Introduction to Epidemiological Surveillance

Marco De Nardi
Outline

• Objectives
• The scope of epidemiology
• Definitions and concepts related to surveillance
• Characteristics of surveillance system
• Surveillance objectives
• Surveillance types
• Application on dairy farm
• Surveillance vs Inspection
• The scope of epidemiology
### Contributions of Epidemiology

<table>
<thead>
<tr>
<th>Contributions</th>
<th>Examples</th>
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</thead>
<tbody>
<tr>
<td>Establish <strong>causes</strong> of disease</td>
<td>Discovery that a bacteria was the cause of anthrax</td>
</tr>
<tr>
<td>Discover <strong>new</strong> pathogens</td>
<td>Listeria</td>
</tr>
<tr>
<td>Discover <strong>routes</strong> of infection</td>
<td>Cholera linked to contaminated water sources</td>
</tr>
<tr>
<td>Detect patterns and unusual occurrences of diseases within a population</td>
<td>Milkmaids (through exposure to cowpox) were not becoming infected with smallpox</td>
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How did it all begin?...
London Cholera Outbreaks

Mid-1840s

- Soho and Golden Square districts, London, 500 deaths from cholera in 10 days
- John Snow plotted dates and mortality rates
- Assessed flow of water from wells and pumps
- Found that virtually all deaths took place within a short distance of the Broad Street water pump
- Outbreak ended quickly after pump handle was removed

Snow’s work serves as a foundation for descriptive and analytic epidemiologic approaches. He is often referred to as the *Father of Epidemiology*
Louis Pasteur (1822-1895)

- In 1870s, anthrax was a major epidemic that affected farm animals and had severe economic impacts on farmers.

- Louis Pasteur believed that a bacteria was the cause of anthrax, however was unclear about the exact association.

- Pasteur demonstrated that microorganisms cause disease > “Cause-effect association” exists between microbes and disease.

- Pasteur went on to develop a vaccine against anthrax that was tested in sheep.
Epidemiology Definition

Epi = upon
Demos = population
Logos = study of

The study of how disease is distributed in populations and the factors that influence or determine this distribution.

Epidemiology, Third Edition, Leon Gordis
Key Word: Distribution

*Distribution* refers to the **frequency** and **pattern** of health and events in a population.

**Frequency** - the number of events, and relationship to the size of population.

**Pattern** – Occurrence of events by time, place, and person

Ex. *Time* patterns – annual, seasonal – *Temporal analysis*

Ex. *Place* patterns – rural, urban, - *Spatial analysis*
### Key Words: Determinant & Health Related Events

**Determinant (exposure)**

Any physical, biological, social, cultural or behavioral factor that influences health

<table>
<thead>
<tr>
<th>Health Related Event (outcome)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Disease</td>
</tr>
<tr>
<td>• Death</td>
</tr>
<tr>
<td>• Injury</td>
</tr>
<tr>
<td>• Disability</td>
</tr>
<tr>
<td>• Decrease in animal production</td>
</tr>
</tbody>
</table>

**Determinants (risk factors) ➔ Health related event (outcome)**
Objectives of Epidemiology

• Identify the **etiology** or cause of disease
• Determine the **magnitude** of disease (impact) and **trends** over time and space
• Determine the **mode of transmission**
• Identify **risk factors** or **protective variables**
• Determine the role of the **environment**
• Identify potential **interventions/control measures**
• Evaluate the **impact** of prevention/control measures
• Definitions and concepts
Definition and concepts

• Monitoring

• **Disease Monitoring** describes the ongoing (or repeated) efforts directed at assessing the health and disease status of a given population (e.g. animals or humans).

• **Disease Surveillance** (in contrast to disease monitoring) is characterized by a perspective for actions: disease control, disease eradication, further investigation.
Definition of Epid. Surveillance

• “Ongoing systematic and continuous collection, analysis and interpretation of health data (often designed to detect the appearance of specific diseases),

allowing epidemiologists to follow in time and space the health status and some risk factors associated with diseases for a given population,

for use in the planning, implementation and evaluation of disease control measures”

(Toma et al., 1999)
Definition of Epid. Surveillance

- **Co-existing factors:**
  
  - **Descriptive epidemiology:** provide reliable picture of the epidemiological situation (frequency of disease, risk factors, temporal and spatial characteristics),

  - **Long term system:** permanent, continuous recording system,

  - **Communication:** dissemination of information,

  - **Perspectives for actions:** further studies, control measures, eradications.
• General characteristics of a surveillance system
General characteristics of a (public health or veterinary or one health) Surveillance System

- **Systematic**: organized, not haphazard

- **Ongoing**: continuous recording system (not just a one time survey)

- **Analytical**: data is not only collected, but it should also be reviewed and analyzed.

- **Disseminated**: analysis is disseminated

- **Perspectives for actions**: linked to public health/veterinary practices to implement programs and policies to improve practices
## Differences between longitudinal surveys and epidemiological surveillance (Adjusted from: Toma *et al.*, 1998)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Longitudinal Survey</th>
<th>Epidemiological Surveillance</th>
</tr>
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<tbody>
<tr>
<td>Duration</td>
<td>Limited</td>
<td>Long term</td>
</tr>
<tr>
<td>Quantity of data collected at each time point</td>
<td>Can be considerable</td>
<td>Small</td>
</tr>
<tr>
<td>Type of epidemiology</td>
<td>Descriptive or Analytical</td>
<td>Descriptive or Analytical</td>
</tr>
</tbody>
</table>
Monitoring vs Surveillance

• Disease Surveillance systems requires 3 components:

1. A defined disease **monitoring** system
2. A defined **threshold** for disease level (predefined critical level at which action will be taken)
3. A predefined **directed actions** (interventions)

• So surveillance is a specific case of monitoring in which control or eradication measures are implemented whenever **certain threshold levels** related to the infection or disease status have been exceeded
• But what’s a threshold?
• How can we calculate it?
Definitions and concepts: Threshold

- A **marker** that alerts public or veterinary health officials to take action
- Use **past data** to decide if a current event is abnormal
- Help identify possible **outbreaks** with surveillance data
Reported diarrhea cases by week, East Amman, Jordan 1995-2000
Do you see an unusual situation? a possible outbreak?
Calculating Expected Cases

• Can be useful to calculate expected number of cases for comparison

• “Baseline” for what you would expect the number of cases to be

• Often calculated using historical data
  - e.g. the mean number of cases for a past period

• Not a threshold in itself, but helps to gain an understanding of what is normal vs. abnormal
Calculating Expected Cases

Diarrhea cases by year and week, Aqaba, Jordan 1997-2001

<table>
<thead>
<tr>
<th>Week</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
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<td>2</td>
<td>63</td>
<td>87</td>
<td>72</td>
<td>44</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>84</td>
<td>48</td>
<td>39</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>97</td>
<td>82</td>
<td>37</td>
<td>48</td>
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<td>5</td>
<td>88</td>
<td>50</td>
<td>80</td>
<td>23</td>
<td>65</td>
<td>?</td>
</tr>
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</table>
Calculating Expected Cases

Diarrhea cases by year and week, Aqaba, Jordan 1997-2001

<table>
<thead>
<tr>
<th>Week</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
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<tbody>
<tr>
<td>1</td>
<td>69</td>
<td>36</td>
<td>37</td>
<td>71</td>
<td>59</td>
<td>54.4</td>
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<td>44</td>
<td>67</td>
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<tr>
<td>3</td>
<td>10</td>
<td>84</td>
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<td>39</td>
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<td>43.6</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>97</td>
<td>82</td>
<td>37</td>
<td>48</td>
<td>61.2</td>
</tr>
<tr>
<td>5</td>
<td>88</td>
<td>50</td>
<td>80</td>
<td>23</td>
<td>65</td>
<td>(61.2)</td>
</tr>
</tbody>
</table>

\[88 + 50 + 80 + 23 + 65 = 306\]

\[306/5 = 61.2\text{ expected cases}\]
• Objectives of surveillance
Objectives of Surveillance

• Objectives should contribute to improve epidemiological knowledge of the situation,

• Objectives need to be defined in details before surveillance comes into operation,

• Depending on the objectives, appropriate surveillance mechanism (voluntary notification, mandatory notification, sentinel surveillance, structured surveys, outbreak investigation, census) and type (active, passive, targeted, sentinel, serological, mixed) will be chosen,

• Often several objectives can become intertwined, but it is essential to separate and circumscribe them
Specific objectives of Surveillance

1) Allows rapid detection of *diseases outbreaks*,

2) Support early identification of *diseases problems* (endemic and non-endemic),

3) Provide an *early warning system* able to identify new and emerging diseases,

4) Assess the *health status* of a defined population (estimating level of occurrence/trends among diseases),

5) Confirm *absence* of a specific disease.
Final aims of Surveillance

1. Enable prompt response to disease outbreaks,

2. Definition of priorities for disease control and prevention (efficient allocation of resources!),

3. Evaluation of disease control programmes effectiveness,

4. Provision of information to plan and conduct research (development of research hypothesis),

5. Support the planning, development and implementation of policies for animal and public health (hierarchy of importance of different diseases),
Surveillance types
Animal health surveillance

Surveillance may be based on many different data sources and can be classified in a number of ways, including:

i) the means by which data are collected (active versus passive surveillance);

ii) the disease focus (pathogen-specific versus general surveillance); and

iii) the way in which units for observation are selected (structured surveys versus non-random data sources).

(Chapter 1.4. - Animal health surveillance, 2010 © OIE - Terrestrial Animal Health Code)
Types of animal health surveillance


- General surveillance
- Early warning surveillance (epidemiological watch, epidemiovigilance)
- Indicator-based surveillance
- Hazard-specific surveillance
- Syndromic surveillance
- Event-based (media-based, digital) surveillance
- Risk-based surveillance
- Sentinel surveillance
- Participatory surveillance
- **Active** (proactive) surveillance
- **Passive** (reactive) surveillance
- **Enhanced passive** surveillance
Types of animal health surveillance

The distinction between **Passive** and **Active** surveillance is probably among the more important futures in animal health surveillance because the objectives/scopes/expectations are different.

- **Active (proactive) surveillance**: Investigator-initiated **collection of animal health related data** using a defined **protocol** to perform actions that are scheduled in advance. Decisions about whether information is collected, and what information should be collected from which animals is made by the investigator.

- **Passive (reactive) surveillance**: Observer-initiated **provision of animal health related data** (e.g. voluntary notification of suspect disease) or the use of **existing data** for surveillance. Decisions about whether information is provided, and what information is provided from which animals is made by the data provider.

- **Enhanced passive surveillance**: Observer-initiated **provision of animal health related data** with active investigator involvement e.g. by actively encouraging producers to report certain types of disease or by active follow up of suspect disease reports.
Active or Passive Surv.?

Passive
Monitor animal populations to detect:
• the undefined
• the unexpected

Active
Seek answer to a specific question about:
• a defined disease or condition
• using agreed mechanism for detection

Both of them are necessary components of National Surveillance Systems
Passive Surveillance

• **Continuous watch** over the endemic (and non endemic) disease profile so that the **unexpected** and **unpredicted** can be detected (early warning system),

• Any surveillance activity based on the **spontaneous or compulsory notification** of cases or suspected cases of a disease under surveillance,

• It is **impossible to know in advance** the amount, type and localization of data that will be collected,

• Possible to define a **threshold level** which will trigger in-depth investigation or to evidentiate an unseasonally excessive number of samples submitted for lab diagnosis
This increase in mortality led to further investigations in the region. The subsequent outbreak investigation confirmed first detection of Peste des Petits Ruminants (PPR) in Algeria.
Reccomended actions:
- A contingency plan based on enhanced surveillance and preventive vaccination of small ruminants was therefore promoted to control the disease and to prevent the occurrence of new outbreaks.
Passive Surveillance

- **Data streams (voluntary or statutory):**

  1. Notifications from *farmers* and *practicing vets*,
  2. Herd information from *pastoralists*,
  3. Information from members of the *public*,
  4. Notifications from *diagnostic laboratories*,
  5. Notifications from *slaughterhouses* (meat insp.),
  6. Reports of veterinary inspections at *markets*,
  7. Identification of *illegal imports* of animals and animal products,
  8. Information resulting from the collation of *worldwide surveillance*
Passive Surveillance

• **Strenghts:**
  - Able to detect unexpected and unpredicted diseases (!!!),
  - **Limited cost** per case detected,

• **Weaknesses:**
  - Potential under-reporting (**poor sensitivity**),
  - Cannot prove that a specific disease is NOT present (**poor specificity**),
  - Cannot determine disease level and geographical patterns,
  - Cannot demostrate disease status to trading partners (i.e. freedom from disease),
  - Cannot determine the **importance** in terms of costs, p. health,
  - Cannot set priorities, plan, implement and monitor national disease controls programs
Active Surveillance

• Any surveillance methods based on a **search for data** through actions **scheduled in advance**, 

• It is possible to **know in advance** the amount, type and localization of the data which will be collected, 

• **Options:**
  - **Risk-based sampling**: population can be categorized according to the risk of being affected by the outcome (high-risk, low-risk),
  - **Population based**: no regards to risk grouping
Active surveillance objectives

• Estimation of **prevalence** of outcomes like clinical disease, infection, sero-positive animals (**prevalence survey-cross sectional surveys**),

• Assessment of **disease presence or absence** (**outbreak investigation, flock-herd diagnosis, disease freedom certification**),

• Estimation of **incidence**

• Frequency of **risk factors** and its potential association with survey’ outcome (**risk estimates: RR, OR**)

• Detect **difference** in prevalence or incidence between groups.
Active surveillance

• Variety of methods:

1. Exhaustive surveillance/Census
2. Surveillance on representative samples
3. Risk Based/Targeted surveillance
4. Sentinel
5. Combination of methods:
• Application to dairy sector
Objective: to determine the incidence of clinical and subclinical mastitis under field conditions.

Results: cattle incidence of clinical mastitis at the five farms was 12.5, 17.64, 16.84, 19.44 and 19.88%, respectively. The fore and hind quarters were the regions with 34.34 and 60.78% infection rate of mastitis, respectively. The maximum infection rate of mastitis was observed during and after sixth lactation.

Due to mastitis, the total economic losses were estimated at Rs. 1, 94,920.00 in all the five clusters, whereas at a farmer level it was Rs.8, 405.00 per annum.
Guidelines for coordinated human and animal brucellosis surveillance

Incidence of clinical mastitis in Danish dairy cattle and screening for non-reporting in a passively collected national surveillance system

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A survey of management practices that influence production and welfare of dairy cattle on family farms in southern Brazil

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\textsuperscript{1}For correspondence

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Surveillance vs Inspection

Def. inspection:
- an inspection is, most generally, an organized examination or formal evaluation exercise.
- In government, an inspection is the act of a monitoring authority administering an official review of various criteria (such as documents, facilities, records, and any other assets)
- Inspections are used for the purpose of determining if a body is complying with regulations.
- The inspector examines the criteria and talks with involved individuals. A report and evaluation follows such visits.
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  allowing epidemiologists to **follow in time and space** the health status and some **risk factors** associated with diseases for a given population,

  for use in the planning, implementation and evaluation of disease **control measures”**

  *(Toma et al., 1999)*
• Is there any difference?
Thanks