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The Ebola Virus Disease Outbreak in Guinea, Liberia and Sierra Leone - Data Management Implementation and Outcomes for Movement and Monitoring of Travelers at Points of Entry

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The Ebola Virus Disease Outbreak in Guinea, Liberia, and Sierra Leone: Data Management Implementation and Outcomes for Movement and Monitoring of Travelers at Points of Entry

by

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Approval Page

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Abstract

Data management in resource-limited settings can be a mountainous problem if not approached with a thorough understanding of those limitations and a mindset prepared for rapid changes in the environment. Data management becomes even more challenging at multiple points of entry, where there are many interwoven parts working together in order to get a potential traveler from his/her first steps into an airport area to boarding a plane, all while ensuring that the traveler has been thoroughly screened for any signs or symptoms of a possible Ebola virus disease infection. This capstone describes the history of the International Health Regulations' effects on control of disease spread and importation at points of entry, the Do Not Board/Lookout List's role in disease control in the United States, and the CDC's International Assistance Team's unique task in creating and implementing country-specific databases to meet the needs of Ebola-affected countries. The most critical data management need at these countries' points of entry is specifically to prevent the exportation of Ebola virus disease in order to keep each country's airspace open and allow goods, personnel and services to continue to be imported into these countries during this sustained Ebola outbreak.

KEYWORDS: Data management, resource-limited, Ebola, travel restrictions, Epi Info

Legend of Acronyms

CDC – Centers for Disease Control and Prevention

CFR – Case-fatality rate

DHS – United States Department of Homeland Security

DNB/LO – Do Not Board/Lookout List

EBOV – Ebola virus (also known as Ebola virus disease)

EHF – Ebola hemorrhagic fever (now known as Ebola virus, or Ebola virus disease)

EVD – Ebola virus disease (also known as Ebola virus; previously known as Ebola hemorrhagic fever)

H1N1 – Influenza A virus subtype H1N1 (also known as "swine flu")

HIS – Health information system

HHS – U.S. Department of Health and Human Services

IHRs – International Health Regulations (previously known as International Sanitary Regulations)

ISRs – International Sanitary Regulations (now known as International Health Regulations)

MoH – Ministry of Health

MDR/XDR-TB – Multi-drug resistant/Extensively-drug resistant tuberculosis

MSF – Médecins Sans Frontières (also known as Doctors without Borders)

NHP – Non-human primate

PHEIC – Public Health Emergency of International Concern

SQL – Structured Query Language

WHA – World Health Assembly

WHO – World Health Organization

Chapter 1 (Introduction)

Ebola: History, Taxonomy, Transmission and Symptoms

Ebola virus disease (EVD), previously known as Ebola hemorrhagic fever (EHF), is a severe disease that can be contracted by humans and non-human primates (NHPs); it appears seemingly sporadically and is often fatal in its infected host. It is caused by infection with one of the special viruses under the genus *Ebolavirus*, in the family *Filoviridae* (Kuhn et al., 2010; "Ebola", 2014). The virus is named after the river where it was first discovered in 1976 in the Democratic Republic of Congo (formerly known as Zaire). Since then, it has been responsible for 30 known outbreaks in humans, ranging from 1 to over 14,000 infected. As of December 3, 2014, the current Ebola outbreak is responsible for about 88% of all cases since 1976, and for 79% of all deaths (World Health Organization, December 2014).

There are five different species, also known as subtypes or strains, of EVD: *Bundibugyo ebolavirus*, *Taï Forest ebolavirus* (formerly known as *Côte d'Ivoire ebolavirus*), *Sudan ebolavirus*, *Zaire ebolavirus*, and *Reston ebolavirus* ("Ebola", 2014). *Reston ebolavirus* has never been proven to cause disease in humans (only in NHPs), whereas all four other subtypes have. *Zaire ebolavirus* in particular has been associated with over half of all EVD outbreaks in the past four decades. Because the *Zaire ebolavirus* strain has caused the majority of cases and deaths in humans since its discovery, it is now commonly referred to in shorthand as Ebola virus, or EBOV. From this point on, the *Zaire ebolavirus* will be the subtype referenced to whenever the word *Ebola* is mentioned.

Ebola is confirmed to be transmitted through two main routes: firstly, through direct contact with a symptomatic, infected individual's blood or other bodily fluids (including mucus, vomitus, semen, feces, saliva, and urine); and secondly, through direct contact with objects that

have been recently tainted with these blood or bodily fluids of a human or non-human primate ("Ebola", 2014). In addition, it is thought to be introduced into a human or non-human primate population by direct contact with the blood or other bodily fluids of an animal host (thought to be fruit bats or duikers); this route has not been confirmed but has been purported as the most likely transmission mechanism at this time (Olival & Hayman, 2014). The main symptoms of Ebola include fever, headache, vomiting, diarrhea, muscle pain, stomach pain, and inexplicable bleeding or bruising ("Ebola", 2014).

Ebola Outbreak of 2014: Past, Present and Future

The current Ebola outbreak in West Africa was first reported by the Guinea Ministry of Health on March 21, 2014 (Dixon & Schaefer, 2014). The report stated that there were 49 cases, including 29 deaths, in four Guinean districts bordering Liberia and Sierra Leone; seven blood samples were sent to Institut Pasteur in France, where polymerase chain reaction testing found Ebolavirus in six of the samples ("Ebola virus disease in Guinea", 2014). Since this initial report, the virus has spread to Liberia, Sierra Leone, Nigeria, Senegal, Spain, the United States, and Mali. Senegal and Nigeria have since been declared Ebola-free (on October 17 and 20, respectively), whereas Guinea, Liberia and Sierra Leone are still attempting to stem transmission of the disease ("Nigeria is now free", 2014; "The outbreak of Ebola", 2014). The United States, Spain, and Mali are still within the two incubation periods of their last Ebola case. As of November 12, 2014, there are 14,098 cases, with 5,160 deaths – this includes 1,878 cases with 1,142 deaths in Guinea; 6,822 cases with 2,836 deaths in Liberia; and 5,368 cases with 1,169 deaths in Sierra Leone (World Health Organization, November 2014).

The World Health Organization, the Centers for Disease Control and Prevention, Médecins Sans Frontières (MSF), the U.S. military, the Cuban Ministry of Health, the International Red Cross, and countless other agencies have deployed individuals to these

countries to assist in efforts to combat the outbreak (Dixon & Schafer, 2014; Kelland & Miles, 2014; McKay, 2014). This outbreak is the largest Ebola epidemic in history. On September 26, the CDC reported that if sufficient changes have not been made in community behavior and additional interventions have not been made, that the count of Ebola cases may reach 1.4 million in Liberia and Sierra Leone by January 20, 2015 (Meltzer et al.). Never before has there been such a need for mass education and large-scale public health interventions.

Chapter 2 (Review of Literature)

International Health Regulations & Public Health Emergencies of International Concern

According to the World Health Organization (WHO), "the International Health Regulations (IHRs) are an international legal instrument that is binding on 196 countries across the globe, including all the Member States of WHO. Their aim is to help the international community prevent and respond to acute public health risks that have the potential to cross borders and threaten people worldwide" ("International Health Regulations", n.d.).

In 1951, the first set of these regulations appeared under the name of International Sanitary Regulations (ISRs). They were adopted by the World Health Assembly (WHA), the WHO's decision-making body, that met in 1951. The ISRs focused largely on sanitary measures and procedures during travel, and on six diseases that were quarantinable at the time: plague, cholera, yellow fever, smallpox, typhus, and "relapsing fever" (World Health Organization, 1951; Hardiman, 2012). At that time, relapsing fever covered a variety of otherwise unspecified diseases that manifested with fever as an underlying symptom.

On July 25, 1969, a new set of regulations entitled the *International Health Regulations (IHRs)* were adopted by the World Health Assembly; its purpose was "to ensure the maximum security against the international spread of diseases with a minimum interference with world

traffic" (World Health Organization, 1995). The regulations were later amended by WHAs in both 1973 and 1981. These IHR amendments established only three diseases as quarantinable: plague, cholera, and yellow fever (World Health Organization, 1995).

In 2005, the World Health Organization proposed a radically revised set of International Health Regulations. One of the biggest differences is that these IHRs are not limited to any certain diseases, which means that they can be relevant and applicable for a longer period of time, especially in the wake of new infectious diseases that have been discovered at higher rates than ever before in mankind's recorded history (*International Health Regulations*, 2005; Merianos & Peiris, 2005).

One of the 2005 International Health Regulations' innovations is a set of "procedures for the determination by the Director-General of a 'public health emergency of international concern' and issuance of corresponding temporary recommendations, after taking into account the views of an Emergency Committee" (*International Health Regulations*, 2005). In the *International Health Regulations*, a public health emergency of international concern (PHEIC) is defined as an "extraordinary event" that constitutes a public health risk to other countries and potentially requires an internationally coordinated response.

Since the establishment of PHEIC reporting, there have been three issuances: firstly, in April 2009 as a response to the H1N1 (swine flu) pandemic; secondly, in May 2014 as the incidence of polio cases began to rise in spite of public health eradication efforts; and most recently, on August 8, 2014, in response to the current Ebola outbreak in West Africa ("Swine flu illness", 2009; MacKenzie, 2014; "WHO statement", 2014). Whenever a PHEIC is issued, the WHO may offer international risk severity assessments and collaboration of international assistance mobilization, which has proven particularly crucial in the current response as multiple

countries and partners ally against the Ebola epidemic (*International Health Regulations*, 2005; Green, 2014).

Do Not Board/Lookout List

In January 2007, the WHO published recommendations on involuntary treatment of individuals with extensively drug-resistant tuberculosis (XDR-TB), saying that "if a patient willfully refuses treatment and, as a result, is a danger to the public, the serious threat posed by XDR-TB means that limiting that individual's human rights may be necessary to protect the wider public" ("WHO guidance on human rights", 2007). In the same month, a patient in Georgia underwent screening for tuberculosis, and was found to have a multidrug-resistant (MDR) strain in May 2007. After being warned not to travel on any commercial conveyances until he was no longer infectious, the patient proceeded to advance his departure date and traveled on May 12, regardless of this action (Fidler, Gostin, & Markel, 2007).

CDC tracked the patient down in Rome on May 23 and requested that he abstain from travelling on commercial air conveyances since he posed a threat to the public. The following day, as CDC began exploring options for a treatment regimen and for bringing the patient back without exposing others, the patient traveled again, to Prague and Montreal. On this same day (May 24), the U.S. Department of Health and Human Services (HHS) sent word to the WHO that this situation may qualify to be classified as a PHEIC. The patient re-entered the United States by automobile from Canada and was located and ordered to go to a hospital in New York City for federal isolation.

Shortly after this incident, in June 2007, HHS and the CDC established a "Do Not Board" list in conjunction with the U.S. Department of Homeland Security (DHS). This gives power to international and domestic public health agencies to request boarding restrictions for individuals with certain communicable diseases who pose a threat to the public (Penfield et al., 2008). In

essence, it is a modified version of the already existing "No Fly" list, adapted to suit public health needs. When first established, CDC's three requirements for an individual to be placed on the "Do Not Board" list were as follows:

> (1) the individual has an a communicable disease that would constitute a public health threat if he or she were allowed to travel by airplane; (2) the individual is unaware of, or will become nonadherent to, public health recommendations regarding treatment or other instructions; and (3) the individual intends to travel by airplane. (Bascetta & Larence, 2008)

After an individual has been determined to no longer pose a public health threat, namely due to reaching a state of non-infectiousness, that patient is removed from the Do Not Board list. From June 2007 to December 2011, over 200 individuals were added to the Do Not Board list due to meeting the above-listed criteria; and as of mid-2012, almost 90% of those individuals had been removed (Kim et al., 2012).

Data Management in Limited Resource Environments: An Overview

Data management is an often undervalued necessity during infectious disease outbreaks. Much importance is placed on study design, data collection, and analysis, but the data management component – the foundation of the data itself – is often misunderstood and overlooked. This rings especially true in international and large collaborative studies, where data can often come from varying sources at aberrant times, greatly increasing the chances for misinterpretation (Ali et al., 2006; Pandav et al., 2002).

According to multiple international agencies, there is a growing recognition that improved health information systems (HISs) are needed in order to address issues of health service delivery, including immunization coverage, outbreak predictions, and budgetary need for public health interventions (Braa, Monteiro & Sahay, 2004).

Guinea, Liberia and Sierra Leone have each had significant challenges in terms of data management. They have no vital statistics records from 2005 to 2012, meaning that they cannot accurately report their leading causes of death, though other methods have been used in attempts to try to bridge that gap (Masquelier et al., 2014; Phillips et al., 2014). In addition, Guinea, Liberia and Sierra Leone each have been found to be separated from other African countries by a large disparity of operational research being conducted there (Smith, 2008). When surveyed on the state of their national health research systems by the World Health Organization, none of the three countries responded (Kirigia & Wambebe, 2006). In addition, Guinea, Liberia and Sierra Leone's Internet penetration rates are among the lowest in Africa, at .5%, .03%, and .2%, respectively (Nwagwu & Ibitola, 2010).

Data Management of Health Systems in Guinea

After repeated outbreaks of cholera in Guinea from 2004-2008, which were responsible for 17,638 cases and 786 deaths, Guinea created a surveillance system solely responsible for providing early alerts to the Ministry of Health in order to quickly detect any new outbreaks; this system relies on indicators such as cholera microbiological surveillance (Rebaudet et al., 2014). After a country-wide cholera epidemic in 2012, genotype mapping, whole-genome sequencing, and genome-wide phylogeny analysis were used to suggest that it was started by an imported case from Sierra Leone. These results were used to stress the importance of robust surveillance systems to track cross-border identifiers and survey mobile and vulnerable populations in order to better identify and prevent future epidemics at their source (Rebaudet et al., 2014).

According to a study conducted by the Institute of Tropical Medicine in Belgium, well-functioning health services are instrumental in preventing deaths due to epidemics in Guinea; the researchers from this study greatly stressed the importance of case management in epidemics of diseases such as (but not limited to) cholera, meningococcal meningitis and measles (Damme &

Lerberghe, 2004). However, their results were riddled with limitations due to a lack of centralized data management – in particular, they used different primary and secondary sources for cost estimates and imprecise estimates of case fatality rates (CFRs) and attack rates of disease (Damme & Lerberghe, 2004).

Unfortunately, Guinea has had instability in its healthcare funding, despite the above-mentioned arguments for better health services and more robust case management. In particular, in the aftermath of the global financial crisis of 2007 to 2008, a descriptive study was conducted by the World Health Organization in 2011 that indicated that Guinea was unsure whether they would see government funding for their health programs increase, decrease, or stay the same in the next fiscal year (Kirigia, Nganda, Mwikisa, & Cardoso, 2011).

Data Management of Health Systems in Liberia

From 1980 to 2003, Liberia was entrenched in local conflicts that led to years of civil war (Bøås & Utas, 2014). Some of the major setbacks caused by these wars were an interruption of education due to devastating damage to university laboratories and classrooms, a lack of reliable electricity and water, and shortages of university staff (Challoner & Forget, 2011). Other setbacks that impact data management operations in Liberia include poor roads, geographic distances, and poor communication infrastructure (Lori, Munro, Boyd & Andreatta, 2012).

In 2003, Liberia began rebuilding their health care sector, and alongside it, they began strengthening their data management capacities. Assessments done on different health care data management systems suggest that increased additional measures to strengthen data management at all levels of their health systems are still needed (Lee et al., 2011).

Data Management of Health Systems in Sierra Leone

In Sierra Leone, a country that had just recently exited a civil war that waged from 1991 to 2002, there has been very little infrastructure for robust data management and public health

surveillance (Kebede et al., 2013; Mitton, 2012). In prior data management system implementations, challenges included rapid staff turnover, interruptions in electrical power supplies, the departure of humanitarian assistance groups after the war's end, the rebuilding of health and education facilities, disruption of training in healthcare workers, fragmented information systems, inconsistent data definitions, and overall poor data quality (Sæbø, Kossi, Titlestad, Tohouri, & Braa, 2011; Kebede et al., 2013; Shaffer et al., 2014). Additional technical ineffective gaps in Sierra Leone's primary and peripheral health units have recently been identified. Namely, more than half of Sierra Leone's peripheral health units, maternal and child health posts, community health centers, and community health posts are operating at sub-optimal levels of technical efficiency (Renner at al., 2005; Kirigia et al., 2011).

According to multiple studies, many of these issues have improved after conducting intensive training, involving community health staff and other stakeholders in discussions on how to improve current systems, holding regular meetings to review data harmonization progress, securing stable funding for data management programs, establishment of timelines specific to data-oriented goals, and recruitment of community volunteers to conduct interviews for baseline studies (Koroma et al., 2011; Sæbø, Kossi, Titlestad, Tohouri, & Braa, 2011; Kebede et al., 2013).

Chapter 3 (Methodology)

Before data can be reported out to external partners, news outlets, and the general public as a whole, a data management system has to be established from the bottom up. In order to develop a robust data management system that can be used internationally, the following questions must be addressed:

- What is the process that is being captured in a data management system, from beginning to end?
- What is each country's existing data management approach, specifically for purposes of public health surveillance?
- What data can we anticipate being collected?
- Is the system meant to be used for active or passive surveillance?
- What data system(s) should be used for management of the data collected?
- What capacity exists for data entry, quality assurance, etc. – is the system that will be set up going to be sustainable after its initiation?
- What will the country in question do with the data that is entered – will it be used to make policy decisions? Budgetary resolutions? Track individuals?
- Who will/should have access to the data entered?

To answer the first question, "what is the process being captured", the exit screening process must be described in some detail. Exit screening of passengers leaving countries with widespread Ebola transmission started around August of 2014, with collaboration between the WHO, the CDC, and local airports, airlines, and healthcare workers. Across each of the three countries, exit screening was initiated as a measure to prevent potentially infected individuals –

and contacts of those individuals – from flying out of the country and spreading Ebola to other countries.

Exit Screening: The Process

Exit screening consists of three levels: primary screening, secondary screening, and referral for medical evaluation and public health notification. Every traveler who plans to board a flight leaving a country with widespread Ebola transmission must undergo primary screening. During this step, each traveler is screened for preliminary signs, symptoms, or risks of exposure to Ebola (Centers for Disease Control, 2014). This is done by a trained airport worker who administers a primary screening form that asks questions about the signs, symptoms, and exposures being assessed. In addition, the airport worker uses a non-contact thermometer to take each passenger's temperature, and records it on the primary screening form. If the passenger being screened answers "Yes" to any of the questions about signs, symptoms, or exposures, or if a passenger's temperature is greater than or equal to 38°C/100.4°F, then that traveler is then taken to secondary screening. The primary screening form that is administered to each passenger looks like the template that the CDC provided to each country (see Figure 1).

If a passenger is taken to secondary screening, (s)he is evaluated further by an individual with public health and/or medical training. An in-depth public health interview is administered in order to better understand any signs, symptoms and/or risks of exposure that the passenger has reported, and a second temperature measurement is taken. At this point, the passenger is either restricted from traveling, referred for medical evaluation and/or treatment, or released to travel. More specifically, if a passenger is determined to be at risk of developing Ebola, but is asymptomatic during screening, that traveler should be denied boarding until the end of the 21 day incubation period (which started on the last date of the traveler's self-reported exposure).

The secondary screening form that is administered to passengers undergoing this level of screening looks like the template provided by CDC as well (see Figures 2-4).

Appendix: 4: Primary Screening Form

Disposition: □ Clear □ Secondary **Temperature** (°C or °F):_____

Dear Traveler: Due to an outbreak of Ebola, public health officials are asking travelers to complete the following health declaration form. We need your help to prevent the spread of this disease.

(Name as it appears on your travel and boarding documents) **Today's Date** (DD/MM/YY):_____

Surname:_____ First name:_____

Other name(s):_____

Phone number(s) with country code: 1)_____ 2) _____

Country Issuing Passport:_____ Passport Number:_____

Airline:_____ Flight Number:_____ Final Destination:_____

Have you had any of the following symptoms today OR within the past 2 days? *Please check yes or no.*	**Yes**	**No**
Fever of ≥38.6°C or feeling feverish		
Severe headache		
Muscle or joint pain		
Vomiting		
Diarrhea		
Stomach or abdominal pain		
Unexplained bleeding or bruising (bleeding from mouth, nosebleed, bloody vomit, bloody/black diarrhea, coughing blood)		
In the last 21 days, have you experienced any of the following? *(Check yes or no)*	**Yes**	**No**
Were you ever exposed to blood or other body fluids of a person with Ebola?		
Did you provide direct care to anyone with Ebola while the person was sick? This includes in a household or health care setting.		
Have you worked in a laboratory that processes body fluids of Ebola patients?		
Did you directly handle dead bodies? This might include participating in funeral or burial rites or any other activities that involved handling dead bodies.		
Do you live in the same household as a person with Ebola while that person was sick?		
Have you had spent time in the same room within 1 meter of any person with Ebola, spent significant time with an Ebola patient, or any physical contact with an Ebola patient?		
Have you ever been stuck with a needle or other sharp object, or splashed in the eye, nose or mouth with bodily fluids of someone with Ebola?		
Have you been interviewed as part of a contact investigation for someone with Ebola?		

Figure 1 – Primary Screening Form template (from CDC's guidance on Pre-Departure/Exit Screening).

Appendix 5: Secondary Screening Form

Form ID: ☐

Point of Entry/Departure: ☐

Date of Interview (DD/MM/YYYY): ☐

Reason Individual Referred for Secondary Screening (Check All that Apply)*: ☐ Fever ☐ Exposure(s) ☐ Other symptom(s)

***PLEASE ATTACH PRIMARY SCREENING FORM TO THIS DOCUMENT**

SECTION 1: TRAVELER INFORMATION

Family name:_____ First name:_____

Other name(s):_____

Age: _____ Date of Birth: _____/_____/_____ (DD/MM/YYYY) Gender: ☐ Male ☐ Female

Passport #: _____ Passport Country: _____

Head of Household: _____ Village/Town: _____ Parish:_____

Country of Residence: _____ District: _____

Sub-County: _____

Location Where Traveler Either Became Ill or Had Exposure:

Village/Town: _____ District: _____

Sub-County: _____

If different from permanent residence, Dates residing at this location: ___/___/_____ (DD/MM/YYYY) to ___/___/_____ (DD/MM/YYYY)

Date of Exposure (If Applicable): ____/____/_____ (DD/MM/YYYY)

SECTION 2: CLINICAL SIGNS AND SYMPTOMS **Temperature (°C):** ☐

Has the traveler experienced any of the following symptoms today OR within the past 48 hours?

Date of First Symptom Onset: ___/___/_____ (DD/MM/YYYY)

Fever (≥38.6° C)	☐ Yes	☐ No	☐ Unk	**Unexplained bleeding from any site**	☐ Yes	☐ No	☐ Unk
If yes, Onset date ____/____/_____ (DD/MM/YYYY)				***If yes:***			
Temp:____°C				**Bleeding of the gums**	☐ Yes	☐ No	☐ Unk
Vomiting/nausea	☐ Yes	☐ No	☐ Unk	**Bleeding from injection site**	☐ Yes	☐ No	☐ Unk
Diarrhea	☐ Yes	☐ No	☐ Unk	**Nose bleed (epistaxis)**	☐ Yes	☐ No	☐ Unk
Intense fatigue/general weakness	☐ Yes	☐ No	☐ Unk	**Blood or black stools (melena)**	☐ Yes	☐ No	☐ Unk
Anorexia/loss of appetite	☐ Yes	☐ No	☐ Unk	**Fresh/red blood in vomit (hematemesis)**	☐ Yes	☐ No	☐ Unk
Abdominal pain	☐ Yes	☐ No	☐ Unk	**Coughing up blood (hemoptysis)**	☐ Yes	☐ No	☐ Unk
Chest pain	☐ Yes	☐ No	☐ Unk	**Bleeding from vagina, other than menstruation**	☐ Yes	☐ No	☐ Unk
Muscle pain	☐ Yes	☐ No	☐ Unk	**Bruising of the skin (petechiae/ecchymosis)**	☐ Yes	☐ No	☐ Unk
Joint pain	☐ Yes	☐ No	☐ Unk	**Other hemorrhagic symptoms**	☐ Yes	☐ No	☐ Unk
Headache	☐ Yes	☐ No	☐ Unk	***If yes*, please specify: _____**			
Cough	☐ Yes	☐ No	☐ Unk	_____			
Difficulty breathing	☐ Yes	☐ No	☐ Unk	**Other non-hemorrhagic clinical symptoms**	☐ Yes	☐ No	☐ Unk
Difficulty swallowing	☐ Yes	☐ No	☐ Unk	***If yes*, please specify: _____**			
Sore throat	☐ Yes	☐ No	☐ Unk				
Jaundice (yellow eyes/gums/ skin)	☐ Yes	☐ No	☐ Unk				
Conjunctivitis (red eyes)	☐ Yes	☐ No	☐ Unk				
Skin rash	☐ Yes	☐ No	☐ Unk				
Pain behind eyes/sensitive to light	☐ Yes	☐ No	☐ Unk				
Confused or disoriented	☐ Yes	☐ No	☐ Unk				

Figure 2 – Secondary screening form template, page 1 (from CDC's guidance on Pre-Departure/Exit Screening).

SECTION 3: EXPOSURES AND RISK FACTORS

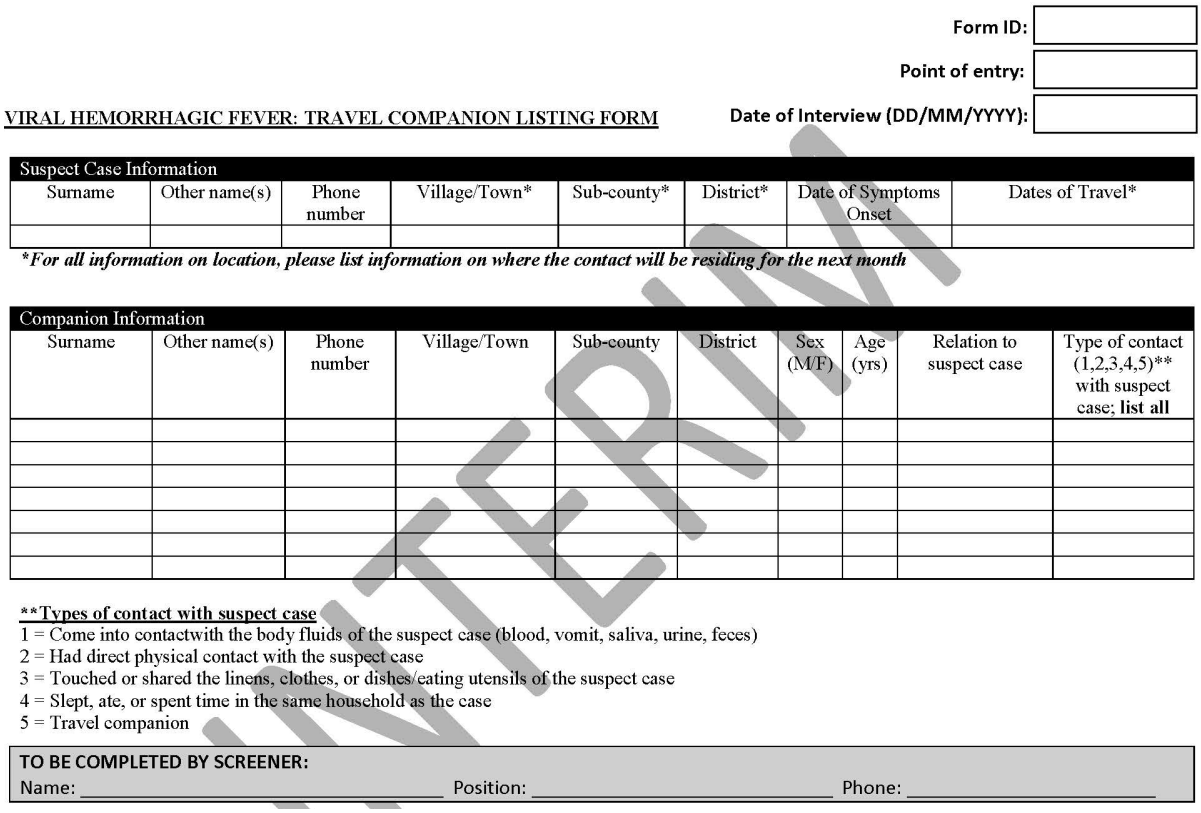
In the past three weeks, have you done any of the following?:

Were you exposed to blood or other body fluids of a person with Ebola ?	☐ Yes ☐ No ☐ Unk
Did you get stuck with a needle or other sharp object, or splashed in the eye, nose, or mouth?	☐ Yes ☐ No ☐ Unk
Did you ever **fail** to wear waterproof gloves, gown, facemask, and goggles?	☐ Yes ☐ No ☐ Unk
Did you provide direct care to any person with Ebola while the person was sick?	☐ Yes ☐ No ☐ Unk
Did you ever **fail** to wear waterproof gloves, gown, facemask, and goggles?	☐ Yes ☐ No ☐ Unk
Did you work in a laboratory where body fluids of Ebola patients were processed?	☐ Yes ☐ No ☐ Unk
Did you ever **fail** to wear waterproof gloves, gown, facemask, and goggles?	☐ Yes ☐ No ☐ Unk
Did you directly handle dead bodies, such as participating in a funeral or burial rites or other activities that involve the handling of dead bodies?	☐ Yes ☐ No ☐ Unk
Did you ever **fail** to wear waterproof gloves, gown, facemask, and goggles?	☐ Yes ☐ No ☐ Unk
Have you spent time in the same room as any person with Ebola?	☐ Yes ☐ No ☐ Unk
Did you ever **fail** to wear waterproof gloves, gown, facemask, and goggles?	☐ Yes ☐ No ☐ Unk
If no, were you always at least 1 meter **away from** the person with Ebola?	☐ Yes ☐ No ☐ Unk
If no, did you spend a long period of time in the room (more than walking by the area)?	☐ Yes ☐ No ☐ Unk
If no, did you have any physical contact with the person with Ebola, such as shaking hands or touching any body part?	☐ Yes ☐ No ☐ Unk
Have you been interviewed as part of a contact investigation for someone with Ebola?	☐ Yes ☐ No ☐ Unk

SECTION 4: TRIAGE AND RESPONSE

Travel Intervention (check one):	**Medical Assessment and Intervention (check all that apply)**: contact Public Health Authority for all transported and referred travelers
☐ Allowed to board flight ☐ Not allowed to board flight	☐ Transported to hospital/healthcare facility ☐ Referred home to symptom watch ☐ Other, specify:

Figure 3 – Secondary screening form template, page 2 (from CDC's guidance on Pre-Departure/Exit Screening).



Form ID:

Point of entry:

VIRAL HEMORRHAGIC FEVER: TRAVEL COMPANION LISTING FORM

Date of Interview (DD/MM/YYYY):

Suspect Case Information

Surname	Other name(s)	Phone number	Village/Town*	Sub-county*	District*	Date of Symptoms Onset	Dates of Travel*

*For all information on location, please list information on where the contact will be residing for the next month

Companion Information

Surname	Other name(s)	Phone number	Village/Town	Sub-county	District	Sex (M/F)	Age (yrs)	Relation to suspect case	Type of contact (1,2,3,4,5)** with suspect case; list all

**Types of contact with suspect case

1 = Come into contactwith the body fluids of the suspect case (blood, vomit, saliva, urine, feces)
2 = Had direct physical contact with the suspect case
3 = Touched or shared the linens, clothes, or dishes/eating utensils of the suspect case
4 = Slept, ate, or spent time in the same household as the case
5 = Travel companion

TO BE COMPLETED BY SCREENER:

Name: _____ Position: _____ Phone: _____

Figure 4 – Secondary screening form template, page 3 (from CDC's guidance on Pre-Departure/Exit Screening).

Exit Screening: Database Creation

In order to accurately capture the data obtained during exit screening, the CDC's Global Migration Task Force created a Data Management Unit to develop low-technology data management solutions for countries with widespread Ebola transmission implementing exit screening. The Data Management Unit created an Epi Info database that was identical to the primary and secondary screening forms. Epi Info is a free software tool first developed by the CDC over 20 years ago; the most recent version, 7.1.4, was released on July 11, 2014. It has been an open source program since its source code was first published to Codeplex, an open source project hosting website, in 2008. Since Epi Info was first created, it has been downloaded in over 180 countries and has been used in countless epidemiologic investigations.

While creating the Epi Info database to capture information from the exit screening process, the Data Management Unit closely followed an already existing database designed by the CDC's Ebola Epidemiology & Surveillance team for community-level contact investigations (CIs), in hopes that a link would later be found between the two databases. The link would then be able to provide a method of communication between the CI database and the exit screening database in order to query whether an outbound passenger going through exit screening had already been identified as a contact of an Ebola case in a contact investigation. In order to maintain close uniformity with this CI database, the Data Management Unit modeled most of its variable names to match the CI variables in existence, so that if a link was found, the variables could merge seamlessly.

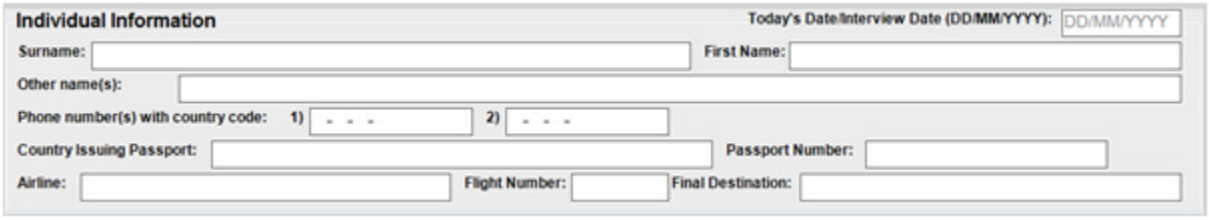


Figure 5 – A snapshot of a data enterer's view of the exit screening database created in Epi Info.

For example, if the Surname in Figure 5 (listed above) had a variable name of *Surname*, but the CI database had a variable name of *Lastname* for the same field, those variables would not be seamlessly merged when comparing the data from the two databases. Much time was spent ensuring that each variable matched as closely as possible to allow for this capability.

In addition to developing a fully functional Epi Info database, the Data Management Unit created a data dictionary with descriptions of each variable, and a Data Entry guide that could be easily tailored to each country's exit screening database. This way, if there was quick turnaround in the data entry staff in each country, the new data enterer(s) could quickly learn the rules for data entry into the database without requiring much intensive training.

Exit Screening: Database Deployment

After creating the database to be used in each country, the Data Management Unit encountered a unique obstacle: *How does one successfully deploy a database in a country that has intermittent Internet access (at best) at each point of entry?* One of the most important structures that a database requires to work effectively is the ability to share information in real-time on different computers. This is important because of the three following reasons:

- If data entry is required on more than one computer at the same time, that data needs to still be entered into the same centralized database; if data is entered separately and later merged, the chances of duplication are greatly increased.
- If data entry is happening on one side of the airport, the individuals conducting exit screening need to be able to see that entered data in real time in order to successfully ensure that no passengers with possible signs, symptoms or exposures are able to board a plane (ex. – if a passenger attempts boarding a plane on Monday and is denied boarding due to self-reporting a risk, and then that passenger attempts boarding again on Wednesday, (s)he will show up in the system as flagged due to a previously reported exposure fewer than 21 days ago).
- If changes need to be made to the original database (ex. – a new question is added to the secondary screening form and the database now needs to be able to capture it), that same database needs to be updated in real-time for any computers being used to enter data.

In order to tackle this issue, the Data Management Unit set to work on finding a solution. Quickly, the Unit was able to identify one: they would send two rugged laptops and one high performance laptop with a partitioned hard drive, giving it the capability to act as a SQL server, along with a switch and cables that would effectively set up a local area network to ensure the

capability to have multiple data enterers enter data into the same system in each country conducting exit screening in real time (see Figures 6-7). The Unit deployed two teams to Liberia and to Sierra Leone in order to first implement the Epi Info version of the database.

Figure 6 – The switch and cables (one cable per laptop) used to set up a Local Area Network (LAN).

Figure 7 – One of the rugged laptops. Two rugged laptops and one high performance laptop were deployed per country.

Chapter 4 (Results)

Data Management in Liberia

On August 14, 2014, the Data Management Unit deployed two individuals to Liberia in order to initiate the first local area network-enabled database to be used to capture exit screening data for individuals leaving the country through its airport in the capital, Monrovia – Roberts International Airport. Once they were on the ground in Liberia, the team quickly encountered several setbacks. The three biggest problems were: 1) a lack of manpower to enter data for every traveler who was screened, 2) a lack of diversity in the data, and 3) no foreseeable way to link the exit screening database with Liberia's community-level CI database.

Firstly, the lack of manpower was due to an already taxing amount of work being placed on the screeners at the Roberts International Airport in Monrovia, Liberia. With the current outbreak draining time and resources from all parts of Liberia's workforce, the screening staff were already overworked and did not have individuals to spare to perform data entry on each form. In order to address this issue, the team came to an agreement that data would only be entered on individuals who were referred for secondary screening – that is, the public health interview. Individuals who only went through primary screening would not be entered into the database, but their forms would still be counted to show the number of travelers being exit screened, and then they would be stored in a secure manner (e.g. – locked filing cabinets) in case one needed to be accessed later.

Secondly, the lack of diversity in the data was closely tied to the first problem – very few individuals were actually referred for secondary screening because most said "No" to each of the symptom and exposure questions. If an individual had an Ebola-related exposure, but was not running a fever when (s)he was exit screened, then (s)he could decline to self-report the exposure

and successfully make it through exit screening unnoticed. This is what happened in the case of the first imported case of Ebola to the United States, which is discussed further in the conclusion.

Lastly, it was discovered that there was no existing link that would allow for accurate and effective data integration between the exit screening database and the community-level contact investigation database. The reason for this was that the information being collected at the community level was very different in terms of identifiers. For example, passport numbers make sense to be collected in an airport setting, but in a community setting where most don't even have a government-issued ID, it's not a realistic variable to record. The unique identifier for the community-level CI database was generated from each contact's relationship with a probable or confirmed case. Other than that, there were no unique identifiers available to link the two databases together. Please see Table 1 for further details on identifier comparisons between the two databases.

Data Management in Sierra Leone

Due to the setbacks identified in Liberia, it was decided that the Data Management Unit would not send out additional data managers into the field at this time. However, the Unit would still provide databases, guides and recommendations for data management to the CDC staff who were already deployed in country and working on other aspects of exit screening (such as training screening staff on how to don and doff personal protective equipment, how to take temperatures with non-contact thermometers, meeting with airport staff and community stakeholders to emphasize the importance of exit screening, etc.). In mid-August, the CDC team deployed to Sierra Leone requested a database fashioned to match the amended primary and secondary screening forms they were using for in-country exit screening at the Lungi International Airport. The Data Management Unit got to work on this request and provided a database package in less than a week.

After sending the database package, the Unit provided a walkthrough training on the database to a local employee who was working with the CDC staff in order to enter data into the database. It was decided that only individuals who were sent for secondary screening would have records entered into the database (like Liberia had already decided), eliminating much of the need for increased data entry staffing. Since the initial send-out of the database, there were several revisions to Sierra Leone's exit screening forms, which the Unit has been able to incorporate into new versions of the database.

Data Management in Guinea

At the end of August, the Data Management Unit attempted getting a database and team out to Guinea, but were set back by competing priorities. By mid-September, it was verified that Guinea did not want a database to capture exit screening processes at this point in time. At the Conakry International Airport in Guinea, the contracted airport authority SOGEAC (Societe de Geston et D'Exploitation de L'Aeroport de Conakry) and local leadership were already content with the current screening process. Due to the structure of the airport, everyone that would fly out internationally was screened 3 times before they boarded a plane (twice in primary screening and a third time at the boarding gate).

According to CDC staff in country, the forms were exchanged for boarding passes or entry into the security screening area, and then collected by the contract airport authority (SOGEAC). Passengers that are denied boarding were processed differently, and their records kept in a log book. In an airport authority business meeting, it was determined that SOGEAC would maintain the original copies and a copy would be logged into the log book. Data would be collected by SOGEAC (from the screening cards) and provided to CDC on each Thursday to report out.

Chapter 5 (Conclusion and Discussion)

The first imported Ebola case in the United States – Going Forward

On September 30, 2014, the first imported case of Ebola was diagnosed at Texas Health Presbyterian Hospital in Dallas. It was quickly discovered that this individual had flown to the United States from Liberia, and during exit screening, did not display any symptoms or report any exposures, though he had been exposed to an individual who was displaying symptoms of Ebola shortly before he departed the country (Onishi & Santora, 2014). After this case was diagnosed, the Liberian government decided to add a line to its exit screening form stating that each individual who filled this form out must answer it truthfully or else be subject to prosecution.

On October 11, fewer than two weeks after this case of Ebola was imported, the CDC initiated entry screening procedures at the John F. Kennedy International Airport in New York as an additional security measure. By October 16, the Newark Liberty International Airport (EWR), Dulles International Airport (IAD), Hartsfield-Jackson International Airport (ATL) and Chicago-O'Hare International Airport (ORD) began entry screening as well. This added measure ensures that any traveler who is coming from one of the countries with widespread Ebola transmission is actively monitored by the appropriate state health department for any signs or symptoms of Ebola for 21 days after departing the country.

On October 23, an additional case of Ebola was diagnosed in a doctor who had returned to the United States from Guinea, further emphasizing the importance of entry screening as an added measure and active monitoring by state health departments (Hartocollis & Santora, 2014). Since then, the CDC has published a revised version of its Monitoring and Movement Guidance, which is used as a recommendation for states in determining what type of monitoring to pursue

for travelers with different levels of risk for Ebola. As of now, any traveler from Guinea, Liberia, Mali, or Sierra Leone with no symptoms or exposures is considered to be in the low (but not zero) risk category, and is recommended to be actively monitored for 21 days.

Discussion on Screening versus Travel Bans

On November 5, the Director for WHO's Global Capacities, Alert and Response Division, released a commentary on travel bans, stating clearly that they are not going to solve this outbreak:

> Cutting off beleaguered West African nations would be catastrophic to families and economies. People in countries, far from the hot zone, may be lulled into a false sense of security, believing Ebola can never reach them if flights are halted. In reality, it is impossible to stop the movement of people motivated to see loved ones or seek a better life for their children. Every day there are millions of people crossing the planet, not only by airplane but traversing uncontrolled land borders in remote areas, or as crew on the thousands of ships trading goods up and down the world's coastlines. The key to stopping the international spread of this disease is global vigilance… All countries need to have strong systems in place to identify people at risk at the earliest possible moment, and apply stringent prevention and control measures for any case detected (Nuttall, 2014).

The following day, the World Health Organization published its "Interim Guidance on Ebola Virus Disease Exit Screening at Airports, Ports and Land Crossings", which used much of the content that CDC's International Assistance Team had recommended, including the templates that CDC's Data Management Unit had created to be used in exit screening procedures (World Health Organization, 2014).

Since the inception of exit screening, researchers have found that screening travelers who are exiting countries with widespread Ebola transmission prevents 2 to 8 of these travelers at risk

for developing Ebola from traveling internationally (Bogoch et al., 2014). Even though data management's future in assessing these exit screening procedures may be uncertain, the public can be confident that the Centers for Disease Control and Prevention, the World Health Organization, and myriads of stakeholders on a global, national and local scale are all working together in the midst of a localized, yet massive outbreak, to prevent it from spreading widely in a borderless world. The Data Management Unit is continuing to look for avenues to provide recommendations and support as exit screening continues in these countries, until there is a definite end to this sustained epidemic.

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Vita Auctoris

Faith Michelle Washburn was born in 1990 in Greenville, South Carolina. In 2007, she graduated from Brunswick High School in Brunswick, Georgia. From there she went to the College of Coastal Georgia, where she obtained an Associate of Science degree in Psychology in 2009. Then she went to Armstrong State University, where she became a first-generation college graduate by obtaining a Bachelor's of Health Sciences in Public and Community Health in 2011. In the Spring of 2013, she enrolled at Georgia State University and is graduating December 2014 with a Master's of Public Health in Epidemiology. She has been working as a contracted researcher in the Centers for Disease Control and Prevention's Division of Global Migration and Quarantine under the Quarantine and Border Health Services branch since April of 2012 and is currently employed under Eagle Medical Services, LLC. She is currently serving as a data manager for entry screening under the Emergency Operations Center activation for the CDC's Ebola response.

Unique Identifiers	Manually assigned or automatically generated?	Assigned to what type of individual?	Universal or Database-Specific?	Available in which database(s)?
Passport Number	Manually assigned	Any individual with intent of international travel undergoing screening	Universal	Only in exit screening database
Form ID	Manually assigned	Any traveler referred to secondary screening at a point of entry/exit	Database-specific	Only in exit screening database
UniqueKey	Automatically generated	Any individual with intent of international travel undergoing screening	Database-specific	Only in exit screening database
Outbreak Case ID	Manually assigned	Any suspect, probable or confirmed VHF case	Database-specific	Only in contact investigation database
Health Facility Case ID	Manually assigned	Any suspect, probable or confirmed VHF case	Database-specific	Only in contact investigation database
ID	Automatically generated	Any contact of a suspect, probable or confirmed VHF case	Database-specific	Only in contact investigation database

Table 1 – Comparison of unique identifiers across two Epi Info databases.