Case Study 3: Viral Hemorrhagic Fevers

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Financial Disclosures

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Learning Objectives

- Recognize when to be concerned about potential emerging infections
- Outline universal actions that can and should be taken to care for patients, staff, and public
- Describe diagnostics for Ebola virus disease
(S1) Child, 2 years old  
Fever, black stool, vomiting  
Onset Dec 2, 2013; Died Dec 6, 2013

(S2) Sister of S1, 3 years old  
Fever, black diarrhea, vomiting  
Onset Dec 25, 2013; Died Dec 29, 2013

(S3) Mother of S1 and S2  
Bleeding  
Died Dec 13, 2013

(S14) HCW at Guéckédou hospital  
Fever, diarrhea, vomiting  
Onset Feb 5, 2014  
Went to Macenta hospital  
Died Feb 10, 2014

(S6) Village midwife  
Fever  
Hospitalized in Guéckédou  
Jan 25, 2014; Died Feb 2, 2014

Mapping Ebola Outbreak in Guinea

Conakry

Sierra Leone

Liberia

Macenta

Pregnant

HCWs and Ebola

- 1995 outbreak (Kikwit\(^1\))
  - 80 (25%) occurred in HCWs
- 2013-2016 outbreak (West Africa\(^2,3\))
  - 881 HCWs infected
  - 513 deaths
  - 21- to 32-fold higher risk

Courtesy of Dr. Tom Fletcher.

2. CDC. www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa;
Source of HCW Infection

- Difficult to identify the precise risk factor and setting
  - Community vs nosocomial transmission?
- Serious gaps in IPC
  - Deficiencies in administrative and environmental control
  - Inappropriate use or lack of PPE
  - Defective IPC practice and behavior
  - Poor employment conditions and social determinants

Infection in HCWs Can and Must Be Prevented

- HCW protection is **PARAMOUNT** to maintain healthcare capacity
  - 38%-111% increase in maternal mortality
  - 45%-140% increase in untreated malaria
- HCW infection decreased with training
  - 12% in July 2014 to 1% in February 2015

Ebola Virus Ecology

Human-to-Human Transmission

- Ebola is spread through direct contact (through broken skin or unprotected mucous membranes) with:
  - An infected person’s blood or body fluids, including but not limited to urine, saliva, diarrhea, vomit, semen, vaginal fluid, and breast milk
  - Contaminated objects (eg, needles, syringes)
- Human-to-human transmission via aerosols has not been demonstrated
- Asymptomatic individuals are generally not infectious (vs sexual activity)
- Infectivity increases with illness severity

How Contagious Is Ebola?

The number of people that one sick person will infect (on average) is called $R_0$. Here are the maximum $R_0$ values for a few viruses.

- Hepatitis C (2)
- Ebola (2)
- HIV (4)
- SARS (4)
- Mumps (10)
- Measles (18)

Doucelf M. www.npr.org/blogs/health/2014/10/02/352983774/no-seriously-how-contagious-is-Ebola.
Ebola Transmission in the US

- **Sep 20, 2014**: Liberia to Texas
- **Sep 24, 2014**: Symptom onset
- **Sep 25, 2014**: ED → Sinus infection
- **Sep 28, 2014**: Admitted to hospital
- **Oct 8, 2014**: Died
- **Oct 10, 2014 and Oct 15, 2014**: 2 HCWs infected

Contact with 48 individuals

Contact with 120 individuals

Viral Load Correlates With Illness

Ebola Diagnosed Outside of Africa and Secondary Transmission

Ohio
164 contacts traced
0 transmissions

New York
117 contacts traced
0 transmissions

Texas
177 contacts traced
0 prehospital transmissions

United Kingdom
55 contacts traced
0 transmissions

Spain
83 contacts traced
0 transmissions

Persistence of Ebola Virus in Body Fluids

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Acute phase</th>
<th>Convalescent phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viremia/Blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saliva/Swab</td>
<td></td>
<td></td>
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<tr>
<td>Urine</td>
<td></td>
<td></td>
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<tr>
<td>Tears/Conj.</td>
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<td></td>
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<tr>
<td>Semen</td>
<td></td>
<td></td>
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<tr>
<td>Skin/Sweat</td>
<td></td>
<td></td>
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<tr>
<td>Vaginal</td>
<td></td>
<td></td>
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<tr>
<td>Rectal/Feces</td>
<td></td>
<td></td>
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<tr>
<td>Breast Milk</td>
<td></td>
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<tr>
<td>CSF</td>
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</tbody>
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Infection Prevention and Control

- **Goal**—to decrease exposure
  - **Environmental controls**
    - Construction/maintenance of an appropriate facility
    - Establishment of clean water and sanitation
    - Waste management
  - **Administrative controls**
    - Triage
    - Training of HCW (including donning/doffing processes)
  - **Personal controls**
    - Standard precautions (including hand hygiene and PPE use)
IPC: Environmental Considerations

- Dedicate a zone for screening and organize areas into:
  - A low-risk zone for HCW
  - A high-risk zone for suspected and confirmed cases
  - A triage area accessible to both high- and low-risk zones
- Ensure unidirectional flow
- Restrict all nonessential staff and visitors from screening/isolation areas
- Ensure proper waste management
  - Sharps disposal

Personal communications with Dr. Fischer.
Institutional and Environmental Controls

Personal communications with Dr. Fischer.
Rapid Identification and Isolation

- **ASK**
  - Ask every patient with fever or symptoms of Ebola if he/she recently traveled to Ebola epidemic country
    - Headache, weakness, nausea/vomiting, diarrhea, muscle/joint/abdominal pain, hiccups, unexplained hemorrhage
  - Travel history is the 6th vital sign

- **ISOLATE**
  - CALL (hospital epidemiology, state health department, and CDC)

Identification of Suspected Cases

1. Epidemiologic risk factor

- **High risk**
  - Percutaneous or mucous membrane exposure to blood or body fluids from an infected patient
  - Direct contact with a symptomatic patient without appropriate PPE
  - Direct contact with a dead body without appropriate PPE

- **Some risk (in countries with widespread transmission)**
  - Direct contact while using appropriate PPE
  - Any direct patient care in non-Ebola healthcare settings

Identification of Suspected Cases (cont.)

1. **Epidemiologic risk factor (cont.)**
   - **Low risk**
     - Having been in a country with widespread transmission
     - Brief contact (e.g., shaking hands) with an infected patient in the early stages of disease (without appropriate PPE)
     - Direct contact with an infected patient (while using appropriate PPE) in countries without widespread transmission
     - Having traveled on an airplane with an infected person

Identification of Suspected Cases

1. Epidemiologic risk factor
2. Clinical signs/symptoms of Ebola

<table>
<thead>
<tr>
<th>Presenting Signs/Sx</th>
<th>All Patients (%)</th>
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<tbody>
<tr>
<td>Fever</td>
<td>84-89</td>
</tr>
<tr>
<td>Fatigue</td>
<td>65-76</td>
</tr>
<tr>
<td>Headache</td>
<td>53-80</td>
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<tr>
<td>Weakness</td>
<td>79</td>
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<tr>
<td>Vomiting</td>
<td>43-68</td>
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<tr>
<td>Diarrhea</td>
<td>61-67</td>
</tr>
<tr>
<td>Unexplained hemorrhage</td>
<td>18-19</td>
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# Confirmation of Ebola Virus Infection

<table>
<thead>
<tr>
<th>Analyte (Method)</th>
<th>Outcome</th>
<th>Incubation Period</th>
<th>Acute Illness</th>
<th>Convalescence</th>
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</thead>
<tbody>
<tr>
<td>IgG (ELISA)</td>
<td>Non-fatal</td>
<td></td>
<td></td>
<td>ND</td>
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<tr>
<td></td>
<td>Fatal</td>
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<tr>
<td>IgM (ELISA)</td>
<td>Non-fatal</td>
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<tr>
<td></td>
<td>Fatal</td>
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<tr>
<td>Antigen (ELISA)</td>
<td>Non-fatal</td>
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</tr>
<tr>
<td></td>
<td>Fatal</td>
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<td></td>
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</tr>
<tr>
<td>RNA (RT-PCR)</td>
<td>Non-fatal</td>
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<tr>
<td></td>
<td>Fatal</td>
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**Symptom Onset:** 2-21 days

**Days Post-Symptom Onset:**
- 3, 5, 9, 12, 15, 18, 21, 24, 27, 39, 33, 27, 36, 42, 45, 39, 80, 80 Years

**Confirmation of Ebola Virus Infection**


State Coverage for Ebola Testing

LRN Labs
LRN Labs Testing for Ebola
Hospitals Accepting Ebola Patients

Ebola: Expected Diagnostic Test Results Over Time

Critical Information: Date of Onset of Fever/Symptoms

- Viremia
- IgM
- IgG

Days post onset of symptoms:
- Fever
- RT-PCR
- ELISA IgM: up to 3-6 months
- ELISA IgG: 3-5 years or more (life-long persistence?)

Interpreting Negative Test Results

- If symptoms started ≥ 3 days before the negative result
  - Ebola is unlikely → consider other diagnoses
  - Infection control precautions for Ebola can be discontinued unless clinical suspicion for Ebola persists
- If symptoms started < 3 days before the negative RT-PCR result
  - Interpret result with caution
  - Repeat the test at ≥ 72 hours after onset of symptoms
  - Keep in isolation as a suspected case until a repeat RT-PCR ≥ 72 hours after onset of symptoms is negative

Transmission Can Be Prevented With Barrier Precaution

- Standard
- Contact
- Droplet

Personal Protection Equipment

- PPE
  - Scrubs
  - Rubber boots
  - 2 pairs of gloves
  - Tychem suit
  - Hood
  - N-95
  - Goggles
  - Apron

PPE Works, but It’s NOT Enough

Photo courtesy of Tom Fletcher.
Hand Hygiene: Parts That Are Typically Forgotten

- The use of gloves does not replace the need to practice good hand hygiene after removing gloves

Perform Hand Hygiene—Duration of the Entire Procedure: **40-60 Seconds**

WHO. http://apps.who.int/medicinedocs/documents/s16320e/s16320e.pdf.
This Will Happen Again
Poverty Increases Interaction With Potential Reservoirs
Inadequate Basic Healthcare Infrastructure
Distrust From Decades of Civil Conflict

Courtesy of Dr. Meredith Dixon.
Additional Reading

- National Ebola and Training Center (NETEC) (netec.org/resources/)
- PPE for Confirmed Patients or PUI (www.cdc.gov/vhf/ebola/healthcare-us/ppe/guidance.html)
- The Joint Commission standards - safely and effectively managing the infectious Ebola patient (www.jointcommission.org/joint_commission_standards_safely_and_effectively_managing_the_infectious_ ebola_patient/)