Student name(s) _____

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School name and state _____

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KEY

DISEASE DETECTIVES

Division C

National Science Olympiad Tournament
Nebraska State University
Lincoln, Nebraska
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Developed by

Centers for Disease Control and Prevention (CDC)

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Public Health Service

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

Instructions and Introduction

Instructions: Unless otherwise indicated, only 1 correct answer is available for each question — select the best choice. For multiple choice questions, the number of points is the same as the number of correct answers. To receive full credit regarding questions involving calculations, show the formula (1 pt); all values that you include with the formula (1 pt); the answer, circled (1 pt); and correct units (1 pt).

The emphasis of the 2015 Disease Detectives events is about population growth. The association between public health and population growth is complex. For example, public health works to reduce teen pregnancy and mortality among pregnant women and infants and to promote reproductive health and family planning. It works to reduce morbidity and improve quality of life, while minimizing crowding and environmental influence. Population growth increases crowding (potential person-to-person disease transmission) and contact with wild animals in previously remote areas. In part, the 2014–2015 West African epidemic of Ebola infections is a consequence of population growth. Population growth also increases demand for clean water, food, and other resources and problems with pollution and waste disposal. The Nigerian gold mining scenario is an example of the consequence of these problems. To a degree, public health successes in certain areas have created challenges in others.

Part. I: Ebola in West Africa

Figure 1. Ebola treatment clinic in Guinea — 2014–2015 West African epidemic

Source: Centers for Disease Control and Prevention, Public Health Image Library)

The largest epidemic of Ebola virus infection in recorded history has occurred in West Africa during 2014–2015. The problem is believed to have started in Guinea and then spread to other West African countries. Ebola is a rare and potentially deadly disease caused by infection with 1 of 5 identified Ebola virus strains. Ebola can cause disease among humans and nonhuman primates (monkeys, gorillas, and chimpanzees). Ebola viruses have been reported in multiple African countries. Ebola was first reported in 1976 near the Ebola River in what is now the

Democratic Republic of the Congo. Data from that first outbreak are presented in the following. Since then, outbreaks have occurred sporadically in Africa. The natural reservoir host of Ebola virus remains unknown. However, on the basis of evidence and the nature of similar viruses, researchers believe that the virus is animalborne, and bats are the most likely reservoir. Four of the 5 virus strains occur in an animal host native to Africa. Because the natural reservoir host of Ebola viruses has not yet been identified, the manner in which the virus initially appears in a human at the start of an outbreak is unknown. However, scientists believe that the first patient becomes infected through contact with an infected animal (e.g., fruit bat or primate [apes and monkeys]), which is called a spillover event. Person-to-person transmission follows and can lead to a substantial number of affected persons. During certain previous Ebola outbreaks, primates were also affected by Ebola, and multiple spillover events occurred when persons touched or ate infected primates.

1. **(2 pts) Ebola infections are caused by a virus. Viruses exhibit only a limited number of the characteristics of living organisms. For example, they do reproduce and they do mutate. Provide 1 characteristic of living organisms that is not shared by viruses**.
   Viruses do not metabolize. (Answer)
   Viruses are not composed of cells. (Answer)
   Viruses do not grow. (Answer)
   Viruses do not maintain homeostasis. (Answer)
   Viruses consist of only 1 type of nucleic acid. (Answer)

2. **(2 pts) What term refers to the habitat in which an infectious agent normally lives, grows, and multiplies, which can include humans, animals, or the environment?**
   Reservoir. (Answer)

3. **(4 pt – 2 pts ea) Describe the source and route of transmission that is most likely to have caused the first human case during the 2014–2015 West Africa Ebola epidemic?**
   Source – blood or tissues of infected animal-bat or primate
   Exposure – direct contact – cleaning or dressing

4. **(2 pts) What term is used to describe an infectious disease that is transmissible from animals to humans?**
   Zoonoses or a zoonotic disease. (Answer)

5. **(1 pt) You have been charged with developing an educational campaign to prevent spillover events. Which of the groups would be your primary audience?**
   A. **Doctors and nurses.**
   B. **Hunters. (Answer)**
   C. **Laboratory workers.**
   D. **Shopkeepers from urban areas.**

6. **(1 pt) Which is the most important message that you would tell your primary audience to prevent spillover events?**
   A. **Avoid reusing syringes or needles that were used with other patients.**
   B. **Wear masks, gowns, and gloves when working with sick persons.**
   C. **Avoid contact with blood and body fluids when preparing bats or primates for consumption. (Answer)**
   D. **Avoid areas where a substantial number of mosquitoes are present.**

Infected humans can spread the virus to other persons in multiple ways. Ebola is spread through direct contact (through broken skin or mucous membranes in, for example, the eyes, nose, or mouth) or other methods, including

- blood or body fluids (e.g., urine, saliva, sweat, feces, vomit, breast milk, and semen) of a person who is sick with Ebola;
- objects (e.g., needles or syringes) that have been contaminated with the virus; and
- infected fruit bats or primates (apes and monkeys).

Ebola is not spread through the air or by water, or typically, by food. However, in Africa, Ebola might be spread as a result of handling bushmeat (wild animals hunted for food) or contact with infected bats. No evidence is available that mosquitos or other insects can transmit Ebola virus. Only a limited number of mammal species (e.g., humans, bats, monkeys, and apes) have shown the ability to become infected with and spread Ebola virus.

7. **(2 pts) Ebola infections can be spread by direct contact with objects that have been contaminated with the virus. Inanimate objects (e.g., bedding, towels, or surgical instruments) that can be vehicles for transmission of an infectious agent) are referred to as _____**
   fomites. (Answer)

8. **(2 pts) Although Ebola is not typically spread by food, it might be spread as a result of handling bushmeat. This first introduction of the virus into humans from an animal reservoir is referred to as a _____ _____**
   spillover event. (Answer)

9. **(1 pt) Which of the following persons would be at the least risk for contracting an Ebola infection?**
   A. Someone who flew aboard a plane with a person who was infected with the Ebola virus. (Answer)
   B. A person who washed the body of a patient who died from Ebola.
   C. A nurse who cared for a patient with severe vomiting who was infected with Ebola.
   D. A patient who was injected by a needle previously used to treat another patient with Ebola.

10. **(1 pt) Which of the following would be least important in controlling an epidemic of Ebola infections?**
    A. Avoid contact with blood or body fluids of persons suspected of having an Ebola infection.
    B. Ask patients with Ebola to wear masks to protect health care workers from infection. (Answer)
    C. Avoid reusing syringes or needles used for injections in health care settings.
    D. Perform proper burial of persons suspected of dying from Ebola infection.

Symptoms can appear during 2–21 days after exposure to Ebola, but the average is 8–10 days. Symptoms can include

- fever;
- severe headache;
- muscle pain;
- weakness or fatigue;
- diarrhea;
- vomiting;
- abdominal (stomach) pain; and
- unexplained hemorrhage (bleeding or bruising).

It is important to take into consideration the sensitivity and specificity of case definitions and laboratory test. Sensitivity and specificity are statistical calculations that determine how well each case definition or test works. Sensitivity measures the proportion of actual cases or infected persons which are correctly identified as such (e.g., the percentage of sick people who are correctly identified as having the condition). Specificity measures the proportion of people who are not true cases or do not have the infection which are correctly identified as such (e.g., the percentage of healthy people who are correctly identified as not having the condition). Together, these factors can help identify the trade-offs of conducting and drawing conclusions based on that definition or test.

11. (4 pts; 1 pt each) Epidemiologists often use what is referred to as a hierarchical case definition where patients are classified as suspect, probable, or confirmed, depending on available information. Table 1, includes descriptions of 4 persons. Indicate which is likely to be classified as not a case, suspect, probable or confirmed.

Table 1. Indicate the hierarchical case definition category for each person

Category	Description
Suspect (Answer)	**Person developed fever, diarrhea, and vomiting 1 week after helping prepare the body of a family member for burial who is believed to have died from Ebola virus.**
Not a case (Answer)	**Person from an area with cases, but no known exposure to a person with Ebola, their blood, or body fluids developed fever, diarrhea, and vomiting. The person denies contact with bats or eating bushmeat.**
Confirmed (Answer)	**Person developed fever, diarrhea, and vomiting with no known exposure to a person with Ebola, but has a positive test for IgM antibodies to Ebola virus.**
Probable (Answer)	**Person has fever, diarrhea, and vomiting 10 days after caring for a person confirmed as having Ebola virus.**

12. (2 pts) Which of the case definition categories (suspect, probable, or confirmed) is likely to have the greatest sensitivity?
Suspect. (Answer)

13. (2 pts) Which of the case definitions categories is likely to have the greatest specificity?
Confirmed. (Answer)

Ebola virus is detected in blood only after symptom onset, most notably fever, which accompanies the increase in circulating virus within the patient's body and can take up to 3 days after symptoms start for the virus to reach detectable levels. Laboratory tests used in diagnosis include antigen-capture enzyme-linked immunosorbent assay (ELISA) testing, IgM ELISA, polymerase chain reaction, virus isolation, and testing for IgM and IgG antibodies.

14. (2 pts) According to the previous information, 3 days after symptoms start might be necessary for the virus to reach detectable levels in the patient's blood. This would affect the _____ or the ability of any test done within 3 days of symptom onset to accurately identify true cases.
Sensitivity (Answer)

15. **Researchers have tested livers and spleens from Ebola culture-positive (i.e., infected) and Ebola culture-negative (i.e., noninfected) monkeys for antigen by using a sandwich enzyme immunosorbent assay (EIA); 44 of 45 (97.8%) liver homogenates and 38 of 41 (92.7%) spleen homogenates that were culture-positive were positive for viral antigen, whereas 85 of 87 (97.7%) culture-negative liver homogenates and 66 of 66 (100%) culture-negative spleen homogenates were reported to be antigen-negative.**
(Source: Ksiaczek TG, Rolling PE, Jahrling PB, Johnson E, Dalgard DW, Peters CJ. Enzyme immunosorbent assay for Ebola virus antigens in tissues of infected primates J Clin Microbiol 1992;30:947–50.)

A. (2 pts) Which tissue provided the greatest sensitivity by EIA?
Liver. (Answer)

B. (2 pts) Which tissue provided the greatest specificity by EIA?
Spleen. (Answer)

Health care providers caring for Ebola patients and family and friends who are in close contact with these patients are at the highest risk for getting sick because they might come in contact with infected blood or body fluids of sick patients.

During Ebola outbreaks, disease can spread quickly within health care settings (e.g., clinic or hospital). Exposure to Ebola can occur in health care settings where hospital staff are not wearing correct personal protective equipment, including masks, gowns, gloves, and eye protection.

Dedicated medical equipment (preferably disposable) should be used by health care personnel providing patient care. Thorough cleaning and disposal of instruments (e.g., needles and syringes) is also important. If instruments are not disposable, they must be sterilized before reuse. Without adequate instrument sterilization, virus transmission can continue and amplify an outbreak.

After a person recovers from Ebola, they can no longer spread the virus.

16. **(1 pt) Contact tracing is an important part of efforts to control an Ebola epidemic. On the basis of what you have read with the previous information, which of the following would be the lowest priority person to contact?**
    - **A. A health care worker in a poorly equipped hospital who cared for patients with Ebola infection.**
    - **B. The spouse of a person with Ebola infection.**
    - **C. A patient in a poorly equipped hospital treating multiple patients with Ebola virus.**
    - **D. The neighbor of a person with Ebola infection. (Answer)**

On March 24, 2014, CDC issued the following outbreak update:

> According to the World Health Organization (WHO), the Ministry of Health (MoH) of Guinea has reported an outbreak of Ebola hemorrhagic fever in four southeastern districts: Guekedou, Macenta, Nzerekore and Kissidougou. Reports of suspected cases in the neighboring countries of Liberia and Sierra Leone are being investigated. In Guinea, a total of 86 suspected cases, including 59 deaths (case fatality ratio: 68.5%), had been reported as of March 24, 2014. Preliminary results from the Pasteur Institute in Lyon, France suggest Zaire ebolavirus as the causative agent. Médecins sans Frontières (MSF/Doctors without Borders) is helping the Ministry of Health of Guinea in establishing Ebola treatment centers in the epicenter of the outbreak. CDC is in regular communication with its international partners WHO and MSF regarding the outbreak, to identify areas where CDC subject matter experts can contribute to the response.

You are one of the CDC subject matter experts asked to contribute to the response. You are on a flight to Guinea and access the following information about Guinea from the U.S. State Department website.

> The U.S. State Department describes Guinea as "a developing country in western Africa with minimal facilities for tourism. Travelers who plan to stay in Conakry, the capital, should make reservations well in advance. French is the official language; Pular, Malinké, and Soussou are also widely spoken." The website indicates that "Medical facilities are poorly equipped and extremely limited, both in the capital city and throughout Guinea. Medicines are in short supply and of questionable quality, sterility of equipment should not be assumed, and treatment is frequently unreliable. Some private medical facilities provide a better range of treatment options than public facilities, but are still well below western standards. Ambulance and emergency rescue services are extremely limited in Conakry and practically non-existent in the rest of the country."

Figure 2. Map of Guinea

Source: U.S. State Department (http://travel.state.gov/content/passports/english/country/guinea.html).

17. (2 pts) What single piece of information from the U.S. State Department description of Guinea best explains why an epidemic of Ebola might be occurring?
Medical facilities are poorly equipped OR Sterility of equipment should not be assumed. (Answer)

Part of your preparation to go to the field includes reviewing what is known about Ebola virus infections. You review 2 early reports from the Bulletin of the World Health Organization. The first report describes 218 cases of acute viral hemorrhagic fever in southern Sudan during June–November 1976. The second report discusses 318 cases in Zaire during September–October 1976. Although both outbreaks occurred at approximately the same time, testing has indicated different strains were involved, and they appear to be unrelated.

The index case in the Zaire outbreak involved a man aged 44 years who was an instructor at the Yambuku Mission School. He had symptom onset beginning September 1, 1976, after receiving an injection of chloroquine for presumptive malaria at the outpatient clinic at Yambuku Mission Hospital (YMH). Within a week, multiple YMH patients became ill. The 120-bed hospital was closed on September 30, after 11 of 17 staff had died from the illness. Investigators from WHO and other groups conducted active surveillance and a series of investigations. During November–December, 10 teams of 4 persons each visited 550 villages and interviewed 34,000 families. They collected serum specimens from persons in villages in the epidemic area if the person reported acute febrile illness during the epidemic period and had been in contact with a probable case, and from all volunteers in 8 villages, each of which had ≥5 probable cases.

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18. (1 pt) WHO and other groups conducted active surveillance. Which of the following determines if surveillance is active or not?

- **A. The type of information that is collected.**
- **B. The source of information that is collected.**
- **C. How the information is analyzed.**
- **D. How the information is collected. (Answer)**
- **E. All of the above.**

19. (5 pts; 1 pt each) Investigators have developed hierarchical case definitions for cases and contacts. For cases, definitions included, in increasing confidence,

- **A. possible (i.e., suspect) case-patient,**
- **B. probable case-patient, and**
- **C. proven (i.e., confirmed) case-patient.**

Contacts were classified as

- **D. primary contacts, or**
- **E. or secondary contacts**

Put the letter for each category in the box next to the definition that best fits that category.

Table 2. Hierarchical case definitions for case-patients and contacts

Category	Definition
E (Answer)	**A person having had face-to-face contact with a primary contact.**
B (Answer)	**A person living in the epidemic area who died ≥1 day after experiencing ≥2 of the following symptoms and signs: headache, fever, abdominal pain, nausea or vomiting, and bleeding. The patient must have during <3 preceding weeks received an injection or had had contact with a probable or a proven case, and the illness not having been otherwise clinically diagnosed.**
C (Answer)	**A person from whom Ebola virus was isolated or demonstrated by electron microscopy or who had an indirect fluorescent antibody (IFA) titre of ≥1: 64 to Ebola virus <3 weeks after symptom onset.**
A (Answer)	**A person with headache or fever for ≥24 hours, with or without other symptoms and signs and who had contact with a person who was a probable or a proven case <3 weeks previously.**
D (Answer)	**A person having had direct, face-to-face contact (sleeping in same room, sharing meals, caring for patients, preparing a cadaver for burial, or touching the body at a funeral) with a person who was a probable or proven case during the period from 2 days before symptom onset to the death or clinical recovery of the patient.**

Another 6 teams visited all villages reporting possible cases to the surveillance teams and gathered detailed information. They selected a group of control subjects, meaning persons from the same village as probable case-patients and, if possible, matched by age and sex with a probable case-patient in the same family.

20. (2 pts) What study design was used for the investigation?
Case-control. (Answer)

21. (1 pt) Which answer best explains why investigators selected persons from the same village as probable case-patients and matched them by age and sex with a probable case-patient in the same family.
- **A. They did not have to go elsewhere for information, and the selection was a matter of convenience.**
- **B. They wanted control subjects to be as similar as possible to case-patients, except for those factors possibly related to exposure. (Answer)**
- **C. They wanted to be sure to get the same information from both case-patients and control subjects.**
- **D. They wanted to reduce the likelihood of observer bias.**
- **E. None of the above.**

During September 1–October 24, a total of 318 probable and confirmed cases of Ebola hemorrhagic fever were reported with 280 deaths. The age and sex distribution of case-patients are displayed in Table 3.

Table 3. Age and sex distribution of cases

Age (yrs)	Male		Female		Total	
	No.	%	No.	%	No.	%
Newborns & Infants	10	3.1	14	4.4	24	7.5
1-14	18	5.7	22	6.9	40	12.6
15-29	31	9.7	60	18.9	91	28.6
30-49	57	17.9	52	16.4	109	34.3
≥50	23	7.2	26	8.2	49	15.4
Unknown	2	0.6	3	0.9	5	1.6
Total	141	44.2	177	56.0	318	100

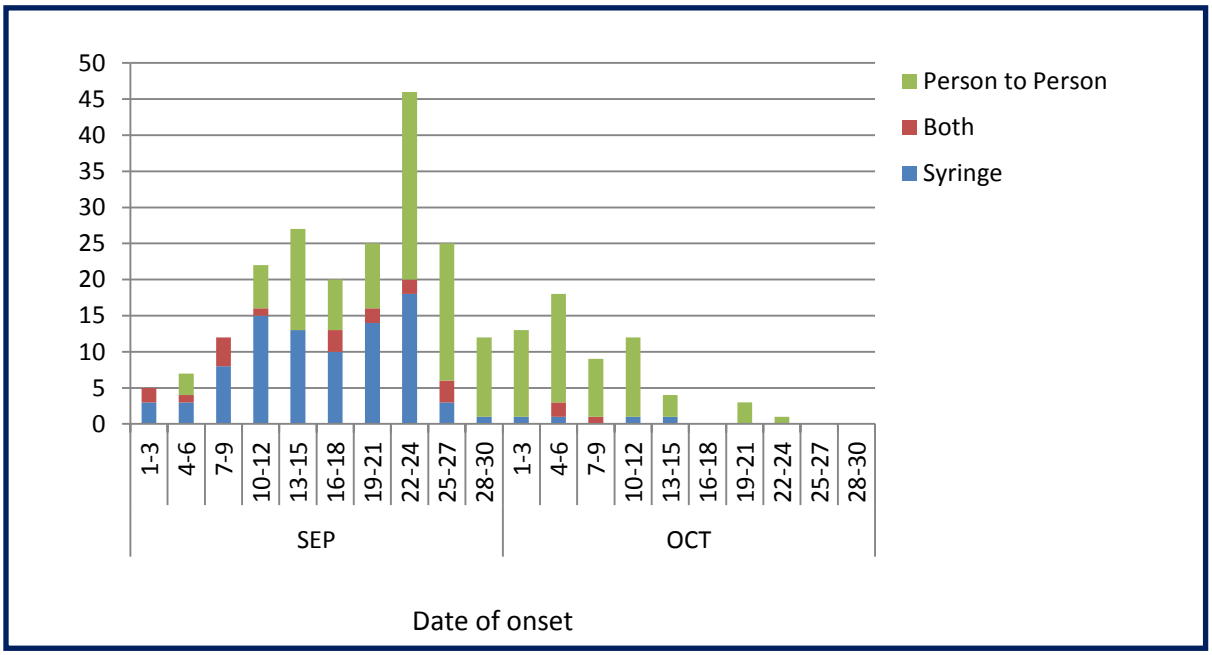
[**Source:** Must include table source and receive written permission to use this material.]

22. (2 pts) Which age group had the greatest incidence of Ebola infection?
This information cannot be determined because no denominators were included. (Answer)

23. (4 pts) The greatest number of cases was among women aged 15–29 years. Write 1 hypothesis to explain why the greatest number of cases was in women in this age group.
This group was the most likely to care for sick parents, spouses, or children. (Answer)
This group was the most likely to prepare bodies of dead people for burial. (Answer)
This group was the most likely to be treated at a health care clinic and infected at that location. (Answer)

A likely source of infection or mode of transmission was identified for 288 case-patients. Onset and probable infection type are displayed in Figure 3.

Figure 3. Number of cases of Ebola hemorrhagic fever in the Équateur Province region, by day of onset and probable type of transmission



[Source: need to add source for this image and receive written permission to use.**]**

24. (2 pts) What term do epidemiologists use for the graph in Figure 3?
An epidemic or epi curve. (Answer)

25. (1 pt) Which of the following statements is not supported by this graph?
- **A. Contaminated syringes were a major factor in transmission early during this outbreak.**
- **B. Contaminated syringes were what caused the outbreak. (Answer)**
- **C. Person-to-person transmission was important in the latter part of the epidemic.**
- **D. Person-to-person transmissions caused more cases than were caused by contaminated syringes.**

26. (1 pt) Contact tracing indicates that multiple people were infected at the Yambuku Mission Hospital during the start of this epidemic. These are examples of _____
- **A. zoonotic infections.**
- **B. occupational infections.**
- **C. health care–associated infections. (Answer)**
- **D. doctor-acquired infections.**

Factors associated with person-to-person spread were evaluated by comparing information about exposure with Ebola cases from persons infected by person-to-person contact, with that from family control subjects and village control subjects. Results are displayed in Table 4.

Table 4. Factors associated with person-to-person spread to case-patients, family control subjects, and village control subjects*

Risk factor	Person-to-person case-patients		Family control subjects		Village control subjects	
	No.	% yes	No.	% yes	No.	% yes
Cared for a patient	119	70.8	84	71.4	22	68.2
Touched a patient	126	85.7	91	83.5	22	68.2
Slept in same room as a patient	116	69.0	85	66.3	22	22.7
Aided in delivery of child of a sick patient	104	18.3	74	9.5	22	4.5
Prepared a cadaver for burial	116	58.6	87	57.5	22	54.5
Attended a funeral	126	85.7	98	85.7	22	96.5

* Adapted from an international commission report. World Health Organization. Ebola haemorrhagic fever in Zaire, 1976. Bull World Health Organ 1978;56:271–93.

27. (6 pts) Use the information from Table 4 regarding aiding in the delivery of the child of a sick patient to complete the following table.

Table 5: Numbers of person-to-person case-patients, family control subjects and village control subjects who did and who did not aid in the delivery of a child of a sick patient.

	Aided in delivery of child of sick patient	
	Yes	No
Person-to-person contacts	19 (Answer)	85 (Answer)
Family control subjects	7 (Answer)	67 (Answer)
Village control subjects	1 (Answer)	21 (Answer)

28. (6 pts) Calculate the measure for strength of association, comparing the risk for illness among person-to-person case-patients with that among family control subjects. (Show your work.)
Odds ratio = (a × d) ÷ (b × c); (19 × 67) ÷ (85 × 7) = 2.14 (Answer)

29. (6 pts) Calculate the measure for strength of association, comparing the risk for illness among person-to-person case-patients with that among village control subjects. (Show your work.)
Odds ratio = (a × d) ÷ (b × c); (19 × 21) ÷ (85 × 1) = 4.69 (Answer)

Table 6. Odds ratios and 95% confidence intervals, comparing various exposures among Ebola patients with those among both family control subjects and village control subjects, Zaire[*]

Risk factor		Family control subjects	Village control subjects
Cared for a case-patient	Odds ratio	0.96	1.12
	95% CI[a]	(0.52–1.78)	(0.42–2.98)
Touched a case-patient	Odds ratio	1.18	2.8
	95% CI	(0.56–2.50)	(1.00–7.81)
Slept in same room as a case-patient	Odds ratio	1.13	7.55
	95% CI	(0.62–2.05)	(2.59–22.07)
Prepared a cadaver for burial	Odds ratio	1.05	1.8
	95% CI	(0.60–1.84)	(0.47–2.95)
Attended a funeral	Odds ratio	1	0.29
	95% CI	(0.47–2.12)	(0.04–2.26)

[*] Adapted from an international commission report. World Health Organization. Ebola haemorrhagic fever in Zaire, 1976. Bull World Health Organ 1978;56:271–93.
[a] CI = confidence interval.

30. (2 pts) Table 6 lists odds ratios and 95% confidence intervals, comparing different exposures among Ebola patients with those among both family control subjects and village control subjects. List the exposure and comparison group (i.e., family control subjects or village control subjects) for those associations that are most likely to be statistically significant (i.e., have *P* values <.05).
Touched a case-patient. (Answer)
Slept in the same room as a case-patient. (Answer)

31. (1 pt) Associations among the exposures listed and subsequent illness are greater in comparisons among Ebola patients and village control subjects than those involving family control subjects. Which comparison group gives the best estimate of risk?
Village control subjects. (Answer)

32. (2 pts) What term is used for a flaw in study design that might lead to spurious conclusions about an exposure-disease association?
Bias or confounding. (Answer)

Investigators examined the spread of Ebola infection within families by generation of transmission. First-generation cases were the first person infected within a family. Second-generation cases were among persons who were apparently infected by exposure to first-generation cases, whereas third-generation cases were among those infected by exposure to second-generation cases. Fourth-generation cases were among those exposed to persons with third-generation cases.

Table 7. Attack rate in family contacts, by generation of transmission*

Generation	Number of families with cases	Number of family exposures	Number of subsequent cases
1	61	498	38
2	65	459	20
3	18	117	3
4	5	29	1

* Adapted from a report of an international commission. World Health Organization. Ebola haemorrhagic fever in Zaire, 1976. Bull World Health Organ 1978; 56:271–93.

33. (4 pts) What is the attack rate among families with fourth-generation cases?
Attack rate = number cases ÷ number exposures = 1 ÷ 29 = 3.4/100 exposures. (Answer)

34. (2 pts) Which generation had the highest attack rate?
First-generation. (Answer)

During November 1976–January 1977, investigators collected serum specimens from persons in the epidemic area if the person had reported acute febrile illness during the epidemic period and had been in contact with probable case-patients, and from all volunteers in 8 villages, each of which had ≥5 cases. Serum specimens were tested for Ebola virus antibodies by using the IFA technique. Titers or levels of antibodies that reacted when diluted ≥1:64 times were considered positive. Results are displayed in Table 8.

Table 8. Ebola virus indirect fluorescent antibody (IFA) antibodies among residents of the epidemic area, by age, sex, and exposure status

Category	Sex	Age (yrs)						Unknown	Total
		1–9	10–19	20–29	30–39	40–49	≥50		
Ill	M	2	5	15 (2)	16 (2)	7	10 (1)		55 (5)
	F	2 (2)[a]	11 (2)	14 (3)	16 (6)	11 (2)	12		66 (15)
Contact, not ill	M	19	19	55 (1)	40	35	64 (2)	11	243 (3)
	F	31 (1)	25 (1)	22 (1)	30	29 (1)	35 (3)		172 (7)
Not contact, no illness	M	49	57	35	27 (1)	27 (1)	44 (2)		248 (3)
	F	43	48	33	21	21	31		200 (1)
		146 (3)	165 (3)	174 (7)	162 (9)	130 (4)	196 (8)	11	984 (38)[b]

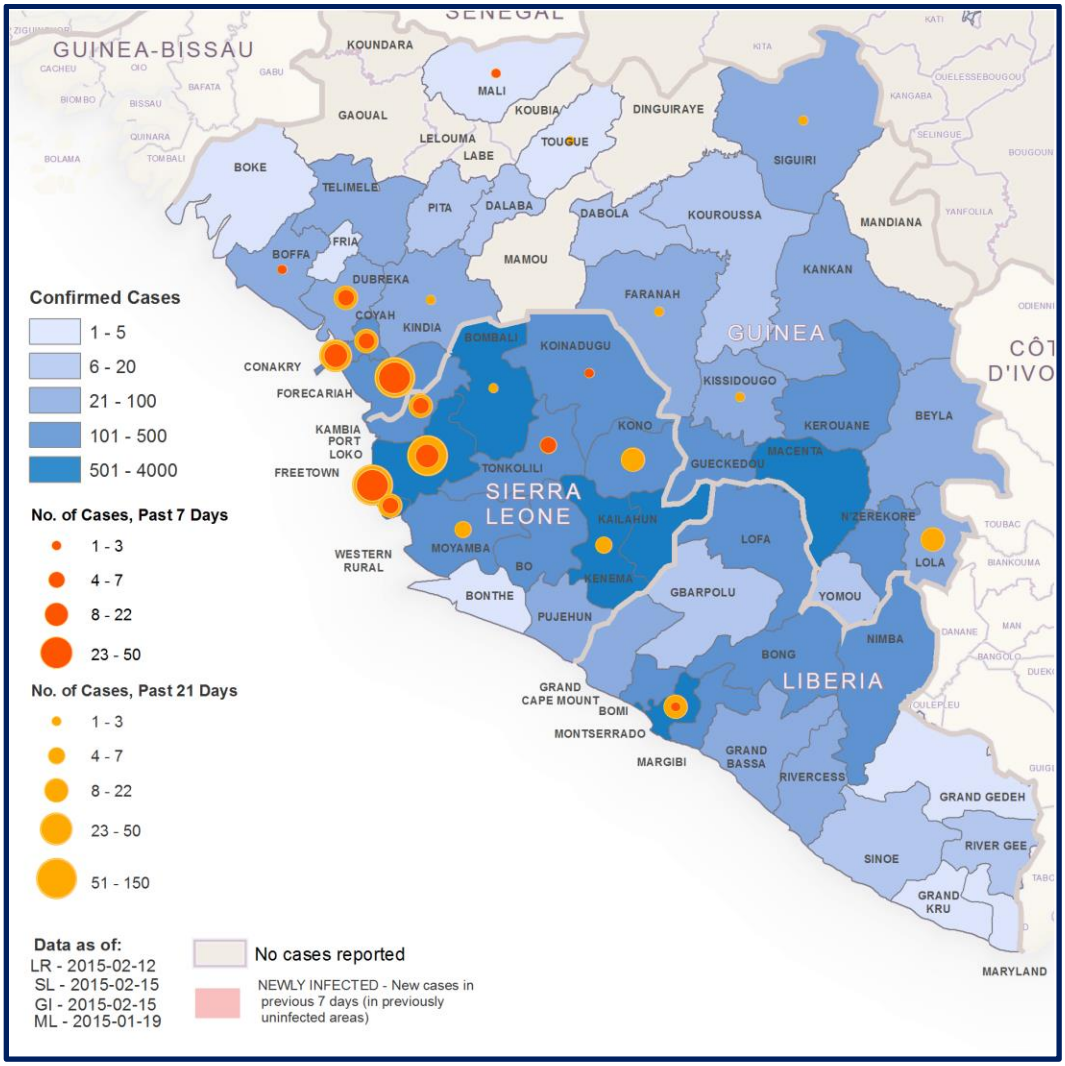
[a] Numbers in parentheses indicate the number of persons with Ebola virus IFA titers of ≥1:64.
[b] Includes 4 positive titers with unknown history.

35. (4 pts) Thirty-eight of 984 (3.9%) persons tested had positive titers or evidence of Ebola infection. Is this a measure of incidence or prevalence? Explain your answer.
This is a prevalence rate because the calculation is for existing antibody levels and not for new infections and no period is involved. (Answer)

36. (2 pts) Which age category was the most likely to have antibody to Ebola virus?
30–39 years. (Answer)

Your plane is about to land in Guinea, and you have a limited time before you have to turn off your electronic devices. You check the WHO website for the latest information about the epidemic and view the following map.

Figure 4. Geographic distribution of new and total confirmed cases of Ebola as of February 18, 2015



Source: World Health Organization (http://apps.who.int/ebola/en/ebola-situation-report/situation-reports/ebola-situation-report-18-february-2015).

37. (4 pts; 2 pts each) You expect that you will be sent to the area where the highest number of Ebola infections has been reported. On the basis of the number of cases reported during the last 7 days and the number of cases reported during the last 21 days, to what 2 areas are you most likely to be assigned?
Freetown or Forecariah. (Answers)

Your plane has landed and your adventure is about to begin.

Pt. II. Nigerian Tragedy

In May 2010, you have just started your job as an Epidemic Intelligence Service (EIS) Officer at the Centers for Disease Control and Prevention (CDC). Your supervisor comes by your office and says, "I just got an email from the Nigerian government and Médecins Sans Frontières (also known as Doctors Without Borders or MSF). They have come across a number of children who have died in 7 villages in Northern Nigeria with what they think is poisoning by lead (an element) but there also has been a problem with Lassa Fever (an infectious disease that causes symptoms like Ebola). We need to figure this out quickly and I want you to run the investigation."

1. **(6 pts-2 pts ea) What are the next three actions (in order of priority) you should take to get to the bottom of this?**

1. Establish existence of an outbreak (Answer)
2. Verify the diagnosis (Answer)
3. Define a case (Answer)

2. **(4 pts-2 pts ea) Agent/host/environment is one of the main triads in epidemiology. Epidemiologists often divide agents into 3 broad categories. Physical includes things like radiation and heat. List the two possible categories of agents that could have caused the outbreak at this time.**

1. Biological (give 1 pt for things like 'infectious' or 'living') (Answer)
2. Chemical (Answer)

3. **(2 pts) In either case, what single activity would be most useful in verifying the diagnosis?**

Collect/test specimens from possible cases (Give 1 pt for "Examine possible cases") (Answer)

Lassa fever is transmitted among humans by contact with urine or droppings from rodents and causes a hemorrhagic fever with symptoms similar to that of Ebola. You know from your past experience that lead is an element on the periodic table that is often associated with mining activities in developing countries. You quickly grab a reference book and read about lead poisoning.

4. **(8 pts-1 pt ea) Below is a list of epidemiologic observations and phenomena. Some are characteristic of communicable diseases with person-to-person transmission such as Lassa fever. Others are characteristic of environmental problems such as lead poisoning. Put an "ID" beside those suggesting an infectious cause, a "Pb" beside those suggesting an environmental cause, and a "B" beside those that support either cause.**
   - **A. __B___ Similar illness in other household members.**
   - **B. __ID___ Relatively constant time interval between onset of cases in households with multiple causes.**
   - **C. __ID___ Illness in people who just moved into the area or were passing through.**
   - **D. __B___ Relatively level epi curve.**
   - **E. __Pb___ Increasing frequency or severity of illness among individuals with increasing exposure.**
   - **F. __ID___ Those who recover never experience the same symptoms again.**
   - **G. __ID___ Reports of similar illness in other areas around the same time period**
   - **H. __Pb___ Symptoms limited to a group of individuals with similar occupations and ages.**

You call the MSF staff in the field to get a better handle on the situation and the director says:

"While doing routine surveillance for malaria in Northern Nigeria we heard reports of many children and some adults dying in at least seven remote villages. The symptoms of people reporting to the health clinic include nausea, vomiting, slowness (lethargy), and seizures. Two Local Government Areas (similar to counties in the U.S.) in Kano had 140 probable cases and 117 suspect cases since January, 2010. Most notably, a majority of the cases did not have fevers. While there was recently a Lassa fever outbreak in this region, we tested the blood of eight children and two adults who came to the clinics in the last five days for Lassa fever and it was negative. We sent the specimens to a reference laboratory in Germany to confirm our Lassa results and test for lead but the final results are still pending."

You tell her the following: "It sounds like Lassa Fever is less likely and the symptoms sound like lead poisoning. Lead is an element on the periodic table that comes from ore taken from the earth. As a positively-charged particle (i.e., cation) it can substitute for calcium, sodium, or potassium in a person's body which interferes with muscle and nerve function. Children are more exposed to lead dust (being closer to the ground and having more hand-mouth activity than adults) and are more susceptible to poisoning. There is no biologic benefit to lead and no level of lead is considered "safe." CDC recommends interventions being when a child's lead level meets or exceeds 5 micrograms per deciliter (µg/dL) of blood. There has only been one recorded fatality due to lead in the U.S. since 1990 but levels over 100 µg/dL have been shown to be fatal."

5. (4 pts – 2 pts ea) What two pieces of information in the above exchange makes you think that Lassa Fever is not likely to be the cause of this problem?

Negative lab results (Answer)

Absence of fever in most cases (Answer)

She says "I've just sent you some of the preliminary information we have and I would like for you to interpret it as I am missing some information." You open your email and find the following tables.

Table 1. Characteristics of probable and suspected cases of acute lead poisoning in select LGAs (Jan 1—June 1, 2010), Kano State, Nigeria. *

	Probable (N=143)		Suspected (N=119)		Total (N=262)	
	No.	%	No.	%	No.	%
Age group	(n=140)		(n=117)		(n=257)	
<5	130	92.9	45	38.5	175	68.1
5-15	10	7.1	31	26.5	41	16.0
>15	0	0	41	35.0	41	16.0
Gender	(n=141)		(n=118)		(n=259)	
Male	76	53.9	49	41.5	125	48.3
Female	65	46.1	69	58.5	134	51.7
Outcome						
Died	70	49.0	10	8.4	80	30.5
Alive	73	51.0	109	91.6	182	69.5

* Note the names of the state, LGAs, and villages have been changed to protect the identity of individual areas affected. Also, the census data was adjusted to fit this scenario and is not the actual data for these locations

6. (4 pts) If we assume that the ratio of males to females in this population is exactly 1:1, what is the relative risk of illness among women as compared to men? (show your work)

Give 1 pt if they say they cannot calculate RR because they do not have a denominator. If they just put down 1.07 with no work – give 2 pts. If they show 134/125 and get 1.07, give 3 pts. If they set up a "dummy" denominator say 'X" and say that $X_{men}=X_{women}$ and then cancel them out – give full credit.

7. (2 pts) Based on the categorical data in Table 1, what statistical test would you use to test the hypothesis that the age distributions of probable and suspect cases were the same?

Chi square (Answer)

8. (4 pts) Based on the information in Table 1, what was the overall case-fatality rate in this outbreak for all probable and suspect cases?

Case fatality rate = 80/262 = 30.5% (Answer)

Table 2. Total number of probable cases and population of Kano State, LGAs, and select villages as of 2000 Census. *

	Population	Total Cases	Mortality Rate Per 10,000 In last 6 months
LGA			
Gabasawa	211,055	81	***
Minjibir	213,794	62	***
Village			
Gezawa	114,084	81	***
Bagwai	63,862	41	***
Dambatta	109,241	19	***
Makoda	60,102	1	***
Kunchi	30,201	1	***

* Note that this census data was adjusted to fit this scenario and is not the true data for these locations

9. (5 pts) Which village had the highest mortality rate? What was that rate? (show your work)

Gezawa (1 pt) (Answer)

Incidence = Total number cases/population=81/114084 = 71 per 100,000 population (Answer)

10. **(5 pts) How much more likely were residents of the Gabaswa LGA to have the illness than those of Minjibir LGA?**

RR=$I_{Gabasawa}/I_{Minjibir}$ = (81/211055)/(62/213794) = 0.000383786/0.000289999 = 1.32 (Answer)

11. **(4 pts) Table 2 presents information on mortality rates rather than morbidity (the usual measure in tables of this type). What is the difference between the two rates?**

Mortality rates measure death while morbidity rates measure illness. (Answer)

Table 3. Characteristics of probable and suspected cases of acute lead poisoning in select LGAs (Jan 1—June 1, 2010), Kano State, Nigeria.

	Died (N=78)		Alive (N=179)		Case fatality rate
	No.	%	No.	%	
Age group					
<5	72	92.3	103	57.5	41.1%
5-15	6	7.7	35	19.6	14.6%
>15	0	0	41	22.9	0%
Total	78	100	179	100	30.4%

12. **(6 pts- 1 pt ea)Below are a number of statements about the information in Table 3. Put a T beside those that are true and an F beside those that are false.**
    - A. **__T___ Almost one-third of cases died.**
    - B. **__F___ Adults were more likely to be affected than young children.**
    - C. **__T___ Children less than 5 years of age were the most likely to die from this illness**
    - D. **__F___ Children less than 5 were 27 times more likely to die than those between 5 and 15 years of age**
    - E. **__F___ Adults appear to have been exposed as much to whatever caused the illness as young children.**
    - F. **__T___ The illness was both more common and more severe among children less than 5 years of age than among older children or adults.**

The results you see clearly indicate that something is wrong and you help your supervisor assemble a team from CDC, the Nigerian Government, and the World Health Organization (WHO). As the EIS officer you have been assigned to lead the epidemiology team. Your team is responsible for determining the "Who, What, Where, and When" of the outbreak.

Upon arriving in Nigeria you connect with the rest of the team members to figure out what to do next. The MSF director lets you know that the blood test results for the 10 specimens all came back negative for Lassa fever but lead levels that ranged from 110 µg/dL to 365 µg/dL with an average of 230 µg/dL.

13. **(2 pts) How many of these are within the safe level of lead in blood?**

None – there is no safe level (Answer)

14. (2 pts) How many of these persons would be recommended for treatment?
All 10 (Answer)

15. (2 pts) How many of these persons have blood lead levels above those shown to be fatal?
All 10 (Answer)

16. (2 pts) What step of the outbreak investigation process is addressed by these results?
Verifying the diagnosis (Answer)

Your team first heads out to the two most affected villages (Gezawa and Bagwai) to talk with people and get a better feel of what is going on. The villages are about 1 hour apart on rough roads and both in very remote locations just south of the Sahara desert. In Gewaza you find mud-wall houses with some farm fields nearby. There are dirt paths between homes and a central well for water. There are numerous new graves in the cemetery, most of them are about the length of your arm. There are a number of people working near the water well around a flour grinder. You ask the MSF doctor what they are doing and he says,

"Ah we started seeing people come with loads of heavy rocks in fall of last year and they hired villagers to use hammers and their flour grinders to crush and grind the rocks into a powder. They then put the dust into a bowl of water, run it over carpet on a slope, and let the carpet dry. They then beat the dust out of the top of the carpet onto another sheet, add the dust to another bowl, and mix it with a silvery liquid. This creates a paste with metallic-looking globules." He shows you this step. (See figure 1)

Figure 1. Paste with shiny, metallic-looking globules. (Courtesy CDC Nigeria Lead Investigation Team)

He continues, "The villagers then put these globules in gum wrappers and hold a lighter underneath them. The shiny substance then boils off and leaves a yellow ball. They have continued to bring these rocks each month and they take away the yellow balls."

As you pick up a rock you notice that it is heavier than you expect for its size and it shines like silver. You see it has flecks of a shiny yellow-colored ore scattered throughout it. You turn and speak to the team,

"Oh no, this looks like a form of lead ore with flecks of gold and I am worried that this could be causing the deaths. I would imagine they are undertaking ore processing activities that are like panning for gold. Letting the muddy water run down the carpet deposits the lead and the gold at the top. Then, combining the dust at the top with what appears to be mercury binds the gold. Once they vaporize off the mercury they are left with more concentrated gold. Lead dust and mercury are both known to cause severe medical conditions, we need to get to the bottom of this fast."

The environmental health expert calibrates his X-ray fluorescent (XRF) analyzer and puts it on some ore to test it. He then says:

"You're right, this is pretty concentrated lead ore that has gold in it but how do you think people are getting it into their bodies? Lead ore is not very easily absorbed and nobody has ever seen people get these levels of blood lead poisoning from just being around lead ore."

You're next stop is the 1-room clinic in the village and you see 10 children, all under 5 years old, lying on the floor or in their mothers arms. An exam of one indicates a child who is almost comatose. He has no reflexes and seems to be having slight seizures on one side of his body. The doctor from the medical team pulls out a portable blood lead analyzer, calibrates it, and tests a small sample of the child's blood. She says:

"Hrm, this is confusing. Although the machine had normal calibration and is reading the high and low blood lead standards it came with fine, the child's reading for blood lead has exceeded the limits of the machine, which is 65 µg/dL."

She tests all of the other children and finds the same thing. Then, she dilutes one child's blood with a sample of her own to see if she can get an estimate of the child's blood lead level. This results in a reading that can be extrapolated to estimate the blood lead level and she finds the blood lead level to be approximately 400 µg/dL. She says,

"This is critical, this child has lead levels that are well-known to be fatal. We need to figure out which children are ill with lead poisoning and how they are being exposed."

The MSF doctor says, "Unfortunately we have one to two children that show the same signs and symptoms as this child who die each day and it seems to be getting worse."

As the preliminary information is not very accurate, you decide to undertake a door-to-door survey of every house in Gezawa and the second village (Bagwai) to identify ill children for emergency care and determine how children are getting exposed.

17. (2 pts) What kind of study will this be?
Cross-sectional (Answer)

People in these villages generally live in compounds consisting of one or more buildings that house several (often related) families surrounded by a common wall. You administer the survey to all households in Gezawa and Bagwai to get the following demographic information.

Table 4. Demographic results of household survey in Gezawa and Bagwai, Nigeria, May, 2010.

Demographic	Gezawa (n = 53 homes)	Bagwai (n = 65 homes)	Both villages (n = 118 homes)
Mean number of married men per compound	3.1	2.1	2.6
Mean number of mothers per compound	3.7	3.0	3.4
Mean number of children aged <5 years per compound	4.8	3.1	4.2
Total number of children aged <5 years in the village, as of May 2009	259	204	463
	No. (%)	No. (%)	No. (%)
Number of children aged <5 years living at time of survey (%)	181 (70)	164 (80)	345 (75)
Number of children aged <5 years who had died within last 12 months before survey (%)	78 (30)	40 (20)	118 (25)
Number compounds with ≥1 pregnant women (%)	26 (49)	24 (37)	50 (42)

18. **(1 pt) Which of the below statistical tests would you use to test the hypothesis that the mean number of children <5 years of age per compound in Gezawa was not statistically significantly different than that in Bagwai?**
    - **A. Chi square**
    - **B. Fishers exact**
    - **C. Paired t-test**
    - **D. Students t-test (Answer)**

19. **(4 pts) What percentage of children under 5 years of age had died within the last 12 months in the two villages combined?**

Percentage = No. died/(No. living at time of survey+No. died) = 118/463 = 25.5% (Answer)

20. **(6 pts) What is the odds ratio of children dying in Gezawa as compared to Bagwaj?**

Odds Ratio = (78*164)/(181*40) = 1.77 (Answer)

21. **(5 pts) During the last months, how many children under 5 years of age died per day in these two villages combined?**

 # deaths/day = (# deaths/year)/(#days/year) = 118/365 = 0.32 (Answer)

Investigators made the assumption that all deaths were due to lead poisoning although post mortem findings and blood lead levels were not available for deceased children. Nor did they collect information about other cultural or nutritional factors that could explain the high mortality rates.

22. (2 pts) What type of experimental error may be at play here?
Misclassification bias (Answer)

23. (2 pts) Will estimates of strength of association be artificially increased, decreased or remain the same if this error is evenly distributed among both exposed and exposed cases?
Decreased (Answer)

You are amazed at these numbers and decide to look up the United Nation's High Commission on Refugees set-points for emergencies in refugee camps to find 1/10,000/day! That means that the United Nations considers it a emergency when the death rate among children < 5 years of age is greater than 1 per 10,000. This is truly an emergency!

Table 5. Odds ratios of ore processing activities in the household as reported by survey respondents in Gezawa and Bagwai, Nigeria, May, 2010.

Activity	Gezawa No. (%) (n = 53 homes)	Bagwai No. (%) (n = 65 homes)	Odds ratios
Participate in ≥1 of the below activities	42 (79)	42 (65)	3.81
Rock breaking	29 (55)	39 (60)	0.81
Rock grinding	10 (19)	15 (23)	0.78
Rock washing	27 (51)	27 (42)	1.46
Rock drying	33 (62)	29 (45)	
Rock separating	22 (42)	30 (46)	0.83
Rock melting	22 (42)	32 (49)	0.73
Mean number of activities	3·4	4·1	

* 56 households who participated in ≥ 1 ore-processing activity had started in the last 12 months.

Moving on to the exposure information, you find the number of compounds in each of the two villages where various activities involved with gold extraction take place within the compound itself (Table 5).

24. (6 pts) Calculate the odds ratio for rock drying in Gezawa as compared to Bagwai.
Odds ratio = a*d/b*c = 33*36/20*29 = 2.04 (Answer)

At this stage of the investigation, you have conducted an in depth investigation of potentially risky activities in two separate villages and have found that they are more common in the village with the highest mortality rate.

25. (1 pt) These types of studies of risk-modifying factors on health or other outcomes based on comparisons of populations rather than individuals are referred to as

A. Ecological studies (Answer)
B. Case control studies
C. Prospective studies
D. Experimental studies
E. None of the above

You turn your attention to individual children and compare survey information about maternal activities and other environmental risk factors among children who died with that from children who were alive.

Table 6: Potential risk factors for child mortality in Gezawa and Bagwai, Nigeria, May, 2010.

	Outcome		
Potential risk factor	**Deceased**	**Alive**	**Odds ratio (95% CI)**
Soil lead level (ppm)			
<400	8	53	Reference group
400-1200	20	11	1.2 (0.5, 2.9)
>1200	90	178	3.4 (1.5, 7.4)
Main water source			
Community well	35	38	
Private well	83	307	
Mother performs			
>1 ore-processing activity	74	163	
No ore-processing activities	44	182	

26. **(2 pts) You find that the odds ratio associated with soil lead level gets larger as the soil lead level increases. What term do epidemiologists use to describe this change in effect or risk with changes in levels of exposure?**

Dose-response (Answer)

27. (2 pts) At what soil lead level does the exposure become statistically significant?

>1200 ppm (Answer)

28. (6 pts) Calculate the odds ratio for using community wells as opposed to private wells for main water source.

Odds ratio = a*d/b*c = 35*307/38*83 = 3.41 (Answer)

29. (2 pts) What statistical test would you use to determine the statistical significance of the main water source results?

Pearsons chi square (Answer)

Chelation therapy can reduce blood lead levels in children and deaths due to lead poisoning. You work with local, national and international groups to institute an effective program and find that deaths among children have dropped from 43% to less than 1%.

30. (1 pt) Which of the below programs would be the least effective in preventing this problem from happening again?

A. Prohibit ore processing in villages (Answer)

B. Set aside special areas for ore processing in villages that are removed from children and water supplies.

C. Clean up the environment – remove and safely dispose of contaminated topsoil and replace it with new soil.

D. They would all be effective.

Congratulations – you have come to the end of the 2015 National Disease Detectives Division C Competition. We look forward to seeing you in Atlanta