NORTH CAROLINA
SCIENCE OLYMPIAD

2011 DISEASE DETECTIVES (B,C)

Adapted from presentations given by Karen Lancour, PhD and Ralph Cordell, PhD

Epidemiology

NORTH CAROLINA SCIENCE OLYMPIAD

- 2011 focus is food born illness
- Content
  - Definitions of basic epidemiologic terms
  - Categories of disease causing agents
  - Modes of disease spread
  - Triads of analysis (e.g., person/place/time & agent/host/environment
  - Basis for taking action to control and prevent the spread of disease
- Process Skills – hypothesis, observations, inferences, predictions, variable analysis, data analysis, calculations, and conclusions
- Event Parameters – be sure to check the rules for resources allowed

What are Disease Detectives?

- Variety of educational backgrounds
  - Physicians
  - Veterinarians
  - Microbiologists
  - Statisticians

NORTH CAROLINA SCIENCE OLYMPIAD

What do Disease Detectives Do?

All use the scientific method to study distribution and determinants of disease in human populations and control those diseases.

Epidemiology Key Words:

NORTH CAROLINA SCIENCE OLYMPIAD

- Epidemiology – basic science of public health, high quantitative discipline based on principles of statistics and research methodologies
- Distribution – frequencies and patterns of health events within groups in a population. Questions- who, what, where, when?
- Determinants – causes or factors associated with increased risk or probability of disease. Questions – how, why?
- Populations – epidemiology deals with groups of people rather than with individual patients.
- Control – data steers public health decision making and aids in developing and evaluating interventions to control and prevent health problems.
- Health-related events – chronic diseases; environmental problems; behavioral problems; injuries; infectious diseases

Epidemiology Key Words:

NORTH CAROLINA SCIENCE OLYMPIAD

- Outbreak – (localized epidemic) – more cases of a particular disease than expected in a given area or among a specialized group of people over a particular period of time.
- Epidemic – large numbers of people over a wide geographic area affected.
- Pandemic -An epidemic occurring over a very wide area (several countries or continents) and usually affecting a large proportion of the population.
- Cluster –an aggregation of cases over a particular period esp. cancer & birth defects closely grouped in time and space regardless of whether the number is more than the expected number. (often the expected number of cases is not known.)
- Public Health Surveillance - the systematic collection, analysis, interpretation, and dissemination of health data to gain knowledge of the pattern of disease occurrence in order to control and prevent disease in the community.

Epidemiology Key Words:

NORTH CAROLINA SCIENCE OLYMPIAD

- Surveillance - The monitoring of diseases that have a certain prevalence in a population. The ongoing systematic collection, analysis, interpretation, and reporting of health data.
- Risk - The probability that something will cause injury or harm.
- Vector - a vector is an insect or any living carrier that transmits an infectious agent.
- Fomite - any inanimate object capable of absorbing, retaining, or transporting disease-causing microorganisms.
- Zoonosis - is any infectious disease that can be transmitted (in some instances, by a vector) from non-human animals, both wild and domestic, to humans or from humans to non-human animals

Scientific Method as related to Disease Detectives

NORTH CAROLINA SCIENCE OLYMPIAD

- Obtain Background Information
- Define the Problem
- Formulate Hypothesis
- Develop a Study to Test the Hypothesis
- Collect Data and Observations
- Evaluate Results
- Determine if Hypothesis is true/modify
- Formulate Conclusions
- Report Results

Compare these steps to 10 Steps in Outbreak Investigation

Types of skills needed

NORTH CAROLINA SCIENCE OLYMPIAD

- Recognize risk factors for health problems
- Know the components of the scientific method used in investigating a disease outbreak to real-life situations affecting health
- Understand and interpret the basic concepts of mathematics (rates & proportions as attack rate, relative risk & odds ratio) used to assess health risks
- Recognize an epidemiological case definition
- Know the different types of study designs used by epidemiologists and be able to recognize them from written accounts

Outbreak Investigation - 10 Steps

Step 1: Prepare for Field Work

NORTH CAROLINA SCIENCE OLYMPIAD

1. Research, supplies & equipment – research the disease or situation and gather needed supplies & equipment to conduct the investigation
2. Administrative arrangements – make official administrative and personal travel arrangements
3. Local contacts - follow protocol

Outbreak Investigation - 10 Steps

Step 2: Establish the Existence of an Outbreak

NORTH CAROLINA SCIENCE OLYMPIAD

1. Expected # of cases for area – use records as health dept., hospital records, death records, physician records, doctor survey to determine expected # for the area in a given time

2. Other factors in play – numbers may exceed normal due to factors such as better reporting, seasonal fluctuations, population changes

Step 3: Verify the Diagnosis

NORTH CAROLINA SCIENCE OLYMPIAD

1. Proper diagnosis - verify the procedures used to diagnose the problem and check methods used for identifying infectious and toxic chemical agents
2. Not lab error – be sure that the increase number of cases are not due to experimental error
3. Commonality – interview several persons who became ill to gain insight concerning possible cause, source, and spread of disease or problem

Outbreak Investigation - 10 Steps

Step 4: Define and Identify Cases

NORTH CAROLINA SCIENCE OLYMPIAD

Case definition – establish with the 4 components or standard criteria for determining who has the disease or condition

a) Clinical information – about the disease or condition

b) Characteristics - of the affected people

c) Location or place - as specific as possible as restaurant, county, or several specific areas

d) Time sequence - specific time during which the outbreak or condition occurred

Case Definition for Influenza-like (ILI)

NORTH CAROLINA SCIENCE OLYMPIAD

- *A case of influenza-like illness (ILI) or influenza* is defined as a person with fever of 37.8° C (100° F) or greater orally or 38.3° C (101° F) rectally PLUS cough during the influenza season (October 1 through May 31).
- A person with laboratory confirmed influenza is also considered a case even if the person does not have cough and fever.

Identifying cases

NORTH CAROLINA SCIENCE OLYMPIAD

Identification of specific cases – kind & number – count specific cases

Confirmed – have diagnosis with case definition plus lab verification

Probable – many factors point to diagnosis but may lack lab verification

Possible – some factors point to diagnosis

Note: Initial reports may be only a small sampling of the total problem. Be sure to expand search to determine the true size and extent of the problem

Line Listing

NORTH CAROLINA SCIENCE OLYMPIAD

Line Listing – chart of specific cases including information about each case

- Identifying information - ID or case # - left column + name or initials
- Clinical information – diagnosis, symptoms, lab results, hospital – death?
- Descriptive: time – date & time of onset + date of report
- Descriptive: person – age, sex, occupation, other characteristics
- Descriptive: place – street, city or county + specific site
- Risk factors & possible causes – specific to situation (disease) and outbreak setting

Sample Line Listing

NORTH CAROLINA SCIENCE OLYMPIAD

Sample Line Listing from six case report forms on a wedding reception outbreak

ID #	Initials	Date of Onset	Diagnosis Confirmed	How	Age	Sex	County	Physician	Wedding	
1	KR	7/23	probable trichinosis	Not done	29	M	Columbia	Goodman	Yes	
2	DM	7/27	trichinosis		Biopsy	33	M	Columbia	Baker	Yes
3	JG	8/14	probable trichinosis	Not done	26	M	Columbia	Gibbs	Yes	
4	RD	7/25	trichinosis		Serologia	45	M	King	Webster	Yes
5	NT	8/4	trichinosis		Not done	27	F	Columbia	Stanley	Yes
6	AM	8/11	R/Otrichinosis	Pending	54	F	Clayton	Mason	Yes	

Step 5: Describe in terms of Time, Place and Person Triad

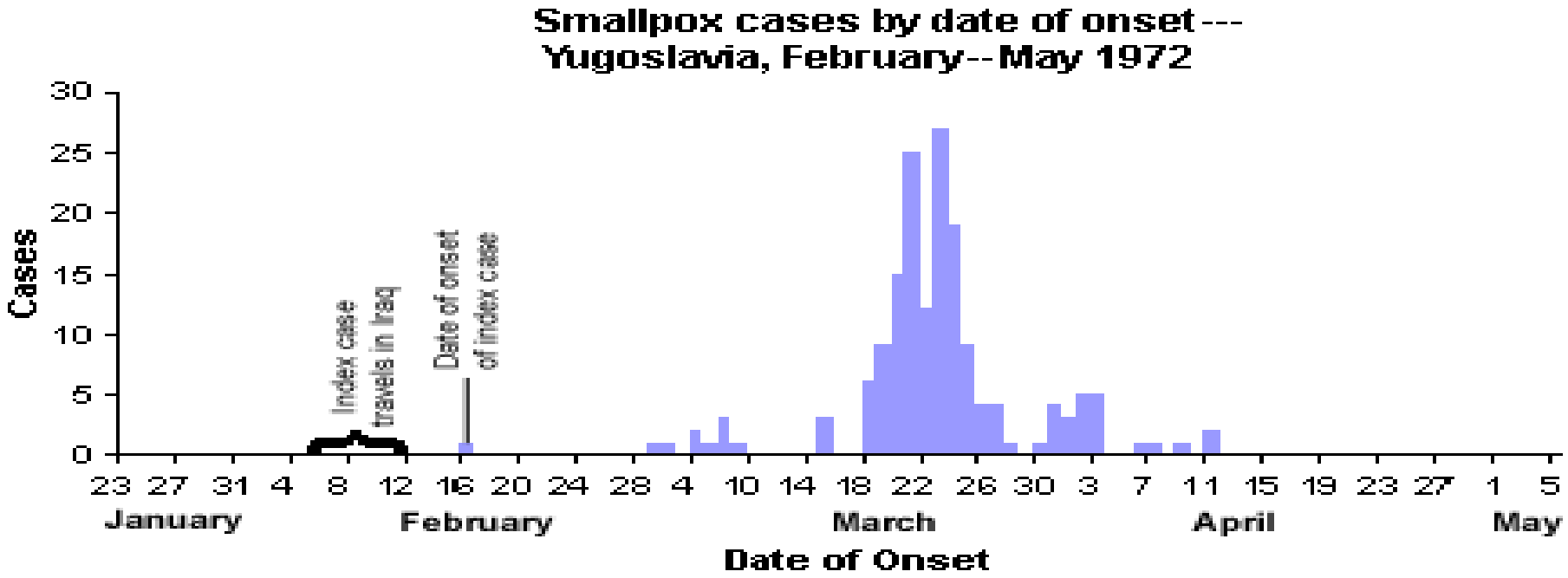
NORTH CAROLINA SCIENCE OLYMPIAD

- TIME – a histogram showing the course of the disease or outbreak to identify the source of the exposure Epidemic Curve or Epi curve (Begin early & update often)

- PLACE – geographic extent plus spot map of cases to identify groups specific to a location or environmental factors

- PERSON – identify the affected population by type of person or by exposures as age, sex, high risk exposure as with AIDS

EPI Curve (Epidemic Curve)



x axis= units of time equal to 1/4 to 1/3 incubation time and y axis = # of cases

Note: a single point or source will have only one peak, a plateau will show a continuous common source, several uniform peaks will indicate a propagated outbreak spread from person to person

Types of Descriptive Studies

NORTH CAROLINA SCIENCE OLYMPIAD

Types of Descriptive Studies – Study the distribution of a problem by cases or outcome, frequency in population, exposure, time pattern or environmental factor (Studies without a control group can be used for descriptive purposes!)

a) Case report/case series – case report = detail report of a single patient from one or more doctors while case series = characteristics of several patients

b) Correlative studies – correlates general characteristics of the population with health problem frequency with several groups during the same period of time
   a) Time series analysis – correlate within the same population a different point in time
   b) Ecologic relations – correlate relative to specific ecological factors as diet

c) Cross sectional - a survey of a population where participants are selected irrespective of exposure or disease status

Step 6: Develop Hypothesis (Agent/Host/Environment triad)

NORTH CAROLINA SCIENCE OLYMPIAD

1. Agent /host /environment = agent capable of causing disease & its source host or persons susceptible to agent + environment allowing them to get together

   Infectious Groups: viruses, bacteria, protistans (protozoa), fungi, animals (worms)

2. Testable – hypothesis must be in a form that is testable

3. Current knowledge & background – it should be based upon current knowledge and be updated or modified as new information is uncovered!!!

Step 7: Evaluate Hypothesis (Analytical Studies = Control Group)

NORTH CAROLINA SCIENCE OLYMPIAD

1. Compare with established fact – these are used when evidence is strong and clear cut

2. Observational Studies: (Study determinants of health problems – how & why)

   Cohort – Based upon *exposure status* whether or not they have outcome (illness) *works forward from exposure*

   Case-Control - Works *backward from effect or illness* to suspected cause.

3. *Must have lab verification to validate hypothesis*.

Cohort Study – Exposure

NORTH CAROLINA SCIENCE OLYMPIAD

- Both groups have a known exposure and are checked for future outcomes or illness.
- retrospective: (historic cohort) starts at exposure in past & moves forward to outcome
- prospective: starts a present exposure and moves forward in time to outcome

Sample Cohort Study using 2 X 2 table

NORTH CAROLINA SCIENCE OLYMPIAD

- 400 people attended a special awards dinner
- Some persons became ill. The suspected culprit was the potato salad. The population at the dinner was then surveyed to determine who became ill.

	Disease Yes	Disease No
Exposed (Ate salad)	150 (a)	30 (b)
Unexposed(no salad)	50 (c)	170 (d)

Calculating Attack Rate & Relative Risk

NORTH CAROLINA SCIENCE OLYMPIAD

	Disease Yes	Disease No
Exposed (Ate salad)	150 (a)	30 (b)
Unexposed (no salad)	50 (c)	170 (d)

- *Attack rate* – the rate that a group experienced an outcome or illness= number sick ÷ total in that group (Look for high attack rate in exposed & low rate in unexposed)

exposed = a ÷ (a+b) = 150 ÷ 180 = 80%

unexposed = c ÷ (c + d) = 50 ÷ 220 = 20%

- *Relative risk* = [a ÷ (a+b)] / [c ÷ (c+d)] =

80% ÷ 20% = 4

Interpreting Results of Cohort Study

NORTH CAROLINA SCIENCE OLYMPIAD

- Relative risk estimates the extent of the association between an exposure and a disease. It estimates the likelihood of developing the disease in the exposed group as compared to the unexposed group.
- A relative risk >1.0 indicates a positive association or an increased risk. This risk increases in strength as the magnitude of the relative risk increases.
- A relative risk = 1.0 indicates that the incidence rates of disease in the exposed group is equal to the incidence rates in unexposed group. Therefore the data does not provide evidence for an association.
- Relative risk is not expressed in negative numbers.

Case Control - Illness

NORTH CAROLINA SCIENCE OLYMPIAD

- Works *backward from effect or illness* to suspected cause.
- Control group is a selected group who has similar characteristics to the sick group but is not ill.
- They are then checked for similar exposures.
- It is often hard to select the control group for this type of study.
- *Odds Ratio* is calculated to evaluate the possible agents & vehicles of transmission

Sample Case-Control Study

NORTH CAROLINA SCIENCE OLYMPIAD

Sample:

Several patients were diagnosed with Hepatitis A.

- The local Restaurant A was thought to be the source of the infection.
- 40 case patients and a similar disease free group or control were contacted to determine if they ate at Restaurant A.

2 X 2 table of data

Ate	Case patients	Controls	Total
Yes	a = 30	b = 36	66
No	c = 10	d = 70	80
Total	40	106	146

Calculating Odds Ratio

2 X 2 table of data:

Ate	Case patients	Controls	Total
Yes	a = 30	b = 36	66
No	c = 10	d = 70	80
Total	40	106	146

Odds Ratio =

$$\frac{\text{Odds of exposure in cases}}{\text{Odds of exposure in controls}} = \frac{a/c}{b/d} = \frac{a\,d}{b\,c} = \frac{30 \times 70}{36 \times 10} = 5.8$$

This means that people who ate at Restaurant A were 5.8 times more likely to develop hepatitis A than were people who did not eat there.

a = # of case patients exposed b = # of control exposed

c = # of case patients unexposed d = # of control unexposed

Step 8: Refine Hypothesis and do Additional Studies

NORTH CAROLINA SCIENCE OLYMPIAD

1. No confirmation of hypothesis - where analytical studies do not confirm hypothesis. May need to look for a new vehicle or mode of transmission

2. More specific – May need to be more specific in make up of case patients & controls

3. Verify with environmental/laboratory studies - verification with very control conditions is very important

Step 9: Implement Control and Preventative Measures

NORTH CAROLINA SCIENCE OLYMPIAD

1. As soon as source is known – people are sick or hurting and need he must know agent & source of agent + susceptibility of host+ chain of transmission
2. Aim at chain of agent-source-host – break the chain of transmission at any of its 3 points
3. May interrupt transmission or exposure – with vehicles as isolation
4. May reduce susceptibility – with immunization, legal issues, and/or education

Criteria to Draw Conclusions

NORTH CAROLINA SCIENCE OLYMPIAD

1. Temporality – cause/exposure must precede effect/outcome
2. Consistency – observation of association must be repeatable in different populations at different times
3. Coherence, 1-1 relationship – exposure is always associated with outcome/ outcome is always caused by the specific exposure
4. Strength of association – relationship is clear and risk estimate is high
5. Biological plausibility – biological explanation makes sense
6. Dose/response (biologic gradient) – increasing risk is associated with increasing exposure

Step 10: Communicate Findings

NORTH CAROLINA SCIENCE OLYMPIAD

1. **Oral briefing** – inform local health officials or other need-to-know groups as soon as information is available
2. **Written report** – usually done in scientific format for future reference, legal issues, and education

Division B – Regional/State

NORTH CAROLINA SCIENCE OLYMPIAD

- modes of transmission
- Calculate health-related rates (attack, incidence, prevalence, case fatality)
- Calculate a simple relative risk and describe what it means
- Interpret epi curves, temporal patterns and other simple graphic presentations of health data..
- List, discuss and recognize examples of disease causing agents (physical and biological)
- Demonstrate an understanding and ability to use terms such as endemic, epidemic and pandemic; population versus sample, association versus cause.
- Describe various types of prevention and control strategies (e.g. immunization, behavior change, etc) and situations where they might be used

Division C – Regional/State

NORTH CAROLINA SCIENCE OLYMPIAD

- Recognize differences between study designs.
- Calculate measures of risk (e.g. relative risk or odds ratio) when given a description of the study design
- Calculate measures based on data that is not given but that can be readily extracted.
- Recognize how gaps in information influence the ability to extend conclusions to the general population.

DON'T FORGET

NORTH CAROLINA SCIENCE OLYMPIAD

- Each participant must bring a writing implement.
- Each participant may bring a non-programmable, non-graphing calculator.
- Each team may bring one 8.5 x 11 inch two-sided page of notes that contain information in any form from any source.
- This year's event is on food borne illness!

Major Foodborne Problems

NORTH CAROLINA SCIENCE OLYMPIAD

- **Naturally occurring toxins**, such as mycotoxins, marine biotoxins, cyanogenic glycosides and toxins occurring in poisonous mushrooms, periodically cause severe intoxications. Mycotoxins, such as aflatoxin and ochratoxin A, are found at measurable levels in many staple foods; the health implications of long-term exposure of such toxins are poorly understood.

- **Unconventional agents** such as the agent causing bovine spongiform encephalopathy (BSE, or "mad cow disease"), is associated with variant Creutzfeldt-Jakob (vCJD) Disease in humans. Consumption of bovine products containing brain tissue is the most likely route for transmission of the agent to humans.

- **Persistant Organic Pollutants (POPs)** are compounds that accumulate in the environment and the human body. Known examples are Dioxins and PCBs (polychlorinated biphenyls). Dioxins are unwanted byproducts of some industrial processes and waste incineration. Exposure to POPs may result in a wide variety of adverse effects in humans.

- **Metals**: such as lead and mercury, cause neurological damage in infants and children. Exposure to cadmium can also cause kidney damage, usually seen in the elderly. These (and POPs) may contaminate food through pollution of air, water and soil.

Other Major Foodborne Diseases from Microorganisms

NORTH CAROLINA SCIENCE OLYMPIAD

- **Salmonellosis** is a major problem in most countries. Salmonellosis is caused by the Salmonella bacteria and symptoms are fever, headache, nausea, vomiting, abdominal pain and diarrhoea. Examples of foods involved in outbreaks of salmonellosis are eggs, poultry and other meats, raw milk and chocolate.

- **Campylobacteriosis** is a widespread infection. It is caused by certain species of Campylobacter bacteria and in some countries, the reported number of cases surpasses the incidence of salmonellosis. Foodborne cases are mainly caused by foods such as raw milk, raw or undercooked poultry and drinking water. Acute health effects of campylobacteriosis include severe abdominal pain, fever, nausea and diarrhoea. In two to ten per cent of cases the infection may lead to chronic health problems, including reactive arthritis and neurological disorders.

- Infections due to **enterohaemorrhagic** (causing intestinal bleeding) **E. coli**, e.g. E.coli O157, and **listeriosis** are important foodborne diseases which have emerged over the last decades. Although their incidence is relatively low, their severe and sometimes fatal health consequences, particularly among infants, children and the elderly, make them among the most serious foodborne infections.

- **Cholera** is a major public health problem in developing countries, also causing enormous economic losses. The disease is caused by the bacterium Vibrio cholerae. In addition to water, contaminated foods can be the vehicle of infection. Different foods, including rice, vegetables, millet gruel and various types of seafood have been implicated in outbreaks of cholera. Symptoms, including abdominal pain, vomiting and profuse watery diarrhoea, may lead to severe dehydration and possibly death, unless fluid and salt are replaced.

Resources

NORTH CAROLINA SCIENCE OLYMPIAD

- http://www.cdc.gov/excite/
- http://soinc.org/disease_detectives_c
- Use event resources at sciencenc.com
- http://www2acdc.gov/epicasestudies/
- www.sph.unc.edu/nccphp
- http://www.cdc.gov/epiinfo/
- http://bookstore.phf.org/prod275.htm