# Ebola Epidemic: Teacher Pages

## Summary

This lesson engages students in a series of inquiry-based activities providing information on the current outbreak of Ebola in West Africa, including: a jigsaw activity using resources from the Centers for Disease Control, a simulation based on fluid exchange to model the spread of an outbreak of an infectious disease, and a "disease detective"-style mapping activity based on published data outlining the start of the current Ebola outbreak in Guinea.

## Time Estimate

Two ~45 minute class periods; alternatively, the jigsaw portion can be given as a homework assignment, in which case the Modeling/Tracking an Outbreak components can fit into one class period.

## Learning Styles

Visual, kinesthetic, and auditory

## Vocabulary

**Agent**: a microbe that causes a disease ("what" of the Epidemiological Triangle)

**Endemic**: an outbreak of disease affecting a population or location at consistent levels and for consistent periods of time

**Environment**: external factors that cause or allow transmission of a disease ("where" of the Epidemiological Triangle)

**Epidemic**: an outbreak of disease affecting a disproportionately high number of individuals at a given time

**Epidemiology**: branch of science dealing with the spread and control of disease throughout populations or systems

**Host**: an organism harboring a disease ("who" of the Epidemiological Triangle)

**Index Case**: the initial patient in a population of an epidemiological investigation; also referred to as **Patient Zero**

**Outbreak**: an occurrence of disease greater than would otherwise be expected at a particular time or place

**Pandemic**: an epidemic that occurs over a wide area, such as over multiple continents or across the whole world

**Spillover Event**: Occurs when a reservoir population causes an epidemic in a novel host population. The epidemic is transmitted by the reservoir population and not the host population

## Student Learning Outcomes
The student will be able to:
- Describe the following for Ebola Virus Disease: symptoms, sources and risk factors, diagnosis and detection, treatment, prevention and control.
- Simulate the spread of an infectious disease
- Analyze and graph data, determining dependent and independent variables
- Describe the Epidemiological Triangle: agent, host, and environment
- Describe how epidemiologists think about the origins and spread of infectious disease

## Standards

### Next Generation Sunshine State Standards

**HE.912.C.1.3** Evaluate how environment and personal health are interrelated

**HE.912.C.1.5** Analyze strategies for prevention, detection, and treatment of chronic and communicable diseases

**HE.912.C.2.4** Evaluate how public health and government regulations can influence health promotion and disease prevention

**HE.912.C.2.6** Evaluate the impact of technology on personal, family, and community health

**HE.912.C.2.7** Analyze how culture supports and challenges health beliefs, practices, and behaviors.

**SC.912.L.14.6** Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspective of both individual and public health.

### Common Core State Standards

**RH.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.

**RH.11-12.9** Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information where possible.

**HSS-IC.B.6** Evaluate reports based on data.

**WHST.9-12.7** Conduct short, as well as more sustained, research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

**WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research.

### Next Generation Science Standards – Disciplinary Core Ideas

**ESS3.B: Natural Hazards** Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.

**LS2.A: Interdependent Relationships in Ecosystems** Ecosystems have carrying capacities resulting from biotic and abiotic factors.  The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem.

**LS2.C: Ecosystem dynamics, functioning, and resilience** If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem.

**LS4.D: Biodiversity and humans**

Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth

## Background Information

The information necessary to complete each task is provided in the accompanying handouts or in the introduction of the student worksheets for each component of the lesson.  The Modeling an Outbreak activity is based on two existing activities available from Science Take Out and Project Learning Tree (see references).  The two activities were combined into one, and adapted to be used for Ebola Virus Disease.  The Tracking an Outbreak activity is based on real data published in the New England Journal of Medicine.  Although the vast majority of the information provided for this component adheres to the article, some of the "Investigation Details" provided in the Patient Epidemiological Reports has been slightly altered to better help facilitate completion of the activity.  The portion of this activity discussion the Epidemiological Triangle has been adapted from PBS NewsHour Extra's lesson plan on Ebola (see references).

## Advanced Preparation & Implementation

### Ebola Jigsaw

- Either print out enough copies of the "Ebola Jigsaw" handout for each student in each group, or have enough iPads/computers so that each group has 1-2 devices to look up the CDC website to read.
- Once the groups have gathered and exchanged information, go over the answers together as a class.
- Optional: Have the Ebola infographic (provided) ready to project when the jigsaw is complete, as it gives a good summary and reinforces the most pertinent information in a single visual aid.

### Modeling an Outbreak

- Before class, prepare a small solution of a contaminant (a basic solution). It will serve as the source of the infection. You can mix water with baking soda (1 tablespoon in 200 milliliters [ml] of water will allow detection of up to six exchanges) to obtain a basic solution. For larger or more advanced classes, you can use 0.01 M sodium hydroxide (dissolve 0.4 grams NaOH in 100 ml of distilled water), since this mixture will allow detection of at least eight exchanges.
- Obtain one test tube (or small cup or container) for each student in the class, plus two extra containers to serve as a positive control and a negative control.
- Fill two test tubes (2-5 ml) with the contaminant (basic) solution. Set aside one for the positive controls, and use the remaining one as the source for the class activity. The tube that contains the "contaminant" or basic solution should be marked in an inconspicuous manner, so that only you are aware of who is starting the activity with the contaminated sample.
- Fill the remaining tubes halfway (2 ml) with distilled water. Label one as the positive control.
- Obtain pH indicator strips (pH range 0-14) to use as dipsticks for the test.  Alternatively, phenolphthalein (pH indicator) or a similar indicator can also be used. In this case, you will add approximately 25 microliters (µl) of phenolphthalein (about 1 drop) to each sample to test for contamination.  However, the student worksheet would need to be modified to reflect use phenolphthalein (a positive sample would change from clear to a pinkish-red color).
- Make enough copies of Student Page: Fluid Exchange Record Sheet for each student.
- This activity is designed to have students perform three fluid exchanges, making for a relatively simple deduction of which sample belonged to "patient zero".  For advanced groups, NaOH can be used in place of the baking soda to allow for more exchanges, and thereby increase the difficulty of the activity.

**Tracking an Outbreak**

- Print out copies of the Patient Epidemiological Reports (each pair/group will handle 2 patients). Each patient is given a case number that starts with 01 or 02 – this is based on the NEJM article from which the data was obtained – case numbers beginning with 01 are laboratory-confirmed cases, while case numbers beginning with 02 suspected cases of Ebola. The same basic information is provided for each patient – 01 patient reports indicate that confirmation of Ebola has been received from laboratory tests, while 02 patient reports provide investigation details gathered by workers at the scene.

- Print a large copy of the map of Guinea (provided, but also available from http://www.un.org/Depts/Cartographic/map/profile/guinea.pdf), and put up on a corkboard (for using pushpins), or a wall (for using sticky tabs). Alternatively, you can project this map onto a whiteboard, and have students mark the locations with whiteboard markers or sticky tabs, although the resolution may be too poor when projected to read the village names.

- Post-It Flags of various colors (at least 4); each group will need different color flags, depending on which patients they are given. The following chart, provided in the student worksheet, should be used to determine which color flags to give to each group. These can be altered based on the preference of the teacher and availability of colors, but the student worksheet will also need to be changed to reflect any alterations.

| Date of Onset or Date of Patient Sample | Flag color for Guinea Wall Map |
|---|---|
| December 2013 | Red |
| January 2014 | Yellow |
| February 2014 | Green |
| March 2014 | Blue |

- The questions accompanying this section are designed to be discussed in class as a group, as all of the students have different information. Depending on the level of the students, some of the answers may not be obvious at first, especially questions five and six. The relevant information is provided in the accompanying answer key. Question 6 also provides an excellent opportunity to discuss culture, in particular funeral and burial practices as they are key to the spread of the outbreak in West Africa (see references for article from The Washington Post discussing these practices).

## Extensions

These are based off of the suggested teacher resources from the Ebola Outbreak lesson provided by PBS NewsHour Extra (see References/Resources).

- Math Skills: Analyzing the Data worksheet – Learn more about the patterns in the outbreak and better understand the spread of the Ebola virus in its human hosts by analyzing the latest data from the World Health Organization.

- Reading Skills: Excerpt from *The Hot Zone* by Richard Preston – Learn about the devastating symptoms humans infected with Ebola experience in this excerpt from the frightening true story. However, please be prepared to address misconceptions, as outlined here: http://io9.com/how-the-hot-zone-created-the-worst-myths-about-ebola-1649384576
  - o For higher level students, the article in the New England Journal of Medicine on which the third lesson is based can be used as an introduction to primary literature sources. The following link provides a relatively simple guide for reading scientific papers: http://www.csus.edu/indiv/d/dulaik/papers/Critiquing%20scientific%20papers4.pdf

- Documentary: *Ebola Outbreak* – a 27-minute documentary film from Frontline that brings the viewer into the center of the health crisis burning through West Africa. The story follows the lives of the patients, doctors and volunteer workers joined together by the deadly virus Ebola in its worst recorded outbreak in history.
- To further investigate the biotechnology component, instructors can provide further information on assays such as ELISA, which are often used to diagnose infectious diseases. A standalone lesson on EVD, modified from an existing lesson on Dengue virus, takes the students through the steps of an ELISA using storyboards, and then has the students perform a simulated test to determine which patients are positive for EVD. This extension activity is available for download along with full module at www.cpet.ufl.edu/ebolaepidemic.

## References/Resources

Centers for Disease Control: http://www.cdc.gov/vhf/ebola/

World Health Organization: http://www.who.int/csr/disease/ebola/en/

Project Learning Tree – Biotechnology and Human Health Curriculum: https://www.plt.org/biotechnology

PBS NewsHour Extra: (http://www.pbs.org/newshour/extra/lessons_plans/ebola-outbreak-lesson-plan/.

Baize, S., Pannetier, D., Oestereich, L., Rieger, T., Koivogui, L, Magassouba, N., … Gunther, S. (2014) *Emergence of Zaire Ebola Virus Disease in Guinea.* New England Journal of Medicine, 371(15): 1418-25.

**Ebola Epidemic: Answer Key**

Ebola Virus Disease (EVD), also known as Ebola hemorrhagic fever, is a rare and deadly disease.  The 2014 Ebola epidemic is the largest in history, affecting multiple countries in West Africa.  Two imported cases, including one death, and two locally acquired cases in healthcare workers have been reported in the United States.  Today's activity will help us learn more about Ebola as a disease, as well as the specifics of Ebola epidemic in West Africa.
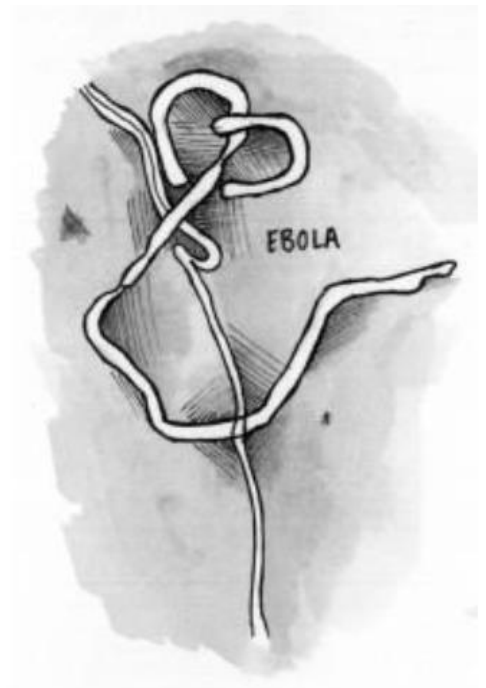
**Part 1: Ebola Jigsaw**

A.  Each group will go onto the CDC website on EVD, available at the following website: http://www.cdc.gov/vhf/ebola/index.html. If you don't have internet access, your instructor will provide you with paper handouts of the same information. Your group will gather information on your topic, as listed below, to share with students in the other groups. You will have ~15 minutes to gather information on your topic from the CDC site, and other reputable sites (please list your sources). From the information that you gather on your topic, you will have about 1 minute to share with other students, so you will need to decide with your group members what is the most relevant information, writing out key details in the space provided.

| Group | Topic |
|-------|-------|
| A | General Information |
| B | Illness and Symptoms |
| C | Sources of Infection and Risk Factors |
| D | Diagnosis and Detection |
| E | Treatment |
| F | Prevention and Control |

Answers here will vary depending on what students feel is the most important information, but should reflect details contained on the website/jigsaw handout.

B.  In groups A-F, count off within your group, 1-4. Form new groups by number (1-4). Each new group should have at least 1 person from each of the topic groups (A-F). Each person should take about 1 minute to share about their topic. Use this information to answer the questions on the next page. Answer each question to the best of your ability based on the information you collected.

1.  Is Ebola a bacteria or a virus?

    Virus

2.  How many species of Ebola are there? Do all of the species cause disease in humans?

    5 species of Ebola; 4 known to cause disease in humans

3. What is the natural host of Ebola virus?

   Undetermined, but suspected to be Fruit Bats

4. List five symptoms of Ebola.

   Fever, severe headache, muscle pain, weakness, fatigue, diarrhea, vomiting, abdominal pain, unexplained hemorrhage (bleeding or bruising).

5. How long after exposure to the virus do symptoms appear?

   Symptoms may appear anywhere from 2 to 21 days after exposure to Ebola, but the average is 8 to 10 days.

6. Can the virus be spread by someone who is not showing any signs or symptoms?

   No

7. What tools are used to diagnose Ebola?

   ELISA (Enzyme-linked immunosorbent assay); IgM/IgG antibodies; Virus Isolation; PCR (polymerase chain reaction); Immunohistochemistry

8. How is the disease transmitted?

   The virus can be spread to others via direct contact with blood of bodily fluids (e.g. urine, saliva, feces, vomit, semen) of an infected person, objects (such as bedding or syringes) that have been contaminated with the virus, or infected animals (such as fruit bats or non-human primates).

9. Is the Ebola virus airborne?

   No; although technically it is possible to transmit the virus by droplet respiration, this is a distinct scenario from being considered an "airborne" illness like the flu.

10. How can Ebola be prevented?
    Good outbreak control relies on applying a package of interventions, namely case management, surveillance and contact tracing, a good laboratory service, safe burials and social mobilization. Community engagement is key to successfully controlling outbreaks. Raising awareness of risk factors for Ebola infection and protective measures that individuals can take is an effective way to reduce human transmission.

11. Which strain of Ebola is responsible for the current outbreak in West Africa?

    Zaire Ebolavirus

12. What countries in West Africa have been affected by the 2014 oubreak?

    The three countries primarily affected by the 2014 outbreak are Guinea, Sierra Leone, and Liberia.  There were a small number of cases reported in Nigeria and a single case reported in Senegal; however, these cases are considered to be contained, with no further spread in these countries.

13. How many total cases of Ebola have been reported in the 2014 outbreak?  How many of these have been confirmed by laboratory testing? How many deaths have been reported?

    As of March 24, 2015: 24,962 total cases; 14,745 laboratory-confirmed cases; 10,353 deaths

**Part 2: Modeling an Epidemic**

In this activity, you are going to model how diseases can spread. You will be given a container full of a liquid.  One person in the class will have a liquid that is already "infected." You will combine your fluid with three of your classmates and then will use a biotechnology technique called an assay to determine if your sample has been infected. The assay involves the use of a dipstick which changes color based on whether the sample is positive or negative.

1. Examine the liquid in your container. Briefly explain what it looks like by describing the color and clarity. Then indicate the volume (for example, is your container half full, three-quarters full, etc.).

   These answers will vary depending on the container used; however, the solution should be clear and colorless to begin with (regardless of whether baking soda or sodium hydroxide was used).

2. Pick a classmate and combine the liquid from your two containers into one. This action will cause the liquid to mix. If the infection is present in one liquid, it will spread to the other liquid. After mixing the two liquids, pour half back into the other container. You should each end up with the same volume of liquid as when you started. Record the name of the person you exchanged fluids with below, as well as the color of your liquid after the exchange.

   Person you exchanged fluids with: Name of Student or Sample Number
   Color of your liquid after exchange: Variable

3. Repeat the fluid exchange with a different classmate, and record the information below.

   Person you exchanged fluids with: Name of Student or Sample Number
   Color of your liquid after exchange: Variable

4. Repeat the fluid exchange for a third and final time. Make sure to pick someone you have not already exchanged fluids with. Record the information below.

   Person you exchanged fluids with: Name of Student or Sample Number
   Color of your liquid after exchange: Variable

5. You are now ready to conduct an assay to determine if your sample is infected. First, you will want to test the assay to ensure that it works by using a positive and negative control. Your teacher has set up a single positive and negative control for the class. Record the results of the controls below, and write a brief description below each entry of what the results mean.

   Positive Control (circle one):      Dark Blue Square

   What does this result indicate?

   As expected for this control, the sample is positive for ebolavirus.

   Negative Control (circle one):      Green Square

   What does this result indicate?

6.  Now, it is time to test your sample. Follow the instructions shown here, and record the results here:

    Experimental Sample (circle one): Answers will vary depending on sample.

    What does this result indicate?

    Answers will vary, but should follow according to the dipstick results (e.g. If the dipstick shows a green square, the sample is negative for ebolavirus. If the dipstick shows a dark blue square, the sample is positive for ebolavirus).

7.  Your teacher will ask how many students are infected. Write the total here: Variable, dependent on number of exchanges

8.  How do you think this number might vary if you increased or decreased the number of exchanges? Explain:

    The relationship is linear, i.e. an increased number of exchanges should lead to a higher number of infections, while a decreased number of exchanges should lead to fewer infections.

9.  The following information was obtained from a class of 25 students who conducted the same experiment but varied the number of exchanges. Graph the data, making sure to label the axes.
    The independent variable (x-axis) is the number of exchanges, while the dependent variable (y-axis) is the number of infections. The graph should appear something like this:
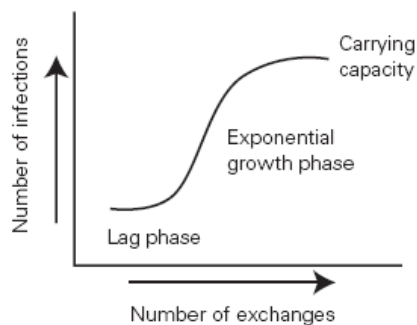


10. Describe the shape of the curve that you drew.
    The curve should be S-shaped (a logistic growth curve, as shown above), characterized by an exponential middle phase and leveling off at the end. In the students experiment of disease transmission, the number of infections will eventually level off (reach carrying capacity), because only a finite number of students in the class can become infected.

11. Why does it never exceed 25 infections?
    Because there are only 25 students in the class (there cannot be a higher number of infections than people).

**Part 3: Tracking an Epidemic**

Epidemiology is the study of the distribution and determinants of health problems in specified populations and the application of that information to control health problems. In other words, epidemiology is the study of health problems—specifically who they affect, what factors play a role in getting a disease and how to contain it. It is the scientific method of problem-solving used by "disease detectives," which includes epidemiologists, laboratory scientists, statisticians, physicians and other health care providers, and public health professionals. These professionals work to get to the root of health problems in a community, solving issues that range from a measles outbreak on a small college campus to a global influenza pandemic, an increase in homicide in a single community to a national surge in violence, or a localized to widespread rise in cancer.

Like investigators at the scene of a crime, disease detectives begin by looking for clues. They systematically gather information about what happened, asking questions like: Who is sick? What are their symptoms? When did they get sick? Where could they have been exposed to the illness? Using statistical analysis, investigators study the answers to these questions to find out how a particular health problem entered a community. The Epidemiological Triangle is a model that scientists have developed to understand infectious diseases and how they spread.  The triangle has three corners (vertices):

- **Agent**, or microbe that caused the disease (the "what" of the triangle)
- **Host**, or organism harboring the disease (the "who" of the triangle)
- **Environment**, or external factors contributing to disease transmission (the "where" of the triangle)

The mission of an epidemiologist is to break at least one side of the triangle, disrupting the connection between the agent, the host, and the environment, and stopping the continuation of the disease.

**Instructions**

In the previous section of this lesson, you modeled an outbreak of infectious disease.  In this portion, you will act as a disease detective, using patient epidemiological reports provided by healthcare workers active on the scene, to track the current outbreak of Ebola Zaire in Guinea to its origin.

Each group will be given 2-3 patient records.  Based on the information provided, each group will:

1. Determine the chronology of the outbreak in Guinea.  Using the chart below, indicate the date and patient case number on the flag as shown on the sample here.

12/13, 01101
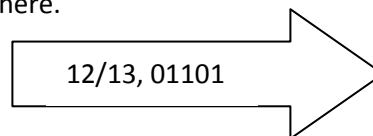
| Date of Onset or Date of Patient Sample | Flag color to use on Wall Map |
| --- | --- |
| December 2013 | Red |
| January 2014 | Yellow |
| February 2014 | Green |
| March 2014 | Blue |

2. Once you have a flag for each patient, place the flags in the correct location on the large wall map of Guinea. If the patient is deceased, label the map with the flags at the location of death.

Once all the flags have been placed, the map should look something like this:

**Questions**

1. Based on the placement and color of the flags, when and where did the outbreak begin?

   The red flags are the ones indicating patients with the earliest dates of onset.  The outbreak began in early December of 2013 in Guéckédou.

2. Can we determine Patient Zero of the outbreak?  Suggest at least one way the patient could have gotten infected.

   Based on the epidemiological reports, patient zero is case number 02101, a two-year old boy whose symptoms began on December 2$^{nd}$, and passed away four days later on December 6$^{th}$.  There are several possibilities for how the boy could have gotten infected, which include: eating infected bushmeat, eating fruit/food that had been contaminated with animal bodily fluids (i.e. bat urine), or touching the carcass of an infected animal.

3. Using the investigation details provided on the epidemiological report, identify which patients are likely to have aided in the spread of the outbreak from city to city.
   02109 – Friend of the patient 02106 (village midwife, Guéckédou), died in Kaliahun, Sierra Leone.

   02110 – Nephew of patient 02106, died in Conakry (capital of Guinea).

   02112 – Worked as a trader/merchant; traveled to Loffa County, Liberia prior to death

   02114 – Healthcare worker at Guéckédou hospital and relative of patient 01107; died in Macenta.

   02115 – Doctor of patient 02114 at Macenta hospital; funeral took place in Kissidigou.

   01112, 01114 – Patients were diagnosed at Macenta hospital, but died in Nzérékoré

4. Briefly outline the spread of the outbreak through Guinea (and beyond).
   Note: It is less important that the students trace the outbreak through the villages of Guéckédou, the most important information comes in tracking the spread of the disease from city to city.
   The outbreak started in **Guéckédou** in December, beginning in the Meliandou village and spreading to Dawa, Dandou Pombo, and Baladou in January (Guéckédou villages are not shown on the map, but this information is given in the Epidemiological Reports).  Early in February, a health care worker at Guéckédou hospital became symptomatic, and died 5 days later in **Macenta**.  The doctor treating the patient in Macenta also contracted the

illness, but had his funeral in **Kissidigou** in late February.  Two others diagnosed in Macenta died and were buried in **Nzérékoré,** a regional capital city**,** in March.  As described in the previous question, several patients (who likely contracted the disease in Guéckédou or Macenta), traveled to **Conakry**, **Sierra Leone**, and **Liberia**.

5.  Looking at the map, what other factors may have also contributed to the spread?
    There is essentially one main road to travel through Guinea (the heavy red line on the map; see Map Legend). There are some smaller branches of the main road near the country's borders, but travel across the country requires use of a single road. All of the airports (5) in Guinea are on this main road, including the international airport in Conakry (Guinea's capital).  Guéckédou, where the outbreak began, sits right on the borders of Sierra Leone and Liberia.

6.  Fill in the epidemiological triangle for the ebola outbreak based on all the information you've been given.
    - Agent: Zaire Ebolavirus
    - Host (Assumed): Fruit Bat
    - Environment: Rural Guinea

7.  As an epidemiologist trying to curb the outbreak, which side of the triangle would you target?  Suggest potential strategies to prevent the spread of ebola based on the vertex of the triangle you selected.
    Answers will vary.

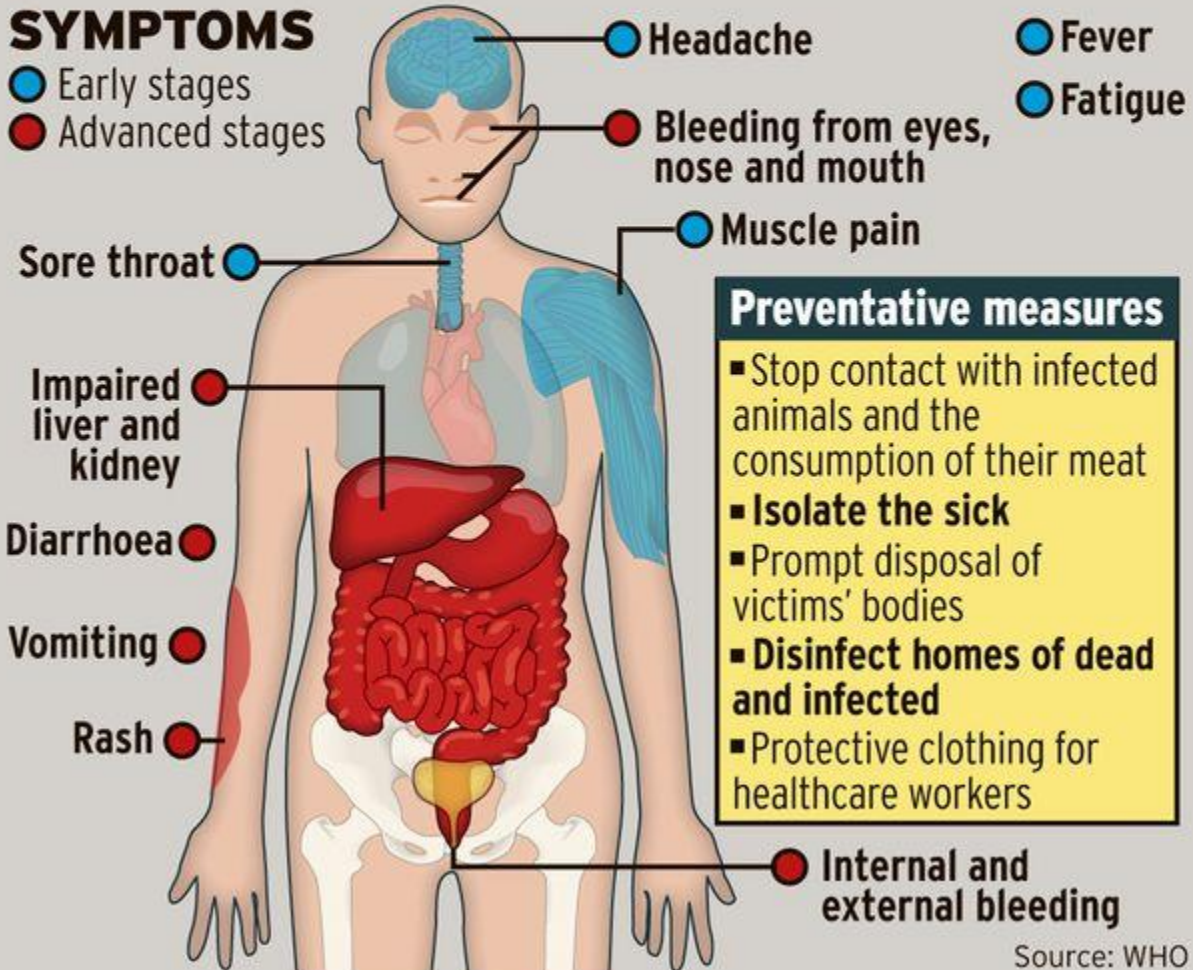Appendix A: Ebola Infographic to accompany Jigsaw

# EBOLA: KILLER VIRUS

An outbreak of the deadly Ebola virus is spread by close contact and kills between 25 and 90 percent of victims. There is no cure or vaccine

## SYMPTOMS
- Early stages
- Advanced stages

- Headache
- Fever
- Fatigue
- Bleeding from eyes, nose and mouth
- Muscle pain
- Sore throat
- Impaired liver and kidney
- Diarrhoea
- Vomiting
- Rash
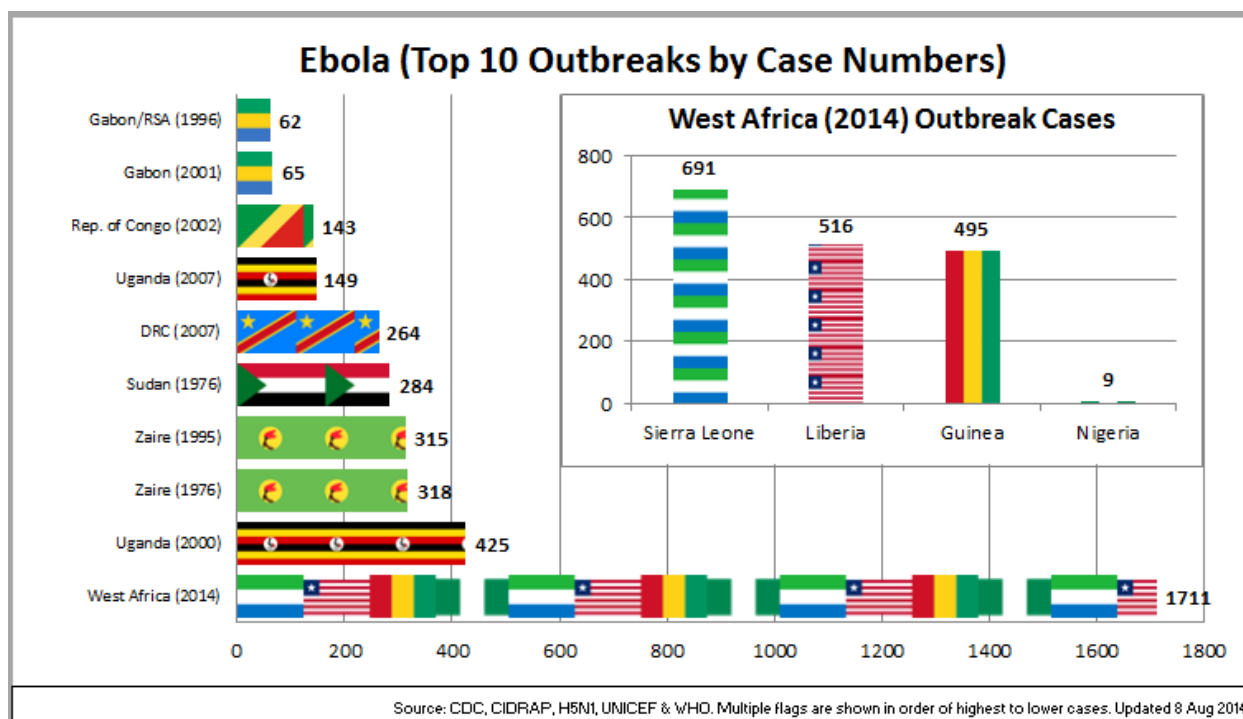- Internal and external bleeding

### Preventative measures
- Stop contact with infected animals and the consumption of their meat
- **Isolate the sick**
- Prompt disposal of victims' bodies
- **Disinfect homes of dead and infected**
- Protective clothing for healthcare workers

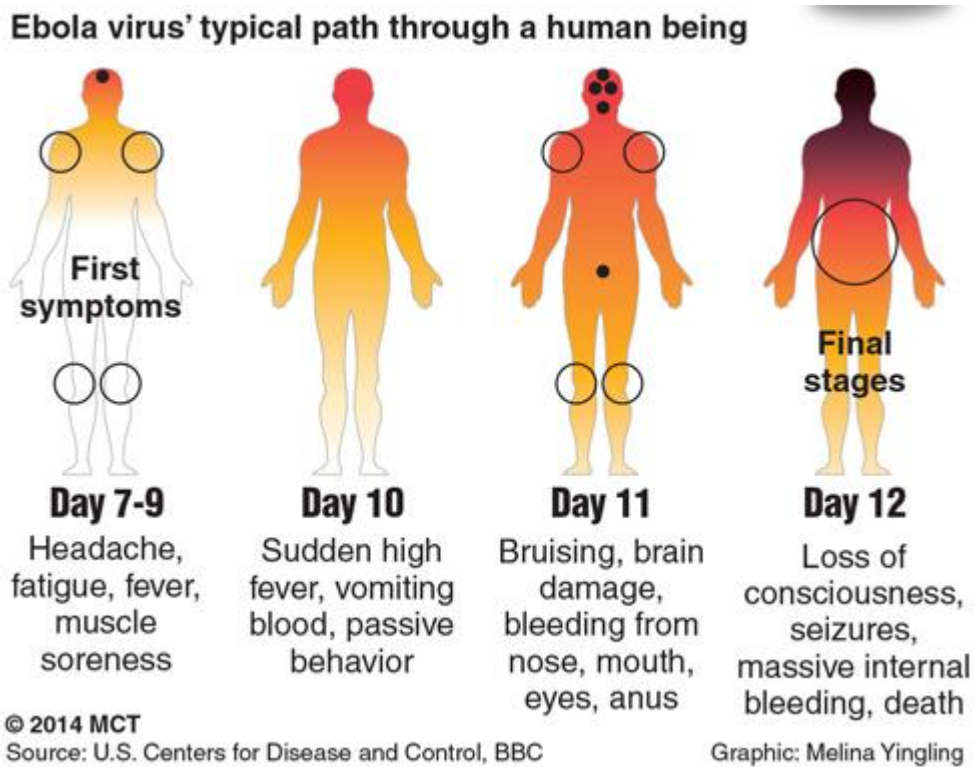Source: WHO

# General Information

The 2014 Ebola epidemic is the largest in history, affecting multiple countries in West Africa (Guinea, Liberia, Sierra Leone). There were a small number of cases reported in Nigeria and a single case reported in Senegal; however, these cases are considered to be contained, with no further spread in these countries. Two imported cases, including one death, and two locally acquired cases in healthcare workers have been reported in the United States.

Ebola, previously known as Ebola hemorrhagic fever, is a rare and deadly disease caused by infection with one of the Ebola virus strains. Ebola can cause disease in humans and nonhuman primates (monkeys, gorillas, and chimpanzees). Ebola is caused by infection with a virus of the family *Filoviridae,* genus *Ebolavirus*. There are five identified Ebola virus species, four of which are known to cause disease in humans: Ebola virus (*Zaire ebolavirus*); Sudan virus (*Sudan ebolavirus*); Taï Forest virus (*Taï Forest ebolavirus*, formerly *Côte d'Ivoire ebolavirus*); and Bundibugyo virus (*Bundibugyo ebolavirus*). The fifth, Reston virus (*Reston ebolavirus*), has caused disease in nonhuman primates, but not in humans.

## Ebola (Top 10 Outbreaks by Case Numbers)

| Outbreak | Cases |
| --- | --- |
| Gabon/RSA (1996) | 62 |
| Gabon (2001) | 65 |
| Rep. of Congo (2002) | 143 |
| Uganda (2007) | 149 |
| DRC (2007) | 264 |
| Sudan (1976) | 284 |
| Zaire (1995) | 315 |
| Zaire (1976) | 318 |
| Uganda (2000) | 425 |
| West Africa (2014) | 1711 |

### West Africa (2014) Outbreak Cases

| Country | Cases |
| --- | --- |
| Sierra Leone | 691 |
| Liberia | 516 |
| Guinea | 495 |
| Nigeria | 9 |

Source: CDC, CIDRAP, H5N1, UNICEF & WHO. Multiple flags are shown in order of highest to lower cases. Updated 8 Aug 2014

# Illness and Symptoms

Symptoms of EVD include: fever, severe headache, muscle pain, weakness, fatigue, diarrhea, vomiting, abdominal pain, unexplained hemorrhage (bleeding or bruising).  Symptoms may appear anywhere from 2 to 21 days after exposure to Ebola, but the average is 8 to 10 days.  Recovery from Ebola depends on good supportive clinical care and the patient's immune response. People who recover from Ebola infection develop antibodies that last for at least 10 years.

## Ebola virus' typical path through a human being

**First symptoms**

**Final stages**

**Day 7-9**
Headache, fatigue, fever, muscle soreness

**Day 10**
Sudden high fever, vomiting blood, passive behavior

**Day 11**
Bruising, brain damage, bleeding from nose, mouth, eyes, anus

**Day 12**
Loss of consciousness, seizures, massive internal bleeding, death

© 2014 MCT
Source: U.S. Centers for Disease and Control, BBC

Graphic: Melina Yingling

A person is considered PUI (Person Under Investigation) has both consistent signs/symptoms and risk factors as follows:
1. Elevated body temperature or subjective fever or symptoms, including severe headache, fatigue, muscle pain, vomiting, diarrhea, abdominal pain, or unexplained hemorrhage; **AND**
2. An epidemiologic risk factor within the 21 days before the onset of symptoms.

The average Ebola case fatality rate is around 50%.  Case fatality rates have varied from 25% to 90% in past outbreaks.

# Sources of Infection and Risk Factors

Ebola viruses are found in several African countries. Ebola was first discovered in 1976 near the Ebola River in what is now the Democratic Republic of the Congo. Since then, outbreaks have appeared 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 animal-borne and that bats are the most likely reservoir. Four of the five virus strains occur in an animal host native to Africa.

Because the natural reservoir host of Ebola viruses has not yet been identified, the way in which the virus first 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, such as a fruit bat or primate (apes and monkeys), which is called a spillover event. Person-to-person transmission follows and can lead to large numbers of affected people. In some past Ebola outbreaks, primates were also affected by Ebola and multiple spillover events occurred when people touched or ate infected primates.

When an infection occurs in humans, the virus can be spread to others through direct contact (through broken skin or mucous membranes in, for example, the eyes, nose, or mouth) with

- blood or body fluids (including but not limited to urine, saliva, sweat, feces, vomit, breast milk, and semen) of a person who is sick with Ebola
- objects (like needles and syringes) that have been contaminated with the virus
- infected fruit bats or primates (apes and monkeys)

Ebola is not spread through the air, by water, or in general, by food. However, in Africa, Ebola may be spread as a result of handling bushmeat (wild animals hunted for food) and contact with infected bats.
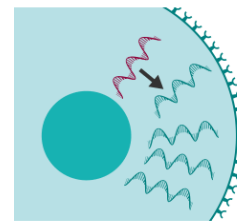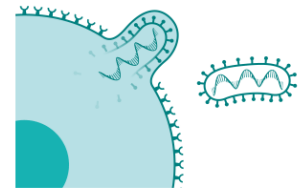
**How Ebola virus spreads**

**Human cell**

**Virus**

**Nucleus**
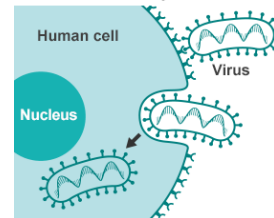
**1** Ebola virus fuses with cells lining respiratory tract, eyes or body cavities
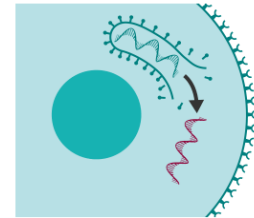
**2** The virus's genetic contents are released into the cell

**3** This ger machine

Source: World Health Organization

There is no evidence that mosquitoes or other insects can transmit Ebola virus. Only a few species of mammals (e.g., humans, bats, monkeys, and apes) have shown the ability to become infected with and spread Ebola virus.

Healthcare providers caring for Ebola patients and family and friends in close contact with Ebola patients are at the highest risk of getting sick because they may come in contact with infected blood or body fluids. During outbreaks of Ebola, the disease can spread quickly within healthcare settings (such as a clinic or hospital). Exposure to Ebola can occur in healthcare settings where hospital staff are not wearing appropriate personal protective equipment.

Dedicated medical equipment (preferably disposable, when possible) should be used by healthcare personnel providing patient care. Proper cleaning and disposal of instruments, such as needles and syringes, also are important. If instruments are not disposable, they must be sterilized before being used again. Without adequate sterilization of instruments, virus transmission can continue and amplify an outbreak.

Once people recover from Ebola, they can no longer spread the virus to people in the community. However, because Ebola can stay in semen after recovery, men should abstain from sex (including oral sex) for three months. If abstinence is not possible, condoms may help prevent the spread of Ebola. Sexual transmission of Ebola has never been reported.

# Diagnosis and Detection

Diagnosing Ebola in a person who has been infected for only a few days is difficult because the early symptoms, such as fever, are nonspecific to Ebola infection and often are seen in patients with more common diseases, such as malaria and typhoid fever.  However, if a person has the early symptoms of Ebola and has had contact with the blood or body fluids of a person sick with Ebola; contact with objects that have been contaminated with the blood or body fluids of a person sick with Ebola; or contact with infected animals, they should be isolated and public health professionals notified. Samples from the patient can then be collected and tested to confirm infection.

Ebola virus is detected in blood only after onset of symptoms, most notably fever, which accompany the rise in circulating virus within the patient's body. It may take up to three days after symptoms start for the virus to reach detectable levels.

Laboratory tests used in diagnosis include:

| Timeline of Infection | Diagnostic Tests Available |
| --- | --- |
| Within a few days after symptoms begin | <ul><li>Antigen-capture ELISA</li><li>IgM ELISA</li><li>Polymerase Chain Reaction (PCR)</li><li>Virus Isolation</li></ul> |
| Later in disease course, or after recovery | <ul><li>IgM and IgG antibodies</li></ul> |
| Retrospectively in deceased patients | <ul><li>Immunohistochemistry testing</li><li>PCR</li><li>Virus Isolation</li></ul> |



Source: World Health Organization

# Treatment

Symptoms of Ebola and complications are treated as they appear. The following basic interventions, when used early, can significantly improve the chances of survival:
- Providing intravenous fluids (IV) and balancing electrolytes (body salts).
- Maintaining oxygen status and blood pressure.
- Treating other infections if they occur.

No FDA-approved vaccine or medicine (e.g., antiviral drug) is available for Ebola.  Experimental vaccines and treatments for Ebola are under development, but they have not yet been fully tested for safety or effectiveness.

Recovery from Ebola depends on good supportive care and the patient's immune response. People who recover from Ebola infection develop antibodies that last for at least 10 years, possibly longer. It is not known if people who recover are immune for life or if they can become infected with a different species of Ebola. Some people who have recovered from Ebola have developed long-term complications, such as joint and vision problems.  If you travel to or are in an area affected by an Ebola outbreak, make sure to do the following:
- Practice careful hygiene. For example, wash your hands with soap and water or an alcohol-based hand sanitizer and avoid contact with blood and body fluids.
- Do not handle items that may have come in contact with an infected person's blood or body fluids (such as clothes, bedding, needles, and medical equipment).
- Avoid funeral or burial rituals that require handling the body of someone who has died from Ebola.
- Avoid contact with bats and nonhuman primates or blood, fluids, and raw meat prepared from these animals.
- Avoid facilities in West Africa where Ebola patients are being treated. The U.S. embassy or consulate is often able to provide advice on facilities.
- After you return, monitor your health for 21 days and seek medical care immediately if you develop symptoms of Ebola.



Source: Centers for Disease Control

# Prevention and Control

Good outbreak control relies on applying a package of interventions, namely case management, surveillance and contact tracing, a good laboratory service, safe burials and social mobilization. Community engagement is key to successfully controlling outbreaks. Raising awareness of risk factors for Ebola infection and protective measures that individuals can take is an effective way to reduce human transmission. Risk reduction messaging should focus on several factors:

- **Reducing the risk of wildlife-to-human transmission** from contact with infected fruit bats or monkeys/apes and the consumption of their raw meat. Animals should be handled with gloves and other appropriate protective clothing. Animal products (blood and meat) should be thoroughly cooked before consumption.
- **Reducing the risk of human-to-human transmission** from direct or close contact with people with Ebola symptoms, particularly with their bodily fluids. Gloves and appropriate personal protective equipment should be worn when taking care of ill patients at home. Regular hand washing is required after visiting patients in hospital, as well as after taking care of patients at home.
- **Outbreak containment measures** including prompt and safe burial of the dead, identifying people who may have been in contact with someone infected with Ebola, monitoring the health of contacts for 21 days, the importance of separating the healthy from the sick to prevent further spread, the importance of good hygiene and maintaining a clean environment.



Healthcare workers who may be exposed to people with Ebola should follow these steps:
- Wear appropriate personal protective equipment (PPE).
- Practice proper infection control and sterilization measures.
- Isolate patients with Ebola from other patients.
- Avoid direct, unprotected contact with the bodies of people who have died from Ebola.
- Notify health officials if you have had direct contact with the blood or body fluids, such as but not limited to, feces, saliva, urine, vomit, and semen of a person who is sick with Ebola. The virus can enter the body through broken skin or unprotected mucous membranes in, for example, the eyes, nose, or mouth.

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| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01101<br>**Age:** 20<br>**Gender:** Female<br>**Hospital:** Guéckédou<br>**Sample Date:** March 12<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Deceased, March 18<br>**Laboratory Confirmation:** Y | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01102<br>**Age:** 25<br>**Gender:** Female<br>**Hospital:** Guéckédou<br>**Sample Date:** March 13<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Deceased, March 25<br>**Laboratory Confirmation:** Y |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01103<br>**Age:** 35<br>**Gender:** Female<br>**Hospital:** Guéckédou<br>**Sample Date:** March 13<br>**Symptoms:** Fever, vomiting<br>**Outcome:** Deceased, March 17<br>**Laboratory Confirmation:** Y | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01104<br>**Age:** 25<br>**Gender:** Female<br>**Hospital:** Guéckédou<br>**Sample Date:** March 18<br>**Symptoms:** Fever, diarrhea, vomiting, hemorrhage<br>**Outcome:** Deceased, March 18<br>**Laboratory Confirmation:** Y |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01105<br>**Age:** 16<br>**Gender:** Female<br>**Hospital:** Guéckédou<br>**Sample Date:** March 19<br>**Symptoms:** Miscarriage<br>**Outcome:** Survived<br>**Laboratory Confirmation:** Y | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01106<br>**Age:** 27<br>**Gender:** Female<br>**Hospital:** Guéckédou<br>**Sample Date:** March 20<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Deceased, Date unknown<br>**Laboratory Confirmation:** Y |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01107<br>**Age:** 47<br>**Gender:** Female<br>**Hospital:** Guéckédou<br>**Sample Date:** March 20<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Deceased, March 22<br>**Laboratory Confirmation:** Y | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01108<br>**Age:** 29<br>**Gender:** Male<br>**Hospital:** Macenta<br>**Sample Date:** March 16<br>**Symptoms:** Fever, hemorrhage<br>**Outcome:** Deceased, March 16<br>**Laboratory Confirmation:** Y |
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| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01109<br>**Age:** 55<br>**Gender:** Female<br>**Hospital:** Macenta<br>**Sample Date:** March 16<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Deceased, March 19<br>**Laboratory Confirmation:** Y | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01110<br>**Age:** 17<br>**Gender:** Male<br>**Hospital:** Macenta<br>**Sample Date:** March 16<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Unknown<br>**Laboratory Confirmation:** Y |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01111<br>**Age:** 7<br>**Gender:** Male<br>**Hospital:** Macenta<br>**Sample Date:** Unknown<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Deceased, March 26<br>**Laboratory Confirmation:** Y | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01112<br>**Age:** 30<br>**Gender:** Male<br>**Hospital:** Macenta<br>**Sample Date:** February 28<br>**Symptoms:** Fever, vomiting<br>**Outcome:** Deceased, February 28 in Nzérékoré<br>**Laboratory Confirmation:** Y |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01113<br>**Age:** 50<br>**Gender:** Male<br>**Hospital:** Macenta<br>**Sample Date:** March 12<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Outcome:** Deceased, March 12<br>**Laboratory Confirmation:** Y | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01114<br>**Age:** 41<br>**Gender:** Male<br>**Hospital:** Macenta<br>**Sample Date:** March 13<br>**Symptoms:** Fever, diarrhea, vomiting, hemorrhage<br>**Outcome:** Deceased, March 16 in Nzérékoré<br>**Laboratory Confirmation:** Y |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 01115<br>**Age:** 28<br>**Gender:** Female<br>**Hospital:** Kissidougou<br>**Sample Date:** March 17<br>**Symptoms:** Fever, diarrhea, vomiting, hemorrhage<br>**Outcome:** Survived<br>**Laboratory Confirmation:** Y | |
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| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02101<br>**Village:** Meliandou, Guéckédou<br>**Symptoms:** Fever, black stool, vomiting<br>**Onset:** December 2, 2013<br>**Outcome:** Deceased, December 6<br>**Investigation Details:** Male Child, Age 2 | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02102<br>**Village:** Meliandou, Guéckédou<br>**Symptoms:** Fever, black stool, vomiting<br>**Onset:** December 25, 2013<br>**Outcome:** Deceased, December 29<br>**Investigation Details:** Age 3, sister of patient 02101 |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02103<br>**Gender:** Female<br>**Village:** Meliandou, Guéckédou<br>**Symptoms:** Bleeding<br>**Onset:** Unknown<br>**Outcome:** Deceased, December 13<br>**Investigation Details:** Mother of patients 02101 and 02102 | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02104<br>**Gender:** Female<br>**Village:** Meliandou, Guéckédou<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Onset:** Unknown<br>**Outcome:** Deceased, January 1<br>**Investigation Details:** Grandmother of patients 02101 and 02101 |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02105<br>**Gender:** Female<br>**Village:** Meliandou, Guéckédou<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Onset:** January 29, 2014<br>**Outcome:** Deceased, February 2<br>**Investigation Details:** Nurse | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02106<br>**Gender:** Female<br>**Village:** Meliandou, Guéckédou<br>**Symptoms:** Fever, diarrhea, vomiting<br>**Onset:** January 25, 2014<br>**Outcome:** Deceased, February 2<br>**Investigation Details:** Village Midwife |
| **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02107<br>**Gender:** Female<br>**Village:** Dawa, Guéckédou<br>**Symptoms:** Fever, diarrhea, vomiting, hemorrhage<br>**Onset:** January 20, 2014<br>**Outcome:** Deceased, January 26<br>**Investigation Details:** Sister of patient 02104 | **Epidemiological Report**<br>**Patient Summary**<br><br>**Case Number:** 02108<br>**Gender:** Female<br>**Village:** Dawa, Guéckédou<br>**Symptoms:** Fever, bleeding<br>**Onset:** January 25, 2014<br>**Outcome:** Deceased, January 30<br>**Investigation Details:** Attended funeral of patient 02104 |
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| Epidemiological Report<br>Patient Summary | Epidemiological Report<br>Patient Summary |
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| **Case Number:** 02109<br>**Symptoms:** Fever, hemorrhage<br>**Onset:** February 28, 2014<br>**Outcome:** Deceased, exact date unknown<br>**Investigation Details:** Friend of patient 02106; died in Kaliahun, Sierra Leone | **Case Number:** 02110<br>**Symptoms:** Fever, vomiting, diarrhea<br>**Onset:** Unknown<br>**Outcome:** Deceased, February 1<br>**Investigation Details:** Nephew of patient 02106; died in Conakry, Guinea |
| Epidemiological Report<br>Patient Summary | Epidemiological Report<br>Patient Summary |
| **Case Number:** 02112<br>**Village:** Baladou District, Guéckédou<br>**Symptoms:** Fever, diarrhea, hemorrhage<br>**Onset:** February 28, 2014<br>**Outcome:** Deceased, March 12<br>**Investigation Details:** Trader by occupation; traveled to Loffa County, Liberia prior to death | **Case Number:** 02113<br>**Village:** Pombo, Guéckédou<br>**Symptoms:** Fever, hemorrhage<br>**Onset:** February 4, 2014<br>**Outcome:** Deceased, February 11<br>**Investigation Details:** Family member of patient 02106 |
| Epidemiological Report<br>Patient Summary | Epidemiological Report<br>Patient Summary |
| **Case Number:** 02114<br>**Village:** Pombo, Guéckédou<br>**Symptoms:** Fever, vomiting, diarrhea<br>**Onset:** February 5, 2014<br>**Outcome:** Deceased, February 10<br>**Investigation Details:** Related to patient 01107. Health care worker at Guéckédou hospital; died in Macenta | **Case Number:** 02115<br>**Symptoms:** Vomiting, bleeding, hiccups<br>**Onset:** February 19, 2014<br>**Outcome:** Deceased, February 24<br>**Investigation Details:** Doctor of patient 02114 at Macenta hospital.  Funeral took place in Kissidigou |
| Epidemiological Report<br>Patient Summary | Epidemiological Report<br>Patient Summary |
| **Case Number:** 02116<br>**Symptoms:** Fever, vomiting<br>**Onset:** February 24, 2014<br>**Outcome:** Deceased, March 7<br>**Investigation Details:** Brother of patient 02115 | **Case Number:** 02117<br>**Symptoms:** Fever, vomiting, hiccups<br>**Onset:** February 24, 2014<br>**Outcome:** Deceased, March 8<br>**Investigation Details:** Brother of patient 02115 |