
_____ Total Score

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School Name: _____

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(2): _____

DIVISION B
DISEASE DETECTIVES

National Science Olympiad
University of Wisconsin
Madison, Wisconsin
May 21, 2011

Developed by the
Career Paths to Public Health Program
Centers for Disease Control and Prevention (CDC)

Part A: Food Illness/Safety

The Disease Detectives topic for 2011 and 2012 is foodborne illness or food poisoning. The World Health Organization defines foodborne diseases as those diseases, usually either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food. The Centers for Disease Control and Prevention (CDC) estimates roughly 1 out of 6 Americans (or 48 million people) get sick, 128,000 are hospitalized, and 3,000 die of foodborne illnesses annually. Reducing foodborne illness by 10% would prevent about 5 million Americans from getting sick each year. The most common foodborne illnesses are caused by the bacteria *Campylobacter*, *Salmonella*, and Shigella, and by a group of viruses called calicivirus, also known as the Norwalk and Norwalk-like viruses. Symptoms vary depending on the type of pathogen and severity of the illness. Common symptoms of many foodborne illnesses include nausea, vomiting, abdominal cramps and diarrhea. In the United States, most states require reporting of known or suspect cases of food borne illness as part of the National Notifiable Disease Surveillance Data System (NNDSS). CDC has a number of other data collection, or surveillance systems for monitoring the occurrence and types of foodborne illnesses in the United States, such as the Foodborne Diseases Active Surveillance Network (FoodNet) collaborative. The following table presents information on the numbers of illnesses, hospitalizations and deaths based on known and unknown causes.

Table 1. Estimated annual number of domestically acquired, foodborne illnesses, hospitalizations, and deaths due to 31 pathogens and unspecified agents transmitted through food, United States 2011

Foodborne Agents	Number of illnesses	%	Number of hospitalizations	%	Number of deaths	%
31 known pathogens	9.4 million	20	55,961	44	1,351	44
Unspecified agents	38.4 million	80	71,878	56	1,686	56
Total	47.8 million	100	127,839	100	3,037	100

From CDC Website (http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html) accessed 4/08/11

1. (1 pt.) What term do epidemiologists use to refer to the ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health? **(**Public health surveillance.)

2. (2 pts.) What percentage of illnesses from known pathogens are hospitalized? Please give your answer as a percent with 3 significant figures. (55961/9400000 = 0.5953% = 0.595%.)

points

3. (2 pts.) Give two (2) reasons why a person may be classified as having an unspecified agent? (They were not tested. Their test came back negative. Also accept that they did not go to the doctor or hospital or they had an unknown pathogen.)

Table 2. Top five pathogens contributing to domestically acquired foodborne illnesses, resulting in hospitalizations and deaths, 2011 United States estimates.

Pathogen	**Number of illnesses**	**Pathogen**	**Number of hospitalizations**	**Pathogen**	**Number of deaths**
Norovirus	5,461,731	*Salmonella*, nontyphoidal	19,336	*Salmonella*, nontyphoidal	378
Salmonella, nontyphoidal	1,027,561	Norovirus	14,663	*Toxoplasma gondii*	327
Clostridium perfringens	965,958	*Campylobacter spp.*	8,463	*Listeria monocytogenes*	255
Campylobacter spp.	845,024	*Toxoplasma gondii*	4,428	Norovirus	149
Staphylococcus aureus	241,148	*E.coli* (STEC) O157	2,138	*Campylobacter spp.*	76

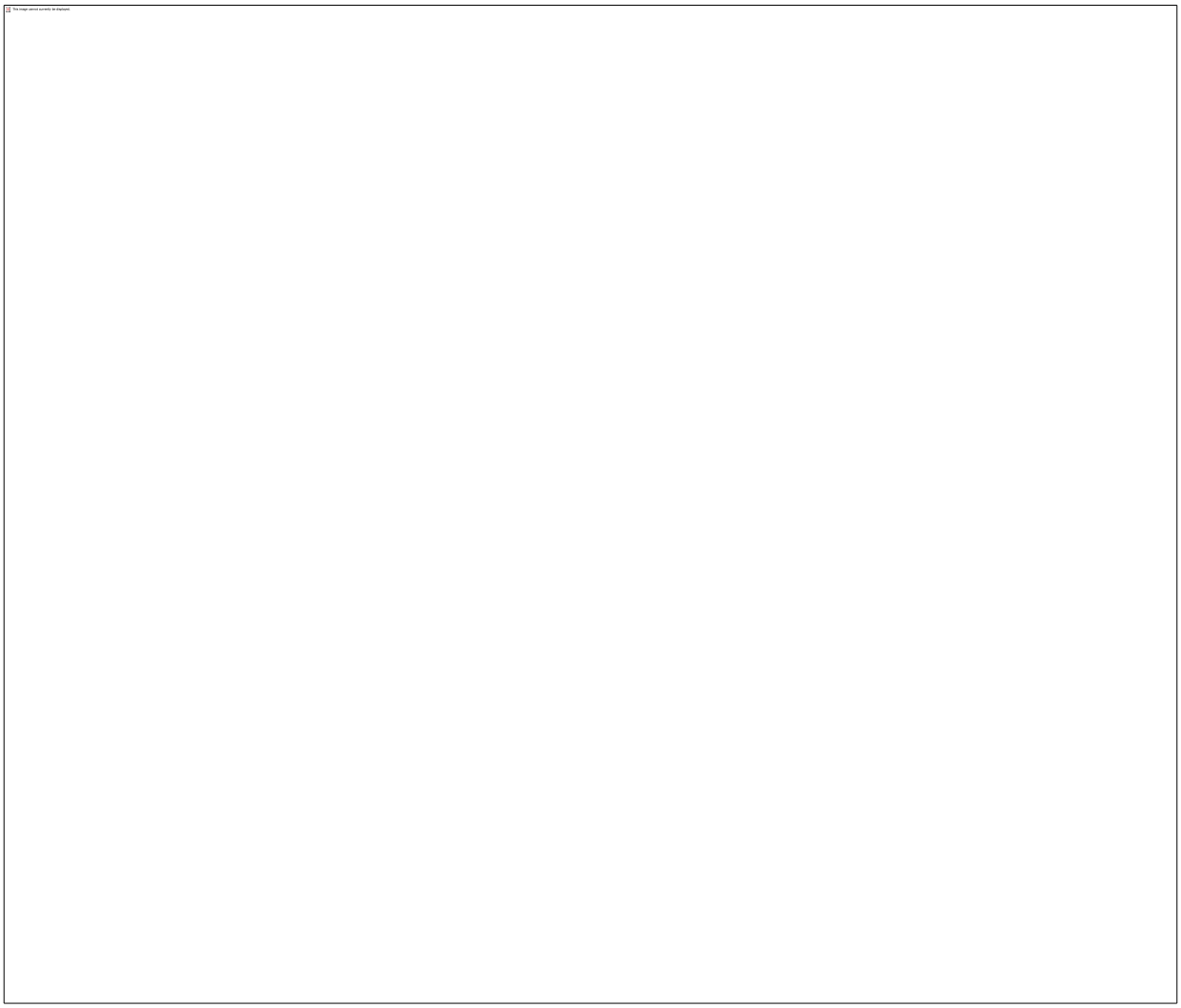
From CDC website (http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html) accessed 4/08/11.

4. (2 pts.) Of the following three pathogens *Campylobacter*, norovirus, and *Salmonella* nontyphoidal, which has the largest proportion of illnesses resulting in hospitalization? Norovirus = 14663/5461731 = 0.002685; *Salmonella* = 19336/1027561 = 0.01882; *Campylobacter* = 8463/845024 = 0.010015

5. (1 pt.) Although most foodborne illnesses are untreated, which of the five (5) pathogens in the third column is least likely to respond to antibiotics? (Norovirus.)

points

Figure 1. Rate of reported foodborne disease outbreaks per 100,000 standard population and number of outbreaks, by state and major etiology group --- United States, 2007.



¶Includes 17 multistate outbreaks, which are assigned as an outbreak to each state involved. An outbreak in Puerto Rico is not shown.

** Includes one multistate outbreak, which is assigned as an outbreak to each state involved.

6. (1 pt.) Which state had the most bacterial outbreaks in 2007? (California)

7. (1 pt.) Which state had the most chemical outbreaks in 2007? (Florida.)

8. (2 pts.) The maps above represent choropleth maps, in which higher rates typically have darker colors. In the bacterial outbreak map, two states had a relatively low number of outbreaks

points

compared to other states, but they had the highest rates. Why were these two states shaded in the darkest color? (Smaller populations.)

Table 3. Number and percentage of reported foodborne outbreaks and outbreak-associated illnesses, by pathogen — United States, 2007.

Pathogen	Outbreaks		Illnesses	
	2007		2007	
	Total		Total	
	No.	(%)	No.	(%)
Bacterial				
Salmonella	142	20	3,515	23
Clostridium perfringens	45	6	1,606	10
Escherichia coli, Shiga toxin-producing (STEC)	42	6	603	4
Bacillus cereus	19	3	164	1
Shigella	11	2	355	2
Vibrio parahaemolyticus	1	0	5	0
Escherichia coli, enterotoxigenic	2	0	142	1
Other bacterial	4	1	43	0
Chemical				
Scombroid toxin/Histamine	20	3	74	0
Ciguatoxin	14	2	84	0
Mycotoxins	3	0	10	0
Paralytic shellfish poison	1	0	4	0
Other natural toxins	3	0	12	0
Other chemical	5	1	18	0
Parasitic				
Cryptosporidium	3	0	14	0
Giardia	2	0	51	0
Viral				
Norovirus	317	45	8,024	52
Hepatitis A	4	1	28	0
Rotavirus	2	0	18	0
Other Viral	1	0	17	0

9. (2 pts.) Based on the information above, which bacterial pathogen had the greatest number of illnesses per outbreak in 2007? (*E. coli* enterotoxigenic. 142/2 = 71)

points

10. (2 pts.) List two (2) groups of people that are more likely to get sick from foodborne illness. (Elderly, young children, pregnant women, immunocompromised.)

11. (2 pts.) During a foodborne outbreak, why do disease detectives interview people who did not get sick as well as people who did get sick? (Need a control or comparison group.)

Most people usually become infected with foodborne illness when they eat a contaminated food item. A person can reduce the risk of becoming infected by always following food safety rules and guidelines: clean, separate, cook, and chill. Safe steps in food handling, cooking, and storage are essential to preventing foodborne illness.

12. (1 pt.) To wash your hands properly, you must wash them with warm, soapy water for at least how many seconds?

    1. 10 seconds
    2. 20 seconds
    3. 45 seconds
    4. 60 seconds

13. (1 pt.) What effect does chilling have on bacteria? (Chilling slows growth.)

14. (1 pt.) What effect does cooking food to appropriate temperatures have on bacteria? (Cooking kills bacteria.)

15. (1 pt.) What two effects does freezing have on bacteria? (Freezing slows growth and can kill bacteria. Give half credit for each answer.)

16. (1 pt.) To minimize bacterial growth in foods, it is important to keep food temperatures out of the range called the "Danger Zone." Which of the following temperature ranges represent the "Danger Zone"?

    1. 0 degrees F
    2. 40-140 degrees F
    3. 140-180 degrees F
    4. 180-210 degrees F

points

17. (1 pt.) Food safety experts recommend refrigerating or freezing perishables, prepared foods, and leftovers within ___2___ hours or less. (Half credit for any answer of less than or equal to 4 hours that is not 2.)

18. (1 pt.) Which of the following federal agencies is responsible for regulating meat and poultry in the United States?

1. USDA (U.S. Department of Agriculture)
2. FDA (Food and Drug Administration
3. EPA (Environmental Protection Agency)
4. CDC (Centers for Disease Control and Prevention)

19. (1 pt.) No one person or group has the sole responsibility for ensuring food safety. Everyone on the Farm-to-Table Continuum plays a major role in keeping our food safe. If a link in this continuum is broken, the safety and integrity our food supply can be threatened. Put the following steps of the Farm-to-Table Continuum in order: home table, processing, farm, retail, transportation

(Farm__ → _processing__ → _transportation__ → __retail__ → _home table.)

(Students should have farm and home table. 1 point for 3 middle steps as 1/3 credit)

20. (1 pt.) Bacteria multiply through a process in which the cell's DNA doubles, the cell splits, and two independent cells are formed. What is the name of this process?

1. Fertilization
2. Binary fission
3. Fragmentation
4. Budding
5. Parthenogenesis

21. (2 pts.) Under the right conditions, a single bacterium will double with each division. If no bacteria die, how many divisions does it take for there to be 2,048 bacteria? (11)

points

Part B: Botulism1

Botulism is a rare but serious paralytic illness that causes disability and death; foodborne botulism is one of the more serious foodborne illnesses. The following describes one of the largest outbreaks of foodborne botulism reported in the United States in recent times. Although this was an unusual event, foodborne botulism continues to be a problem with approximately 20 cases reported each year. Most cases of foodborne botulism come from home-canned or other home-prepared foods.

On Sunday morning, April 10, 1994, a physician at an El Paso, Texas hospital notified the local health department that two people arrived at the hospital emergency room with blurred or double vision, difficulty breathing, and weakness. The sudden onset and nature of these symptoms suggested botulism.

Botulism is caused by *Clostridium botulinum,* an anaerobic, spore-forming gram-positive bacillus. Spores are dormant forms that are highly resistant to heat, drying and other environmental conditions. They are commonly found in soil and on food items contaminated with soil and can survive improper canning, cooking, or other processing methods used to preserve food. Under low-acid (pH > 4.6), anaerobic conditions, the spores germinate and produce a potent neurotoxin. This botulinum toxin is inactivated by heating to >80°C for at least ten minutes. When a person ingests toxin-contaminated food, the toxin molecules are absorbed into the bloodstream. They then spread throughout the body and bind to the ends of neurons. This prevents a neurotransmitter, acetylcholine, from carrying messages to muscles. A person who has botulism will become paralyzed, starting with the top of their body (descending paralysis), as more and more nerve endings become blocked. The classic symptoms of botulism include double vision, blurred vision, drooping eyelids, slurred speech, difficulty swallowing, dry mouth, and muscle weakness. Although the most frequent source of botulism today is home-canned foods, outbreaks associated with restaurants or with commercially prepared foods do occur. The toxin does not change the taste or smell of the food. Botulism cannot be transmitted from one person to another because the illness results from eating the spores or the toxin.

22. (1 pt.) What type of organism is *C. botulinum*?

1. A parasite
2. A virus
3. A fungus
4. A bacterium

1 While the outbreak presented here occurred many years ago (1994), these are examples of classic investigations used for this competition.

points

23. (1 pt.) What does "anaerobic" mean? (No air or no oxygen.)

The physician contacted the El Paso Public Health Department after learning that the patients, a father and son, had recently shared a meal at a Greek restaurant in El Paso. An epidemiologic investigation was started immediately. Other area hospitals were contacted and an additional 4 suspect cases were identified within 4 hours of the initial report. Each of these persons had eaten at the same Greek restaurant.
On learning of these additional cases, the health department closed the restaurant and issued a press release informing the general public that persons who had symptoms of botulism should seek immediate medical attention. The next day, area physicians were notified of the outbreak and asked if they had seen any patients with symptoms of botulism. Interviews with the initial group of case-patients suggested that exposure most likely took place on April 8 or April 9. Investigators got a list of employees and used meal tickets, credit card receipts, cancelled checks and interviews of staff and patrons to identify persons who might have eaten at the restaurant on those two days. They identified 235 persons who ate food from the restaurant on April 8 or 9, 1994 (230 patrons and 5 employees). All restaurant patrons were interviewed using a standard questionnaire regarding food and beverages consumed, signs and symptoms of illness, and onset and duration of illness.

24. (2 pts.) What was the purpose of these interviews?

a. to determine if the restaurant was involved
b. to identify the particular food item that was involved
c. both a and b
d. neither a nor b

Explain your answer. (To determine the food that was involved. Since the study population included only people who ate at the restaurant there was no way that this investigation could demonstrate an association with the restaurant. 1 point for answer; 1 point for explanation)

25. (1 pt.) What was the study design used in this part of the investigation? (A cohort study.)

Confirmed cases had *C. botulinum* detected in their stool. A probable case was defined by electromyography (EMG), a test in which an electrical current is used to establish muscle function findings. A suspect case was defined by the presence of symptoms without diagnostic evidence of infection. Thirty persons met one of the case definitions for botulism: 18 confirmed cases, 5 probable cases, and 7 suspect cases. Case-patients were 12–59 years old (median, 28); 17 (57%) were female. Twenty-one were hospitalized and 4 required ventilator support. There were no deaths. Illness onset ranged from April 9 (p.m.) to April 13 (a.m.), with a median incubation period of 40 hours.

points

26. (1 pt.) What was the attack rate among all people who may have been exposed during this outbreak?

1. 9.4%
2. 7.6%
3. 12.8%
4. 60%

27. (2 pts.) What is the hospitalization rate of the cases? Show your work. 21/30 = 70% (2 pts. for showing work and having correct answer; 1 pt. if failed to show work but have correct answer; no pts. if answer is not given as a rate: such as 70%, 70 per 100, etc.)

Use Table 4 for questions 28–29.

Table 4. Symptoms of persons with confirmed, probable, or suspected botulism, El Paso Texas, April 1994.

Symptom	Percentage			
	Confirmed Case (n=18)	Probable Case (n=5)	Suspected Case (n=7)	All Cases (n=30)
Fatigue	89	40	66	73
Double vision	83	60	0	60
Blurred vision	78	80	86	80
Dizziness	78	40	43	63
Difficulty speaking	67	60	14	53
Difficulty breathing	78	40	43	57
Dry mouth	67	40	57	57
Constipation	56	40	0	40
Nausea	50	20	57	47
Diarrhea	50	0	57	43
Muscle weakness	50	20	43	43
Dysphagia	44	40	43	43
Sore throat	44	20	43	40
Parathesias	44	20	43	40
Abdominal pain	39	0	57	37
Vomiting	22	20	14	20

28. (1 pt.) What are the three (3) most frequent symptoms among all cases? (Fatigue, blurred vision, and dizziness.)

29. (2 pts.) What is the proportion of confirmed cases? Give your answer as a percent and show your work. (18/30 = 60%) (2 pts. for showing work and having the correct answer; 1 pt. if failed to show the work, but has correct answer; no points if "%" is not shown.)

points

Use Figure 2 to answer questions 30–35.

Figure 2. Symptomatic cases of botulism (N=27) by date of illness onset and date persons ate at implicated restaurant, El Paso, Texas, April 1994.

30. (1 pt.) What do disease detectives call this type of chart? (Epi curve or histogram.)

31. (1 pt.) The typical incubation period of botulism is 18–36 hours. What is an incubation period? (The time between when someone is infected by a pathogen and when they start to show symptoms.)

points

32. (1 pt.) Based on the background and incubation periods of the ill patrons, what type of outbreak is this?

1. Continuous common source
2. Propagated common source
3. Progressive source
4. Contiguous point source
5. Point source
6. Propagated source

33. (2 pts.) Define the answer you chose in question 32. (Point source: a single contaminated item that causes an outbreak at a single point in time.)

34. (1 pt.) What is the range of onset dates of symptoms? (April 9–13.)

35. (1 pt.) Based on the information provided in the graph, which meal was associated with the highest number of symptomatic cases? (Dinner on 04/09.)

Disease detectives were able to interview 198 of the 235 people that may have been exposed during this outbreak. They learned the following information from Table 5.

Table 5.

	Ate the Food			Did not Eat the Food		
	Ill	Total	Attack Rate	Ill	Total	Attack Rate
Black olives	19	93	20.4%	11	105	10.5%
Eggplant dip	6	9	66.7%	24	189	12.7%
Feta cheese	22	106	20.8%	8	92	8.7%
Greek salad	12	94	12.8%	18	104	17.3%
Gyros	12	90	13.3%	18	108	16.7%
Potato dip	19	22	86.4%	11	176	6.3%
Spaghetti	5	27	18.5%	25	171	14.6%

36. (3 pts.) Fill in the gaps in the above table. (3 pts, ½ pt for each correct answer.)

37. (2 pts.) What type of study design is reflected in this table? Why did disease detectives choose this type of design? (A cohort design, because everyone had the same exposure.)

points

38. (1 pt.) What does the number 27 represent in the attack rate among the exposed for spaghetti? (The number of individuals who ate spaghetti.)

39. (2 pts.) Based on the information in the table above, what two foods are most likely to have been the cause of the outbreak?

1. Black olives
2. Eggplant dip
3. Feta cheese
4. Greek salad
5. Gyros
6. Potato dip
7. Spaghetti

40. (10 pts.) Create a 2x2 table for each of the two foods you identified as most likely to have caused this outbreak in question 39. Include the names of the food items as well as row and column labels. (5 pts. for each table; 10 pts. total for all questions; ½ pt. off for each incorrect number if eggplant and potato dip were correctly identified. If food items are wrong but numbers are correct for mis-identified food items, take off 2.5 pts. per incorrect table. If food items are wrong ***and*** numbers are wrong, no points given.)

Food Item:	Got Sick	Didn't Get Sick	Total
Exposed	*19*	*3*	*22*
Not Exposed	*11*	*165*	*176*
	30	*168*	*198*

Food Item:	Got Sick	Didn't Get Sick	Total
Exposed	*6*	*3*	*9*
Not Exposed	*24*	*165*	*189*
Total	*30*	*168*	*198*

41. (3 pts.) Calculate the relative risk (RR) of eating feta cheese and give your answer to three significant figures. (22/106) / (8/92) = 2.39 (Give 6 pts.; one each for getting the right numbers in the right places to start; 2 pts. for the correct answer with three significant figures; 1 pt. for not-quite-the-correct answer based on the wrong number of significant figures. This is a possible tie-breaker question.)

42. (1 pt.) Was feta cheese a likely source of the outbreak? (No.)

points

43. (2 pts.) Provide an interpretation of the relative risk of feta cheese. The risk of becoming ill was 2.39 times higher for restaurant patrons who ate feta cheese compared to patrons who did not eat feta cheese.

44. (1 pt.) What information does a confidence interval (CI) provide when interpreting RR? (The CI provides information on the precision reliability [significance] of the estimate of the relative risk.)

45. (1 pt.) What does it mean if the confidence interval includes 1? (Not significant.)

Knowing the effectiveness of diagnostic tests is important in defining criteria for confirmed and probable cases of botulism. Among the restaurant patrons and employees in El Paso, a confirmed case of botulism was defined by detection of *C. botulinum* in stool. A probable case was defined as electromyography (EMG) findings indicating botulism in a restaurant patron or employee who either did not have *C. botulinum* detected in stool or did not have a stool specimen tested for *C. botulinum*. Symptoms of botulism were not necessary for confirmed or probable cases. Positive EMG findings alone did not confirm a case of botulism, but it did indicate the likelihood that a person was infected.

46. (1 pt.) According to the way in which EMG findings are applied to the above case definitions, would you expect the positive predictive value (PPV) of EMG to be higher or lower than the PPV of *C. botulinum* detection in stool? (I would expect electromyography to have a lower PPV than a stool test.)

47. (2 pts.) Define "positive predictive value" and explain how you reached your conclusion from question 46. (PPV is the proportion of positive test results that accurately diagnose a case. The outbreak investigators felt confident enough to define a confirmed case according to a positive stool test, but only used a positive electromyography test to indicate that a case was probable. Therefore, we can assume that a positive stool test more reliably predicts a case of botulism and therefore has a higher PPV than electromyography. Accept any reasonable answer.)

The true sensitivity and specificity of electromyography is not precisely known. The investigation into the El Paso botulism outbreak demonstrated the diagnostic utility of EMG for persons with symptoms suggestive of botulism, but for whom a diagnosis of botulism has not yet been confirmed (even if several weeks had passed since the onset of illness). EMG can also be helpful in distinguishing botulism from other diseases, such as myasthenia gravis and Guillain-Barré syndrome, which may present with similar symptoms.

points

Consider the scenario in which EMG with rapid repetitive stimulation at 50 Hz was conducted on 40 persons after they had eaten at the restaurant. Assume we know that 25 persons had botulism, 10 of whom were asymptomatic, and the remaining 15 persons did not have botulism. Of the persons with botulism, 20 tested positive; whereas of the persons who did not have botulism 10 tested positive.

48. (2 pts.) Fill in the 2x2 table below. (2 pts, ½ for each correctly-filled box.)

	Test (+)	Test (-)
Botulism (+)	*20*	*5*
Botulism (-)	*10*	*5*

49. (4 pts.) Calculate the sensitivity and specificity of the EMG testing described in the scenario above. (Sensitivity = 20 / (20 + 5) = 20/25 = 80%; Specificity = 5 / (5 + 10) = 5/15 = 33%.) (4 pts.; 1 each for correct calculations; and 1 each for every correct answer.)

50. (4 pts.) Based on your calculations in question #49, would you agree with how the investigators considered EMG as criteria in their definitions of confirmed and probable cases? Explain why you agree or disagree. (Yes. The high sensitivity of the test (80%) indicates that persons with botulism will likely be detected by the test. However, the low specificity (33%) suggests that persons who do not have botulism are also likely to have a positive electromyography (EMG) test. Therefore, because a positive test is inclusive of cases but not exclusive of non-cases, investigators were wise to not consider all positive electromyography (EMG) tests as confirmed cases, but rather to use it as an indication of a probable case. ACCEPT ANY ANSWER THAT CORRECTLY INTERPRETS SENSITIVITY, SPECIFICITY, AND LINKS IT BACK TO CASE DEFINITIONS.(4 pts.; 1 for "yes," 1 for relating high sensitivity to the answer, 1 for relating low specificity to answer, and 1 for linking between sensitivity and specificity.)

points

Part C: Lassa Fever2

The primary mode of transmission of Lassa virus to humans is through the airborne route by inhalation of rodent urine or feces. Although Lassa fever is not normally thought of as a foodborne illness and cooking inactivates the virus, transmission may occur during preparation of raw meat or through eating food contaminated with rodent feces or urine. For this reason, the epidemiology of this infection provides a striking example of the importance of food safety and the issues surrounding food safety in developing countries.

Secondary human-to-human transmission typically occurs through direct contact with the infected body fluids of a symptomatic Lassa fever case (i.e., an infected person) or the remains of infected persons who have died. Multiple diseases can have a single mode of transmission, and one disease can have multiple modes of transmission, which can make prevention and control of the disease more difficult. Similarly, Lassa fever may be associated with mixed exposure outbreaks. These typically begin with a common source and then generate secondary cases through person-to-person spread.

51. (1 pt.) Of the following types of outbreak curves, which one is characteristic of multi-mode transmission or a mixed exposure outbreak of Lassa fever? See Figures 3a-d.

Figure 3a.

2 Some of the studies and data presented in this event have been fabricated or pooled in an effort to develop a cohesive event. However, we believe the underlying concepts and descriptions of the epidemiology of Lassa fever to be scientifically sound.

points

Figure 3b. = correct answer

Figure 3c.

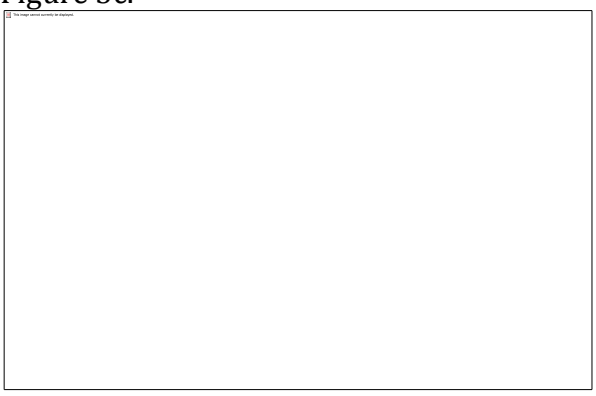
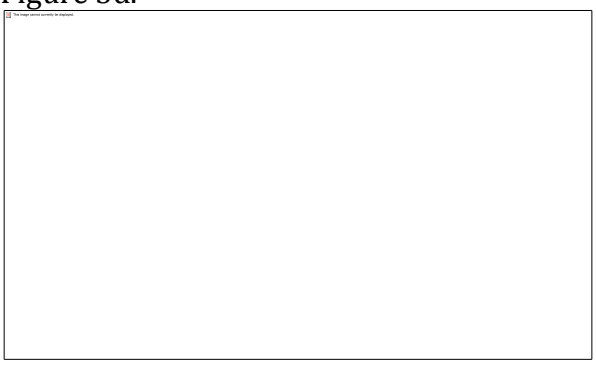


Figure 3d.



points

Lassa fever illness was discovered in 1969 when two missionary nurses died in Lassa, Nigeria. One of the first identified outbreaks of Lassa fever occurred in January and February 1970 on the Jos Plateau in northern Nigeria. In mid-January 1970, a number of patients entered Evangel Hospital in Jos town severely ill with an unidentified acute febrile illness. Because of the similarity between these cases and the cases of Lassa fever seen at Jos just 1 year earlier, paired serum specimens from several patients were obtained for virus studies. By mid-February, there were 26 suspected cases with 10 deaths. Seven of these cases were provisionally confirmed based on antibody testing. Virus isolation was not attempted at that time because of safety concerns. Most of the patients were young adults, but the age range was from 5 months to 46 years; 17 patients were females, 9 males. The severe and fatal cases presented a common clinical picture. Illnesses were characterized by weakness, generalized muscle aches, headache and severe sore throat. The illness lasted from 1 week to over 4 weeks, and those who died did so between 1 and 2 weeks from the onset of symptoms.

52. (1 pt.) In this initial outbreak, what was the case fatality rate? Please give your answer as a percent with 3 significant figures. (10/26 = 38.5%.)

53. (1 pt.) What percentage of the cases was provisionally confirmed? Please give your answer as a percent with 3 significant figures. (7/26 = 26.9%.)

The most striking feature of the 1970 outbreak was the apparent transmission of Lassa infection from one person to possibly 16 others who were exposed to this patient in the hospital ward. Every patient, except for the index case, could be traced to some prior known human source of infection. The index case-patient was presumably infected in Lassa, a town in northeast Nigeria, and subsequently traveled to Jos for treatment.

Since 1970, there have been numerous outbreaks of Lassa fever in Nigeria, Sierra Leone, and other west African countries. Epidemiologists now know much more about the disease, its origin, how it is transmitted, and how it can be controlled and prevented.

54. (1 pt.) Now that epidemiologists know more about the disease, which of the following types of transmission are applicable to Lassa fever. Choose all that apply.

1. Airborne transmission
2. Biologic vector transmission
3. Direct contact
4. Mechanical vector transmission
5. Vehicle borne transmission

Lassa fever is a viral hemorrhagic disease that is acquired from the multimammate rat *Mastomys natalensis*, which sheds the virus in its urine and feces without becoming ill itself. Lassa fever produces an acute illness of 1–4 weeks in duration, with about 80% of human infections being asymptomatic in endemic areas. The incubation period is usually 7–12 days, but it may range between 3 and 21 days. Death usually occurs within 14 days of onset

points

in fatal cases. The disease is especially severe in late pregnancy, with maternal death and/or fetal loss occurring in more than 80% of cases during the third trimester.

55. (1 pt.) An infectious disease that can be transferred from animals to humans is a (an) (zoonosis.)

56. (1 pt.) What term do epidemiologists use to describe the role that *Mastomys rodents* play in the transmission of Lassa virus? (Reservoir — if they only have host minus 0.5 point for Div. C; 1 pt. for Div. B.)

***Mastomys natalensis* (www.fieldmuseum.org)**

People at greatest risk are those living in rural areas where *Mastomys* are usually found, especially areas of poor sanitation or crowded living conditions. The rat typically lives near field crops and stored food and is frequently resident around human settlements. Possible risk factors for Lassa infection include hunting *Mastomys*, cleaning or cooking *Mastomys*, and having one's house infested by rodents. Rodent consumption is also a possible risk factor, since they are considered a delicacy and are eaten by up to 90% of people in some areas.

57. (1 pt.) Inanimate objects such as eating utensils, bedding, and table surfaces that become contaminated and serve to transmit infection are referred to as __fomites__.

Lassa fever is estimated to affect 2 million people annually and cause 5,000–10,000 deaths. Overall, about 1% of Lassa fever case-patients die, but deaths are estimated to occur in 15%–20% of hospitalized patients. Because the symptoms of Lassa fever are so varied and non-specific, clinical diagnosis is often difficult, especially in the early stages of the disease. Lassa fever is difficult to distinguish from many other diseases that cause fever — including

points

malaria, shigellosis, typhoid fever, yellow fever, and other viral hemorrhagic fevers. Therefore, an accurate diagnosis of Lassa fever involves consideration of clinical manifestations, epidemiologic data, and results of laboratory findings.

From January to April 2003, 90 possible cases of Lassa fever reported to Kenema Hospital from two camps holding Liberian refugees in Sierra Leone. Of the admitted patients, 60% were female, 87% were adults aged 18 or older and 21% of the case patients died.

The case definition given in Figure 4 is for **probable** cases of Lassa fever. A **confirmed** case of Lassa fever is defined as a person with signs and symptoms plus laboratory confirmation using a diagnostic test. A **suspect** case is any person with a fever ≥ 38° C. who has been exposed to a confirmed Lassa fever patient. A patient who does not fulfill the criteria for a confirmed, probable, or suspect case is **not a case**.

Figure 4. World Health Organization (WHO) case definition of Lassa fever for diagnosis and treatment of patients where laboratory confirmation is not possible.3

A patient with fever ≥ 38°C not responding to effective anti-malarial and broad-spectrum antibiotics, with no obvious localizing signs of infection and at least 2 major or 1 major and at least 2 minor criterion, are regarded as a probable case of Lassa fever.

Major Criteria

1. Unexplained bleeding from mucous membranes (gum, nose, vagina), skin, or gastrointestinal system
2. Swollen neck or face
3. Conjunctivitis or subconjunctival hemorrhage (red or bloody eyes due to swollen blood vessels)
4. Spontaneous abortion
5. Unexplained tinnitus (ringing of the ears) or altered hearing during a febrile illness
6. Persistent low systolic blood pressure
7. Known exposure to a confirmed Lassa patient
8. Markedly elevated SGOT/AST levels (liver enzyme blood tests)

Minor Criteria

9. Headache

3 Adapted from Bonner, Schmidt, et al (2007). Poor Housing Quality Increases Risk of Rodent Infestation and Lassa Fever in Refugee Camps of Sierra Leone. *Am. J. Trop. Med. Hyg.* 77(1): 169-75.

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10. Sore throat
11. Persistent vomiting
12. Diffuse abdominal pain/tenderness
13. Retrosternal pain (pain behind the chest wall)
14. Diarrhea
15. Generalized myalgia and arthralgia (muscle or joint aches)
16. Profuse weakness
17. Proteinuria (protein in the urine)
18. White blood count < 4000/µL

19. (6 pts.) The line listing is a sample of 12 patients admitted to Kenema Hospital with possible Lassa fever infection. Classify each patient as "Probable," "Confirmed," "Suspected," or "Not a case" using the WHO case definition above and the clinical and laboratory information in the line listing in Table 6.

Table 6.

Case	Temp.	Resp.	Exp.	Bleed	Headache	Vomit	Swelling	Conj.	Diarr.	WBC	Weak	Lab	Classification
1	38.0	N	N	Y	N	Y	N	Y	N	2500	N	N	Probable
2	38.5	N	N	N	N	Y	Y	N	N	4500	N	N	(Not a case)
3	38.6	N	Y	Y	Y	N	N	N	N	10000	N	N	(Suspect)
4	39.1	N	Y	Y	N	Y	Y	Y	N	5000	N	Y	Confirmed
5	38.4	N	Y	N	Y	N	Y	Y	N	6000	Y	Y	Confirmed
6	39.4	N	Y	Y	N	N	Y	N	N	8000	Y	Y	(Confirmed)
7	38.8	N	N	N	Y	Y	N	N	Y	5000	Y	N	Not a case
8	39.0	N	N	Y	N	N	N	N	N	3000	Y	N	(Probable)
9	38.4	N	Y	N	Y	N	Y	N	N	4500	N	N	(Probable)
10	39.1	N	Y	Y	N	N	N	N	N	8000	N	N	(Suspect)
11	38.4	N	Y	N	Y	Y	N	Y	N	4000	Y	N	Probable
12	38.0	N	Y	N	N	N	N	N	N	2000	N	N	Suspect

Key: Y = Yes, N = No
Resp. = Responsive to
Temp. = Oral Temperature, in °C
Bleed = Unexplained bleeding

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Exp. = Exposed to confirmed Lassa
Conj. = Conjunctival hemorrhage
WBC = White Blood Count

Diarrh. = Diarrhea
Lab = Laboratory confirmed

20. (1 pt) Among these 12 patients, what proportion of Lassa fever cases was confirmed?
(3/12 = 25% (or 250 per 1000, other units are acceptable.)

21. (2 pts.) List two (2) reasons why a good case definition is important to epidemiologists. (Possible answers include:
1. Ensure every case is diagnosed consistently
2. Using objective criteria
3. Sensitive and specific case definition captures only true cases of the disease in question
4. So that we can compare cases across time and place with some certainty that they're really the same condition
5. To detect differences in disease occurrence
6. Accept all reasonable answers)

7. (2 pts.) Based on the case definition above, give two (2) reasons why Lassa fever may be difficult to diagnose correctly. (Because of its non-specific symptoms, Lassa fever can easily be confused with other illnesses common in the tropics, like malaria, typhoid, and other viral hemorrhagic fevers. In low-income countries, laboratory facilities may not be available to perform diagnostic tests.)

It was unclear whether rodent-to-human or person-to-person was the dominant transmission pattern in this outbreak. A team of epidemiologists set out to learn more about these 90 case- patients and how the disease was transmitted. The study was conducted in 8 camps in Sierra Leone inhabited by Liberian refugees. Households with Lassa fever included households with at least one case of Lassa fever among permanent household members. Households without Lassa fever were recruited at random from the same camp's population, but not from the same community. Known risk factors for Lassa infection include hunting, cooking, and having one's house infested by rodents. The epidemiologists interviewed household members of the case- patients as well as nearby

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households to determine the prevalence of certain risk factors. They developed a questionnaire and interviewed representatives from 206 households with an average of 17 persons per household and 2.4 persons per room.

Table 7. Rodent Contact and Housing Quality of Households in Sierra Leone Refugee Camps—2003.

Question	Households with Lassa fever (n = 84)		Households without Lassa fever (n = 122)	
	n[1]	%	n[1]	%
Rodents present in/near home	82	98	40	33
Can identify *Mastomys*	71	85	20	16
Hunt rodents for meat	76	91	0	0
Store open food	29	35	5	4
Find excrement in food	81	96	18	15
Rodent burrows in/near home	81	96	65	53
Good housing quality*	34	40	73	60
Good external hygiene**	16	19	68	56

1 These figures represent the number and percentage of 'Yes' responses on the questionnaire.
*Building material made of concrete or solid mud and wood. Windows are tightly protected. Roof is well-maintained. No holes are visible. Foundation is solid and in good condition.
**No debris or clutter against or within 20 feet of the house.

8. (3 pts.) Calculate the appropriate measure of association between having Lassa fever in the household and storing open food. (1 point for correct numbers, 2 points for calculations; minus 2 points if not odds ratio)

	Households with Lassa Fever	Households without Lassa Fever
Storing open food	*29*	*5*
Not storing open food	*55*	*117*

(12.34 or = 29*117/55*5 = 3393/275 = 12.34)

points

9. (2 pts.) Write an interpretation of the measure of association that you calculated in question 62. (Households that store open food have 12.34 times the odds (more likely) to have Lassa fever than people who live in households that do not store open food.)

10. (3 pts.) Calculate the appropriate measure of association between having Lassa fever and good housing quality. (1 point for correct numbers, 2 points for calculations; minus 2 points if not odds ratio)

	Households with Lassa Fever	Households without Lassa Fever
Good Housing Quality	*34*	*73*
Poor Housing Quality	*50*	*49*

(0.456 OR = 34*49/50*73 = 1666/3650 = 0.456)

11. (2 pts.) Write an interpretation of the measure of association that you calculated in question 64. Households that have good housing quality have 0.456 times the odds (54.4% less likely) to have Lassa fever than people who live in households that have poor housing quality. Also can be 1/0.456 or 2.193 times the odds (119.3 % more likely).)

12. (1 pt.) Based on the measure of association that you calculated for good housing quality, epidemiologists would consider good housing quality to be a protective factor.

13. (1 pt.) What study design is involved here? (Case control.)

Studies have shown that about 1% of Lassa fever case-patients die, but deaths are estimated to occur in 15%–20% of hospitalized patients, and these patients are frequently

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the source of data for studies of Lassa fever. In many of these outbreaks, a Lassa fever patient infects other people, including doctors and nurses at the hospital.

14. (1 pt.) What term do epidemiologists use to describe transmission of infectious diseases in a hospital or other healthcare setting? (Nosocomial, healthcare-associated infections, or HAIs.)

15. (1 pt.) How many of the case-patients at Kenema Hospital died? (19)

16. (2 pts.) List two (2) precautions hospital staff can take to reduce transmission in the hospital setting. (Wear gloves, masks, protective clothing, don't reuse syringes, or patient isolation.)

17. (2 pts.) Give two (2) possible explanations why more hospital cases of Lassa fever die than non-hospital cases. (Hospitals have more severe cases and patients in the hospital are in later stages of the disease.)

18. (2 pts.) Provide one (1) advantage and one (1) disadvantage of using data from hospitalized cases compared to using data from the community, from death records, or from other sources.

A: Possible advantages include:

1. Serious illness, so many cases go to the hospital
2. Because medical professionals can provide a correct diagnosis
3. Because medical records are available from hospitals

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4. Hospitalized patients are a "captive audience" and will answer questions about risk factors
5. Poor community-based surveillance
6. Easier to collect data

B: Possible disadvantages include:

1. No information on less severe cases that don't go to the hospital or more severe cases that die before they get to the hospital
2. Selection bias for people who can get to the hospital
3. Might miss very rural or very poor people who can't get to the hospital
4. Eighty percent of cases asymptomatic

5. (3 pts.) List three (3) strategies that people at risk of Lassa fever can do to prevent rodent-to-human transmission in their community. (Use rodent-proof containers, dispose of garbage away from the home, keep a clean house, keep cats, keep food off the ground, use mouse traps, health education, and do not eat rats.)

6. (2 pts.) List two (2) ways to prevent person-to-person transmission in the community. (Stay away from infected people, bandage sores and cuts, and do not exchange body fluids.)

points