A Brief Introduction to Epidemiology

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The purpose of this lecture is to provide an overview of the fundamentals of epidemiology as the basis for the science of public health.
Why Teach Epidemiology?

Epidemiology is an objective, scientific method of problem solving based on quantitative analysis.

Teaching epidemiology

• improves students' reasoning and research skills,
• enhances their ability to analyze and solve complex problems, and
• sensitizes them to good health practices.

http://www.cdc.gov/excite/about.htm#2
Outline

1. Define epidemiology and explain its role as the foundation for public health
2. Describe common measures of disease frequency
3. Descriptive and analytic epidemiology
   - John Snow and cholera in London 1854,
   - Case – control study, cohort study, clinical trials
4. Disease / Public health surveillance
   - Influenza surveillance
5. Outbreak investigations
   - Emerging Infectious Diseases
   - SARS     Health Communication
6. Screening Test
7. OR and RR
8. Four types of causal relation
9. Guidelines for assessing causation
10. Summary
1. Define epidemiology and explain its role as the foundation for public health
Medicine

Clinical medicine

Preventive medicine
Clinical Medicine

The study and practice of medicine by direct examination of the patient.

Webster's Online Dictionary
Preventive Medicine

The branch of medicine concerned with preventing disease; "the medical establishment doesn't profit from preventive medicine".

Webster's Online Dictionary
Public Health

The science and act of preventing diseases, prolonging life, and promoting health and efficiency through organised community efforts.

Specialty Definition: Webster's Online Dictionary
Public health

• The approach to medicine that is concerned with the health of the community as a whole.
• Public health is community health.
• It has been said that:
  "Health care is vital to all of us some of the time, but public health is vital to all of us all of the time."

Core Public Health Functions

1. Assessment
2. Policy development
3. Assurance
The three core public health functions

1. The assessment and monitoring of the health of communities and populations at risk to identify health problems and priorities;

2. The formulation of public policies designed to solve identified local and national health problems and priorities;

3. To assure that all populations have access to appropriate and cost-effective care, including health promotion and disease prevention services, and evaluation of the effectiveness of that care.

Notable public health achievements in the 20th century

- Vaccination
- Control of infectious diseases
- Safe and healthier foods
- Fluoridation of drinking water
- Decline in deaths from coronary heart disease and stroke
- Recognition of tobacco as a health hazard
- Motor vehicle safety
- Healthier mothers and babies
- Family planning
- Safer workplaces

“Ten Great Public Health Achievements -- United States, 1900-1999 ”by USCDC
Epidemiology

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

A Dictionary of Epidemiology, Last JM et al., eds.
Epidemiology

• The study of the distribution and determinants of health-related states or events (including disease), and the application of this study to the control of diseases and other health problems.

• Various methods can be used to carry out epidemiological investigations:
  - surveillance and descriptive studies can be used to study distribution;
  - analytical studies are used to study determinants.

http://www.who.int/topics/epidemiology/en/
Epidemiology

The study of the distribution and determinants of health problems in specified populations and applying the learned information to control the health problems.

http://www.cdc.gov/excite/about.htm
Epidemiology

Study

• Epidemiology is the basic science of public health.

• It's a highly quantitative discipline based on principles of statistics and research methodologies.

http://www.cdc.gov/excite/classroom/intro_epi.htm
Epidemiology

Distribution

- Epidemiologists study the distribution of frequencies and patterns of health events within groups in a population.
- To do this, they use descriptive epidemiology, which characterizes health events in terms of person, place and time.

http://www.cdc.gov/excite/classroom/intro_epi.htm
Epidemiology

Determinants

• Epidemiologists also attempt to search for causes or factors that are associated with increased risk or probability of disease.

• This type of epidemiology, where we move from questions of "who," "what," "where," and "when" and start trying to answer "how" and "why," is referred to as analytical epidemiology.

http://www.cdc.gov/excite/classroom/intro_epi.htm
Epidemiology

Health-related states

• Although infectious diseases were clearly the focus of much of the early epidemiological work, this is no longer true.

• Epidemiology as it is practiced today is applied to the whole spectrum of health-related events, which includes chronic disease, environmental problems, behavioral problems, and injuries in addition to infectious disease.

http://www.cdc.gov/excite/classroom/intro_epi.htm
Epidemiology

Populations

One of the most important distinguishing characteristics of epidemiology is that it deals with groups of people rather than with individual patients.

http://www.cdc.gov/excite/classroom/intro_epi.htm
Finally, although epidemiology can be used simply as an analytical tool for studying diseases and their determinants, it serves a more active role.

Epidemiological data steers public health decision making and aids in developing and evaluating interventions to control and prevent health problems.

This is the primary function of applied, or field, epidemiology.
What is Epidemiology?

• Like investigators at the scene of a crime, disease detectives begin by looking for clues.
• They systematically gather information about what happened—
  - Who is sick?
  - What are their symptoms?
  - When did they get sick?
  - Where could they have been exposed to the illness?
• Using statistical analysis, investigators study the answers to these questions to find out how a particular health problem was introduced into a community.

http://www.cdc.gov/excite/about.htm
What is Epidemiology?

Disease *detectives* then use what they have learned to prevent further illness.

For example, when in 1993 more than 200 people in Washington State developed similar gastrointestinal symptoms, investigators traced the illnesses to undercooked hamburgers from a fast-food chain. Warnings to cook beef until it is no longer pink halted the outbreak and prevented further transmission.

http://www.cdc.gov/excite/about.htm
What is Epidemiology?

It is the **scientific method** of problem solving used by "**disease detectives**"—epidemiologists, laboratory scientists, statisticians, physicians, other health care providers, and public health professionals—

to get to the root of health problems in a community, whether the problem is

- a measles outbreak on a small college campus or
- a global influenza pandemic,
- an increase in homicide in a single community,
- a national surge in violence, or
- a localized or widespread rise in cancer.

http://www.cdc.gov/excite/about.htm
Epidemiology

- Epidemiology has been defined as the study of the distribution and determinants of disease and injury in human populations.
- Epidemiologist study the variation of disease in relation to age, sex, race, occupational and social characteristics, place of residence, susceptibility, exposure to specific agents or other pertinent characteristics.
- Also of concern are the temporal distribution of disease, the examination of trends, cyclical patterns and intervals between exposure to causative factors and onset of disease.

http://www.ph.ucla.edu/epi/
Epidemiology advances the field of knowledge of disease causation, transmission and prevention through studies of the distribution of diseases in human populations, through laboratory studies and through incorporation of techniques derived from other disciplines; and provides a technical base for development of the optimal use and distribution of health resources for the promotion of community health.
Epidemiology

- The scope of the field ranges from study of the causes of disease to the control of prevention of disease and distribution of health resources.
- It should be emphasized that epidemiology focuses on health problems in population groups rather than on an individual.
- Epidemiology is a relatively young field with constantly expanding boundaries.

http://www.ph.ucla.edu/epi/
Epidemiology

The range of activities which may be at least partly epidemiologic includes

- Investigation and control of disease outbreaks
- Study of environmental and industrial hazards
- Evaluation of new, preventive or curative clinical treatment and intervention
- Determination of the health needs of the populations
- Evaluation of effectiveness of health services
Epidemiology

• Many of the tools of epidemiology are borrowed from other fields such as microbiology, immunology, medicine, statistics, demography and medical geography.

• There is a growing core of purely epidemiologic methodology.

• This methodologic core includes not only statistical methodology and principles of study design but a unique way of thinking which is beyond the rote memorization of rules

http://www.ph.ucla.edu/epi/
Epidemiology

• The contribution of epidemiology to any study involving groups of people is increasingly being recognized and demanded.

• An epidemiologist may work in a wide variety of settings, including
  - international health agencies,
  - state and local health departments,
  - federal government agencies and health programs,
  - health maintenance organizations, colleges and universities, and
  - numerous research institutions, both privately and publicly sponsored.

http://www.ph.ucla.edu/epi/
Three essential components

1. Disease distribution:
   how are cases of the condition of interest spread
   across a population differently by
   gender, age, geographic location,
   socio-economic status, other features?

2. Disease determinants:
   what risk factors or antecedent events
   are associated with the appearance of a disease or condition?

3. Disease frequency:
   how many cases of the condition occur over a given time period?
Epidemiology in Action

- Outbreak and cluster investigations
- Public health surveillance and
- Community screening programs

Represent key areas of public health practice in which systematic application of epidemiologic methods have a large and positive impact.
Outbreaks and Clusters

Outbreaks
- Generally involve infectious disease
- The problem is unexpected
- An immediate response may be demanded
- Public health epidemiologists must travel to and work in the field to solve the problem
- The extent of the investigation is likely to be limited because of the need for timely intervention
Clusters

- Usually refer to an aggregation of relatively uncommon events / diseases of noninfectious origin (e.g., leukemia, spontaneous abortions, suicides) in space and/or time in amounts believed or perceived to be greater than expected by chance.

- These events are often perceived to be due to environmental exposures.
Cluster investigators

Clustering of disease is *intriguing* and some cluster investigations have led to important scientific discoveries.

For example, investigation of the spatial clustering of enamel discoloration led to the discovery of the relation between *fluoride levels in drinking water* and dental caries.

Most cluster investigations *focus on cancer.*

Many carcinogens have been discovered through occupational or medical cluster investigations.
Cluster investigators

Studies of disease clusters often are challenging because of the constraints of information available to investigators.

Some of the biggest issues include:
- Rare health events
- Vague definition and/or heterogeneity of cases
- Lack of a population base for rate calculation
- Weak association and multiple risk factors
- Long induction periods
- Multiple comparisons
- Low-level, long-term, heterogeneous exposures
- Intense publicity
- Resource intensiveness of full investigations
The Objective of Epidemiology

• To identify the etiology or the cause of a disease and the risk factors
• To determine the extent of disease found in the community and set up priorities for interventions
• To study the natural history and prognosis of disease
• To evaluate public health intervention, policies and modes of health care delivery
• To provide the foundation for developing public policy and regulatory decisions relating to environmental problems
• To communicate the findings to health professionals and the public
Field Epidemiology
by Michael B. Gregg

• “The constellation of problems faced by epidemiologists who are called upon to investigate urgent public health problems...”
• “Public health epidemiologists must travel to and work in the field to solve the problem.”
• Thus, for those practicing in this arena, the motivation is not primarily research oriented but rather geared to those problems for which government agencies usually are given the primary mandates and responsibilities.
• Perhaps the title of “The Field of Acute Public Health Epidemiology,” although awkward, is a better description of the content of this book.
We can define field epidemiology as the application of epidemiology under the following set of general conditions:

- The problem is unexpected.
- A timely response may be demanded.
- Public health epidemiologists must travel to and work in the field to solve the problem.
- The extent of the investigation is likely to be limited because of the imperative for timely intervention.
Field Epidemiology Training Programs

• “CDC has re-emphasized the priority it places on responding effectively and efficiently to health threats—domestic or global—and

• Reaffirmed its traditional focus on science and evidence-based public health practice.

• Key to this has been the strengthening of surveillance and epidemiology—historically among the organization’s greatest assets.”

Thomas Frieden, CDC Director

Global Early Warning System for Major Animal Diseases, including Zoonoses (GLEWS)

- Disease emergence and spread do not respect geographical boundaries, and animals are often implicated as the source of human infection.
- Zoonotic disease management therefore requires an integrated approach that involves different sectors; mainly human, animal and food.
- Efficient early warning and forecasting of zoonotic disease trends through functional surveillance systems is key to effective containment and control.
- Early intervention during a disease epidemic often leads to better outcomes with reduced disease burden and associated economic impact.

Global Health - Global Disease Detection and Emergency Response

**Health Systems Reconstruction**

- National laboratory systems
- National surveillance systems
- Field Epidemiology and Laboratory Training Program (FELTP)
- Vector Control Program
- Water Sanitation and hygiene interventions
- National nutrition surveys
- Childhood immunizations
- HIV and TB control
- Reproductive health and emergency obstetrical care

[Link](http://www.cdc.gov/globalhealth/gdder/hsr/)
The epidemiologic triad of a disease

- Agent
- Environment
- Host
- Vector

Infectious agent
Epidemiologic triad

Host
- Demographic characteristics
- Biological characteristics
- Socioeconomic characteristics

Agent
- Biological agents
- Physical agents
- Chemical agents
- Nutrient agents
- Mechanical agents
- Social agents

Environment
- Physical environment
- Biological environment
- Social environment
Disease is the result of forces within a dynamic system consisting of:

Agent  Host  Environment
Agent

The entity necessary to cause disease in a susceptible host.

- Biological - bacterium, parasite, or virus
- Physical force - motor vehicle crashes
- Chemical - environmental problem
- Nutritional imbalance - rickets

Several characteristics are important to consider:

- **Infectivity** - the capacity to cause infection in a susceptible host
- **Pathogenicity** - the capacity to cause disease in a host
- **Virulence** - the severity of disease that the agent causes in the host

http://www.cdc.gov/excite/classroom/intro_epi.htm
Host

• **Person**, or in a more generic definition, the organism, that is **susceptible** to the effect of the agent.

• The **status** of the host is quite important and is generally classifiable as **susceptible**, **immune**, or **infected**.

• Finally, and also quite important, is that the host's **response to exposure** can vary widely, from showing **no effect** to manifesting **subclinical disease**, **atypical symptoms**, **straightforward illness**, or **severe illness**.

http://www.cdc.gov/excite/classroom/intro_epi.htm
Environment

• The **conditions** or influences that are not part of either the agent or the host, but that **influence their interaction**.
• A wide variety of **factors**, including **physical, climatologic, biologic, social,** and **economic conditions**, can come into play.
• For instance, in a study of **motor vehicle injuries**, the agent (mechanical energy) and the host (driver) could be affected by the topography, the weather, and the actions of other drivers.
• In many infectious disease outbreaks, **social and economic conditions** cause **overcrowding** and lead to high levels of exposure.

http://www.cdc.gov/excite/classroom/intro_epi.htm
Chain of infection
Reservoir  
(of infectious agents)

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.
• **Descriptive Epidemiology**
  provides the
  Who
  What
  When and
  Where
  of health-related events in a population

• **Analytic Epidemiology**
  attempts to provide the
  Why and
  How (To react and control)
  of health-related events in a population
Descriptive Studies

• Collecting information that characterizes and summarizes a health event or health problem.

• Routinely collected data from such sources as death certificates, hospital discharge records, health surveys (e.g., cross-sectional surveys) and disease surveillance programs are used for most descriptive studies.

• Characteristics related to person may include age, gender, race, ethnicity, marital status, socioeconomic class and occupation.

• Descriptive studies on occurrence of conditions according to place might involve examining their frequency within or between natural or political boundaries, urban versus rural localities, or latitude.

• Examination of time relationships can both identify and evaluate possible causes for changes in health conditions.
Causal Pathway of Disease or Disability

- Environment (pre-exposure)
- Hazard / agent
- Behavior/risk factor
- Exposure
- Pre-symptomatic phase
- Apparent disease
- Death
Disease natural history & HIV/AIDS intervention

Primordial prevention
Primary prevention
Behavior surveillance & intervention

Secondary prevention
HIV surveillance

Tertiary prevention
AIDS surveillance

Risk behavior
Pathology
Symptoms
Seek Care
Diagnose
AIDS
Treatment

Outcome
Cure
Control
Disability
Death

Health
Asymtomatic
Clinical

Agent
Host
Environment

0 3 Month ± 10 Year ±
Proposed diagram of an environment and epidemiology network

Data from:
- Epidemiological intelligence
- Infectious disease surveillance
- Meteorology
- Entomology
- Water monitoring
- Air monitoring
- Flora
- Fauna
- Geology
- Remote sensing
- Demography
- Biodiversity
- Agriculture
- Land use

Climate change and infectious diseases in Europe, The Lancet Infectious Diseases, Volume 9, Issue 6, June 2009,
2. describe common measures of disease frequency
Disease frequency

Expected level
baseline level of observed occurrence of a particular disease

Endemic
persistent occurrence at a low to moderate level, sometimes referred to as a high background rate

Sporadic
irregular pattern with occasional cases occurring at irregular levels

Epidemic
occurrence of a disease within an area exceeds expected level for a given time. Also called an outbreak.
Note that these mean basically the same thing, but public perspective is that epidemic is much more serious than an outbreak.

Pandemic
epidemic that has spread over several countries or continents, affecting large numbers of people
Measures of Disease Frequency

Prevalence and incidence are commonly confused. They are similar, but differ in the number of cases included in the numerator:

- **Prevalence** includes all cases (new and old) during a given time period.
- **Incidence** includes only the number of new cases during a given time period.
Prevalence

Prevalence = number of existing cases divided by total population

The numerator for prevalence includes all persons during a specified interval or point in time, regardless of when the condition began.

For example, a visual examination survey of 2477 persons between the ages of 52 and 85 years showed that 310 had cataracts.

The prevalence of the condition was

\[
\frac{310}{2477} \times 100 = 12.5\%
\]
Prevalence

Several types of prevalence rates

<table>
<thead>
<tr>
<th>Rate</th>
<th>Numerator</th>
<th>Denominator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease rate at autopsy</td>
<td>Number of cases disease</td>
<td>Number of persons autopsied</td>
</tr>
<tr>
<td>Birth defect rate</td>
<td>Number of babies with a given abnormality</td>
<td>Number of live births</td>
</tr>
<tr>
<td>Smoking rate</td>
<td>Number of people who smoke</td>
<td>Total population</td>
</tr>
</tbody>
</table>

All have in common a numerator that includes all cases (new and old) of the condition under study.
Ten episodes of an illness in a population of 20

\[ x = \text{cases present between 10/1/90 and 9/30/91} = 10 \]
\[ y = \text{population} = 20 \]
\[ \frac{x}{y} \times 100 = \frac{10}{20} \times 100 = 50 /100 \]
So Period prevalence 10/1/90~9/30/91 was 22 cases per 100 population.
Incidence

Incidence = number of **new cases** in a given period of time divided by the total population at risk

The numerator for incidence includes **only** those persons who develop the condition during the specified time period.

For example, in a study of 2390 women between 16 and 49 years of age, it was found that 482 used oral contraceptives. 27 of the oral contraceptive users developed bacteremia.

The incidence was therefore:

\[
\frac{27}{482} \times 100 = 5.6 \%
\]
Incidence

Several types of incidence rates

<table>
<thead>
<tr>
<th>Rate</th>
<th>Numerator</th>
<th>Denominator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morbidity</td>
<td>New cases of a disease</td>
<td>Total population</td>
</tr>
<tr>
<td>Mortality</td>
<td>Number of deaths from a disease</td>
<td>Total population</td>
</tr>
<tr>
<td>Case-fatality</td>
<td>Number of deaths from a disease</td>
<td>Number of cases of that disease</td>
</tr>
<tr>
<td>Attack</td>
<td>Number of cases of a disease</td>
<td>Total population at risk during a epidemic period</td>
</tr>
</tbody>
</table>

All have in common a numerator that includes only new cases of the condition under study.
Ten episodes of an illness in a population of 20

\[ x = \text{new cases occurring 10/1/90} \sim \text{9/30/91} = 4 \]
\[ y = \text{total population at midpoint} = 20 \sim 2 = 18 \]
\[ \frac{x}{y} \times 100 = \frac{4}{18} \times 100 = 22 \times 100 \]

So the one-year incidence was 22 cases per 100 population.
Relationship between incidence and prevalence

Incidence

Prevalence

Deaths

Cures

Case
3. Descriptive and analytic epidemiology

John Snow and cholera in London 1854

Case – control study
Cohort study
Clinical trials
This site is devoted to the life and times of Dr. John Snow (1813-1858), a legendary figure in the history of public health, epidemiology and anesthesiology. Click with your left mouse key to see and hear the material or and to see the material. The maps and narrations present the Snow story in place and time.

WHAT IS THIS SITE ALL ABOUT?

The following articles describe the intent of the John Snow site and comment about his life.

- "Pioneer..." Chronicle of Higher Education
- "Cyber Sleuths" UCLA Magazine
- "History, maps..." Soc Bulletin (PDF)
- "When Cholera Met Its Match" Science
- "John Snow" BBC Online
- "The Handler" UAB School of Public Health Magazine
- "Popularity of Eel site grows" UCLA School of Public Health Magazine
- "Beyond Google. The great internet search engine is still no match for the expertise of a wise human being." Discover (PDF)
- "Own your Own Words" New York Times

WHO IS JOHN SNOW?

ENCYCLOPEDIA ENTRY ON JOHN SNOW

Providing a summary of John Snow's life in Encyclopedia Britannica is UCLA Professor Emeritus Ralph R. Frerichs, author of this site. Frerichs' description is a good starting point for exploring the extensive material on the life and times of John Snow that are here presented.

SIGHT AND SOUND

Sight and sound animation describing the life and accomplishments of John Snow.

- Instructions and test of system
- Part 1: The Early Years
- Part 2: Broad Street Pump Outbreak
  - The U North Carolina Version
  - Part 3: The Grand Experiment (in process)

THE FATHER OF MODERN EPIDEMIOLOGY

In an article in Old News, David Vachon writes of John Snow's life and achievements, and concludes: "For his persistent efforts to determine how cholera was spread and for the statistical mapping methods he initiated, John Snow is widely considered to be the father of [modern] epidemiology."

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Count, Past Year
Visits (hits): 2,034,070
Count, Sept., 2012
Visitors: 12,888
Total visits: 145,585
Visits per visitor: 11.3
Location of the Broad Street Pump Epidemic

Saint Paul's Cathedral

Houses of Parliament

Thames River
The most common image of Dr. Snow which appears in most textbooks or references.

It was photographed by an anonymous person some time during 1857 when Dr. Snow was 44 years old, one year before his death.

Dr John Snow (1813-1858)
John Snow and cholera in London

- John Snow and cholera in London, which provide a dramatic illustration of epidemiologic analysis.

- When a wave of Asiatic cholera first hit England in late 1831, it was thought to be spread by "miasma in the atmosphere." By the time of the Soho outbreak 23 years later, medical knowledge about the disease had barely changed.

- In August 1854, the most terrible outbreak of cholera which ever occurred in this kingdom, is probably that which took place in Broad Street, Golden Square, and the adjoining streets.

- In 1883, 29 years later, Robert Koch finally identified *Vibrio cholerae* as the causative agent.
Deaths from Cholera in 10,000 Inhabitants by Elevation of Residence Above Sea level, London, 1848 ~ 1849

<table>
<thead>
<tr>
<th>Elevation Above Sea Level (Ft)</th>
<th>Death in 10,000 Inhabitants</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>120</td>
</tr>
<tr>
<td>20 ~</td>
<td>Miasma 65</td>
</tr>
<tr>
<td>40 ~</td>
<td>34</td>
</tr>
<tr>
<td>60 ~</td>
<td>Spurious Association 27</td>
</tr>
<tr>
<td>80 ~</td>
<td>22</td>
</tr>
<tr>
<td>100 ~ 120</td>
<td>17</td>
</tr>
<tr>
<td>340 ~ 360</td>
<td>8</td>
</tr>
</tbody>
</table>

Data from Farr W: Vital Statistics, 1885
# Deaths from Cholera per 10,000 Houses, by Source of Water Supply, London, 1854

<table>
<thead>
<tr>
<th>Water Supply</th>
<th>No. of Houses</th>
<th>Death from cholera</th>
<th>Deaths /10,000 Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southwark &amp; Vauxhall Co.</td>
<td>40,046</td>
<td>1,263</td>
<td>315</td>
</tr>
<tr>
<td>Lambeth Co.</td>
<td>26,107</td>
<td>98</td>
<td>38</td>
</tr>
<tr>
<td>Other districts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In London</td>
<td>256,423</td>
<td>1,422</td>
<td>56</td>
</tr>
</tbody>
</table>

Data adapted from Snow J: On the mode of communication of cholera, 1936
Snow was able to use careful logic and quantitative epidemiological methods to identify the germ origin of cholera, with no recognition during his lifetime of Vibrio cholerae, the organism that causes cholera.

Robert Koch (1843-1910)
German bacteriologist who rediscovered, isolated, and first cultured Vibrio cholerae – the cholera-causing microbe in early 1884.

Louis Pasteur (1822-1895)
French chemist who founded modern microbiology. He provided strong evidence against the miasma theory with a prize winning study in France in 1859.

1 year after the death of John Snow

26 years after the death of John Snow
In 1849 Snow published a small pamphlet “On the Mode of Communication of Cholera” where he proposed that the “Cholera Poison” reproduced in the human body and was spread through the contamination of food or water.
C.F. Cheffins Map modified by Dr. John Snow 1850-54

- Soho Square
- Snow's home until 1852
- Broad Street Pump
- Golden Square
- Snow's final home
A short line to represent each death in the household.
Assembling Data

...a short line to represent each death in the household
"...quantity of morbid matter which is sufficient to produce cholera is inconceivably small..."

"...shallow pump-wells in a town cannot be looked on with too much suspicion..."
• Snow also investigated groups of people who did not get cholera and tracked down whether they drank pump water.

• That information was important because it helped Snow rule out other possible sources of the epidemic besides pump water.
On 7 September 1854, Snow took his research to the town officials and convinced them to take the handle off the pump, making it impossible to draw water. The officials were reluctant to believe him, but took the handle off as a trial only to find the outbreak of cholera almost immediately trickled to a stop. Little by little, people who had left their homes and businesses in the Broad Street area out of fear of getting cholera began to return.
The Complete Outbreak

Number of attacks or deaths

Start of outbreak (Aug 31, 1854)
Mode for fatal attacks (Sept 1, 1854)
Mode for deaths (Sept 2, 1854)
Removed handle from pump (Sept 8, 1854)

Date Unknown

August
September

Fatal attacks (616)
Deaths (616)
In 1883 a German physician, Robert Koch, took the search for the cause of cholera a step further when he isolated the bacterium Vibrio cholerae, the “poison” Snow contended caused cholera.

Dr. Koch determined that cholera is not contagious from person to person, but is spread only through unsanitary water or food supply sources, a major victory for Snow’s theory.

The cholera epidemics in Europe and the United States in the 19th century ended after cities finally improved water supply sanitation.
John Snow and cholera in London

Remember that in Snow’s day the enterotoxmic Vibrio cholerae was unknown.

Snow’s conclusion that contaminated water was associated with cholera was entirely on observational data.

The point is that although it is extremely important for us to maximize our knowledge of the biology and pathogenesis of disease, it is not always necessary to know every detail of the pathogenic mechanism to be able to prevent a disease.

Today, scientists consider, Dr John Snow (1813-1858), a surgeon [actually an anesthesiologist] to be the pioneer of public health research in a field known as epidemiology.
Endemic fluorosis in China from ingestion of food immersed in hot spring water.

Xu RH, Yuan HH, Fan A.

Department of Environmental Health, Health and Epidemic Prevention Station of Guangdong Province, Guangzhou, P. R. China.

PMID: 7749263 [PubMed]
Map showing the geographical location of fluorosis area, control area and two hot springs.
Residents in the fluorosis villages habitually immerse vegetables in hot springs water (≥95°C)
### Children dental fluorosis prevalence and urine fluoride content in five sites and distance between sites and hot spring

<table>
<thead>
<tr>
<th>Residential Sites</th>
<th>Distance between Site and Hot Spring (M)</th>
<th>Dental Fluorosis</th>
<th>Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of Children</td>
<td>Positive</td>
</tr>
<tr>
<td>Fluorosis Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JS</td>
<td>50</td>
<td>499</td>
<td>270</td>
</tr>
<tr>
<td>BX</td>
<td>500</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>DL</td>
<td>600</td>
<td>198</td>
<td>90</td>
</tr>
<tr>
<td>XX</td>
<td>800</td>
<td>73</td>
<td>30</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FX</td>
<td>3000</td>
<td>283</td>
<td>3</td>
</tr>
</tbody>
</table>

Endemic fluorosis in China from ingestion of food immersed in hot spring water
Fluoride content (ppm) in vegetables immersed in hot spring water and well water

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Immersion</th>
<th>H / W</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hot spring Water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(F⁻, 20.33 ppm)</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>147</td>
<td>2.53</td>
</tr>
<tr>
<td>II</td>
<td>151</td>
<td>9.53</td>
</tr>
<tr>
<td>III</td>
<td>115</td>
<td>8.17</td>
</tr>
<tr>
<td></td>
<td>Well water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(F⁻, 0.12 ppm)</td>
<td></td>
</tr>
</tbody>
</table>

Endemic fluorosis in China from ingestion of food immersed in hot spring water

Study Design

Descriptive studies
- Case report
- Case serial reports
- Cross-sectional studies
- Ecological studies

Analytical studies
- Observational studies
  - Case-control studies
  - Cohort studies
    - Prospective
    - Retrospective (historical)

Experimental studies
- Randomized Controlled Clinical trials
- Randomized Controlled field trials
- Non-randomized experiments
Clinical observations

Available data

Ecological or Cross-Sectional Studies

Case - control studies

Cohort studies

Randomized trials

(only used for potentially beneficial treatments)
Case Series and Case Reports

Hospitals

Patients  Chart Notes

Journal Article
Ecologic studies

• A study in which the units of analysis are populations or groups of people, rather than individuals.

• Usually takes advantage of pre-existing data collected for other purposes—an efficient and economical study design.

• No time element—a “snapshot” of populations—think cross-sectional studies of populations, not individual.
Correlation between dietary fat intake and breast cancer by country

A very important Boston surgeon visited the school and delivered a great treatise on a large number of patients who had undergone successful operation for vascular reconstruction.

At the end of the lecture ……

**Student:** Do you have any controls?

**Surgeon:** Do you mean did I not operate on half of the patients?

**Student:** Yes, that’s what I had in mind.

**Surgeon:** Of course not. That would have doomed half of them to their death.

**Student:** Which half?
Simultaneous Nonrandomized Control

• A sea captain was given samples of anti-nausea pills to test during a voyage.
• The need for controls was carefully to him.

Upon return the ship, the captain reported the results enthusiastically.

“Practically every one of the controls was ill, and not one of the subjects had any trouble. Really wonderful.”

A skeptic asked how he had chosen the controls and the subjects.

“Oh, I gave the stuff to my seamen and used the passengers as controls”
Randomization

1. Observational Study

\[ n = 2,000 \]

Myocardial infarction

\[
\begin{array}{c|c}
\text{Intervention} & \text{Non intervention} \\
\hline
1300 & 700 \\
\end{array}
\]

Deaths:

\[
\begin{array}{c|c}
\text{Intervention} & \text{Non intervention} \\
\hline
800 & 500 \\
\hline
200 & 500 \\
\end{array}
\]

\[
\begin{array}{c|c}
\text{Deaths:} & \\
\hline
80 & 50 \\
100 & 250 \\
\hline
180 & 300 \\
\end{array}
\]

Mortality

\[
\begin{array}{c|c}
\text{Without Arrhythmia} & \text{With Arrhythmia} \\
\hline
18\% & 30\% \\
\end{array}
\]

Randomization

1. Observational Study
   - n=2,000
   - Intervention: 1300, Non intervention: 700
     - Deaths: 80 (Intervention), 50 (Non intervention)
     - Total: 180
     - Mortality: 18%

2. Experimental Study
   - n=2,000
   - Intervention: 1300, Non intervention: 700
     - Deaths: 65 (Intervention), 65 (Non intervention)
     - Mortality: 24%

Randomization

- Randomization increases the likelihood that the groups will be comparable
- not only in terms of variables that we recognize and can measure
- but also in terms of variables that we may not recognize and may not be able to measure but nevertheless may affect prognosis.

Analytic Studies

• Case control studies

• Cohort studies
  - Prospective cohort study
  - Concurrent cohort study
  - Historical cohort study
  - Retrospective cohort study
  - Ambispective cohort study

• Intervention studies

• Clinical trials
Case control studies

• Evaluation of risk factors
• Case control studies compare a group of people with a disease or condition to another group of people without it.

The Doll and Hill (1950) study of cigarette smoking and cancer in Britain is a classic example, and is credited with starting our current series of efforts to control tobacco use.
Case control studies

- Persons with a specified condition (the *cases*) and persons without the condition (the *controls*) are selected for study.
- The proportion of cases and controls with certain characteristics or exposure is then measured and compared.
- Comparison is an essential component of epidemiologic investigation and is well exemplified by the case-control study design.

For example, knowing that there are 10 school children with purple spots in grade 3, a set of other third grade children from the same school but without purple spots would be identified as controls, and analysis done to see what different exposures the purple-spotted children had than the non-spotted.
Case control studies

At the beginning of the case control study
The investigator knows that there are some people with a disease \textit{(cases)};
they are matched with similar individuals \textit{(controls)} who do not have the disease.
The investigator \textbf{looks backward} to identify what different exposures the two groups might have had.

For example, when some individuals \textbf{attending a picnic become ill}, they could be \textbf{matched with controls} who also attended the picnic \textbf{but did not become ill}, and all interviewed about what was eaten, \textbf{to identify a possible source} of food-borne illness.
Case control studies

Key
Look backward interview

Before Exposure

Yes
No

Yes
No

Cases

+ Controls

- Time

Compare
Draw
Conclusion

Yes
No

? ?

+ Cases

109
Case Control Studies

Group of interest (e.g. cancer patients)

Comparison group (e.g. non-patients)

Draw conclusion

Compare histories

Take histories

Take histories

time
Cohort studies

Long term population studies

In cohort studies, subjects are categorized on a predetermined basis and followed over time for the development of health conditions.

One well-known example is the Framingham Heart Study in which 5200 residents were followed over 35 years. Findings of this study have been used to develop improved cardiovascular disease prevention methods.
Cohort studies

• **Groups** of individuals with **some common feature** (age and geography, for example) are identified for study **over time** to learn about **differing health and illness experiences**.

• **Comparison of outcome(s)** in an **exposed group** and a **non-exposed group** (or with / without a certain characteristic) is the **hallmark of the cohort design**.

For example, one might enroll in a study all third graders in a school and follow them until graduation, attempting to **identify the differences in experiences** of those who maintained a body weight close to recommended and those who did not.
Cohort studies

- At the beginning of a prospective cohort study, the investigator is aware of a group of individuals, some of whom have been exposed to a hazard.
- All members of the cohort will be followed over time to see if those exposed and those unexposed have different disease experiences.

For example, a public health department may be informed of the exposure of a portion of a school class to an individual with an active case of a communicable disease in the course of a field trip. The entire class (the cohort) would be observed over time to identify any cases of disease that arise, and any difference in disease rate between the two groups.
Cohort studies

Key
Follow up
Overtime

Now
Exposure

Future
Disease

Group of interest
(e.g. smokers)

Comparison group
(e.g. non-smokers)

Comparing Outcomes
Conclusion

- Yes
  - No

- Yes
  - No
Prospective Cohort Studies

Group of interest (e.g. smokers)

Comparison group (e.g. non-smokers)

Follow over time

Compare outcomes

Follow over time

time
Retrospective cohort study

At the beginning of a retrospective cohort study, the investigator is aware of an exposure to a hazard that occurred at some time in the past, sufficiently long ago that if disease were to have occurred, it should by now be evident.

A cohort that includes the exposed individuals is identified, and the health histories of all members explored to identify the presence or absence of disease in all individuals, and the difference in rate between exposed and non-exposed.

Many of the studies of association between environmental exposures and disease have been of this type. A cohort of individuals who lived or worked in an area but had different experiences of exposure/non-exposure to a chemical will be identified. Their health histories in the intervening years will be examined to identify differences, if any, in their rates of disease.
Retrospective cohort study

Key
Exposure identified by historical data

Past Exposure

Now Disease

Yes +

No -

Compare Outcomes

Conclusion

Yes

No

Yes

No

Time
Ambispective cohort study

Combination of concurrent cohort and retrospective cohort designs

Exposure is ascertained from objective records \textit{in the past} (as in a historical cohort study), and \textit{follow-up} and measurement of outcome continue \textit{into the future}
Ambispective cohort study

**key**
Past exposure and follow up into the future

<table>
<thead>
<tr>
<th>Past Exposure</th>
<th>Now</th>
<th>Future Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>No</td>
<td>-</td>
<td>?</td>
</tr>
</tbody>
</table>

Compare Outcomes
Conclusion

- Yes
- No
- Yes
- No
Past | Now | Future
---|---|---
Case Control Studies
Retrospective cohort study
Prospective cohort study
Ambispective cohort study

Time
Clinical trials

To evaluate interventions

Clinical trials in humans are conducted to determine whether methods found effective in laboratory conditions can be safely applied to a large population under normal conditions to demonstrate its application to the control of disease.
Randomized control blind trial

**RCT** Randomized control trial
Randomized clinic trial

RCT is the *gold standard* for evaluating efficacy of therapeutic, preventive, and other measures, both in clinical medicine and public health.

The most ideal design for evaluating efficacy and side effect of new intervention measure.
Randomized Controlled Studies

- **Patients**: Random assignment
- **Intervention**: Treatment group, Control group
- **Outcome**: Follow-up

**Time**
- Enrollment
- Allocation
- Follow-up
- Analysis

Compare results

Outcome
The Double Blind Method

'Please take these pills'

'Please take these pills'

'These are Pill A'

'These are Pill B'

Study manager

Physician

Patients
Interpreting Results
Measurement Errors

• **Bias**
  - information
  - selection

• **Confounding**
  - extraneous factors

• **Effect modification**
  - statistical interaction
Paper/Article Format

Title
Authors Contributors Institute / agency
Abstract / Summary
Key words

IMRAD

Introduction
Material and Methods
Results and Discussion

Acknowledgments
References
4. Disease / Public health surveillance

Influenza surveillance
Definition of Surveillance

• The ongoing systematic collection, collation, analysis and interpretation of data and
• The dissemination of information to those who need to know in order that action may be taken.
Disease / Public health surveillance

Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of data about a health-related event for use in public health action to reduce morbidity and mortality and to improve health.

MMWR 2004;53:RR-5
Surveillance serves at least eight public health functions

1. Supporting case detection and public health interventions,
2. Estimating the impact of a disease or injury,
3. Portraying the natural history of a health condition,
4. Determining the distribution and spread of illness,
5. Generating hypotheses and stimulating research,
6. Evaluating prevention and control measures,
7. Facilitating planning,
8. Outbreak detection, (i.e., identifying an increase in frequency of disease above the background occurrence of the disease).

MMWR 2004;53:RR-5
Purposes of Public Health Surveillance

1. Assess public health status
2. Define public health priorities
3. Evaluate programs
4. Stimulate research
Uses of Public Health Surveillance

1. Detect epidemics / define a problem
2. Determine geographic distribution of illness
3. Portray the natural history of a disease
4. Estimate magnitude of the problem
5. Generate hypotheses, stimulate research
6. Monitor changes in infectious agents
7. Detect changes in health practices
8. Facilitate planning
10. Evaluate control measures
Objectives of surveillance

1. Monitoring trends and estimate magnitude of health problem
2. Epidemic (outbreak) detection and prediction
3. Monitor progress towards a control objective
4. Monitor programme performance
5. Evaluating an intervention
6. Forecast future disease impact
7. Understand characteristics of health events
   • Distribution and spread
   • Natural history
8. Facilitate planning
Components of an effective surveillance system

1. Clear objectives
2. Well-defined health event(s) with clear widely-known case definitions
3. Data sources
4. Laboratory support
5. Established data collection and reporting mechanism
6. Regular data analysis and interpretation
7. Rapid response mechanism
8. Feedback and dissemination of information
9. Monitoring and Evaluation
The components of surveillance and resulting public health action

The goal of surveillance is not merely to collect data for analysis, but to guide public health policy and action.
Sources of Surveillance Data

1. Reports of health events affecting individuals
2. Vital statistics on the entire population
3. Reporting from laboratories
4. Registries
5. Vital statistics
6. Information on the health status, risk behaviors, and experiences of populations
7. Information on potential exposure to environmental agents
8. Information on existing public health programs
9. Information on the health care system
10. Information from other organizations
Community Screening Programs

1. Defining the target population
2. Setting priorities among diseases and conditions
3. Choosing effective screening tests
4. Assessing the effectiveness of screening programs
Surveillance Cycle

Health Care System

Event
Action: Prevention & Control
Intervention

Public Health Authority

Data
Analysis & Interpretation
Information

Reporting
Decision
(Feedback)
Surveillance system flow chart

1. **OCCURRENCE OF HEALTH EVENT**

2. **DIAGNOSIS**

3. **REPORTING SOURCES**
   - **PUBLIC**

4. **DATA RECIPIENTS**
   - Primary Level e.g., County Health Dept.
   - Secondary Level e.g., State Health Dept.
   - Tertiary Level e.g., CDC

**Data Management**
- Collection
- Initial entry
- Editing
- Analysis
- Report generation
- Report dissemination
Public Health Approach

Problem

Surveillance: What is the problem?

Risk Factor Identification: What is the cause?

Intervention Evaluation: What works?

Implementation: How do you do it?
Information Loop of Public Health Surveillance

Real-time surveillance → Rapid intervention → Responsive risk communication

Summaries, Interpretations, Recommendations

Reports

Public

Health Care Providers

Health Agencies

Analysis
WHO Western Pacific Regional Office Conceptualized a Framework for Action

Figure 1 – Framework for Action.
Stages of HealthMap Surveillance

ACQUIRING  CATEGORIZING  CLUSTERING  FILTERING

doi:10.1371/journal.pmed.0050151.g002
Global Influenza Surveillance and Response System (GISRS)

• Established in 1952,
• the network currently comprises
  6 WHO Collaborating Centres,
• 4 WHO Essential Regulatory Laboratories and
• 139 institutions in 109 WHO Member States, which are recognized by WHO as National Influenza Centres, in addition to ad hoc groups established to address specific emerging issues.

http://www.who.int/influenza/gisrs_laboratory/en/
Global Influenza Surveillance and Response System (GISRS)

- Global influenza virological surveillance has been conducted through WHO's Global Influenza Surveillance and Response System (GISRS) for over half a century.
- Formerly known as the Global Influenza Surveillance Network (GISN), the new name came into effect following the adoption of the Pandemic Influenza Preparedness (PIP) Framework in May 2011.
- WHO GISRS monitors the evolution of influenza viruses and provides recommendations in areas including laboratory diagnostics, vaccines, antiviral susceptibility and risk assessment.
- WHO GISRS also serves as a global alert mechanism for the emergence of influenza viruses with pandemic potential.

http://www.who.int/influenza/gisrs_laboratory/en/
China, the first country in the developing world to host a WHO Collaborating Center for Reference and Research on Influenza.
源于中国CDC 冯子建
我国流感监测网络实验室（63个）

源于中国CDC 冯子建
Global circulation of influenza viruses
Number of specimens positives for influenza by subtypes
2009.04.19 ~ 2010.02.27

Data source: FluNet, Global Influenza Surveillance Network (GISN) specimens positives for influenza
Percentage of respiratory specimens that tested positive for influenza
By influenza transmission zone

Status as of week 35
26 August – 01 September 2012

Note: The available country data were joined in larger geographical areas with similar influenza transmission patterns to be able to give an overview (www.who.int/entity/influenza/surveillance_monitoring/update tables/EN_SIP_Influenza_transmission_zones.pdf). The displayed data reflect reports of the stated week, or up to two weeks before if no data were available for the current week of that area.

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Sources: WHO/HP data as of 11 September 2012
Data used are from FluNet (www.who.int/flu). 16:04 UTC
regularly from WHO regional offices and/or ministry of health websites.

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Influenza Laboratory Surveillance Information

by the Global Influenza Surveillance and Response System (GISRS)

Northern hemisphere

Number of specimens per week

Weeks

WHO recommended that the Northern Hemisphere's 2012-2013 seasonal influenza vaccine be made from the following three vaccine viruses:

- an A/California/7/2009 (H1N1)pdm09-like virus;
- an A/Victoria/361/2011 (H3N2)-like virus;
- a B/Wisconsin/1/2010-like virus (from the B/Yamagata lineage of viruses).

http://www.cdc.gov/flu/about/season/vaccine-selection.htm
WHO Global Influenza Surveillance Network

Make recommendations on the influenza vaccine formulation

- Antigenic and genetic analyses (WHO CCs)
- Diagnostic reagents
  - Vaccine strains
  - Potency testing reagents
- Serological studies (National Licensing Agencies)

Isolation of representative strains from clinical samples (National Influenza Centres)

Disease and epidemiological data

血清学分析
Influenza Vaccine Manufacturing Process

RTI International is a trade name of Research Triangle Institute.
A description of the process of seasonal and H5N1 influenza vaccine virus selection and development
Goals of Community Mitigation

**Figure 1.**

Goals of Community Mitigation

1. Delay outbreak peak
2. Decompress peak burden on hospitals / infrastructure
3. Diminish overall cases and health impacts

Daily Cases

Days Since First Case

Pandemic outbreak: No intervention

Pandemic outbreak: With intervention

Interim Pre-pandemic Planning Guidance Community Strategy for Pandemic Influenza Mitigation in the United States
HIV/AIDS Surveillance

• Invest in second-generation monitoring systems to better identify the drivers of the epidemic.
• Study the behavioural patterns of specific at risk groups, and adjust prevention and care policies based on knowledge generated by these studies.

4 key high risk groups:
- Injecting drug users
- Men who have sex with men
- Sex workers
- Prisoner

UNDP 2004
One in five Americans currently living with HIV doesn't know it. If our President and First Lady can get tested -- you can too.

The 14th commemoration of National HIV Testing Day, 2009.06.27, President Obama release a special video. Get test it! You can take control not only your health but the health of those around you!

http://www.whitehouse.gov/blog/GetTested/
Objectives of Epidemic Preparedness and Response

1. Anticipation/prediction
   so that epidemics be prevented
   e.g. meningitis, measles

2. Early detection
   to know when there is a problem
   e.g. EWARS (Early Warning and Reporting System)

3. Rapid Response
   Guidelines / trained staff / supplies
   in place before epidemic

4. Effective Response
   appropriate control methods
   adequate resources and logistics
5. Outbreak Investigations

Emerging Infectious Diseases
SARS
Health Communication
Emerging Infectious Diseases

Ancient Disaster
Modern Threat

GUANGDONG

CHOLERA
CLONORCHIASIS
SARS

PREVENTION

MODERN MENACE

Emerging Infectious Diseases

Ancient Disaster
Modern Threat

FIGHT

& CONTROL

IDU & AIDS

Patient before treatment.

Patient after treatment.
Examples of modern and historically important emerging infectious diseases

(A) Caused by war and famine. Plague in an Ancient City, 430 ~ 426BC

(B) Associated with intent to harm. Black Death (bubonic/pneumonic plague) associated with a bioterrorist attack, Europe, 14th century

(C) Due to travel and trade. Cholera epidemic, spread from Asia to Europe, Paris, 1832

(D) Associated with microbial adaptation and change. Influenza pandemic. 1918~1919

Emerging infections a perpetual challenge, The Lancet Infectious Diseases, Vol. 8, 11, Nov 2008,
Emerging infectious diseases

An emerging disease is one that has appeared in a population for the first time, or that may have existed previously but is rapidly increasing in incidence or geographic range.

http://www.who.int/topics/emerging_diseases/en/
Emerging and re-emerging diseases

- **Emerging infectious diseases**
  newly identified or
  previously unknown infections

- **Re-emerging infectious diseases**
  re-appearance of, or
  increase in number of,
  infections from a disease previously known
What are emerging infectious diseases?

According to the National Institute of Allergy and Infectious Diseases, emerging infectious diseases are commonly defined as:

- **Diseases that have newly appeared in a population.**
  - AIDS
  - Lyme disease
  - Escherichia coli O157:H7 (E. coli)
  - Hantavirus
  - SARS and others

- **Diseases that have existed in the past, but are rapidly increasing in incidence or geographic range.**

- **Re-emergence may also occur because of breakdowns in public health measures for previously controlled infections.**
  - Schistosomiasis
  - Tuberculosis
  - Malaria
  - Cholera
  - Plague
  - Influenza
  - Pneumococcal disease
  - Gonorrhea
  - And others
Preventing Emerging Infectious Diseases

“As we face the new millennium, we must renew our commitment to the prevention and control of infectious diseases, recognizing that the competition between humans and microbes will continue long past our lifetimes and those of our children.”

Jeffrey P. Koplan, Director, US CDC
Factors leading to the emergence of infectious diseases

Changes in demographics and behaviour

Changes in technology and industry

International travel and commerce

Microbial adaptation and change

Increased in host susceptibility

Emerging infectious diseases

Increased in disease transmission

New diseases

Environmental change and land use

Breakdown of public health measures

Increased in disease transmission

New diseases
Zoonosis (Zoonotic Diseases) - all diseases naturally transmissible from animals to man
Factors that affect the emergence of disease

1. Human behavior and demographics
2. Microbial adaptation and change
3. International travel and commerce
4. Human susceptibility to infection
5. Technology and industry
6. Changing ecosystems
7. Climate and weather
8. Breakdown of public health measures
9. Poverty and social inequality
10. Economic development and land use
11. War and famine
12. Lack of political will
13. Intent to harm
Systemic Rapid Assessment Toolkit (SYSRA)


Health Policy, Vol 98, 2-3, Dec 2010, Pages 91-97

- Human monkeypox, 2004
- SARS, 2003
Newly emerging, re-emerging/resurging, and deliberately emerging diseases, 1977~2007

http://hektoeninternational.org/Journal_Emerging_Infections_Lancet.html
Emerging infectious diseases

Conclusion

• Emerging and re-emerging diseases are not new

• Their control does not require new approaches but determination and vigilance at all levels

• Key to success
  - Sound public health practices
  - Awareness and commitment of decision makers
  - Synergy
Outbreak investigations

- Usually retrospective, often relying upon recall of affected persons to identify causal linkages.
- Because they begin without clear hypotheses, outbreak investigations require descriptive studies to generate hypotheses before analytic studies can be conducted.
- Since outbreak investigations are driven by an immediate health concern in the community, the need for responsiveness to community needs and effective risk communication is heightened.
- Require public health officials to weigh the evidence, often in the absence of a clear etiologic connection, and determine when the data are sufficient to take controversial and sometimes unwelcome actions.
- Outbreak investigations often attain national or international prominence (e.g., toxic shock syndrome, Escherichia coli or O157:H7(E. coli), food contamination, SARS and Avian flu).
- Generally involve infectious disease and laboratory confirmation.
Cluster investigators

Clustering of disease is *intriguing* and some cluster investigations have led to important scientific discoveries.

For example,

- Investigation of the spatial clustering of *enamel discoloration* led to the discovery of the relation between fluoride levels in drinking water and *dental caries*.
- Most cluster investigations focus on *cancer*. Many *carcinogens* have been discovered through occupational or medical cluster investigations.
Cluster investigators

Studies of disease clusters often are *challenging* because of the *constraints* of information available to investigators. Some of the *biggest issues* include:

- Rare health events
- Vague definition and/or heterogeneity of cases
- Lack of a population base for rate calculation
- Weak association and multiple risk factors
- Long induction periods
- Multiple comparisons
- Low-level, long-term, heterogeneous exposures
- Intense publicity
- Resource intensiveness of full investigations
Planning for a Contingency Health Emergency

- Emergency Response
- Community Support
- Health Services
- Surveillance
- Communications
Key tasks - carried out by whom?

Regional

Synergy

Global

National
What skills are needed?

- Infectious diseases
- Clinical medicine
- Epidemiology
- Laboratory
- Public Health
- International field experience
- Telecom. & Informatics
- Information management
- Ecology
- Anthropology
- Logistics

Multiple expertise needed!
Prevention Partners

- Hospitals
- Business & Industry
- Local Health Departments
- Political Leaders
- CDC
- Professional Organizations
- Healthcare Providers
- State Health Departments
- Consumers
- International Health Organizations
- Federal Agencies
- Public Health, Medical, & Veterinary Schools
Prevention of Emerging Infectious Diseases Will Require Action in Each of These Areas

1. Surveillance and Response
2. Applied Research
3. Infrastructure and Training
4. Prevention and Control
Preventing Emerging Infectious Diseases

1. Surveillance and Response

- Detect, investigate, and monitor emerging pathogens, the diseases they cause, and
- the factors influencing their emergence, and
- respond to problems as they are identified.
Preventing Emerging Infectious Diseases

2. Applied Research

Integrate laboratory science and epidemiology to increase the effectiveness of public health practice.
Preventing Emerging Infectious Diseases

3. Infrastructure and Training

- Strengthen public health infrastructures to support surveillance, response, and research and to implement prevention and control programs.
- Provide the public health work force with the knowledge and tools it needs.
Preventing Emerging Infectious Diseases

4. Prevention and Control

• Ensure prompt implementation of prevention strategies and

• Enhance communication of public health information about emerging diseases.
Key tasks in dealing with emerging diseases

- Surveillance at national, regional, global level
  - Epidemiological
  - Laboratory
  - Clinical
  - Ecological
  - Anthropological (e.g., behaviours)
- Investigation and early control measures
- Implement prevention measures
  - Behavioural, political, environmental
- Monitoring & Evaluation
Laboratory Response Network (LRN)

- National Laboratories (definitive characterization)
- Reference Laboratories (confirmatory testing)
- Sentinel Laboratories (recognize, rule-out, refer)
Early detection of outbreaks can be achieved in three ways

1. by timely and complete receipt, review, and investigation of disease case reports. **Electronic reporting system** will improve the timeliness and completeness of reporting notifiable conditions.

2. by improving the ability to recognize patterns indicative of a possible outbreak early in its course.
   - **Statistical / analytic tools** for pattern recognition and aberration detection can be applied to screen data for patterns warranting further public health investigation and to enhance recognition of subtle or obscure outbreak patterns.
   - **Automated analysis and visualization tools** can lessen the need for frequent and intensive manual analysis of surveillance data.

MMWR 2004;53:RR-5
Early detection of outbreaks can be achieved in three ways

3. through receipt of new types of data that can signify an outbreak earlier in its course.
   - These new types of data might include health-care product purchases, absences from work or school, presenting symptoms to a health-care provider, or laboratory test orders.
   - Many new surveillance systems, loosely termed *syndromic surveillance systems*, use data that are not diagnostic of a disease but that might indicate the early stages of an outbreak.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFP (Acute flaccid paralysis)</td>
<td>Polio</td>
</tr>
<tr>
<td>ILI (Influenza-like illness)</td>
<td>Influenza</td>
</tr>
<tr>
<td>?</td>
<td>SARS</td>
</tr>
</tbody>
</table>
Global Disease Detection (GDD) Operations Center

The GDD Operations Center is an innovative epidemic intelligence and response operations unit located at CDC headquarters.

It uses non-traditional surveillance methods to provide early warning about international disease threats so that CDC can rapidly respond to protect public health in the United States and the global community.
Process model for early outbreak detection

Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks
Timeline milestones for early outbreak detection

0. Onset of exposure
1. Onset of symptoms
2. Onset of behavior
3. Capture of data
4. Completion of data processing
5. Capture of data in surveillance system
6. Application of pattern recognition tools/algorithms
7. Generation of automated alert
8. Initiation of public health investigation
9. Initiation of public health intervention

MMWR 2004;53:RR-5
Communicable Disease Outbreak Investigation

Outbreak
A localised epidemic of two or more cases of disease related in time and or place in excess of normal expectancy.

Objectives
1. Identify source and mode of spread
2. Interrupt further transmission
3. Prevent secondary spread
4. Educate
5. Introduce future preventative measures
6. (prosecute)
Steps of an Outbreak Investigation

1. Prepare for field work
2. Establish the existence of an outbreak
3. Verify the diagnosis
4. Define and identify cases
5. Describe and orient the data in terms of person, place, time
6. Develop hypotheses
7. Evaluate hypotheses
8. Refine hypotheses and carry out additional studies
9. Implement control and prevention measures
10. Communicate findings

http://www.cdc.gov/excite/classroom/outbreak/steps.htm
Steps of an Outbreak Investigation

• The steps are presented here in conceptual order.
• In practice, however, several may be done at the same time, or they may be done in a different order.
• For example, control measures should be implemented as soon as the source and mode of transmission are known, which may be early or late in any particular outbreak investigation.

http://www.cdc.gov/excite/classroom/outbreak/steps.htm
Steps in Outbreak Investigation

The sequence is not important!

Descriptive steps

1. Determine existence of an outbreak
2. Confirm the diagnosis:
   Which diseases are we talking about?
3. Define a case; find and count cases
4. Orient data as to:
   - Person Who?
   - Place Where?
   - Time When?
The sequence is not important!

• Analyse
  5. Generate hypotheses
  6. Test the hypotheses
  7. Compare each hypothesis with facts
  6. Plan a more systematic study

• Synthesis and action
  9. Write a report, communicate findings
  10. Control measure and prevention
Steps of outbreak investigation

1. Prepare for field work
2. Establish the existence of an outbreak
3. Verify the diagnosis
   a. clinical features: is the disease known?
   b. what are its serologic or cultural aspects?
4. Define and identify cases
   a. establish a case definition
   b. identify and count cases and calculate the attack rates
      **Do not wait for laboratory results to start treatment and control activities!**
5. Perform descriptive epidemiology
   a. time and place distributions of cases
   b. look for time – place interactions
   c. **timely collect samples related to the pathogens**
6. Look for combinations (interactions) of relevant variables
Steps of outbreak investigation

7. Develop hypotheses based on the following
   a. existing knowledge (if any) of the disease
   b. analogy to diseases of known etiology
      (food-, water-, air-, and vector-borne)

8. Test hypotheses
   a. further analyze existing data
      (case–control studies)
   b. collect additional data
   c. as necessary, reconsider/refine hypotheses and
      execute additional studies
      (epidemiologic, laboratory, environmental)

9. Recommend control and prevention measures
   a. control of present outbreak
   b. prevention of future similar outbreaks

10. Communicate findings
    a. share information with public officials
    b. interactions with the Public and Press
Steps of an outbreak investigation

1. Confirm outbreak and diagnosis
2. Define case
3. Identify cases and obtain information
4. Descriptive data collection and analysis
5. Develop hypothesis
6. Analytical studies to test hypotheses
7. Special studies
8. Communicate, including outbreak report
9. Evaluate
Steps in a Foodborne Outbreak Investigation

1. Detecting a possible outbreak
2. Defining and finding cases
3. Generating hypotheses
   - Hypothesis-generating interviews
4. Testing the hypotheses
   - Analytic studies
   - Laboratory testing of samples
5. Finding the point of contamination and source of the food
6. Controlling an outbreak
   - Recall product(s)
   - Remove source of contamination
   - Revise production process
7. Deciding an outbreak is over

If cases continue

If cases stop

Not finding associations between food & illness
Coordinating role of the outbreak control team (OCT) in an outbreak investigation

Foodborne disease outbreaks Guidelines for investigation and control, WHO, 2008
Preparedness

Committee
Priorities
Plan
Co-ordination
Responsibilities
Resources
Supplies
Training
Surveillance
Rapid Response

Outbreak control

Detect & Confirm

Investigate

Analyse

Respond
Treat
Control

Predict & Prevent

Evaluate

205
1. Prepare for field work

- Literature and Technique
- Training
- Coordination
- Investigation group
  What should be done?
- Responsibility
  Who should do it?
- Resources / Supplies / Equipment
- Administrative and personal arrangements
- Local contacts
1. Prepare for field work

Detection

Form Outbreak Control Team?

Team coordinates field investigation

- Routine surveillance
- Clinical / Laboratory
- General public
- Media

- Epidemiologist
- Microbiologist
- Clinician
- Environmentalist
- Government
- Press officer
- Others
Detection

Establish the Existence of an Outbreak
- Health department surveillance records
- Local hospital sources
- Telephone survey

2.

Field investigation

Prepare for field work

Real outbreak?

• Higher than expected?
• Diagnosis verified?
• Link between cases?

• Health department surveillance records
• Local hospital sources
• Telephone survey
2. Real Outbreak Confirmed

Immediate control measures?
- Prophylaxis
- Exclusion / Isolation
- Public warning
- Hygienic measures
- Others

Further investigation?
- Unknown aetiology
- Cases serious
- Cases still occurring
- Public pressure
- Training opportunity
- Scientific interest
3. Verify the diagnosis

- Clinical findings
- Laboratory results
- Appropriate specimens
- Talk to some of patients
- Questionnaire
Define and Identify Cases

**Case definition**
- **Confirmed**
  - Laboratory verification
- **Probable**
  - Typical clinical features of the disease without laboratory confirmation
- **Possible**
  - Usually has fewer of the typical clinical features

"Get it while you can."
- Identifying information
- Demographic information
- Clinical information
- Risk factor information

Verify the diagnosis
Describe and Orient the Data

Define and Identify Cases

5.

Describe and Orient the Data

Descriptive epidemiology

Person - Who are the cases?
Place - Where do they live?
Time - When did they become ill?
Define and Identify Cases

Describe and Orient the Data
Summarize what you know

Explain **why** and **how**
The outbreak occurred
- Source of the agent
- Mode of transmission
- Exposures caused the disease
Visit the homes of people who became ill
Questionnaire

Develop hypotheses
6. Develop hypotheses

Cases

Summarize

Person

Place

Time

Evaluate information

Age Group

Risk factors?

Transmission?

Pathogen?
Develop hypotheses

7.

Evaluate Hypotheses

Comparison hypotheses with facts

• test hypotheses
  - cohort studies
  - case-control studies
• Statistical test

Analytic epidemiology
# Food – specific Attack Rate for Items Consumed

<table>
<thead>
<tr>
<th>Item Consumed</th>
<th>Ate</th>
<th>Did Not Eat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sick</td>
<td>Total</td>
</tr>
<tr>
<td>Beverage</td>
<td>179</td>
<td>264</td>
</tr>
<tr>
<td>Egg salad</td>
<td>176</td>
<td>226</td>
</tr>
</tbody>
</table>

- For both beverage and egg salad, attack rates are clearly higher among those who ate (or drink) than among those who did not.
- This table does not permit us to determine whether the beverage or the egg salad accounted for the outbreak.

### Cross-Table Analysis for Egg Salad and Beverage Consumed

<table>
<thead>
<tr>
<th>Drank Beverage</th>
<th>Sick</th>
<th>Well</th>
<th>Total</th>
<th>Sick % (Attack Rate)</th>
<th>Ate Egg Salad</th>
<th>Did Not Ate Egg Salad</th>
<th>Sick</th>
<th>Well</th>
<th>Total</th>
<th>Sick % (Attack Rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>152</td>
<td>49</td>
<td>201</td>
<td>75.6</td>
<td></td>
<td></td>
<td>19</td>
<td>53</td>
<td>72</td>
<td>26.4</td>
</tr>
<tr>
<td>No</td>
<td>12</td>
<td>3</td>
<td>15</td>
<td>80.0</td>
<td></td>
<td></td>
<td>7</td>
<td>21</td>
<td>28</td>
<td>25.0</td>
</tr>
</tbody>
</table>

- In order to answer this question, we use the technique of *cross-tabulation*.
- Looking at the data *by columns*, drinking the beverage did not increase the incidence of streptococcal illness (75.6% vs. 80% and 26.4% vs. 25%).
- By *horizontal*, eating egg salad significantly increased the attack rate of the illness (75.6% vs. 26.4% and 80% vs. 25%).

Thus, the *egg salad is clearly implicated.*

Refine Hypotheses and Carry Out Additional Studies

8. Evaluate Hypotheses

- When analytic epidemiological studies do not confirm initial hypotheses
  - Reconsider the hypotheses

- Additional epidemiological studies
- Laboratory and environmental studies
Implementing Control and Prevention Measures

9.

Refine Hypotheses and Carry Out Additional Studies

• Control the source of pathogen
• Risk factors
• Interrupt transmission
• Immunization
• Chemoprophylaxis

Should do at any time during the outbreak!!
Communicate Findings

Implementing Control and Prevention Measures

Communicate findings to others who need to know
- Oral briefing
- Written report (IMRAD)

- Right channel
- Right audience
- Right message
- Right time
Steps of Communicable Disease outbreak investigation

1. Preliminary assessment
   - Is it an outbreak?
   - Confirm numbers
   - Is further investigation needed?
   - Literature review
   - Form Outbreak control team (OCT)
   - Initiate immediate control measures

2. Case definition and case findings
   Person        Place        Time
   Clinical symptoms  Laboratory results

3. Descriptive study
   data collection and analysis
   Epidemic curve
   Generation of hypothesis

- Count Cases
- Control outbreak
- Diagnosis verify
- Communicate result
- Surveillance continues to evaluate control
- Hypothesis formulation
- Additional studies
  Micro / Env
- Test hypothesis
  Analytic study
- Epidemic
  Conform exists
- Identify cases
  Create case definition
- Tabulate and orientate data
  Person / Place / Time
  Describe epidemic
Steps of Communicable Disease outbreak investigation

4. Analytical study
   cohort or case control
   to test hypothesis

5. Verify hypothesis
   microbiological or environmental tests

6. Initiate control measures
   - Remove source  Isolate / Treat case
   - Destroy food   Close shop
   - Protect those at risk  Hygiene  Hand washing
   - Water boiling  Prophylaxis e.g. hepatitis B injections
   - Prevent recurrence

7. Communication
   Media  Reports  Guidelines
Better information leads to better results

- A good description of
  - Person
  - Place
  - Time
- Good data collection and preservation of samples
- A well coordinated multidisciplinary team

Immediate detection → Immediate response → Reduced morbidity and mortality
Rapid and coordinated response
Outbreak Detection and Response Without Preparedness

First Case

Late Detection

Delayed Response

Opportunity for control
Outbreak Detection and Response With Preparedness

Early Detection Rapid Response

Speed! Right Answer! Effective!

Potential Cases Prevented
Risk Communication for PHEs

**Preparation**
- Assess
- Coordinate: committee
- Crisis and media plan
- Listening mechanisms
- Message development
- Training

**Response and Control**
- Activate crisis plan
- Social mobilization
- Don’t forget: decision-makers & health professionals
- Message Development

**Recovery**
- Evaluate strategy & plan
- Document & share lessons learned
- Identify actions/plan better
- Use documents developed as templates for future

**Start of emergency**
- Opportunity for control

**CRISIS**

**Evaluation**
Since the early 1950s, approximately 3,200 EIS officers have responded to requests for epidemiologic assistance (Epi-Aid) within the United States and throughout the world. Requests to assist with emergency responses, investigate infectious and environmental disease outbreaks, and quantify the impact of chronic diseases are examples of Epi-Aid responses.

1950s
- Contamination of killed poliovirus vaccine with live virus
- Childhood lead poisoning from peeling paint

1960s
- Smallpox epidemics through 1977
- Hong Kong influenza epidemics

1970s
- Legionnaires disease
- Ebola virus in Zaire and Sudan
- Aspirin-associated Reye syndrome

1980s
- Toxic shock syndrome
- HIV/AIDS
- Accutane-associated birth defects

1990s
- Health effects of Hurricane Andrew
- West Nile virus epidemic
- Cardiac valvulopathy associated with fenfluramine (fen-phen)

2000s
- 9/11 terrorist attacks
- Anthrax terrorist attacks
- Hurricane Katrina
- Nationwide salmonellosis outbreaks
- Pandemic H1N1 influenza

SARS
(Severe Acute Respiratory Syndrome)
Source: Dr. Zhong, Nan shan
Spread from Hotel M
Reported as of March 28, 2003

Guangdong Province, China

Hong Kong SAR
95 HCW

>100 close contacts

Hong Kong

A

H,J

A

B

Vietnam
37 HCW

21 close contacts

C,D,E

Singapore
34 HCW

37 close contacts

Canada
18 HCW

11 close contacts

Ireland
0 HCW

United States
1 HCW

USCDC

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FIGURE 1. Chain of transmission among guests at Hotel M — Hong Kong, 2003

* Health-care workers.
† All guests except G and K stayed on the 9th floor of the hotel. Guest G stayed on the 14th floor, and Guest K stayed on the 11th floor.
‡ Guests L and M (spouses) were not at Hotel M during the same time as index Guest A but were at the hotel during the same times as Guests G, H, and I, who were ill during this period.
SARS
Can It Be Stopped?
The New Age of Epidemics
The SARS virus
Could it become China’s Chernobyl?
Figure 3. Probable SARS cases in selected sites\textsuperscript{16}
Figure 2.

Probable cases of SARS by week of onset
Worldwide* (n=5,910), 1 November 2002 - 10 July 2003

WHO issues first travel advisory 15 March
WHO issues global alert 12 March

* This graph does not include 2,527 probable cases of SARS (2,521 from Beijing, China), for whom no dates of onset are currently available.

Adapted from World Health Organization. Epidemic curves - Severe Acute Respiratory Disease (SARS) http://www.who.int/csr/sars/epicurve/epiindex/en/index1.html
Probable cases of SARS by date of report
China, 1 February - 16 June 2003 (n=5,549*)

* As of 16 June 2003, 5,326 probable cases of SARS have been reported from China.
This graph includes 223 probable cases of SARS who had been discarded and for whom dates of report could not be identified.
Source: Ministry of Health, China, WHO
Probable cases of SARS by date of onset
Canada, 1 February - 13 June 2003 (n=242*)

* As of 16 June 2003, 1 additional probable case of SARS has been reported from Canada for whom no date of onset is available.
Source: Health Canada
Probable cases of SARS by date of onset
Viet Nam, 1 February - 16 June 2003 (n=62*)

* As of 16 June 2003 an additional probable case of SARS has been reported from Viet Nam for whom no date of onset is currently available.
Source: Ministry of Health, Viet Nam, WHO
Probable cases of SARS by date of onset
United States of America, 1 February - 13 June 2003 (n=71*)

*As of 16 June 2003, 1 additional probable case of SARS has been reported from USA for whom no date of onset is available.
Source: CDC United States of America
Probable cases of SARS by date of onset
WHO European Region, 1 February - 16 June 2003 (n=37*)

* As of 16 June 2003, an additional 2 probable cases of SARS have been reported from countries in the WHO European Region for whom no dates of onset are available.
Source: WHO EURO
1st Line of Response: Astute Clinician

Screen all persons being hospitalized for CXR-confirmed pneumonia:

1. In the last 10 days, have you traveled to mainland China, Hong Kong or Taiwan*, or been in close contact with other ill persons who have?

2. “Are you employed as a healthcare worker with direct patient contact?”

3. “Do you have close contacts who have been told they have pneumonia?”

USCDC
Approach to surveillance and reporting

Providers

State and local health departments

Community

Health care facilities

Screening

Updated case definitions, lab evaluation, SARS risk factors

CDC

WHO
University of Hong Kong first to announce the discovery of SARS coronavirus
March 27, 2003
Electron Micrograph of the Coronavirus

Copyright of the University of Hong Kong

magnification = 100.00 K X

100nm

EHT = 20.00 kV

WD = 3 mm

Signal A = SE2

Photo No. = 519

Date: 25 Mar 20

Time: 17:06:07
The microbiologists at the Academy of Military Medical Sciences had discovered the new coronavirus on 26 Feb, but kept quiet about it.
WHO team collected samples at Guangzhou animal market, 2004.01.14
A novel coronavirus (SCoV) is the etiological agent of the Severe Acute Respiratory Syndrome. SCoV-like viruses were isolated from Himalayan palm civets found in a live animal market in Guangdong, China. Evidence of virus infection was also detected in other animal, including a raccoon-dog, and in humans working at the same market. All the animal isolates retain a 29-nucleotide sequence, which is not found in most human isolates. The detection of SCoV-like viruses in small wild mammals in live retail market indicates a route of interspecies transmission, although the natural reservoir is not known.

Science 4 September 2003
Under suspicion. Civets were found to have the SARS virus, but they may not be the primary animal reservoir.
Control Measures in Guangdong

Break the chain of transmission from infected to healthy persons

1. **Early case identification**
   - Efficient surveillance and reporting system
   - Public information and education to encourage prompt reporting of symptoms

2. **Promptly and effectively patient isolation**
   - Strict hospital infection control

3. **Timely contact tracing**
   - Management of close contacts by home confinement or quarantine

4. **Wild animal administration**
   - Farm    Market    Restaurant
Disease prevention messages are slowly integrated into life activities.
Global Alert and Response Network Functions

Alert
- Detection
- Verification
- Communication

Response
- Risk Assessment
- Technical advice and support
- Field investigation
- Research
- Communication

Preparedness
- Assessment
- Planning
- Training
- Stockpiles
- Research
- Communication
Quality Communications

• Accurate / Science based
• Timely and Relevant
• Comprehensible
• Appropriately Targeted
• Credible
• Coordinated

USCDC 2003.10
Preparing Messages

STARCC Principle

- Simple
- Timely
- Accurate
- Relevant
- Credible
- Consistent
Health Communication

Health communication focuses on choosing

the right channel to reach
the right audience with
the right message at
the right time

- Share the information about disease outbreaks nationally / globally as soon as they occur
- Share successful strategies to contain the disease
- Panic is fuelled when information is concealed or only partially disclosed
Best practices for effective communication

1. **Build trust**
   - The foundation for effective outbreak communication
   - Trust in the honesty of authorities reduces public anxiety during the uncertainties of an outbreak

2. **Announce early**
   - Early announcement contributes to early containment in a situation where every day counts

3. **Be transparent**
   - Candid, easily understood, complete, accurate

4. **Respect public concerns**
   - Today, effective risk communication is viewed as a dialogue between technical experts and the public

5. **Plan in advance**
   - Costly errors can be avoided when the issues and principles of risk communication are considered in advance

Best practices for communicating with the public during an outbreak, WHO, 2004
Prevention and treatment condition on SARS presentation in Guangdong
2003.05.16.
WHO team leader at main gate of GDCDC, 2004.01.12
GDCDC communicated with the reporters from main news paper in Guangdong on flu pandemic (H1N1), 2009.05.28
Media communication

Health agency → Media

Right Message

Media → Public

True Report

Provide information → Control information

Serve the media → Media cooperate
6. Screening Test
Medicine screening

Mass examination of the population to detect the existence of a particular disease, as diabetes or tuberculosis.

Webster's Online Dictionary
Health screening

A guideline that recommends interventions performed for the early detection of disease or disease precursors in apparently well individuals so that health care can be provided early in the disease or before the disease manifests (e.g., screening for prostate cancer).

Webster's Online Dictionary
Medicine screening

• Screening is a strategy used in a population to detect a disease in individuals without signs or symptoms of that disease

• Unlike what generally happens in medicine screening tests are performed on persons without any clinical sign of disease

http://en.wikipedia.org/wiki/Screening_(medicine)
The intention of screening is to identify disease in a community early, thus enabling earlier intervention and management in the hope to reduce mortality and suffering from a disease.

http://en.wikipedia.org/wiki/Screening_(medicine)
Principles of Screening
WHO 1968

1. The condition should be an important health problem.
2. There should be a treatment for the condition.
3. Facilities for diagnosis and treatment should be available.
4. There should be a latent stage of the disease.
5. There should be a test or examination for the condition.
6. The test should be acceptable to the population.
7. The natural history of the disease should be adequately understood.
8. There should be an agreed policy on whom to treat.
9. The total cost of finding a case should be economically balanced in relation to medical expenditure as a whole.
10. Case-finding should be a continuous process, not just a "once and for all" project.

Principles and practice of screening for disease, WHO, 1968
Health Screening (Screening tests)

Screening refers to a test or exam done to find a condition before symptoms begin. Screening tests may help find diseases or conditions early, when they are easier to treat. Some conditions that doctors commonly screen for include:

- Breast cancer and cervical cancer in women
- Prostate cancer in men
- Colorectal cancer
- Diabetes
- High blood pressure
- High cholesterol
- Osteoporosis
- Hearing and vision loss
- Sexually transmitted diseases (STDs)
- Newborn screening
- Genetic screening

### Screening Test

<table>
<thead>
<tr>
<th>Test Results</th>
<th>Disease Status</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>A + B</td>
</tr>
<tr>
<td></td>
<td>True</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>False</td>
<td>B</td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>A + B</td>
</tr>
<tr>
<td></td>
<td>False</td>
<td>C + D</td>
</tr>
<tr>
<td></td>
<td>True</td>
<td>C + D</td>
</tr>
<tr>
<td>Test Results</td>
<td>-</td>
<td>B + D</td>
</tr>
<tr>
<td></td>
<td>False</td>
<td>C + D</td>
</tr>
<tr>
<td></td>
<td>True</td>
<td>C + D</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A + C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B + D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sensitivity** = $\frac{A}{A + C}$; the probability of testing positive if disease is truly present

**Specificity** = $\frac{D}{B + D}$; the probability of testing negative if the disease is truly absent

**Positive predictive value** = $\frac{A}{A + B}$; the probability that a person who tests positive actually has the disease

**Negative predictive value** = $\frac{D}{C + D}$; the probability that a person who tests negative actually is free of the disease
7. OR and RR
Basic Presentation of Results

<table>
<thead>
<tr>
<th>Disease</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>A</td>
<td>B</td>
<td>A+B</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>C</td>
<td>D</td>
<td>C+D</td>
</tr>
<tr>
<td>Total</td>
<td>A+C</td>
<td>B+D</td>
<td>A+B+C+D</td>
</tr>
</tbody>
</table>

- Epidemiologists use two-by-two tables to study the association between an exposure and disease.
- Any rates needed for epidemiologic analysis can be calculated from this basic table.
Odds Ratio (OR)

- Calculated to identify the likelihood of exposure to a risk when comparing two groups, one with and one without disease.
- Exposure odds in the disease group divided by exposure odds in non-disease group.

  \[ \text{Ratio} = \frac{\text{exposure odds in disease group}}{\text{exposure odds in non-disease group}} \]

  - Ratio = 1, no association
  - Ratio > 1, association between exposure and disease

For example

If the prevalence of smoking among lung cancer patients is 95/100
the prevalence of smoking among people without lung cancer is 25 /100

\[ \text{Odds Ratio} = \frac{95}{25} = 3.8 \]

Thus, there is an association between lung cancer and smoking.
### Case-control study

<table>
<thead>
<tr>
<th></th>
<th>Cases</th>
<th>Controls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>$a$</td>
<td>$b$</td>
<td>$a+b$</td>
</tr>
<tr>
<td>Unexposed</td>
<td>$c$</td>
<td>$d$</td>
<td>$c+d$</td>
</tr>
<tr>
<td>Total</td>
<td>$a+c$</td>
<td>$b+d$</td>
<td>$T$</td>
</tr>
</tbody>
</table>

We cannot calculate rates or a relative risk from a case-control study, but we can calculate an odds ratio as an estimate of the relative risk.

**Odds ratio** $= \frac{ad}{bc}$
# Case-control study

Exposure to Grocery Store A among cases and controls

Legionellosis outbreak, Louisiana, 1990

<table>
<thead>
<tr>
<th>Shopped at Grocery Store A?</th>
<th>Cases</th>
<th>Controls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>25</td>
<td>28</td>
<td>53</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>26</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>54</td>
<td>81</td>
</tr>
</tbody>
</table>

Odds ratio = \( \frac{ad}{bc} \)

\[ = \frac{25 \times 26}{28 \times 2} = 11.6 \]
Relative risk (RR)

- Calculated to identify differences in disease rate between exposed and unexposed (to a risk) groups.
- Risk of disease among exposed divided by the risk of disease among unexposed
  \[ RR = \frac{\text{Risk among exposed}}{\text{Risk among unexposed}} \]
  - RR = 1, no difference between two groups.
  - RR > 1, association between exposure and disease.

For example,

If lung cancer mortality rate among smokers is 131 per 100,000, and the lung cancer rate among non-smokers is 11 per 100,000, then

\[ RR = \frac{131}{11} = 11.9 \]

Thus, there is an association between smoking and lung cancer
# Attack rate by consumption of vanilla ice cream

Oswego, New York, April 1940

<table>
<thead>
<tr>
<th>Ate vanilla ice cream?</th>
<th>Ill</th>
<th>Well</th>
<th>Total</th>
<th>Attack Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>43</td>
<td>11</td>
<td>54</td>
<td>79.6</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>18</td>
<td>21</td>
<td>14.3</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>29</td>
<td>75</td>
<td>61.3</td>
</tr>
</tbody>
</table>

**Relative risk** = \( \frac{79.6}{14.3} = 5.6 \)

**Attack rate** = \( \frac{\text{Number of new cases among the population during the period}}{\text{Population at risk at the beginning of the period}} \) \times 100
Attributable risk

Calculate to identify the proportion of disease among exposed people that actually results from the exposure

- Individual attributable risk = \( \frac{RR - 1}{RR} \)
- Population attributable risk = \( \frac{Pe (RR - 1)}{1 + Pe (RR - 1)} \)

\( Pe = \text{proportion of population exposed} \)

For example
If RR of lung cancer due to smoking is 15
and that 30% of the population are smokers.

Population attributable risk = \( \frac{(.30) (15 - 1)}{1 + (.30) (15 - 1)} \) = .81

Thus, 81% of lung cancer would be Attributed to smoking
81% of lung cancer would be eliminated if smoking were eliminated
8. Four Types of Causal Relation
From Association to Causation

1. We determine whether there is an association between an exposure or characteristic and the risk of a disease.
   
   To do so, we use:
   
   a. Studies of group characteristics: ecologic studies
   b. Studies of individual characteristics: case - control and cohort studies

2. If an association is demonstrated, we determine whether the observed association is likely to be a causal one.
From Association to Causation

Types of Association

- **Real** association (causal)
- **Spurious** association (non causal, due to confounding)
Interpreting Associations - Causal and Non-Causal

Causal

Characteristic Under Study → Disease

Non-Causal (due to confounding)

Characteristic Under Study

Factor X

Disease → Disease
Interpreting Associations: Causal and Non-Causal

- **Causal**
  - Coffee Consumption
  - Pancreatic Cancer

- **Non-Causal (due to confounding)**
  - Coffee Consumption
  - Smoking
  - Real Association
  - Spurious Association

- Real Association

- Pancreatic Cancer
Types of Causal Relationships: Direct vs Indirect

Direct
- Factor
  - Disease

Indirect
- Factor 1
  - Factor 2
  - Factor 4
  - Factor 3
  - Disease
Types of Causal Relationships: Direct vs Indirect

Direct

- F508 Polymorphism
- DeltaF508

Cystic Fibrosis

Indirect

- High cholesterol
  - Artery thickening
  - Hemostatic factors

Myocardial infarction
What Causes an myocardial infarction (MI)

Epidemiological studies combined with laboratory study identify risk factors

- Cigarette smoking
- Cholesterol
- Elevated blood pressure
- Stress
- Family history
- Obesity
- Etc

Which of the above contribute the most risk
What are the relationship between risk factors
Two Components of Causation

- **Necessary Factor**
  Without that factor, the disease never develops

- **Sufficient Factor**
  In the presence of that factor, the disease always develops

Using these 2 components of Causation, we can produce a unified framework of causation that will encompass all Disease Processes
Four Types of Causal Relation

1. Necessary and sufficient
2. Necessary but Not Sufficient
3. Sufficient but Not Necessary
4. Neither sufficient Nor Necessary
1. Necessary and Sufficient

- Factor A is both **Necessary and sufficient**
- Most infectious disease will not cause illness in everyone, and not all heavy smokers develop lung cancer
- Rarely occur

**Only Factor A** → **Disease**

**Genetic factors** → **Sickle Cell Anemia**
2. Necessary but Not Sufficient

- Each factor is a necessary but not a sufficient cause
- All are necessary to cause disease but each factor alone cannot cause disease
- Thus multiple factors are required often in a specified temporal sequence. For cancer to result, a promoter must act after an initiator has acted.
### 3. Sufficient but Not Necessary

- Each factor is sufficient but not necessary.
- Each factor can produce the disease without the other factors being present.
- For example, radiation exposure or benzene exposure can each produce leukemia without the presence of the other. However, not really sufficient because other co-factors either known or unknown are in the causal process.
4. Neither Sufficient Nor Necessary

- Each factor is neither sufficient nor necessary.
- Risk factors combine in ways we know little about to produce disease, which probably most accurately represent the causal relationships that operate in most chronic diseases.
Addiction

- Biological
- Psychological
- Social
- Genetic
- Neurological
- Spiritual
- Family
What causes tuberculosis?

<table>
<thead>
<tr>
<th>Particular microorganism</th>
<th>Immune deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowded living conditions</td>
<td>Malnutrition</td>
</tr>
<tr>
<td>Silicosis</td>
<td>Some genetic factors</td>
</tr>
</tbody>
</table>

Case 1: the mycobacterium + immune deficiency may operate to cause a case of TB.

Case 2: the mycobacterium + silicosis + malnutrition may operate.

- One cause, the mycobacterium is **necessary**
- Various combinations that include the mycobacterium may be **sufficient**.
High in saturated fats and sugars, and low in fibre and fruit and vegetables.

The risk factor approach

Diet

- Obesity
- Cardiovascular disease
- Type 2 diabetes
- Respiratory disease
- Cancer
- Mental illness

Smoking

Stress

Physical Inactivity

Control

Obesity
Cardiovascular disease
Type 2 diabetes
Respiratory disease
Cancer
Mental illness
A more complex view of causation

Jim has a bad day at work

stops at the bar for a couple of drinks on the way home

He gets into his car, drives too fast

slips on an icy patch as he rounds a curve

collides with Mary's car.

Mary is pregnant

Jim’s car did not have anti-lock brakes?

Mary's car did not have air bags?

Mary was not wearing her seat belt? ?

Mary suffers an abdominal injury, and loses the baby

Mary is pregnant

Mary suffers an abdominal injury, and loses the baby
Association & Causation

- A principal aim of epidemiology is to assess the cause of disease.
- However, since most epidemiological studies are by nature observational rather than experimental, a number of possible explanations for an observed association need to be considered before we can infer a cause-effect relationship exists.
- That is the observed association may in fact be due to the effects of one or more of the following:
  1. Chance (random error)
  2. Bias (systematic error)
  3. Confounding
9. Guidelines for assessing causation
The Henle-Koch postulates

In the mid-19th century, as the germ theory of disease arose, Henle and his pupil Koch formulated postulates from which the inference could be made that a specific living organism caused a particular disease. In simplified form there were three:

1. The organism is always found with the disease.
2. The organism is not found with any other disease.
3. The organism, cultured from one with the disease and cultured through several generations, produces the disease.
Koch’s postulates

An example of deterministic causality.
To prove that an organism causes a disease, he required that

1. The organism must be isolated in every case of the disease (i.e. be necessary)
2. The organism must be grown in pure culture.
3. The organism must always cause the disease when inoculated in to an experimental animal (i.e. be sufficient)
4. The organism must then be recovered from the experimental animal and identified
The Henle-Koch postulates

In 1876 Koch demonstrated that anthrax met these criteria, and many other infectious diseases followed.

The idea that a specific, identifiable agent could cause a specific disease was revolutionary, and paved the way for interventions such as vaccines.
Robert Koch
1843 - 1910 Germany

Discovered the tuberculosis bacillus and also a method of growing it in pure culture (1882)

Led a German expedition to Egypt and India, where he discovered the cholera bacillus (1883)

1905 Nobel Laureate in Medicine
for his investigations and discoveries in relation to tuberculosis.
Almost a century later, in 1964, the Surgeon General's report on smoking implicated tobacco as a cause of lung cancer. This ignited a tremendous controversy about whether such causal thinking could be applied to chronic diseases.

The Surgeon General's report, and a soon published paper by Sir Austin Bradford Hill, advanced standards that could be used to judge when an association might be causal.
English epidemiologist and statistician. He pioneered rigorous statistical study of patterns of disease and, together with William Richard Doll was the first to demonstrate the connection between cigarette smoking and lung cancer.

His work on smoking and lung cancer, which involved collecting data on the smoking habits and health of over 30,000 British doctors for several years, in the precomputer age, is considered to be among the great medical achievements of the century.
Hills Criteria of Causation

Hill's Criteria form the basis of modern epidemiological research, which attempts to establish scientifically valid causal connections between potential disease agents and the many diseases that afflict humankind.
Hills Criteria of Causation

1. Temporal Relationship
2. Strength
3. Dose-Response Relationship
4. Consistency
5. Plausibility
6. Consideration of Alternate Explanations
7. Experiment
8. Specificity
9. Coherence
1. Temporal Relationship

Exposure always precedes the outcome.

If factor "A" is believed to cause a disease, then it is clear that factor "A" must necessarily always precede the occurrence of the disease.

This is the only absolutely essential criterion.

A cause must precede an effect in time. This one is true!
1. Temporal Relationship

- Exposure to the factor must have occurred before the disease developed.
- Easiest to establish in a cohort study.
- Sometimes this is hard to know, especially in cross-sectional studies.
- Time-order can also be uncertain when disease has a long latent period, and when the exposure may also represent a long duration of effect.

( Low serum cholesterol and colon cancer )
1. Temporal Relationship

- Length of interval between exposure and disease very important
- If the disease develops in a period of time too soon after exposure, the causal relationship is called into question

Exposure  | Latent period  | Disease

True time course of relationship

Exposure  | Latent period  | Disease

In this case, the latent period is not long enough for disease to develop if caused by this exposure
1. Temporal Relationship

Asbestos and Lung Cancer

Well-established temporal relationship

Asbestos  Latent period of 10 - 20 yrs  Lung Cancer

New Study

Asbestos  Latent period of 3 yrs  Lung Cancer

In this case, the latent period is not long enough for lung cancer to develop if caused by exposure.
2. Strength

• This is defined by the size of the association as measured by appropriate statistical tests.

• The stronger the association, the more likely it is that the relation is causal.

• Usually measured by relative risk. Higher the relative risk, more likely causal.
2. Strength

• The larger the relative risk or odds ratio, the higher the likelihood that the relationship is causal.

• However, care must be taken to examine confidence intervals and sample size.

If the confidence interval is wide (e.g., 1.8 - 22.6), an OR of 12.0 is less strong because we are less confident of the strength of the odds ratio.
2. Strength

Which odds ratio would you be more likely to infer causation from?

1. \( OR = 1.4 \) 95% CI = (1.2 - 1.7)
2. \( OR = 9.8 \) 95% CI = (1.8 - 12.3)
3. \( OR = 6.6 \) 95% CI = (5.9 - 8.1)
2. Strength

• A strong association, such as a five- or tenfold increase in risk, is more likely to be causal than a weak association, such as a 10% increase in risk, because a weak association is more likely to be spurious, arising from bias, confounding, or chance.

• However, a weak association does not rule out causality! In epidemiology, most causes have much weaker relationship to effects.

  For example, high cholesterol may lead to heart disease, but it need not (insufficient) and heart disease does not require a high cholesterol (unnecessary).
3. Dose-Response Relationship

• As the dose of exposure increases the risk of disease also increases
• This is not considered necessary for a causal relationship, but does provide additional evidence that a causal relationship exists

• Cessation of Exposure
  If exposure is reduced or eliminated risk will decline
  HOWEVER, in certain cases, the damage may be irreversible. Emphysema is not reversed with the cessation of smoking, but its progression is reduced
3. Dose-Response Relationship

- However, as with specificity, the absence of a dose-response relationship does not rule out a causal relationship.

- Dose-response is not relevant to all exposure-disease relationships, because disease sometimes only occurs above a fixed threshold of exposure, and thus a dose-response relationship need not be seen.
3. Dose-Response Relationship

• There is a strong dose response relationship between number of cigarettes smoked per day and mortality from lung cancer.

• A dose-response gradient is helpful, but its absence doesn't rule out causation (Diethylstilbestrol (DES) and vaginal adenocarcinoma, asbestos and mesothelioma) and

• Its presence doesn't prove causation (since it may result from confounding or bias).
Age-standardized death rates due to well-established cases of bronchogenic carcinoma

Mortality Rate per 100,000 Person-Years

- Never Smoked: 3.4
- <1/2 Pack/Day: 51.4
- 1/2-1 Pack/Day: 59.3
- 1-2 Packs/Days: 143.9
- 2+ Packs/Day: 217.3

Adapted from Hammond EC, Horn D: JAMA 166:1294-1308, 1958.)
4. Consistency

• Results *replicated* in other studies.

CONSISTENCY AND UNBIASEDNESS OF FINDINGS
Confirmation of the association by *different investigators*,
in *different populations*, using *different methods*

• This is why *numerous experiments* have to be done
before meaningful statements can be made about the
causal relationship between two or more items.

For example
  it has taken thousands of highly technical studies of the
relationship between *cigarette smoking* and *cancer*
before a definitive conclusion can be made that
*cigarette smoking* *increases the risk* of (but does not cause) *cancer*. 
4. Consistency

• If the association is repeatedly observed in different populations in different settings, it is more likely to be causal than an isolated observation.

• However, lack of consistency does not rule out a causal connection; some causes only work in certain circumstances, say in the presence of cofactors.
4. Consistency

Consistency can mean either:
- Exact replication, as in the laboratory sciences, or
- Replication in different studies and in different populations (under many different circumstances).

In epidemiology, exact replication is impossible!

**Meta-analysis**

is a formal method to assess the consistency of the measure of association across many studies.
5. Plausibility

• The association agrees with currently accepted understanding of pathological processes. However, studies that disagree with established understanding of biological processes may force a reevaluation of accepted beliefs.

• The idea of causation must be biologically plausible. This may be elusive because we hold many fixed ideas; many people doubted for years that peptic ulcer disease could be infectious in origin! (H. pylori bacteria )
5. Plausibility

• Dose the association fit with what we know about the underlying biology

• Sometimes we know little or nothing about the underlying biology

(“Black Box“ epidemiology)
6. Consideration of Alternate Explanations

- Make sure studies have taken other possible explanations into account and effectively ruled out such alternate explanations.

- Requires a knowledge of the literature and known risk factors for the disease.
6. Consideration of Alternate Explanations

- Consider the example of coffee consumption, smoking and pancreatic cancer.
  - Did the investigators consider the associations between smoking, coffee consumption and pancreatic cancer?
  - If the investigators did not consider possible confounders and effect modifiers, the association is less likely to be causal!
7. Experimental evidence

• Supporting data from human or animals experiments, such as lung cancer in animals exposed to cigarette smoke, helps establish a causal relationship.

• The condition can be altered (prevented or ameliorated) by an appropriate experimental regimen.
8. Specificity

- A specific exposure is associated with only one disease. This may be OK for infectious agents but clearly wrong in many other circumstances (chronic diseases).

- This is used by tobacco companies to argue that smoking is not causal in lung cancer.
  - Smoking is associated with many diseases.
  - Such as lung cancer, bladder cancer, emphysema, and heart disease.

- The \textit{weakest of the criteria} (should probably be eliminated).
8. Specificity

- When specificity of an association is found, it provides additional support for a causal relationship. However, absence of specificity in no way negates a causal relationship.
- Causality is most often multiple. Therefore, it is necessary to examine specific causal relationships within a larger systemic perspective.
9. Coherence

- The association should be compatible with existing theory (biological background) and knowledge.

- The evidence must fit the facts that are thought to be related,
  e.g., the rising incidence of dental fluorosis and the rising consumption of fluoride are coherent.
9. Coherence

The idea of causation must **accord with other observations**.

For example, as Hill wrote, a causal relationship between **smoking and lung cancer** was coherent with the observations that **smokers had dysplasia of the bronchial epithelium**, or that lung cancer was a predominantly male disease.

However, the absence of coherent information does not rule out a causal relationship.
Guidelines for Assessing Causation

1. Temporal relationship
   Exposure to risk factor occurred before disease onset

2. Strength of Association
   Usually measured by relative risk.
   Higher the relative risk, more likely causal

3. Dose-response Relationship
   As the dose of exposure increases
   the risk of disease also increases

4. Replication of the Findings
   Results replicated in other studies

5. Biologic Plausibility
   - Dose the association fit with what we know
     about the underlying biology
   - Sometimes we know little or nothing about
     the underlying biology ("Black Box" epidemiology)
Guidelines for Assessing Causation

6. Consideration on Alternate Explanations
   Make sure studies have taken other possible explanations into account and ruled out such explanations

7. Cessation of Exposure
   If exposure is reduced or eliminated risk will decline

8. Specificity of the Association
   A specific agent is associated with only one disease
   Ok for infectious agents
   but falls apart with many risk factors for chronic diseases
   (cigarette smoking associated with several diseases)

9. Consistency with Other knowledge
Guidelines for Assessing Causation

In general, 5 criteria must be met to establish a cause-and-effect relationship:

1. **Strength of association**
   the relationship 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

http://www.cdc.gov/excite/classroom/intro_epi.htm
Summary

Health-related states detective

<table>
<thead>
<tr>
<th>Detection</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>Intelligence</td>
</tr>
<tr>
<td>Cause</td>
<td>Reasoning</td>
</tr>
<tr>
<td>Control</td>
<td>Effective</td>
</tr>
</tbody>
</table>

Speed! Timely!
Right answer!
Effective and efficient!
Coordination!
Communication!

Improve population health!
End

谢谢  Thanks