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**Epidemiology Key Terms and Core Concepts**

**Epidemiology:** The study of the distribution and determinants of health-related states in specified populations, and the application of this study to control health problems.

The term “epidemiology” can be best understood by examining the key words within its definition.

- **Study:** Epidemiology is the basic science of public health. It is a highly quantitative discipline based on principles of statistics and research methodologies.

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**Epidemiology Key Terms and Core Concepts**

- **Distribution:** Epidemiologists study the distribution of frequencies and patterns of health events within groups in a population. Using descriptive epidemiology, epidemiologists characterize health events in terms of time, place, and person.
- **Determinants:** Epidemiologists search for causes or factors that are associated with increased risk or probability of disease.

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### Epidemiology Key Terms and Core Concepts

- **Health-Related States:** Early epidemiological study focused solely on infectious diseases. Today epidemiology studies a variety of health-related events, which includes chronic disease, environmental problems, behavioral problems, and injuries, in addition to infectious disease.
- **Populations:** Epidemiology studies groups of people rather than with individuals.

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### Epidemiology Key Terms and Core Concepts

- **Control:** Epidemiology is used in two ways:
  - 1) As an analytical tool for studying diseases and their determinants, and
  - 2) To guide public health decision-making by developing and evaluating interventions that control and prevent health problems.

**Epidemiology** is a scientific method of problem-solving.

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### Epidemiology Key Terms and Core Concepts

Examples of the types of community health problems investigated by epidemiologists include:

- A measles outbreak on a small college campus
- A global influenza pandemic
- An increase in homicide in a community
- A national surge in violence
- An increase in the number of cancer cases

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## Epidemiology Key Terms and Core Concepts

Epidemiologists answer questions, such as:

- Who is sick?
- What are their symptoms?
- When did they get sick?
- Where were they exposed to the illness?

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## Two Types of Epidemiological Studies

- **Experimental.** Used when epidemiologists have control over the circumstances from the start. Vaccine efficacy trials are good examples of experimental studies because investigators control who gets the vaccine and who does not.
- **Observational.** Used when epidemiologists do not have control over the circumstances. Outbreak investigations are usually conducted to support observational studies. Observational studies can be designed in two ways:
  - Descriptive study design
  - Analytical study design

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## Descriptive Study Design

**Defined:** A type of observational epidemiologic study that has no predetermined hypothesis. A descriptive study simply describes what exists in a population by person, place, or time variables (Oleckno, 2002).

- Descriptive studies are useful in demonstrating trends and generating hypotheses about disease causation.

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### Descriptive Study Design

**Examples:**

- Why does disease occurrence vary with age?
- Why are there health disparities between different socioeconomic levels of the population?

The epidemiologist collects information to characterize and summarize the health event or problem.

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### Descriptive Study Design

**Asks:** Who? Where? When?

Three main elements of descriptive epidemiology:

1. Person
2. Place
3. Time

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### Analytical Study Design

**Defined:** A type of observational epidemiological study where epidemiologists make inferences based on the data they collect. These inferences are the bases for hypotheses, which must be tested using one of two analytical study designs.

Epidemiologists rely on comparisons between groups to determine what role various risk factors had in causing the problem.

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## Analytical Study Design

**Asks:** How? Why?

**Examples:**

- Did the chicken salad at the company picnic cause the Salmonella outbreak?
- Does cigarette smoke cause lung cancer?
- Are alcohol use and motor vehicle crashes related?

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## Analytical Study Design

**Two Types of Analytical Study Designs:**

1. Cohort study design
2. Case-control study design

In analytical study designs, the epidemiologist is attempting to discover the relationship between an exposure or risk factor and a health outcome.

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## Cohort Study Design

**Defined:** A designated group of individuals who are followed or traced over a period or time (Last, 2001).

**Step 1:** The study population is selected according to exposure status, regardless of whether they have the disease or health outcome being investigated.

**Step 2:** The exposed group's development rate of the disease (study outcome) is compared with the non exposed group's rate of development of the disease (study outcome).

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### Cohort Study Design

**Elements:**

- Often referred to as prospective studies because a cohort study follows the population forward in time from suspected cause to effect.
- Used to investigate outbreaks in small, well-defined populations.

**Example:**

- Dividing a group of people on the basis of smoking status and then following them for 20 years to see if they develop lung cancer.

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### Cohort Study Design

Advantages	Disadvantages
Can examine multiple outcomes for a single exposure	Costly in time
Are very useful in examining rare exposures	Costly in resources
Can directly calculate the incidence of disease for each of the exposure groups	Requires a large number of subjects, if the disease is rare.
Is logical; sequence follows the exposure to the development of the disease	Follows study groups forward in time which may result in logistical problems and subjects dropping out of study

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### Case-Control Study Design

**Defined:** A group of individuals with an event or condition of interest (case-subject) is identified and compared to individuals without the event or condition of interest (controls).

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### Case-Control Study Design

**Step 1:** Participants are selected on the basis of the presence or absence of the disease or outcome in question.

**Step 2:** Participants are assigned to one of two groups:

- People with the health problem (case-subjects)
- People without the health problem (controls).

**Step 3:** Case-subjects are compared to controls in order to determine the presence of specific exposures or risk factors.

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### Case-Control Study Design

**Elements:**

- The epidemiologist is working backward from the effect to the suspected cause.
  
- These studies are often referred to as retrospective studies since they look back in time.

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### Analytical Study Design

- Cohort and Case-Control
  
- Attempt to answer the "how" and "why" questions.
  
- Are able to quantify the relationship between an exposure and an outcome.
  
- However, a mathematical or quantitative relationship between the two is not enough to establish causation.

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## Analytical Study Design

**Five criteria must be met to establish a cause-and-effect relationship:**

1. **Strength of association.** The association or relationship between cause and effect must be clear.
2. **Consistency.** Observation of the association must be repeatable in different populations at different times.
3. **Temporality.** The cause must precede the effect.
4. **Plausibility.** The explanation must make sense biologically.
5. **Biological gradient.** There must be a dose-response relationship.

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## Disease Transmission Terminology

**Epidemic:** The occurrence of more cases of a disease than would normally be expected in a specific place or group of people (population) over a given period of time.

- **Note:** To an epidemiologist, "outbreak" means basically the same thing as epidemic. To the public, however, "epidemic" is perceived to be more serious than "outbreak." For this reason, the term "outbreak" is often used to avoid public concern and panic.

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## Disease Transmission Terminology

**Cluster:** A group of cases in a specific time and place that may or may not be greater than the expected rate. Often the aim of investigating clusters is to determine the baseline rate of disease for that time and place.

- **Note:** The word "cluster" is sometimes incorrectly used in place of "epidemic" or "outbreak."

**Endemic:** A high baseline or background rate of disease.

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### Disease Transmission Terminology

**Exposure:** Having a certain feature that is being studied. For example, in a study on alcohol consumption, people who drink alcohol are considered the “exposed” group, while non-drinkers are considered the “unexposed” group.

- **Note:** There is a wide variety of “exposure” to consider when studying a disease, such as exposure related to lifestyle, behavior, occupation, employment, genetics, diet, and the use of medications.

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### Disease Transmission Terminology

**Incidence:** The occurrence of new cases of disease that develop in a population over a specific period of time. It is the frequency with which new disease develops.

**Incubation period:** A period of sub-clinical or non-obvious pathologic changes following an exposure. The incubation period ends with the onset of symptoms.

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### Disease Transmission Terminology

**Latent period:** The interval between disease onset and clinical diagnosis.

**Morbidity rate:** The number of existing or new cases of a particular disease or condition per 1000 people (Achengrau & Seage, 2003).

**Mortality rate:** The total number of deaths per 100,000 people (Achengrau & Seage, 2003).

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## Disease Transmission Terminology

**Pandemic:** An epidemic causing illness or death over an extensive area, generally crossing international borders (Oleckno, 2002).

**Period of communicability**

The time (days, weeks, months) during which an infectious agent may be transmitted, directly or indirectly, from an infected person to another person; infected animal to humans; or from an infected person to animals or arthropods.

**Prevalence:** The proportion of the total population that is diseased. It is the frequency of existing disease.

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## Disease Transmission Terminology

**Prodromal period**

The time during which a disease process has begun but is not yet clinically manifest.

**Reservoir** (of an infectious agent)

Any person, animal, arthropod, plant, soil, or substance (or combination of these) in which an infectious agent normally lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such manner that it can be transmitted to a susceptible host.

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## Chain of Transmission

**Defined:** Occurs when an agent is passed from one host to another, and a suitable mode of spread allows an outbreak to develop.

**Requirement:** A chain of transmission must be present in order to cause an epidemic.

**Elements:**

1. Agent
2. Host
3. Environment

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### Chain of Transmission: Agent

**Defined:** Any substance that can cause death, disease, or other biological malfunction in humans, animals, plants, or other living organisms.

**Three types of agents:**

- A. Biological** - A bacterium, parasite, or virus.
- B. Physical force** - Any type of physical force (e.g., earthquake, car crash, accidentally dropping an object).
- C. Chemical** - Chemical substances, whether gaseous, liquid, or solid, which can be inhaled, ingested, absorbed, or injected.

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### Chain of Transmission: Agent

**Key characteristics of agents:**

- **Infectivity** - The capacity to cause infection in a susceptible host.
- **Pathogenicity** - The ability to cause disease in a host.
- **Virulence** - The severity of disease that the agent causes in the host.
- **Transmissability** - The ease with which the agent can be transmitted.

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### Chain of Transmission: Host

**Defined:** The person or organism that is susceptible to the effect of an agent.

**Key characteristics of hosts:**

- The status of the host is important and is generally classifiable as susceptible, immune, or infected.
- The host's response to exposure varies widely, from showing no effect to manifesting sub-clinical disease, atypical symptoms, or severe illness.

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### Chain of Transmission: Environment

**Key characteristics of the environment:**

- Physical
- Climatologic
- Biologic
- Social
- Economic

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### Chain of Transmission

**Requires Four Phases:**

1. Source for the agent
2. Portal of exit
3. Mode of transmission
4. Portal of entry

Note: When an investigator knows how an outbreak occurs, public health strategies that prevent health problems can be implemented at each phase in the chain of transmission.

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### Chain of Transmission: Phase 1

**Source for the agent:** Often the place where the agent originates - where it lives, grows, and multiplies.

**Example:** The agent that causes botulism (*Clostridium botulinum*) originates in soil, but the source of most botulinum infections is improperly canned food containing *C. botulinum* spores.

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### Chain of Transmission: Phase 2

**Portal of exit:** The pathway by which the agent leaves the source. This pathway is usually related to the place where the agent is localized.

**Example:** The agents causing tuberculosis and the flu are released through the respiratory tract; agents for many stomach ailments are released through the digestive tract. Agents found in the blood, such as Hepatitis B and HIV, can be released through cuts or needles.

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### Chain of Transmission: Phase 3

**Mode of transmission:** Once the agent leaves the source, the means of carrying it to the host is needed. This can happen in a number of ways, some of which are direct and some indirect.

- **Direct transmission mode.** Direct contact with soil, animals, or plants, as well as contact between people.
- **Indirect transmission mode.** No direct contact with the source. Three possible modes of indirect transmission are airborne, vector-borne, or vehicle-borne.

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### Chain of Transmission: Phase 3

**Indirect Transmission:**

- **Airborne:** Agent is carried from the source to the host suspended in air particles.
- **Vector-borne:** Agent is transmitted indirectly by a live carrier, usually an arthropod, such as mosquitoes, fleas, or ticks.
- **Vehicle-borne:** Agent is carried by inanimate objects, such as food or water, blood, or items like handkerchiefs, bedding, and surgical instruments.

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### Chain of Transmission: Phase 4

**Portal of entry:** A pathway into the host that gives the agent access to tissue where it can multiply or act. Often the agent enters the host in the same way that it left the source.

**Example:** The flu virus leaves the source through the respiratory tract and enters a new host through the respiratory tract.

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### Chain of Transmission

**Note:** Infection does not automatically occur when an agent enters the body of a host. Whether exposure to an agent results in infection depends on several factors related to the host, the agent, and the environment.

- Host factors that influence the outcome of an exposure include the presence or absence of natural barriers, the functional state of the immune system, and the presence or absence of an invasive device.

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### Chain of Transmission

**Preventive measures can be implemented at various points in a chain of transmission.**

- The specific agent (e.g., guinea worm)
- The host (e.g., immunization to prevent measles)
- The environment (e.g., sanitation improvements to prevent Salmonella)
- Specific points in the chain of transmission (e.g., thorough cooking of hamburgers to interrupt transmission of the *E. coli* bacterium)

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## Immunity

- **Natural immunity** - Immunity that is naturally present and is not due to prior sensitization to an antigen form, for example, an infection or vaccination. Since it is not stimulated by specific antigens, innate immunity is generally nonspecific.
- **Acquired immunity** - Immunity acquired by infection or vaccination (active immunity) or by the transfer of antibody or lymphocytes from an immune donor (passive immunity), such as from mother to infant via breast milk.

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## Vaccination for Level A Pathogens

### Available vaccines

- Smallpox
- Anthrax
- Some Hemorrhagic Fevers – Yellow Fever

### Conditions for which there is no vaccine

- Botulism
- Ebola
- Some Hemorrhagic Fevers

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## Vaccination

<http://www.cdc.gov/nip/publications/vis/#spox>

### Small pox

The vaccine is made from a virus called *vaccinia*, which is another "pox"-type virus related to smallpox but cannot cause smallpox.

### Who gets vaccinated for smallpox?

- Smallpox response teams
- Certain military and civilian personnel who are or may be deployed in high threat areas
- Some United States personnel assigned to certain overseas embassies

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## Vaccination

<http://www.cdc.gov/nip/publications/vis/#anthrax>

### Anthrax

Vaccine does not contain actual *B. anthracis* cells and does not cause anthrax disease

### Who gets vaccinated for anthrax?

- Lab workers between 18-65
- Military personnel who may be at risk of exposure

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## Vaccines Strengths & Weaknesses

### Strengths

- Cost-effective
- Safe
- Community immunity
- Potential for disease eradication

### Weaknesses

- Some have adverse reactions
- Links to neuro-developmental disorders
- Mass immunization can be labor intensive
- Logistics for mass immunization can be difficult

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## Objectives of Epidemiology

- Determining the extent of disease in a population
- Identifying patterns and trends in disease occurrence
- Identifying the causes of disease
- Evaluating the effectiveness of measures that prevent and treat disease (Aschengrau & Seage, 2003)

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### Objectives of Epidemiology: Your Role

- An important role you may play during times of heightened demand when epidemiology staff capacity is overburdened is to assist the epidemiology staff in achieving epidemiology objectives.
- Your key role will be to gather data that may help prevent, identify, and control disease outbreaks.

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### Possible ways you could be asked to assist in an epidemiology outbreak event:

- Develop interview questionnaire
- Conduct face-to-face and/or phone interviews
- Enter interview data
- Manage documents
- Prepare, record, and document specimens
- Review patient records
- Review pertinent literature and databases
- Handle cases by screening phone calls, screening patients for symptoms, directing and coordinating patients for mass vaccinations, etc.
- Gather and record field evidence

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### How epidemiology is applied in the core processes of public health practice

**Four core processes are used in the field of epidemiology:**

1. Surveillance
2. Screening
3. Outbreak investigation
4. Assessing causation

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### Epidemiology Core Processes: Surveillance

**Defined:** The regular collection, meaningful analysis, and routine distribution of relevant data that provides opportunities for public health action to prevent and control disease.

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### Epidemiology Core Processes: Surveillance

**Reasons for surveillance:**

- Identify cases of diseases (like meningitis) that pose immediate risk to communities
- Detect clusters
- Monitor trends of disease that may represent outbreaks
- Evaluate control and prevention measures
- Develop hypotheses for emerging diseases

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### Epidemiology Core Processes: Surveillance

**Two categories of surveillance:**

**Active surveillance:** Consists of actively searching for cases by proactively calling and visiting hospitals. This type of surveillance is often conducted when an outbreak is detected.

**Passive surveillance:** Refers to information provided to the health agency without an initiating action by the agency. This type of surveillance includes traditional reportable disease surveillance, vital statistics, and disease registries (Bureau of Epidemiology, FDOH, 2005).

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### Epidemiology Core Processes: Screening

**Defined:** The identification of an unrecognized disease or defect by the application of tests, examinations, or other procedures. Screening tests sort out apparently well persons, who probably have a disease from those persons who probably do not.

**Note:** If a screening results in suspicious findings, the individual is referred to a physician for further testing.

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### Epidemiology Core Processes: Outbreak Investigation

**Defined:** A multi-step process for determining the dynamics of a disease outbreak and implementing control and prevention measures.

In an outbreak investigation, the population at risk is investigated.

- **Populations** - Groups of people with common characteristics, such as race, gender, age, place of residence, religion, work place, and/or a shared event.
- **Population at risk** - The group of individuals who are most likely to have the disease or condition being investigated.

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### Epidemiology Core Processes: Outbreak Investigation

**Keys to determining an outbreak:**

- Two or more cases of a disease that are epidemiologically linked.
- In some instances of rare diseases or those with high public health impact, one case is enough to qualify as an outbreak (such as botulism).
- Syndromic surveillance data alerts the epidemiologist to changes in expected disease patterns.

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Epidemiology Core Processes:  
Outbreak Investigation

**Sources of outbreak indicators include:**

- Notifiable disease health department surveillance records,
- Neighboring areas or national data
- School absenteeism
- 911 calls
- Emergency room visits, hospital admissions, discharge records
- Death rates
- Laboratory data
- Pharmacy data

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Epidemiology Core Processes:  
Outbreak Investigation

**When to initiate an outbreak investigation:**

- Outbreak investigations should be initiated as soon as an event is verified so that measures to control and prevent further transmission of the agent can be implemented.
- During an outbreak investigation, it is vital to provide prompt and accurate education to healthcare providers, patients, contacts, facilities, and the public in order to prevent fear and misinformation from other sources.

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Epidemiology Core Processes:  
Outbreak Investigation

- Fact sheets for the common sources of outbreaks should be available ahead of time for quick reference.
- Fact sheets are available and frequently updated on the CDC website located at <http://www.cdc.gov>

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Epidemiology Core Processes:  
Assessing Causation

- It is vital that information gathered through screening and surveillance is entered into a common reporting system that can be accessed by epidemiologists and healthcare practitioners statewide.
- Merlin Reporting System

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Merlin Reporting System

- Merlin is the Bureau of Epidemiology's real-time web-based surveillance system for communicable disease reporting, with the exception of tuberculosis, sexually transmitted diseases and HIV/AIDS.
- The system is a single, statewide database with real-time web pages for entering patient demographics, case data, laboratory results, and extended case report form data, where applicable.

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Merlin Reporting System

- Surveillance data should be analyzed regularly to detect potential outbreaks and disseminate the information collected (Bureau of Epidemiology, FDOH, 2005).
- The Merlin system of operations will not be covered in detail at this time as it is beyond the scope of this course. Simply be aware that such a system for entering data exists and is available from county to county throughout Florida.

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Examples of the use and application of epidemiology

**Example 1:**

In October 2001, Dr. Jean Malecki, Director of the Palm Beach County Health Department (Florida), received a call from an old friend and physician colleague. Her friend, whom she trusted as an excellent physician, spoke very quickly and sounded very concerned. He said, "I did a spinal tap on a man and saw something I haven't seen in my 20 years of practice." The doctor described the situation to Dr. Malecki. They decided to send the specimen from the spinal tap to the county health department laboratory, the State laboratory, and the CDC laboratory to confirm their suspicions that the spinal tap results revealed a case of inhalation anthrax.

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Examples of the use and application of epidemiology

**Example 1:**

The immediate questions were: Is this really anthrax? Could this be related to the recent bioterrorist acts? Should the team err on the side of caution and report the suspected incident or wait and see? In this instance, the decision was to pursue an investigation. The sample turned out to be anthrax and the collaboration and quick action on the parts of the doctor and the health department director led to a head start on addressing the problem (Shapiro, Landis, Mescia, & Reid, 2001).

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Examples of the use and application of epidemiology

**Example 2:**

At 8:30 in the morning on August 2, 1976, Dr. Robert B. Craven of the CDC's Viral Diseases Division received a call from a nurse at a Veterans' Hospital in Philadelphia, Pennsylvania. The nurse reported two cases of severe respiratory illness, one of which had been fatal. Both people had attended the annual American Legion Convention held July 21-24. By the evening of August 2, 71 additional people attending the convention had the same illness - symptoms of acute onset of fever, chills, headache, malaise, dry cough, and myalgia. Further conversations with local and state public health officials revealed that between July 26 and August 2, eighteen conventioners had died. Deaths were due primarily to pneumonia.

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Examples of the use and application of epidemiology

**Example 2:**

An intense investigation began immediately. The incident became known as the first outbreak of Legionnaires' disease and led to the discovery of the gram-negative pathogen, *Legionella pneumophila* (CDC EXCITE, 2004).

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Examples of the use and application of epidemiology

**Example 3:**

In June 2003 the Hillsborough County Health Department, in Florida, was informed by a physician that two people who had eaten at a local BBQ restaurant experienced gastrointestinal illness approximately 24 hours after their meal. Thirteen additional individuals were identified through a resulting epidemiological investigation. Epidemiologic investigations found *Salmonella* Group B to be the agent.

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Examples of the use and application of epidemiology

**These examples illustrate some of the key reasons for needing applied or field epidemiology:**

- The events were unexpected.
- The events demanded an immediate response.
- The investigators had to go outside the health department to solve the problem.
- Collaboration is essential in epidemiology.

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### Epidemiology requires collaboration

One of the most common ways health departments learn about disease outbreaks is through calls from a community doctor, some other health care provider, or a citizen. Without this information, gained through collaboration, it would take far longer for health departments to discover when a problem exists. It is very important to keep the lines of communication open within the health department, between the health department, and healthcare providers.

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### Disease Overview Summary

**In this module, you learned to:**

- Define epidemiology's key terms and core concepts.
- Recognize the objectives of epidemiology in public health practice and describe your role.
- Describe how epidemiology is applied in the core processes of public health practice.
- Describe examples of the use and application of epidemiology.
- Apply the basic terms, concepts, and processes of epidemiology.

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### Disease Overview Summary

**Epidemiology:**

- Is applied to virtually all health-related events, which include chronic disease, environmental and behavioral problems, and injuries, in addition to infectious disease.
- Deals with groups of people rather than with individuals.
- Can be used as an analytical tool for studying diseases and their determinants.
- Can influence public health decision making, policy making, and aid in developing and evaluating interventions to control and prevent health problems.

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