Aims

To provide Environmental Engineering participants with the necessary theoretical knowledge, which when combined with appropriate practical experience, can serve as a foundation for a career as a public health professional in services of related issues such as water supply and environmental sanitation.

Objectives

By the end of the course participants should:

Have a sound understanding of basic epidemiological theory and be able to apply it in a practical setting.

Have the necessary skills to be able to analyze public health problems including:

- selection of appropriate measures to describe the health status of populations and groups
- selection of appropriate measures by which to compare and rank public health problems
- assessment of the potential benefit from the modification of causal exposures
- quantifying the uncertainty of quantities of public health interest

Understand the methods needed to control environmental and communicable hazards.

Understand the principles involved in the design and conduct of health promotion programs.

Understand the principles involved in the economic assessment of health and of services for its protection and restoration.

Understand the main legal and ethical principles relevant to public health work.
Course Outline

Introduction to Public Health and epidemiology
History of Epidemiology
Disease Transmission
Measures of Morbidity and Mortality
Validity and Reliability of Analytical Tests
Descriptive Studies: Person, Place and Time
Relative and Attributable Risks
Ethical Issues
Association to Causation
Definitions and Terminologies

**Epidemiology** is the study of the nature, cause, control and determinants of the frequency and distribution of disease, disability, and death in human populations.

**Epidemiology**: the study of factors influencing the occurrence, transmission, distribution, prevention and control of disease in a defined population

An **Epidemiologist** is a public health scientist, who is responsible for carrying out all useful and effective activities needed for successful epidemiology practice

**Endemic**: a disease or pathogen present or usually prevalent in a given population or geographic region at all times

**Hyperendemic**: equally endemic in all age groups of a population

**Holoendemic**: endemic in most of the children in a population, with the adults in the same population being less often affected

**Epidemic**: a disease occurring suddenly in numbers far exceeding those attributable to endemic disease; occurring suddenly in numbers clearly in access of normal expectancy

**Pandemic**: a widespread epidemic distributed or occurring widely throughout a region, country, continent, or globally

**Epizootic**: of, or related to a rapidly spreading and widely diffused disease affecting large numbers of animals in a given region.

**Incidence**: rate of occurrence of an event; number of new cases of disease occurring over a specified period of time; may be expressed per a known population size

**Prevalence**: number of cases of disease occurring within a population at any one given point in time
**Outbreak**: Sudden occurrence of an epidemic in relatively limited geographic area. While an outbreak is usually limited to a small focal area, an epidemic covers larger geographical areas & has more than one focal point.

**Outbreak Epidemiology**: Study of a disease cluster or epidemic in order to control or prevent further spread of the disease in the population.
Definitions of Public Health

What's in a Name?
Public health has been known by many names, such as Social Medicine, Social Hygiene, Community Health, Community Medicine, Population Health, Public Health Medicine or Preventive Medicine.

The Milbank Memorial Fund Commission (1976) wrote:
"Public health is the combination of sciences, skills, and beliefs that is directed towards the maintenance and improvement of the health of all people through collective or social actions. The programs, services, and institutions involved emphasize the prevention of disease and the health needs of the population as a whole. Public health activities have changed over time with changing technology and social values, but the goals remain the same: to reduce the amount of disease, premature death, and disease-produced discomfort and disability in the population. Public health is thus a social institution, a discipline, and a practice."

[The mission of public health lies in] fulfilling society’s interest in assuring conditions in which people can be healthy. Its aim is to generate organized community effort to address the public interest in health by applying scientific and technical knowledge to prevent disease and promote health. The mission of public health is addressed by private organizations and individuals as well as by public agencies. But the governmental public health agency has a unique function: to see to it that vital elements are in place and that the mission is adequately addressed. The committee finds that the core functions of public health agencies at all levels of government are assessment, policy, and assurance.
The WHO (1978):  
"Public health is the science and art of preventing disease, prolonging life and promoting mental and physical health and efficiency through organized community efforts for the sanitation of the environment, the control of communicable infections, the education of the individual in personal hygiene, the organization of medical and nursing services for the early diagnosis and preventive treatment of disease, and the development of social machinery to ensure to every individual a standard of living adequate for the maintenance of health, so organizing these benefits as to enable every citizen to realize his birthright of health and longevity."

John Last, in the Dictionary of Epidemiology (1999):  
"one of the organized efforts of society to protect, promote and restore the people's health". More recently, Last has noted that public health "can describe a concept, a social institution, a set of scientific disciplines and technologies, and a form of practice. Public health is an organized activity of society to promote, protect, improve, and when necessary restore, the health of individuals, specified groups or the entire population." (Dictionary of Public Health, forthcoming)

The mission of Public Health is to protect, preserve and promote the health of the public. Public health is the art and science of promoting and protecting good health, preventing disease, disability, and premature death, restoring health when it is impaired, and maximizing the quality of life when health cannot be restored. Public health requires collective action by society; collaborative teamwork involving physicians, nurses, engineers, environmental scientists, health educators, social workers, nutritionists, administrators, and other specialized professional and technical workers; and an effective partnership with all levels of government

"public health is the science and art of preventing disease, prolonging life and promoting health through organized efforts of society."
A typical list of public health responsibilities includes:

**Health Surveillance** - collecting, interpreting and communicating health data and acting upon it in order to identify disease trends, emerging pathogens, etc.

**Health promotion** - encouraging healthy behaviors (e.g., smoking legislation), building healthy environments (bicycle paths, etc).

**Population Health Assessment** - monitoring underlying social trends that affect health (poverty, homelessness, drug use, etc.) and encouraging governments to address these. This relates to health promotion, but moves the focus of attention upstream, to address underlying determinants.

**Health Protection** - more specific than health promotion, this targets particular health hazards and reduces people's exposure to them. Drug safety regulations; food inspections; hazardous substances and pollution; vector control and smoke-free spaces are examples.

**Disease and Injury Prevention** - closely related to health protection, this focuses on particular diseases. Many approaches are best implemented at the population level: food safety; immunization; outbreak control; road safety; playground design, etc.

**Emergency Preparedness** - natural disasters, infectious disease, bioterrorism, etc. An aspect of health protection, but more generic as we do not know precisely what we must protect against.

**Vulnerable Groups** - protecting the health of particular groups such as maternal and infant health; refugees, etc.
Terms Associated with Disease Causation, etc.

Host: Epidemiology Any organism that can be infected by a pathogen under natural conditions

Agent: A factor such as a microorganism, chemical substance, or a form of radiation, the presence or absence of which (as in deficiency diseases) results in disease or more advanced disease.

Environment: the aggregate of all of the external conditions and influences affecting the life and development of an organism. It can be divided into physical, biologic, social, cultural; any or all of which can influence the health status of the population.

Fomites: Any inanimate or nonpathogenic substance or material (e.g., sheets, surfaces of furniture, papers and so forth), exclusive of food, which may act as a vector for a pathogen

Vector: a carrier, especially the animal (usually an arthropod) that transfers an infective agent from one host to another

Carrier – active: One who harbors a pathogenic organism for a clinically significant time and is able to pass the infection to others

Incubatory: The development of an infection from the time the pathogen enters the body until signs or symptoms first appear.

Convalescent: a patient who is recovering from a disease, operation or injury.

Healthy: a condition of physical, mental, and social well-being and of absence of disease or another abnormal condition.
Uses of Epidemiology:

1. The history of disease
   - Studies the trends of disease for the prediction of trend
   - The results of epidemiological studies are useful in planning for health services and public health

2. Community diagnosis
   - What are the diseases, conditions, injuries, disorders, disabilities, defects causing illness, health problems, or death in a community of region

3. Look at risks of individuals as they affect groups or populations
   - What are the risk factors, problems, behaviors that affect the group
   - Groups are studied by doing risk factor assessment and health appraisal approaches, e.g. health risk, appraisal, health screening, medical exam, diseases assessments

4. Assessment, evaluation and research
   - How well do public health and health services meet the problems and needs of the population or group
   - Effectiveness, efficiency, quality, quantity, access, availability of services to treat, control, or prevent disease, injury, disability, or death are studied.

5. Completing the clinical picture
   - Identification and diagnostic processes to establish that condition exists or that a person has a specific disease.
   - Cause-effect relationships are determined, e.g. strep throat can cause rheumatic fever.

6. Identification of syndromes
   - Help to establish and set criteria to define syndromes, some examples are: Down, fetal alcohol, sudden death in infants, etc.

7. Determine the causes and sources of diseases
   - Epidemiological findings allow for control, prevention, and elimination of the causes of disease, condition, injury, disability, or death.
Aims of epidemiology:

- Determine the primary agent or ascertain causative factors
- Understand the causation of disease, disorders, or conditions
- Determine the characteristics of the agent or causative factors
- Define the mode of transmission
- Define and determine contributing factors
- Identify and explain geographic disease patterns
- Determine, describe, and report the natural course of disease, disability, injury, and death
- Determine control methods
- Determine preventive measures
- Aid in the planning and development of health services
- Provide administrative and planning data.
Methods of Epidemiology

- Public Health Surveillance
- Disease Investigation
- Analytic Studies
- Program Evaluation
History of Epidemiology

Hippocrates (460-377 B.C.)
*On Airs, Waters, and Places:* Idea that disease might be associated with physical environment

Thomas Sydenham (1624-1689)
Recognized as a founder of clinical medicine and epidemiology
Emphasized detailed observations of patients & accurate recordkeeping

James Lind (1700’s)
Designed first experiments to use a concurrently treated control group

Edward Jenner (1749-1823)
Pioneered clinical trials for vaccination to control spread of smallpox
Jenner's work influenced many others, including Louis Pasteur who developed vaccines against rabies and other infectious diseases

Ignas Semmelweis (1840’s)
Pioneered handwashing to help prevent the spread of septic infections in mothers following birth
John Snow (1813-1858)
Father of epidemiology
Careful mapping of cholera cases in East London during cholera epidemic of 1854
Traced source to a single well on Broad Street that had been contaminated by sewage

History of Epidemiology (Cont’d)
• Vital Statistics
  John Graunt (1620-1674)
  William Farr (1807-1883)

• Occupational medicine & Industrial Hygiene
  Bernardino Ramazzini (1633-1714)

• Role of carriers in transmission
  Typhoid Mary & George Soper
Typhoid Mary & George Soper

Mary Mallon, a cook responsible for most famous outbreaks of carrier-borne disease in medical history

Recognized as carrier during 1904 N.Y. typhoid fever epidemic

When source of disease was traced, Mary had disappeared only to resurface in 1907 when more cases occurred

Again Mary fled, but authorities led by George Soper, caught her and had her quarantined on an island

In 1910 the health department released her on condition that she never accept employment involving the handling of food

Four years later, Soper began looking for Mary again when two new epidemics broke out; Mary had worked as a cook at both places

She was found and returned to North Brother Island, where she remained the rest of her life until a paralytic stroke in 1932 led to her slow death, six years later
U.S. History of Epidemiology

- **Lemuel Shattuck (1850)**
  Proposed creation of a permanent statewide public health infrastructure
  Recommended establishing state & local health offices to gather statistical information on public health conditions

- **Quarantine Commissions (1857)**
- **1st Public Health Book (1879)**
- **U.S. Public Health Service founded (1902)**
- **Pure Food and Drug Act (1906)**
- **Pasteurization of milk (1913)**
- **1st School of Public Health (1913)**

Historic Aspects of the Development of Morbidity Statistics in the U.S.

- **Edgar Sydenstricker (Early 1900’s)**
  Pioneer public health statistician
  Three notable studies:
  Tuskegee syphilis study (1932-1970)
  Framingham heart study (1948-present)
  Epidemiology of cigarette smoking (1950’s - present)
Modern History of Epidemiology in the U.S.

- Mortality stats in first half of century
  - Unstable because of outbreaks of infection
- Stats reversed by 1950’s because of childhood immunizations, medical interventions and public health measures
- Economic growth reduced squalor
- Introduction of antibiotics in 50’s

Wake-up Calls

- Over-optimism in 60’s and 70’s
- AIDS recognized
- Cholera in the southern hemisphere
- Legionnaire’s disease
- New forms of hepatitis
- Chlamydia and heart disease
- Hospital acquired infections
- Antibiotic resistance

Future Challenges

- Instant global transmission of pathogens
  - Population overcrowding
  - Ease of travel
  - Importation of foods
Components of the infectious disease process - Chain of infection

Chain of Infection
- Etiological agent
- Source/Reservoir
- Portal of exit
- Mode of transmission
- Portal of entry
- Susceptible host
# Modes of Transmission

- Contact transmission
- Vehicle transmission
- Vector transmission

<table>
<thead>
<tr>
<th>Mode of Transmission</th>
<th>Diseases Spread Include</th>
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<tbody>
<tr>
<td><strong>Contact Transmission</strong></td>
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<tr>
<td>Direct Contact: e.g., handshaking, kissing, sexual intercourse, bites</td>
<td>Cutaneous anthrax, genital warts, gonorrhea, herpes, rabies, staphylococcal infections, syphilis</td>
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<tr>
<td>Indirect Contact: e.g., drinking glasses, toothbrushes, toys, punctures</td>
<td>Common cold, enterovirus infections, influenza, measles, Q fever, pneumonia, tetanus</td>
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<tr>
<td>Droplet transmission: e.g., droplets from sneezing (within 1 meter)</td>
<td>Whooping cough, streptococcal pharyngitis (strep throat)</td>
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<tr>
<td><strong>Vehicle Transmission</strong></td>
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<tr>
<td>Airborne: e.g., dust particles</td>
<td>Chickenpox, coccidiomycosis, histoplasmosis, influenza, measles, pulmonary anthrax, tuberculosis</td>
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<tr>
<td>Waterborne: e.g., streams, swimming pools</td>
<td>Campylobacter infections, cholera, <em>Giardia</em> diarrhea</td>
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<tr>
<td>Foodborne: e.g., poultry, seafood, meat</td>
<td>Food poisoning (botulism, staphylococcal); hepatitis A, listeriosis, tapeworms, toxoplasmosis, typhoid fever</td>
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<tr>
<td><strong>Vector Transmission</strong></td>
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<tr>
<td>Mechanical: e.g., (on insect bodies) flies, roaches</td>
<td><em>E. coli</em> diarrhea, salmonellosis, trachoma</td>
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<tr>
<td>Biological: e.g., lice, mites, mosquitoes, ticks</td>
<td>Chagas’ disease, Lyme disease, malaria, plague, Rocky Mountain spotted fever, typhus fever, yellow fever</td>
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Epidemic Curves- Classes of Epidemics

A. Common Source Outbreaks: Here the cases of disease arise from a single, shared or 'common' source, such as a batch of bad food, industrial pollution or a contaminated water supply. Controlling the source stops the outbreak.

1. Point source: Here, all cases appear to occur within one incubation period, suggesting that cases did not arise from person-to-person spread. The fact that the outbreak was of short duration suggests that it was a single, brief (hence "point") exposure that did not persist over time. Examples include that embarrassing diarrhea saga following the neighbor's summer barbecue, or a respiratory illness in workers following a breakdown of a fume hood.
2. **Continuous**: As with the point source outbreak, a group of people are exposed to a single noxious influence. But here the exposure continues over a longer time (e.g., a contaminated water supply that doesn't get fixed), so the outbreak persists for longer. The relatively abrupt beginning of the outbreak suggests that many people were exposed simultaneously, rather than it spreading via transmission from one case to another. The fact that no cases arise beyond one incubation period following the termination of the exposure also supports this conclusion.
3. **Intermittent:** You may occasionally see this pattern. This seems to be a common source that is not well controlled, so outbreaks recur. Depending on the time-frame, it could be seasonal or weather-related, or perhaps due to a common source such as an industrial contaminant being emitted at intervals.

The gaps between the outbreaks might initially suggest person-to-person transmission followed by an incubation period, but this is unlikely because in a transmissible disease the successive peaks would become larger and merge together, as in the next examples.
B. Person-to-Person Spread. Here the disease spreads via person-to-person contact – the classic infectious disease pattern. Controlling the source is no longer sufficient to control the outbreak.

1. Index case with limited spread: Here a single 'index' case (for example, a returning traveller) infects other people, and cases arise after an incubation period. (Perhaps confusingly, you may also hear this called a point source with secondary transmission). The outbreak wanes when the infected people no longer transmit the infection to other susceptible people, perhaps because of successful control measures (isolation or quarantine). The graph suggests this was achieved quite quickly.
2. **Propagated:** This begins like an infection from an index case but then develops into a full-blown epidemic with secondary cases infecting new people who, in turn, serve as sources for yet other cases. This produces successively taller peaks, initially separated by one incubation period, but the peaks tend to merge into waves with increasing numbers of cases in each generation. The epidemic continues until the remaining numbers of susceptible individuals declines or until intervention measures take effect.
Disease Outbreak Investigation

Thresholds for detecting an outbreak

Some epidemic prone diseases exist in the community even without an outbreak. Outbreaks occur when there is a sharp rise in cases (e.g. Malaria) in Africa for example.

Some epidemic prone diseases do not exist normally in the community. The occurrence of just one confirmed case is considered an outbreak (e.g. Cholera).

Some epidemic prone diseases are rare and highly deadly when they occur. We do not have to wait for confirmation of a case. Just one suspected case is enough to consider an outbreak (e.g. Ebola).

Therefore, thresholds differ from disease to disease

Cholera – One confirmed case

Ebola – One suspected case

Measles – A cluster of 5 or more suspected cases OR at least 3 confirmed positive cases in a catchment area of a health facility in a month

Malaria – A sharp seasonal rise in cases beyond the usual number of cases
Objectives of an outbreak investigation

1. Verify
2. Recognize the magnitude
3. Diagnose the agent
4. Identify the source and mode of transmission
5. Formulate prevention and control measures

An outbreak comes from a change in the way the host, the environment and the agent interact: This interaction needs to be understood to propose recommendations.
Steps in investigating an outbreak

**Step 1: Initial response and confirmation of outbreak**
- Assemble team and prepare for an initial field visit as soon as possible
- Choose a working case definition and confirm cases
- Find cases systematically
- Confirm whether there is an outbreak by comparing occurrence of cases with thresholds
- Describe who is affected, when and where?

**Step 2: Identify and manage cases**
- Establish a district task force and allocate them their responsibilities
- Use the working case definition to find cases
- Set up a treatment centre

**Step 3: Set up immediate control measures**
- Treat cases to interrupt transmission and reduce deaths
- Consider vaccination, disinfection and protective wear
- Provide health education to those at risk
- Communicate clearly to reduce panic
Step 4: Address the resource gaps

- Ensure adequate medical supplies and logistics to handle cases
- Look for additional resources to address the gaps
- Contact Ministry of Health and partner agencies

Step 5: Determine responsible factors and make a report

- Analyse available information to establish the risk factors
- Prepare a report and disseminate it
- Recommend and implement priority control measures

Step 6: Surveillance: Be on your guard

- Strengthen existing system to be able to find cases actively
- Learn from this outbreak to respond better in future
- Put in place measures to prevent other outbreaks in future
Disease outbreak Investigation

- Establish diagnosis
- Identify specific agent
- Describe according to person, place and time
- Identify source of agent
- Identify mode of transmission
- Identify susceptible populations

Unusual event: Is this an outbreak?

- Yes
  - Are the source and modes of transmission known?
    - Yes -> Control measures
    - No -> Clinical, microbiological and epidemiological investigation

- No

Time, place person description
Formulation of hypothesis

Hypothesis fit the facts:
- Control measures

Hypothesis does not fit the facts:
- Analytical investigations
Concepts of Prevention and Control

**Prevention**: Actions aimed at eradicating, eliminating or minimizing the impact of disease and disability, or if none of these are feasible, retarding the progress of the disease and disability.

The concept of prevention is best defined in the context of levels, traditionally called primary, secondary and tertiary prevention. A fourth level, called primordial prevention, was later added.

**Successful prevention depends upon:**

- a knowledge of causation,
- dynamics of transmission,
- identification of risk factors and risk groups,
- availability of prophylactic or early detection and treatment measures,
- an organization for applying these measures to appropriate persons or groups, and
- continuous evaluation of and development of procedures applied

**Preventable Causes of Disease**

**BEINGS**
- Biological factors and Behavioral Factors
- Environmental factors
- Immunologic factors
- Nutritional factors
- Genetic factors
- Services, Social factors, and Spiritual factors
Levels of Prevention

1. **Primordial prevention** consists of actions and measures that inhibit the emergence of risk factors in the form of environmental, economic, social, and behavioral conditions and cultural patterns of living etc.

   It is the prevention of the emergence or development of risk factors in countries or population groups in which they have not yet appeared.

   For example, many adult health problems (e.g., obesity, hypertension) have their early origins in childhood, because this is the time when lifestyles are formed (for example, smoking, eating patterns, physical exercise).

   In primordial prevention, efforts are directed towards discouraging children from adopting harmful lifestyles.

   The main intervention in primordial prevention is through individual and mass education.
2. **Primary prevention** can be defined as the action taken prior to the onset of disease, which removes the possibility that the disease will ever occur.

It signifies intervention in the pre-pathogenesis phase of a disease or health problem.

Primary prevention may be accomplished by measures of "Health promotion" and "specific protection"

It includes the concept of "positive health", a concept that encourages achievement and maintenance of "an acceptable level of health that will enable every individual to lead a socially and economically productive life".

Primary prevention may be accomplished by measures designed to **promote** general health and well-being, and quality of life of people or by **specific protective measures**
Primary prevention

Achieved by

Health promotion
- Health education
- Environmental modifications
- Nutritional interventions
- Life style and behavioral changes

Specific protection
- Immunization and seroprophylaxis
- Chemoprophylaxis
- Use of specific nutrients or supplementations
- Protection against occupational hazards
- Safety of drugs and foods
- Control of environmental hazards, e.g. air pollution
Secondary prevention: It is defined as “action which halts the progress of a disease at its incipient stage and prevents complications.”

The specific interventions are: **early diagnosis** (e.g. screening tests, and case finding programs…) and adequate **treatment**.

Secondary prevention attempts to arrest the disease process, restore health by seeking out unrecognized disease and treating it before irreversible pathological changes take place, and reverse communicability of infectious diseases.

It thus protects others from in the community from acquiring the infection and thus provide at once secondary prevention for the infected ones and primary prevention for their potential contacts.

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**Tertiary prevention:** It is used when the disease process has advanced beyond its early stages.

It is defined as “all the measures available to reduce or limit impairments and disabilities, and to promote the patients’ adjustment to irremediable conditions.”

Intervention that should be accomplished in the stage of tertiary prevention are **disability limitation**, and **rehabilitation**.

**Impairment** is “any loss or abnormality of psychological, physiological or anatomical structure or function.”

**Disability** is “any restriction or lack of ability to perform an activity in the manner or within the range considered normal for the human being.”

**Handicap** is termed as “a disadvantage for a given individual, resulting from an impairment or disability, that limits or prevents the fulfillment of a role in the community that is normal (depending on age, sex, and social and cultural factors) for that individual.”

**Rehabilitation** is “the combined and coordinated use of medical, social, educational, and vocational measures for training and retraining the individual to the highest possible level of functional ability.”