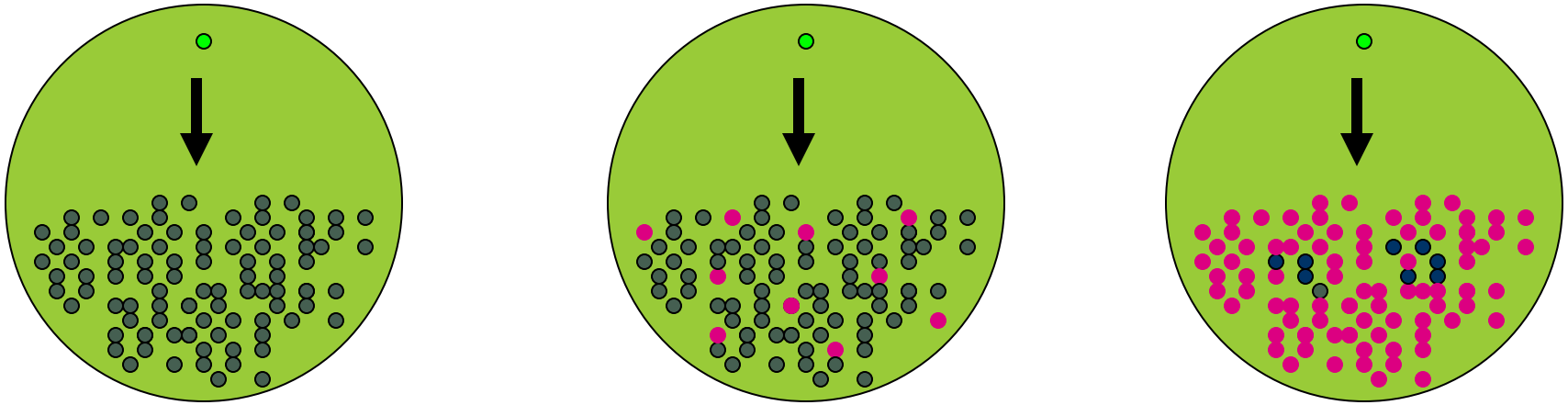
- Immunity in individuals conferred by characteristics of population
- Underlying principle: Decrease probability of adequate contact required for transmission
  - Def - Prob of Adequate Contact: Likelihood that affected individual transmits infection to average susceptible individual
- Affected by circumstantial and biological resistance of its members

Herd Immunity

Equally Susceptible

Immune

Infected



- Individuals have equal “biological” susceptibility
- Individuals differ in likelihood of exposure

Factors Affecting Herd Immunity

- Composition of the population:
  - Number of susceptible individuals
- Contact rate
  - Frequency
  - Adequacy
  - Which individuals
- Ecology of disease

Herd Immunity

- In conclusion
  - Herd immunity is the resistance of a group of animals to the invasion and spread of an infectious agent because of the “collective immunity” of the group due to vaccination or prior exposure.
- Application
  - Vaccination levels for disease eradication do not need to be 100%!

Disease Transmission Basics

- Concept of the basic reproductive rate (R_0)
  - Is the average number of cases directly infected by an infectious case during the case's entire infectious period.
  - Is a measure of the transmissibility of an infection within a population
  - Is determined by basic biological features of the microorganism within a specific population.
  - More highly transmissible diseases have higher average R_0 values.

The calculation of R_o is derived from the basic SIR model:

Where β = the infection rate parameter or transmission rate parameter and
α = the recovery rate parameter.

$$R_0 = \beta T$$

Disease Transmission Basics

- If $R_0 > 1$
  - The average number of cases directly infected by an infectious case is greater than 1 per infectious case
  - If this continues, an epidemic ensues.
- If $R_0 < 1$
  - The average number of cases directly infected by an infectious case is less than 1 per infectious case
  - If this continues, the microorganism eventually disappears from the population.

Vaccination levels for eradication

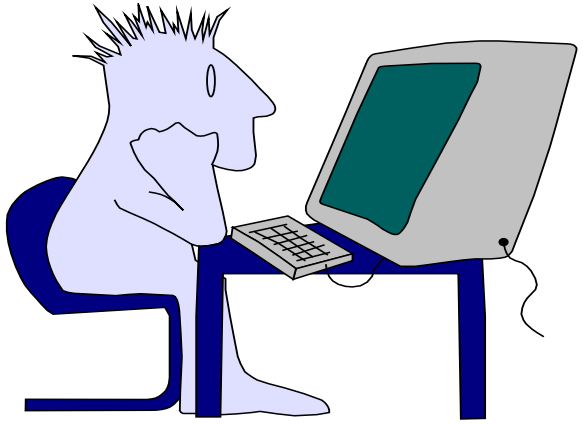
Disease	Vaccination level (%)
Malaria	80 – 99
Pertussis	92 – 94
Measles	83 – 94
Poliomyelitis	80 – 86
Mumps	75 – 86
Diphtheria	~85
Rubella	83 – 85
Smallpox	80 – 85

Conclusions

- No single action against a disease is sufficient
- Effectiveness of management programs commonly require prior knowledge about the ecology of disease in specific populations

Conclusion

- In designing program, must consider
  - Scientific facts
  - Social factors
  - Political climate
- All are important!



Questions and Answers