Introduction to Research

The Scientific Methods

Key Lecture Concepts

- Understanding the process described as "the scientific method"
- The role of a hypothesis in a research study
- Strategies underlying hypothesis formulation
- The manner to frame your statement of a hypothesis

Research is …….

- Knowledge acquisition gained
  - through reasoning
  - through intuition
  - but most importantly through the use of appropriate methods

The Scientific Method

Basic Elements of the Scientific Method

- Empiricism: the notion that enquiry is conducted through observation and knowledge verified through evidence
- Determinism: the notion that events occur according to regular laws and causes. The goal of research is to discover these
- Scepticism: the notion that any proposition is open to analysis and critique

Scientific Method

1. Choose a question to investigate
2. Identify a hypothesis related to the question
3. Make testable predictions in the hypothesis
4. Design an experiment to answer hypothesis question
5. Collect data in experiment
6. Determine results and assess their validity
7. Determine if results support or refute your hypothesis

The Scientific Method

1. Suspicion that a factor (exposure) may influence occurrence of disease or a noted health outcome

   - Observations in clinical practice
   - Examination of disease/outcome patterns
     - Do subpopulations have higher or lower rates?
     - Are disease rates increased in the presence of certain factors?
   - Observations in laboratory research
   - Theoretical speculation

The Scientific Method

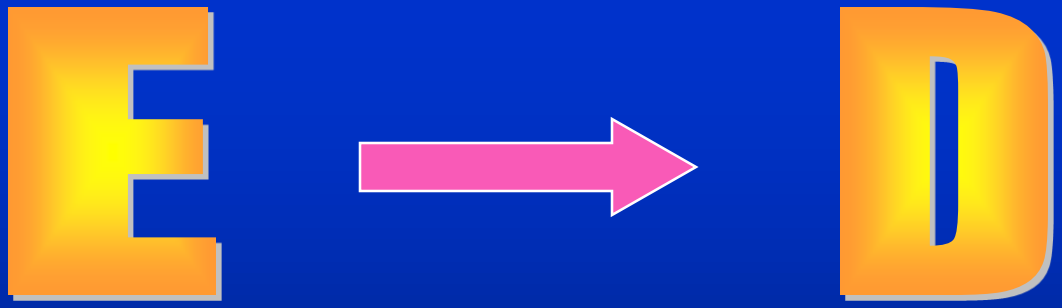
2. Identify variables you are interested in:
   - Exposure - (risk factor, protective factor, predictor variable, treatment)
   - Outcome - (disease, event)

3. Formulate a specific hypothesis
   - Frame a hypothesis which seeks to answer a specific question about the relationship between an exposure and an outcome

Basic Question in Research

Are exposure and disease/outcome linked?

Is there an association between them?



Exposure

Disease / Health Outcome

Next Step: Design Study

- Study Designs …(not exhaustive)
  - Case series
  - Cross-sectional
  - Case-control
  - Cohort
  - Randomized controlled clinical trial

Association

- From the results of your study, does a statistical relationship exist between two or more events, characteristics, or other variables

- Is there a statistical relationship, or association, between exposure and disease/outcome?

Statistical Association

The degree to which the rate of disease or outcome in persons with a specific exposure is either higher or lower than the rate of disease or outcome among those without that exposure.

The Scientific Method

Assess validity of association

- Does the observed association really exist?
  - Is the association valid?
  - Are there alternative explanations for the association?
    - Chance
    - Bias
    - Confounding

Hypotheses

Shape and guide a research study in terms of:

- identification of study sample size
- what issues should be involved in data collection
- the proper analysis of the data
- data interpretation

Hypothesis Formulation

--- **Formulate a hypothesis**

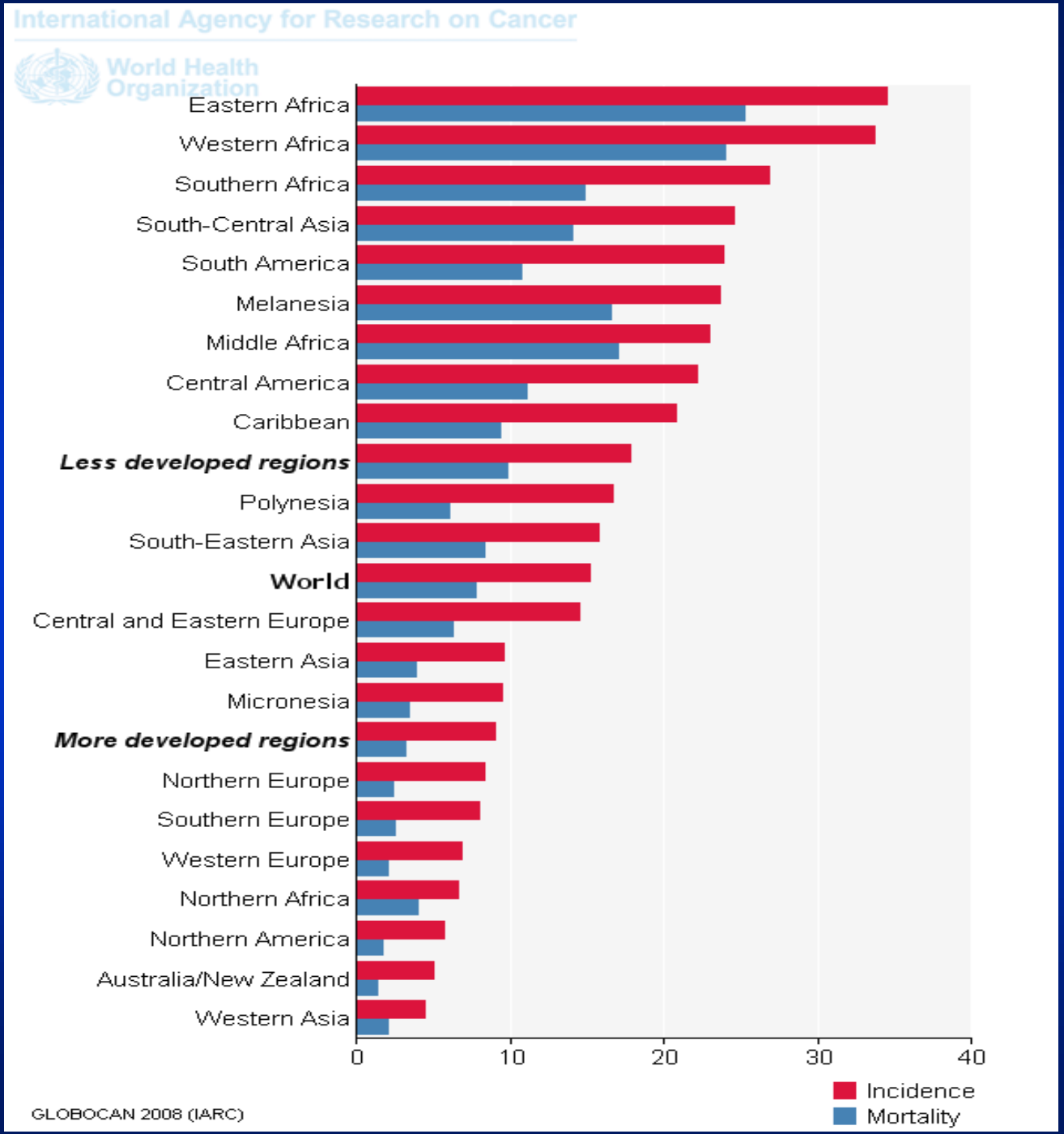
--- **Frame the hypothesis in a format that is testable**

--- **Test the hypothesis**

Hypothesis Formulation

- Observations from:
  - Literature (review PubMed on topic area)
  - Natural experiments (e.g. migrant studies)
  - Multi-national comparisons
  - Descriptive studies (assessment of person, place, and time characteristics)
  - Creativity

Cervical Cancer



- Infectious and chronic diseases show great variation from one country to another.

- Some differences may be attributed to:

  --- Climate
  --- Cultural factors
  --- Diet
  --- Genetics

Descriptive Study Designs

Used to help formulate hypotheses

Case Series Approach

- Identify the experience of a group of patients with a similar diagnosis, or
- Identify the experience of a group of individuals with an exposure in common

  – Patients or individuals may be identified from a single or multiple sources

Population Survey Approach

- Describe issues related to disease or exposure in populations
- Usually rely upon routinely collected data from established surveillance or notifiable disease systems

Unique Component: usually identify the characteristics of an issue from a representative sample of the population

Three essential characteristics that we look to measure in descriptive studies are...

- Person
- Place
- Time

Person

Since disease not does occur at random:

What kinds of people tend to develop a particular disease, and who tends to be spared? What's unusual about those people?

Person Factors

- Age, gender, race, ethnicity
- Genetic predisposition
- Concurrent disease
- Diet, exercise, smoking
- Risk taking behavior
- SES, education, occupation

Place

Since disease not does occur at random:

Where is the disease especially common or rare, and what is different about those places?

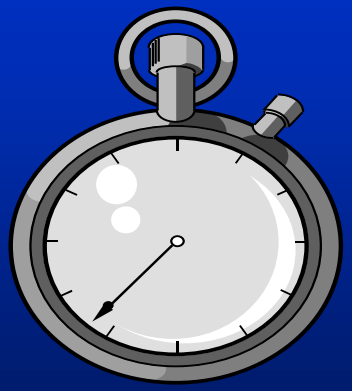
Place Factors

- Geographic place
  - residence
  - occupation
  - climate
  - geology
  - population density
  - economic development
  - nutritional practices
  - medical practices

Time

Since disease not does occur at random:

How does disease frequency change over time, and what other factors are temporally associated with those changes?



Time Factors

- Calendar Time / Time of Day
- Time since an event
- Date of onset
- Age (time since birth in the young)
- Seasonality
- Temporal trends

Remember the Elements of the Scientific Method

Discoveries or hypotheses are sometimes resisted because they seem counter-intuitive

Hypothesis Framing

Traditionally…..

H_0: "Null" hypothesis (assumed)
H_1: "Alternative" hypothesis

Case Series (in practice)

- Description of clinical/epidemiologic characteristics of a number of patients with a given disease
  - usually a consecutive set of clinical cases of disease (or health issue)

- Analyze cases together to learn about the disease (be careful as results do not demonstrate temporal relationships)

Hypothesis Framing

H_0: There is no association between the exposure and disease of interest

H_1: There is an association between the exposure and disease of interest (beyond what might be expected from random error alone)

Hypothesis Framing

Another Type of Framing:

What is the best estimate of the risk of disease in those who are exposed compared to those who are unexposed (i.e. exposed are at XX times higher risk of disease).

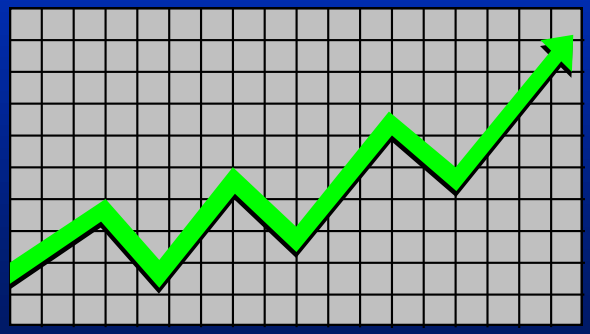
This moves away from the simple dichotomy of yes or no for an exposure/disease association – to the estimated magnitude of effect irrespective of whether it differs from the null hypothesis.

Hypothesis Framing

Ways to Express Hypotheses:

1. Suggest possible events…

The rate of survival will increase after surgery.



Hypothesis Framing

Ways to Express Hypotheses:

2. Suggest relationship between specific exposure and health-related event…

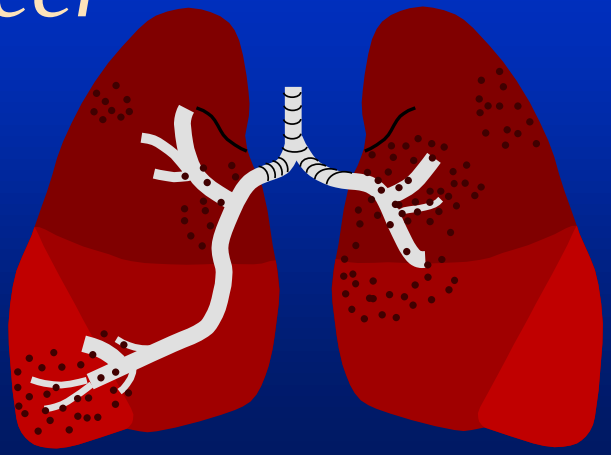
A high cholesterol intake is associated with the development (risk) of coronary heart disease.

Hypothesis Framing

Ways to Express Hypotheses:

3. Suggest cause-effect relationship….

Cigarette smoking is a cause of lung cancer



Hypothesis Framing

Ways to Express Hypotheses:

4. "One-sided" vs. "Two-sided"

One-sided example:

Helicobacter pylori infection is associated with increased risk of stomach ulcer

Two-sided example:

Weight-lifting is associated with risk of lower back injury

Hypothesis Framing

Guidelines for Framing Hypotheses:

1. State the exposure to be measured as specifically as possible.
2. State the health outcome as specifically as possible.

Strive to explain the smallest amount of ignorance

Hypothesis Framing

Example Hypotheses:

POOR

Eating junk food is associated with the development of cancer.

GOOD

The human papilloma virus (HPV) subtype 16 is associated with the development of cervical cancer.

The Next Step

- Formally test the identified hypotheses in a research study
  - The study should follow a specific plan or protocol (the study design)
  - Study designs direct how the investigation is conducted and allows for the translation of a conceptual hypothesis into an operational one

"Disappointment is when a beautiful hypothesis is destroyed by an ugly fact"

Newton