GLOBAL HEALTH JURISPRUDENCE OF INTERNATIONAL HEALTH REGULATIONS: A STUDY OF GLOBAL REGULATIONS REPORTING AND ENFORCEMENT ON THE INFECTIOUS DISEASE FILOVIRUS

by

Deborah D. Carter

RONALD DOWD, DrPH, Faculty Mentor and Chair

ABIDA SOLOMON, PhD, Committee Member

BRADLEY BEAUVAIS, PhD, Committee Member

Patrick Robinson, Dean, School of Nursing and Health Sciences

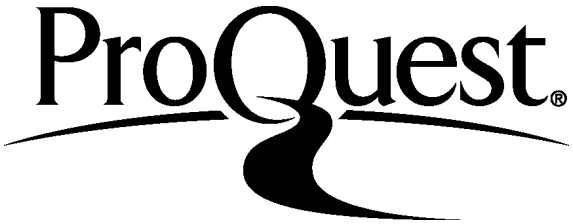
A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Public Health

Capella University

August 2016



Abstract

In 2014 the world was affected by an outbreak of the Zaire Ebola virus. In the end the virus infected 28,652 people, causing 11,325 deaths, traveling 9,184km, and was declared over after 482 days from the first known index case to the last. On August 8, 2014 the Emergency Committee under the direction of the Director-General under the World Health Organization International Health Regulations (2005) declared the 2014 Ebola virus outbreak met the conditions for a public emergency of international concern. The issue being studied is global health and its vulnerability due to the spread of infectious diseases internationally and the relationship between it, the World Health Organizations International Health Regulations, and member States. The study measured delays, non-compliance, and gaps within the International Health Regulations using multivariate time series trending and linear regression, bivariate correlation, descriptive statistics and epidemiology. The study's findings suggest the amended 2005 International Health Regulations has not significantly controlled the spread of the disease filovirus to protect the population.

Dedication

This is dedicated to my spouse Murray as he never complained about the long hours, sleepless nights, and unending requests to read my work. To my mother Carolyn who spent countless hours on the phone with me discussing my dissertations meaning and how it may if at all impact the world. To my sister Charlotte who never failed to ask me daily how school was going. And to my parents Carolyn and Butch who are forever encouraging no matter what I do. Without all of them I would not be where I am today and for this I am grateful.

Acknowledgements

It is with immense gratitude and appreciation that I acknowledge my mentor Dr. Ronald Dowd. His mentorship, guidance, thought provoking questions, and overall collegiality greatly influenced the completion of this dissertation. I also would like to recognize my committee members Dr. Abida Solomon and Dr. Brad Beauvais.

I would be thoughtless if I did not acknowledge the individual who taught me how to write scholarly and professionally, Dr. Mary Gahbauer, Professor Otterbein University.

Table of Contents

List of Tables

List of Figures

Chapter 1. Nature of the Study

Introduction to the Problem

The aspect of global health, does it matter and if it matters who does it affect? The question yields multiplex answers because of diverse human perspectives. However, the question could be better addressed by an analogous raised by scholars Skolnik and Gostin; why should we pay attention to the health of people around the world especially health affected by communicable infectious diseases (Gonzalez-Martin, Gostin, & Burci, 2007; Skolnik, 2008)? The capacity of the question brings about a complex and broad analysis of why we should be paying attention to the health of people around the world that are affected by communicable infectious diseases.

- People throughout the world are interconnected because of the ease to travel long distances and as a result communicable infectious diseases travel long distances
- Diseases do not have boundaries or borders and many have become resistant to leading medications; drug resistance leads to further disease outbreak and spread
- Global health has an ethical component; meet the basic needs of the world's population, promote global health equity, and control infectious disease spread
- Health is linked to economics (trade, tourism, commerce), episodes of crisis in global health such as communicable infectious disease outbreaks often lead to health concession due to States agendas and priorities
- The health of the people around world has an effect on global security and freedom; communicable infectious disease can threaten the health and welfare of others resulting in a restriction of individual's civil liberties to ensure the protection of others within communities, states, provinces, and nations
- Disease outbreaks affect many aspects of life; one parent left to be caretaker of the family, children left parentless, communities with decrease in productive members can cause a dynamic affect resulting in negative economic growth (Skolnik, 2008)

Today global health brings together international public health jurisprudence, global surveillance, and global health infrastructure. This amalgamation has not always been the norm but an evolution throughout history that has emerged from dissociate to an associate framework.

We begin with the origin and development of the international health cooperation that began in the 1830s, the International Sanitary Convention (ISC) (Fidler, 1998). This began global health's first introduction of international public health jurisprudence that would impose quarantine measures restricting trade and travel. The purpose and strategy was to prevent the spread of communicable infectious diseases that were crossing geopolitical boundaries. However, it wasn't until 1851 when the ISC introduced the International Sanitary Regulations (ISR) to control the cholera pandemics and the resulting maritime quarantine that inundated the international world (Maglen, 2003). In reality the only way for states to be protected from international spread of disease and reduce the negative effects of quarantine on trade was by international cooperation and law. The International Sanitary treaty at the time was the sought after link for nations to provide the protection from disease and control the negative effects felt by the protection (quarantine). However, it was a treaty that was discussed but not enforced which further led to a continual of International Sanitary Conferences from 1851-1938 (Fidler, 1998). Each conference desired some form of international agreement regarding the effects of infectious disease across national boundaries. These agreements constituted the States notifying other countries about outbreaks of specific diseases (six diseases subjected to the ISR: cholera, plague, yellow fever, small pox, typhus, and relapsing fever) to ensure disease prevention measures at points of interest with regard to trade and travel.

Unfortunately the agreements were either never imposed or didn't take place until near the end of World War II.

The 1851 International Sanitary Conference for human health was a gateway to control other forms of international diseases affecting plants and animals. The 1878 International Environmental Agreement was the first to address the Phylloxera Vastatrix plants disease that spread internationally and the 1924 International Office of Epizootics was designed to address animal diseases that spread internationally (Fidler, 1998). However, epizootics (a disease that is temporarily prevalent and widespread in an animal population) would lead to zoonosis (any disease that is naturally transmittable from marine invertebrates and vertebrates to humans) (Daszak, Cunningham, & Hyatt, 2001). Although zoonosis in early history existed it essentially would end after its course through the smaller populations causing either immunity or death resulting in the host no longer existing with the end result being a short lived epidemic. As Lederberg et al. discussed the majority of human emerging infectious diseases (EID) listed within the Institute of Medicine are in fact zoonotic (Daszak et al., 2001). EID include influenza, cholera, measles, Monkeypox, pertussis, norovirus, Lyme disease, HIV/AIDS, SARS, Nipah virus disease, West Nile virus, tuberculosis, *Staphylococcus aureus*, malaria, Hantavirus pulmonary syndrome, Hendra virus disease, rabies, plague, yellow fever, Ebola and Marburg hemorrhagic fever to name just a few (Centers for Disease Control and Prevention [CDC], 2005b). But why do we care about epizootics and zoonosis and what basis does it have in relation to emerging infectious diseases and global health? We care for two reasons; the first is because approximately 75% of the human EID are caused by zoonotic pathogens which have a direct and indirect impact with humans

which lead to global spread of the disease with the help of international trade and travel, while the second is the invariable EID re-emerging throughout history (Choi, 2008).

Scientific evidence activated the modification in what was thought of as the source of disease from Miasma theory (diseases were caused by a miasma) to germ theory (diseases caused by pathogenic microbes) which shifted the paradigm. Science became the guide to international health law which instantly included surveillance and its systems. Surveillance became a fundamental intricate piece to international health laws regarding infectious diseases. Surveillance of infectious diseases required surveillance systems and highly developed organizations to operate them. This progression led to the development of global health infrastructure with the creation of four international health organizations by the mid 1920's; the Pan-American Sanitary Bureau 1902, Office international d'Hygiéne publique in Paris 1907, Health Organisation of the League of Nations 1923, and the International Office of Epizootics 1924 (World Health Organization [WHO], 2016c). The driving force to establish these international health organizations were the continuous outbreaks of cholera, plague, yellow fever and the maritime quarantine requirements that followed them. However, these international health organizations were independent institutions practicing as sovereign nations instead of a collaborative body.

World War II (WWII) and its atrocities gave rise to the establishment of the United Nations (UN) for better global governance in June 1945. Specifically, the purpose of the United Nations is to maintain international peace and security, develop relations among nations, solve international problems, and achieve peace (United Nations, 1945). During the set up of the UN it was proposed that a single international

health organization be formed to replace the existing four. As a result, the UN established the World Health Organization (WHO) to be the international health organization with a constitution and it was adopted and signed in on July 22, 1946 by 51 member States of the UN and 10 other nations and put into force April 7 1948 (WHO, 2016c). The WHOs governing body, World Health Assembly (WHA), is comprised of representatives from each of the member States in which their functions include; establish the policies of the Organization, select a Director General, and oversee financial policies and budget.

The WHAs authority to adopt regulations within its articles of constitution adopted the International Health Regulation (IHR) in 1969 replacing the ISR. The ISR list covering specifically six quarantinable diseases (cholera, plague, yellow fever, small pox, typhus, and relapsing fever) was changed to four (cholera, plague, yellow fever, and small pox) when the IHR was adopted (Choi, 2008). This later changed to three when WHA amended the IHR in 1973 removing small pox due to scientific advances and medical intervention with the world assuming defeat over infectious diseases. The IHR would be amended again in 1981 due to global eradication of small pox and 2007 due to the emergence and re-emergence of infectious diseases (WHO, 2008a).

Background of the Study

The WHO's "central and historic responsibility has been the management of the global regime for the control of the international spread of disease" (WHO, 2008a, p.1). These responsibilities are collectively bundled within the WHO IHR doctrine of which was designed to protect humanity against the spread of communicable infectious diseases

that can spread internationally. Unfortunately, the WHO regulations evolution and priorities led the world from the once too much international health law prior to WWII to too little international health law thereafter.

The position of global health and the IHR doctrine were brought back into discussion by WHA in 1995. There were several various factors associated with why the IHR would need further amendment from the original doctrine and previous amendments. The first factor was the relevance of the IHR doctrine listing only three infectious diseases (same three listed by ISC in 1851) without further expansion of any type of public health events causing concern. By the 20th Century the doctrine didn't necessarily need to expand the list of infectious diseases by name but needed to address the factors that can be associated with adverse public health events. These factors cover various issues on a broad scale and may often times fall within diverse pathways. The increase of international trade and travel proliferate the passage for microbes to easily cross borders while the overuse of antimicrobial drugs have caused them to lose their effectiveness or become resistant against such microbes. Therefore, infectious diseases are not contained within a traditional political boundary and they are not assured to be controlled through the use of antimicrobial drugs. The globalization of markets has also weakened the State's ability to address public health concerns. Globalization has contributed to public health capabilities fading, while the development of social, economic, and environmental issues that fuel conditions for global infectious and disease continue. The early part of the 20th century's decline in major global infectious diseases was due to scientific advancement and antimicrobial drug discoveries and treatments; which resulted in them falling off the lists of regulations with no further provisions to the regulations for

emerging or re-emerging infectious diseases. The effect of the factors produced a disregard to the traditional alternatives leaving governments with no adverse consequences to having either a transparent or opaque public health capacity.

The issues of global health intertwined with international trade and travel, the globalization of markets, antimicrobial drug resistance, and the issues within the social, economic and environment contributed to the continuous outbreaks of cholera in the country of Peru in 1991, the 1994 bubonic and pneumonic plague in India, and the 1995 Ebola hemorrhagic fever in Zaire Africa. These issues further fueled the necessity of the IHR to be amended (Gostin, 2004). However, it was the newly infectious disease Severe Acute Respiratory Syndrome (SARS) outbreak that began in Guangdong Province, Mainland China in 2003 that pushed the intensity of the doctrine reform to elevated levels from a suggestion to a needed solution (Mawudeku & Blench, 2005). The SARs outbreak pushed the IHR doctrine modification to be adopted in May 2005 and put into force June 2007.

The newly revised 2005 IHR is a complex global public health governance to prevent and manage the surfacing and recurrence of various known and unknown illnesses and diseases with protection and governance surpassing the previous IHR versions. The latest amended IHR was designed to cover the fundamentals when deciding if a public health event caused concern. The 2005 IHR depicts a guided flow chart to determine if a public health event might constitute a public health emergency of international concern; essentially the pathway asks four simple questions.

1. Has there been an event of known or unknown causes, sources, or diseases of potential public health concern? Has there been a case or event of the following diseases (Smallpox, Poliomyelitis, Human Influenza new subtype,

SARS, Cholera, Pneumonic plague, Yellow fever, viral haemorrhagic fevers [Ebola, Lassa, and Marburg], West Nile fever, and other diseases of regional concern [dengue fever, Rift Valley fever, and meningococcal disease])?

2. Will the public health impact be serious?

3. Is the event unusual, unexpected, or risk of international spread?

4. Will the event cause international travel or trade restrictions?
(WHO, 2008a, p. 43)

The algorithm leads member States to two outcomes, Yes or No. If the flow chart leads to 'Yes' then the event is to be reported to the WHO under the IHR guidelines, while if the process leads to 'No' then the reporting is not required at that specific time but the State needs to further re-assess the situation when more information or data is available to them. One important aspect to this process is defining what is considered a public health emergency of international concern. According to the information contained within the 2005 IHR the WHO gives member States guiding examples located within the Annex to assist in their interpretation regarding what events and criteria would lead to defining and declaring a public health emergency of international concern. The criteria listed follow and expand upon the previous four pathway questions and include examples to further assist in guidance and understanding of the criteria.

The 2005 IHR document gives member States an instrument in which to implement the regulations to control international spread of disease to avoid public health risks and interference with international trade and travel keeping restrictions fair internationally (WHO, 2008a). The instrument is found within the regulations sixty-six articles which cover a range of factors including the scope of communicable infectious diseases, States responsibilities, core public health capacities regarding communicable

infectious diseases, and additional measures put in place for the WHO to acquire data and information beyond what the States make available. Of the sixty-six articles within the 2005 IHR this paper will focus specifically on a few as they directly relate to the purpose of this study.

- WHO Article 2: IHR was designed to prevent, protect, and control international spread of disease
- WHO Article 3: The IHR shall be implemented and upheld by all responsible parties
- WHO Article 5: Member States to develop core public health capacities in accordance with regulations to ensure ability to provide surveillance, data, and information regarding potential causes for spread of international disease
- WHO Articles 6 & 7: Member States to notify the WHO within 24 hours from assessing Public Health Information (known, unexpected, or unusual) that may constitute a public health emergency of international concern
- WHO Articles 9 – 11: WHO may get information from other sources about public health risks of international concern about a member State; the WHO will attempt to verify this information with alleged member State and then notify all States parties and affiliates once confirmed
- WHO Article 13: Develop core public health capacities in accordance with regulations to ensure ability to provide response to public health concerns and emergencies of international concern (WHO, 2008a).

Although the IHR was designed to provide global public health governance and protection internationally it still confronts identified issues of delays and non-compliance from member States and gaps in the enforcement of set regulations. These issues have caused negative effects on global public health resulting in the failure to protect humanity against the spread of communicable infectious diseases. How do we know there are delays and non-compliance and gaps within the IHR and what known evidence suggests these factors cause failure to protect humanity against the spread of communicable

infectious diseases? The 2014 Ebola Virus Disease (EVD) epidemic outbreak, the largest in recorded history, defied not only the prevention and coping mechanisms described in the newly modified 2005 IHR but revealed a breakdown within its regulations and governance. The 2014 EVD epidemic revealed a breakdown within the modified IHR doctrine between the WHO, its member States, and the world. These issues were addressed by the WHO in the 136th special session in which they acknowledged concerns and challenges with the IHR and member States regarding core capacities, timely notification, sharing of information and outbreaks, and measures taken by member States without the notification or approval from the WHO (WHO, 2015a).

The 2014 Ebola crisis revealed these gaps when the outbreak crossed multiple borders causing a high number of cases and fatalities with States public health capacities unable to appropriately respond. In many States the situation caused an overcapacity of resources resulting in vulnerability in global health protection which goes against the purpose, scope, and intentions of the IHR doctrine. The WHO made a statement during the Ebola special session; "The current Ebola situation has highlighted both the continuing gaps in core capacities among State Parties and the inadequacy of current methods to accurately monitor their development and status…these gaps constitute a major ongoing vulnerability in global health security" (WHO, 2015a, p. 2).

Statement of the Problem

There is an international public health focus on meeting the needs and sustaining solutions that have influence on the populations that are the poorest throughout the world. The influence is the prevalence of emerging and re-emerging communicable infectious diseases. The modern ease of travel and trade allows for easy movement of these

pathogens from developing to the developed countries; this reiterates why we should be paying attention to the health of people around the world affected by communicable infectious diseases.

The world has been striving to gain protection from the international spread of disease since the beginning of globalization. However, in spite of nearly 200 years of Conventions and Conferences resulting in Regulations and Agreements we are still struggling for protection against international spread of disease. Although scientific evidence has guided us into global surveillance, global health infrastructure, and international public health jurisprudence the world endures with the emergence and re-emergence of communicable infectious diseases. The world's global health is inundated with issues within social, economic, and the environment, increased antimicrobial drug resistance, globalization of markets, and the efficient and inexpensive means of which millions of people can travel and trade per day around the world.

Global health issues have led the world to organize international health organizations, the last being the WHO established by the UN. The WHA, governing body of the WHO, adopted the international health regulations in 1969 with amendments to the regulations in 1973, 1981, and 2005. However, even with the new amended Regulations the world toils with control of communicable infectious disease spread. But why; why in the age of modern technology, science, and medicine do we as a globe struggle with controlling communicable infectious disease? We struggle because although there are responsibilities, capacities, and regulations there are equally issues of delays, non-compliance, and gaps resulting in a breakdown within the system.

There can be different reasons why there are issues between international public health Regulations, jurisprudence, and the actions of Nations and States. Prior to the last global communicable infectious diseases outbreak in 2014 of Ebola a number of literature articles revealed gaps in core capacities, notification, sharing of information and data, and delays and compliance issues from member States to WHO. The literature also established the lack of enforcement with global public health law and governance between WHO and member States. The emergence and re-emergence of infectious communicable diseases continues which further ascertains a breakdown within the system.

If we are to meet the needs and sustain the solutions of a global population while controlling the emergence and re-emergence of communicable infectious diseases, we need to address a few issues. The first is the rift between authoritative power from governments and the WHO's authoritative international powers; who supersedes who and when? The second are the gaps in enforcement made by the WHO for international health laws; currently there is little to no enforcement only recommendations. The third, Nations and States have not encountered serious interference because of international disease outbreaks; could this be a component of their inaction?

Purpose of the Study

Global public health in general has been a popular topic within the public health sector. Global public health infrastructure is a broad model including international health laws with the first dating back to 1851 developed by the ISC concerning Cholera epidemics running rampant in Europe. The issue being studied is global health and its vulnerability due to the spread of communicable infectious diseases internationally and

the relationship between it, the WHO IHR, and member States. By examining the issues of delays and non-compliance and identifying gaps within the pre and post 2005 IHR reporting standards may assist in identifying the negative effects on global public health to institute change in global health jurisprudence. The purpose of this study is to objectively gain insight and examine the present IHR framework in relation to the communicable infectious disease filovirus; specifically examine the international communicable disease reporting, response, and the enforcement of the Regulations to member States.

The WHO was developed to protect against the international spread of communicable infectious diseases by implementing and utilizing a global surveillance system, global health infrastructure, and international jurisprudence. However, in the institutions sixty-six years they have implemented less than two laws into Regulations (Fidler, 1998). The system has been undeterred by the Regulations and there has been a breakdown that has caused those participating member States of the WHO to not abide by the Regulations set. Further underlying issues within global public health include the international infrastructure and jurisprudence concurring with National and State Practices already in place and the enforcement of these international health laws within National and State jurisdictions.

We are alerted to the problem within global public health jurisprudence based upon the last decade of three major communicable infectious disease outbreaks threatening public health internationally. The first was the 2003 SARS sickening 8,098 with 774 deaths in 24 countries worldwide (CDC, 2012). The second was the 2014 EVD outbreak that reportedly began March 25th 2014 resulting in 28,652 cases and 11,325

deaths spreading over eight Countries (Guinea, Liberia, Sierra Leone, Mai, Nigeria, Senegal, Spain, and the United States of America) (WHO, 2014a). And the third is the Zika Virus Disease outbreak that reportedly began in May 2015 and became a public health emergency of international concern in February 2016 affecting forty countries to date (Americas – 34 countries, Oceania/Pacific Islands – 5 countries, and Cape Verde Africa) (CDC, 2016a).

There can be many reasons there are gaps between international public health jurisprudence and what Nations and States do that cause delays and non-compliance. This study aims to focus on three specific gaps; the first is the rift between authoritative power from governments and the WHO's authoritative international powers; who supersedes who and when? The second are the gaps in enforcement made by the WHO for international health laws, currently there is little to no enforcement only recommendations. And third Nations and States have not encountered serious interference due to international disease outbreaks, could this be a component of their inaction?

Although the WHO IHR briefs outlines the international laws, mandates, and obligations in which member States are required to be compliant, literature and history reflects something different. Literature reviews and historical communicable infectious disease outbreaks indicate the WHO is unable to uphold these authoritative Regulations and the Regulations have become only recommendations with minimal to no consequences when not followed by member States. The issues to the Regulations include; developing countries lacking capabilities for public health core capacities in surveillance, data, and response, inattention to laws and policies, and lack of notification

of public health events of international concern (Fidler, 1998). This is reflected from an analysis of the WHO IHR and the continued emergence and re-emergence of infectious communicable diseases spreading internationally. The relationship between international infectious diseases and the need for change can be reflected in a statement made by the surgeon general in 1969 to Congress boldly stating that the era of infectious disease was near its end; while almost three decades later data from the WHO reveals that every second a new individual is infected with tuberculosis bacilli around the world and Cholera epidemics continue to sweep through nations although announced by experts its eradication decades before. It would be imprudent to avow that communicable infectious diseases can be completely stopped; however, they should be controlled and contained.

This leads us to the discussion of international laws invoking of quarantine to control communicable infectious disease spread. The 2003 SARS pandemic instituted quarantine and isolation measures. The measures were put into place because the disease was new with scientific uncertainty of how it was spreading and the fact is it was spreading quickly. As mentioned earlier presumable experts in the field of infectious communicable diseases and their counterparts have expressed the end of infectious diseases; however, the SARS pandemic nullified these presumptions. The EVD outbreak also a virus thought to stay contained in Africa spread to eight countries within a matter of months, quarantine measures were either null or considered controversial.

The premise of the study and why change is needed is summed up by the international public health focus on meeting the needs and sustaining solutions that have influence on the populations that are the poorest throughout the world. The influence is

the prevalence of communicable infectious diseases and the easy movement of these pathogens from developing to the developed countries.

The basis for addressing this topic initially came from the lack of global public health infrastructure and jurisprudence seen during the 2014 EVD outbreak. After further review of the history of the WHO it is realized that although a global public health entity exists and retains public health powers it doesn't institute necessary authoritative power or jurisdiction to invoke when working in conjunction with other Nations, States, Territories, Provinces, and Tribal governmental agencies regarding global public health jurisprudence and quarantine practices.

Supposition and Research Questions

This study's focus is to examine an identified issue of delays and non-compliance within the 2005 IHR reporting standards from member States to the WHO. The projects goal is to objectively examine the current state of the WHO IHR framework related to international communicable infectious disease reporting and enforcement of member States and compare the compliance of communicable infectious disease reporting and the response to known filovirus outbreaks from its inception in 1967 to present day. This subject is being addressed for three reasons; the first are the delays and non-compliance of the IHR standards of reporting communicable infectious diseases, the second is the IHR has gaps with enforcing global public health jurisprudence of international statutes including quarantine to protect humanity against international spread of communicable infectious diseases, and the third the field of communicable infectious diseases is too large and by choosing one allowed the field to be narrowed and focused.

The project's goal will be accomplished through use of both qualitative and quantitative analysis. The project will use a comparative case study approach through the exploratory examination of the trending differences of health effects throughout time pre and post 2005 IHR implementation. This study will utilize the trend reporting of multivariate time series graphing to examine the reporting of filovirus cases and the breadth/depth of outbreak spread (distance, cases, and deaths) in relation to reporting of the outbreak. By using bivariate correlation analysis, we search for the truth and detect failures within the process of the 2005 IHR put in place to protect humanity from spread of communicable infectious diseases. This approach allows examination of member States pre and post 2005 IHR implementation to address trending and gaps between International, National, and State laws and statutes within quarantine regulations and laws enacted during the event of a communicable infectious disease outbreak.

The practical and theoretical backbone of the research process is in the perception and concern of those affected by global public health. Those affected by global public health fall at the population level because the issue is related to the entire population therefore relevant theories include public health theory, social epidemiological theories (psychosocial/social/ecosocial), miasmic theory, and quarantine (Wilson & Mabhala, 2009). Although there are many theories that relate to global public health and its basis it may not be immediately evident which theory is the most suitable. However, for this study public health theory is very appropriate because it reflects chronological eras related to our study; sanitary movement era, germ theory era, chronic disease era, and social epidemiological theories. Both miasmic and quarantine can easily fit into the existing theories to be described and understood.

There is one act or theory in particular that we as a society must begin to learn to think about and act in new ways; the act/theory of quarantine. Our thinking and reaction to the theory of quarantine leads us to what Gregory Bateson would call *epistemological errors* which are errors built into our way of thinking and the consequences that follow. The theory and its history give us a better understanding and appreciation of why there is pro and anti reaction (Schabas, 2007). The root of this is to re-examine the thought process on and about quarantine and the role it plays in modern global public health practices. There is the postulation that quarantine is based upon fear and used as an act to take away individuals civil liberties by controlling individuals during times of communicable infectious disease outbreaks. In reality quarantine is a primordial theory in which its practices have not changed throughout history and the framework has not been integrated appropriately in the 21st century and versatile for the future. Understanding the public health theory and its components is important because as a society we face the continuous problem internationally for the impending global spread of infectious diseases that are re-emerging and those that are new within multivariate populations; human, plant, and animal.

Three main research questions were structured based upon the goals, literature research and review, theories, and objectives established.

1. What systematic changes in member States core public health capacities within the IHR could reduce negative effects on global health?

   This study will be evaluating the following amendments in the 2005 IHR: (a) member States obligation to develop, implement, and sustain core public health capacities to deal with threat of infectious disease outbreak and (b) member States responsibility to notify WHO of any event that may constitute a public health emergency of international concern. These amendments will be evaluated using

data variables related to the depth/breadth of the outbreaks concerning the infectious disease filovirus pre and post amendment.

2. Can changes in jurisprudence of the IHR provoke changes of core public health capacities in member States?

   This study is using retrospective data to evaluate these changes within the amended 2005 IHR. Pre data (retrospective) will include data from 1967-2004, and post data will include data from 2005-present.

3. Can changes in jurisprudence of the IHR increase cooperation and adherence to policies of member States to the IHR?

   This study will measure cooperation and adherence to policies of the member States to the IHR through evaluation of the trending within multivariate time series graph and bivariate correlation to analyze the differences of the filoviruses breadth/depth of the outbreaks pre and post 2005 amendment. The 2005 amendment was made to address these issues; therefore, we would expect to see changes in trending post amendment in comparison to pre amendment.

Significance of the Study

If we can determine that systematic changes in the core public health capacities of participating member States could reduce the negative effects on global health and the trending reveal the gaps within IHR requiring necessary changes in jurisprudence enforcement; then we have gained insight of the current systematic operation to implement effective change.

This project has the capacity to improve the current systematic operation through the knowledge gained and gaps identified. This will be accomplished through the use of multivariate time series graphing with linear regression and bivariate correlation. Although earlier reports and studies use multivariate time series to model and forecast the spread of disease along with its effects this study is using multivariate time series graphing to study trending differences after the 2005 IHR was enacted in relation to cases prior to the enactment; which currently has not been done. This study will utilize the

multivariate time series graphing and linear regression to examine the reporting of filovirus cases and the breadth/depth of outbreak spread (distance, cases, and deaths) to trend reporting and compare outbreak severity. Bivariate correlation analysis allows us to search for the truth and detect failures within the process put in place to protect humanity from the spread of communicable infectious diseases. This allows examination of delays and non-compliance of member States after the 2005 IHR implementation to address the gap between International, National, and State laws and statutes within quarantine regulations and laws enacted during the event of a communicable infectious disease outbreak. Addressing the gap brings us closer to reduce the factors associated with determinants of health across diverse populations with regards to communicable infectious diseases that have potential to spread internationally.

If this action research project is successful the study and results may influence a change within the global IHR reporting, enforcement, and quarantine on communicable infectious diseases. Through compliance of reporting and proper quarantine procedures we reduce the factors associated with determinants of health and health disparities globally. We increase the people's knowledge associated with communicable infectious disease outbreaks, spread, and the need for proper use of quarantine practices in the 21st century and into the future as we are no longer separate nations but collectively connected.

The practical implications of this study include; addressing known gaps within the IHR reporting, enforcement, and quarantine of the communicable infectious disease filovirus by providing study based evidence that has not been acquired and thereby the

results may influence the international community to improve or change their practices on the issue.

Assumptions and Limitations

There are a few key assumptions pertaining to the proposed project. The first key assumption is that the WHO will be open to the proposed project. The second key assumption is the WHO would be open to looking at their International Health Regulation statutes, quarantine regulations, and laws and willing to addressing the issues with global public health jurisprudence. The third assumption is that this is the true underlying problem or issue. There may in fact be some other problem causing this issue which would cause us to revert back to the true underlying problem needing to be addressed first. The fourth assumption pertains to Nations political sovereignty and the participation of member States. Nations political sovereignty and member States play key roles in compliance with international public health law and getting them to participate and be compliant with the IHR is an unknown factor.

The role of the action researcher in this project will be both as an insider and outsider. The insider role is based upon specifically individual knowledge, experience, and background in public health as a public health professional through preunderstanding (Coghlan & Brannick, 2014). The outsider role is imposed because the researcher is an outsider to the WHO. The researcher is not an organizational member nor involved specifically within the member States of the WHO. The researcher does not have any affiliation with Nations, States, Territories, Provinces, or Tribal governmental agencies.

The researcher's hierarchy status to this study is that of a Doctoral student. The researchers interest with or about this study comes from a self assessment based upon

theoretical beliefs and perspectives in which the research process is viewed. Although there is an awareness of the researcher's individual ideas, views, beliefs, and position these cannot be excluded; an examination of how these variables may influence the design and interpretation and analysis of the research data findings should be constant. There is a belief based upon ethical beliefs, personal integrity and values along with competency in the research process that the researcher's positionality will remain unbiased during the duration of the study. There is an awareness that the positionality of the researcher within the study should always be analyzed and reflected upon to ensure positionality is being clearly articulated and continues to remain as unbiased as humanly possible.

Organization of the Remainder of the Study

This dissertation is organized into five chapters. Chapter 2 gives a thorough literature review of communicable infectious disease, International Health Regulations, and quarantine. Chapter 3 is an outline of the research design and methodology for this study. Chapter 4 presents the results and analysis of the multivariate time series graphing and linear regression, bivariate correlation, descriptive statistics and epidemiology. Chapter 5 provides a summary of the dissertation and implications and suggestions for future research.

Chapter 2. Literature Review

Global Health Infectious Disease Overview

Global health is not new. Infectious disease is not new. So why are they significant? They have significance because the issues within global health and communicable infectious diseases have not been solved and continue to have an effect globally. According to the National Institutes of Health U.S. Library of Medicine, infectious diseases kill more people globally than any other single source (2016).

Communicable infectious diseases account for approximately 40% of the global burden, 36% of total deaths, and 40% of total DALYs (Disability Adjusted Life Year) to middle and low income countries annually (Skolnik, 2008). Globally the two regions hit the hardest are south Asia and Sub-Saharan Africa when comparing deaths from communicable infectious diseases to other causes of deaths; communicable diseases are the largest cause of deaths in Sub-Saharan Africa (Skolnik, 2008).

But why and how do communicable infectious diseases take hold within the globe and why is south Asia and Sub-Saharan Africa the hardest hit regions? According to Semenza et al there are certain determinants and drivers that are responsible for emerging and re-emerging infectious diseases (2016). According to the authors a 2008 study conducted by the European Centre for Disease Prevention and Control identified seventeen drivers which serve as a framework to determine threats of infectious disease. The drivers fall into three relative groups; globalization and environment, sociodemographic, and public health systems. The first group, globalization and environment determinants can include; climate (effects exposure pathways to foodborne, waterborne, and vectorborne diseases), natural environment (land, vegetation, and water

can shift vectors, hosts, and reservoirs to become out of balance), human made environment (enables pathogens; e.g. urbanization), travel and tourism (importation of vectors and pathogens from infected individuals), migration (immigration, asylum seeker, or settler), and global trade (import and export across international and national boundaries) (Semenza et al., 2016). The second group, sociodemographic determinants can include; demographic (population composite), social inequality (unequal distribution of resources), vulnerable groups (individuals with a disadvantage), prevention (vaccination or lack thereof), lifestyle (high risk behavior), occupational (human, animal, and plant workers), and terrorism (biological) (Semenza et al., 2016). The third group, public health systems can include; healthcare system (infrastructure), animal health (zoonosis), food and water quality, surveillance and reporting failure (Semenza et al., 2016). The groups are not exclusive but they provide a broad framework of factors responsible for the majority of infectious disease threats.

Sub-Sahara Africa remains the poorest and least developed region in the world with increase in violence, conflicts, and recurrent Ebola pandemics causing further fragility to the area (World Bank, 2016). These are major factors that feed into the listed drivers responsible for emerging and re-emerging communicable infectious diseases. South Asia according to the WHO has two countries within the world still affected by polio (Pakistan and Afghanistan) mainly due to attacks on immunization teams. South Asia has the highest number of malnourished individuals globally, 40% of the population falls below international poverty of $1.25 a day, 200 million live in the slums, and 500 million live without electricity (World Bank, 2015). The non-exhaustive list of

determinants and drivers along with sub continental factors give us a good indication of why south Asian and sub-Sahara Africa are the hardest hit.

There are numerous communicable infectious diseases that have impacted the globe throughout history. The list is lengthy and supersedes the capacity of this paper. However, a few of the communicable infectious diseases are discussed to emphasize the logical reasoning for why this dissertation work is needed and why the research questions not only should be addressed but for the sake of global health need to be addressed.

Cholera has produced seven pandemics throughout the globe killing millions of people; today it remains an endemic in which there are 1.4 to 4.3 million cases and 28,000 to 142,000 deaths per year worldwide (WHO, 2015c). Avian influenza endured three major pandemics within the 20th century alone. The great Spanish flu of 1918 (H1N1 virus) infecting 20-50% of the world's population and killing an estimated 50 million people worldwide, the Asian flu of 1957 (H2N2 virus) infecting 1-4 million with a global death toll to around 2 million, and the Hong Kong flu of 1968 (H3N2) infecting 1-3 million with estimated deaths at 1 million globally (Kilbourne, 2006; & Skolnik, 2008). The Human Immunodeficiency Virus (HIV) continues as a pandemic thirty-five years after its discovery; global estimates in 2014 with the number of people living with HIV was 36.9 million, deaths were 1.2 million, and 5,600 new cases per day with 66% of these in Sub Sahara Africa (WHO, 2016b). SARS first reported in Asia in February 2003 and spreading to twenty-four other countries covering the North Americas, South Americas, European, and Asian Continents before being contained; resulting in eight thousand being infected and 774 deaths (CDC, 2012). Tuberculosis infects one third of the world's population and is ranked as the leading cause of death worldwide along with

HIV. In 2014, 9.6 million people were infected with Tuberculosis with 1.5 million deaths globally with 95% of the deaths occurring in middle and low income countries (WHO, 2016d).

To date there is only one communicable infectious disease known to be eradicated, Smallpox. Smallpox was considered "one of the world's most devastating diseases known to humanity" but after a global immunization campaign led by the World Health Organization the disease was officially eradicated in 1980; the last natural case of Smallpox was in 1977 in Somalia Africa (WHO, 2016a).

It is unmistakable how the listed communicable infectious diseases data and statistics speak of the continued challenges into the 21st century and beyond. Even today almost three decades later data from the WHO reveals that every second a new individual is infected with tuberculosis bacilli around the world and cholera epidemics continue to sweep through nations although announced by experts its eradication decades before. The emergence and re-emergence of infectious diseases is evidence that as long as microbes can evolve established infectious diseases are at risk to be resistant to current treatments and new infectious diseases will appear. This really calls attention to global public health infrastructure, surveillance, and reporting of the underlying drivers and frameworks in helping to determine the threat of infectious diseases before they occur or spread globally.

Global Health. Infectious Disease. Filoviruses

There are two identified genera of filoviruses that belong to the virus family *Filoviridae*; Marburgvirus contains Marburg virus and Ebolavirus which contain five

viruses: Taï Forest Ebola virus, Sudan Ebola virus, Zaire Ebola virus, Ebola virus, and Bundibugyo Ebola virus with one tentative new species, Lloviu Ebola virus (Olival et al., 2013). Of those listed Reston Ebola virus does not cause severe disease to humans only to nonhuman primates while Lloviu Ebola virus causes only pathological changes to its hosts but to date has not infected humans (Chippaux 2014; Leroy, et al., 2009). The rest cause severe hemorrhagic fever to both humans and nonhuman primates. Both genera are considered zoonotic in which they are transmitted to humans from animals and in which once infected to humans can be spread human to human. The zoonotic pathogen causes lethal hemorrhagic outbreaks among primates (both nonhuman and human) with case fatality rates up to 90% (Olival et al., 2013).

Originally the source was unknown until recently when both *Marburgvirus* and *Ebolavirus* were detected in *Rousettus aegyptiacus*, fruit bats (Brauburger, Hume, Mühlberger, & Olejnik, 2012; Leroy et al., 2009). Originally the virus has been thought to be contained to the Africa region but today studies reveal this is no longer the case. Olival et al study has revealed that although the *Rousettus* fruit bats are reservoirs primarily in Africa they also carry the Reston Ebola virus in the Philippines and now an insectivorous bat in Spain is carrying the new Lloviu Ebola virus; however, the new virus like Reston Ebola is currently only affecting the species at this time not humans (2013). There is the concern these bats infected with *Marburgvirus* and *Ebolavirus* may extend to the southern Asia geographical range.

The first filovirus case was documented in 1967 when laboratory workers in both Germany and Yugoslavia were handling green monkeys imported from Uganda; 31 human cases reported with 7 deaths (CDC, 2014c). The filovirus was given the name

Marburg after the site of the outbreak in Marburg, Germany. The filoviruses are named after their origin of outbreak. To date all contacts of the Marburgvirus has been within Africa; those occurring outside of Africa simply developed after the person left Africa and all resulting from exposure within well known caves inhabited by fruit bats.

Of the two filoviruses Marburgvirus is the deadliest leaving the fewest survivors from outbreaks. According to the Centers for Disease Control and Prevention data and statistics of known cases and outbreaks of Marburgvirus from the first in 1967 to the last documented in 2014 there have been a reported 466 cases with 373 (80.00%) deaths (2014c). The Centers for Disease Control and Prevention data and statistics of known cases of outbreaks of Ebolavirus from the first in 1967 to November 2014 there were 2394 cases with 1601 (66.87%) deaths (2016c). However, the worst global Ebolavirus outbreak in history occurred March 2014 to present day (documented) in which there were 28,646 cases with 11,323 (39.52%) deaths (CDC, 2016c). Therefore, the Ebolavirus infectious disease 40-year history experienced 7.71% of the total cases in 21 outbreaks occurring from 1967 until 2013 and 92.29% of the total cases in one outbreak that began in March 2014 that spread across eight Countries.

Global Health. Jurisprudence and Regulations

Global health laws and regulations are often hindsight after the fact. What drives jurisprudence and International Health Regulations within global health; the experience of being affected by an international infectious disease; or the perception after the fact. History has been the primary documented resource of this issue. Going back to the nineteenth century it took over twenty years, 1834-1851, for international agreements to

begin then another thirty years for those agreements to be reached when cholera, plague, and yellow fever pandemics were running ramped in Europe (Maglen, 2003). When we jump ahead to the twenty first century not much has changed as it was the newly infectious disease SARS and continued avian influenza that pushed Asia into building an infrastructure of international network of global governance (Sohn, Sapsin, Gibson, & Matthews, 2004).

But what exactly does that mean; build an infrastructure of international network of global governance and what entity has the final authority of global governance? The evolution of the Regulations helps us to better understand how today's infrastructure of international networks of global governance came to be.

When we examine the evolution of the global governance we begin back to 1830-1900 when travel and trade restrictions were instituted using quarantine measures. This was the primary (and essentially only) disease prevention strategy during that time at the international level. However, the reasoning of the measures was simple; States realized the only way to keep their territory free of disease and lessen the quarantine burden on their trade was through international cooperation and law (Fidler, 1998). Moving into the 1900-1940 provided advances in science which initiated the International Sanitary Convention to be replaced with the International Sanitary Regulations. This move was meant to unify previous conventions that had taken place over the last hundred years. Under the new Regulation they narrowed six diseases to the regulations; cholera, plague, yellow fever, small pox, typhus, and relapsing fever to protect against international spread of infectious diseases implementing legal obligations requiring (a) member States to notify other countries of outbreaks of specified diseases and (b) maintain adequate public health

capabilities at points of disease entry and exits (Choi, 2008). This era paved the way for limiting public health interference to international trade and travel based on scientific evidence and public health principles. However, this did not broaden the international disease control law but rather it remained a debate.

The 1940-1990 was the era of discovery of antibiotics and vaccines and in 1969 the ISR was changed to the IHR and typhus and relapsing fever removed from the regulation list (Choi, 2008). International law declined during this period due to; modern transportation and improvement of public health caused quarantine to be considered antiquated and scientific advances paved way for medical intervention as a disease prevention strategy leaving traditional alternatives in the background with surveillance, travel, and trade restrictions becoming secondary. Therefore, the IHR of 1969 eventually became unconnected. Why? Because the WHA and WHO allowed it to be based on advances in science. Evidently no one considered that viruses and bacteria were intelligent so they simply let it go to the way side until the emergence of SARS.

SARS caused a re-realization that international trade and travel is still a great way for microbes to travel long distances; in reality they always have throughout history. Inactivity of traditional alternative to disease prevention strategies has led public health capabilities to deteriorated or become nonexistent; severity depended on geography. The great drugs made were losing their effectiveness or becoming resistant all together leading us to the weakening of global public health through the Regulations.

How did the world come to the weakening of global health through Regulations? We evaluate formulations and theoretical frameworks leading us to the problem, to the questions, and significance of the issue. In addition, the inactivity of traditional

alternative disease prevention strategies, perceived authority, and competence are further contributing factors.

Choi introduces models by Daniel Esty and Eric Stein looking at parameters of perceived authority. An example is that of the WHO and their perceived authority and competence; which in the latter will evaluate the 2005 IHR and its extensive authoritative arm of the WHO (2008). Although Esty and Stein use modeling to visualize the relationship between the two it comes down to two major concerns; first someone is losing power somewhere to something else and two decisions and policies are they democratic? Local and national governments are losing power to an international regulating entity with the international entity seen as not having accessibly and being unaccountable to ordinary people (Choi, 2008). What we fail to see, realize, and enact is these agencies were designed to serve ordinary people. The idea is that through integration of organizations; international, national, state, regional, and local there is an equilibrium reached therefore allowing a democratic internationalization of global health which is accessible and accountable to the people; or as the Esty model states it's a global toolbox if you will (Choi, 2008).

The concern of national sovereignty and powerful nations asking questions of legitimacy and authority of a global organization bring up issues and help lay a foundation of perspectives and proposals. A global organization (such as the UN and WHO) adds an additional layer of governance. National officials must answer to another layer of bureaucracy and measures and the added layers and bureaucracy brings up the issue of efficiency and national sovereignty. Essentially having a global organization is asking nations such as the United States, Japan, China, Australia, Soviet Union, Canada,

United Kingdom, ect. to give up national sovereignty to a global institution such as the WHO. Having a global institution make policies and decisions for people of a given nation are being questioned if the process is democratic (Choi, 2008). The question reflects whether if some nations get the national checks and balances needed and are they truly acting in the best interest of the citizens of that nation? This circles back to the Esty's model in which democracy goes into the background and questions of legitimacy, authority, and accountability come to the forefront (Choi, 2008).

The use of modeling to portray institutional competence, effective authority, and authoritative legitimacy brings us to the question; does the current global health authority, WHO, have the competence to be an effective authority when it comes to international global health and what effect does this have on the political, economical, and cultural aspect of the people in various nations, states, regions, and locals? The history of the WHO and its authoritative powers in conjunction with the public health theory and the authority to adopt regulations on sanitation, quarantine, nomenclature of diseases, public health practices, standards for international diagnostic procedures are indicative of competence. How does this support the theoretical basis? When we look at the history and development of the WHO we can better answer this question.

WHO was manifested in 1948 from the 1946 International Health Conference and is an agency built under the UN to act as the directing and coordinating authority on international health with the policies and programs begin governed by the WHA (Choi, 2008). The WHO has 190 member States while the WHA is comprised of one representative from each member State (Gonzalez-Martin et al., 2007). The Charter of the UN gives the WHO a mandate to promote and protect health within the UN system. The

WHO has treaty making powers, authority to promote, adopt, regulate, and recommend any matter falling within its competence which is based on the premise of health. The WHA has the authority to adopt regulations on sanitation, quarantine issues, nomenclature of diseases, cause of death, public health practices, standards for international diagnostic procedures, and authority to promulgate standards for the safety, purity, potency, advertising, and labeling of biological, pharmaceutical, and similar products in international commerce (Choi, 2008). The WHO, a global institution, constructs global policies and procedures while the WHA has the authority to adopt or reject such policies. Why would this type of global institution be considered a democratic organization? Because one representative from every member State is represented within the WHA ensuring continued national checks and balances within and between both entities.

What are the potential solutions to the legitimacy of an international agency in answering if the institutional has competence, effective authority, and authoritative legitimacy? Solutions to authority legitimacy were addressed within the Esty model. The mechanisms listed are not meant to be a catch all but a means in which to begin to answer the question of legitimacy. They include; (a) results based legitimacy – governing institutions ability to deliver good outcomes, (b) order-based legitimacy – governmental authority built on traditions with order and authority, (c) systematic legitimacy – dispersion of authority among many institutions with competing interests as a way of ensuring effectiveness and efficiency as decisions are critiqued over multiple iterations, and (d) deliberative legitimacy – idea that dialogue and participation by those representing a wide range of views reinforces the perception of legitimacy (Choi, 2008). The legitimacy being questioned is the WHO. The answer lies within the research and analysis

at the development and modification of the Regulations of today framed from those in the 19th century.

Fidler brings up the question of the WHO legitimacy in his article, *The Future of the World Health Organization: What Role for International Law* (1998). The issue of the WHO's legitimacy has been questioned by leaders in public health and politics. A contributor to this question of legitimacy is the global need for international law and cooperation due to international issues, such as infectious diseases. The lack of authoritative legitimacy from the WHO in international law coincides with the history of deficient international health cooperation from the States (Fidler, 1998). These issues were noted and discussed during the 2015 Executive Board special session on Ebola held by the WHO. Within the brief it is discussed the continued challenges and deficient international health cooperation that surfaced from the 2014 Ebola crisis. The executive board discussed the continued gaps in member States core capacities, surveillance, timely notification, and adding implemented measures that interfered with international traffic (WHO, 2015a). The brief corroborates the issue Fidler's addresses on the WHO's legitimacy and the deficient international health cooperation from member States.

Infectious disease is a global public health concern requiring international law in which individual sovereign States often turn to because of their inability to independently control the spread. Prior to World War II States received the necessary international law from the established international system; which provided better protection from infectious disease and reduced the burden of quarantine on trade. But why during this time in history did we witness the international community having better success to infectious disease control and a reduction in the burden of quarantine on travel and trade?

This can be answered by using Hedley Bulls definition of an anarchical international society. The definitions position; for States to maintain order is through the existence of an international society, one that incorporates a group of States in which they have common interests, values, and are bound by a common set of rules in relation to each other (Watson, 1987). This changed with the emergence of the WHO and the apathy in international law.

The WHOs apathy in international law has led to a global surveillance system breakdown because; (a) member States did not notify WHO or other member States of public health information of events that may constitute an emergency of international concern, (b) member States non-compliance in global surveillance for infectious disease control, and (c) member States violation of rules ensuring disease control measures resulted in minimum interference with global travel and trade (Fidler, 1998). Unfortunately, the breakdowns and violations are met with only recommendations from the WHO and not with enforcement. However, we ought to be asking a few questions based upon this information. First what caused States that were once receptive to the idea of protection of public health through a multilateral approach (international) before WWII to States changing to a unilateral approach (State sovereignty) after WWII? The second is why WHO's apathy to international law?

The answer to the first question may very well lie in answering the second question. During the era before WWII it is documented and addressed that States were very aware of the benefits of addressing global problems, to maintain public health, control the spread of infectious disease, and reduce burden of quarantine was done

through international cooperation (Fidler, 1998). The change that occurred after WWII was the assembly of the WHO and the advancement in science.

What evidence is there of the WHO's apathy to international law? Currently the evidence is within a line of reasoning based upon a hypothesis formed from known facts. Fidler explains the reasoning is simple; those working in the WHO are primarily individuals with public health and medical backgrounds who often view global health issues as medical-technical issues to be dealt with using the healing arts (1998). This explains the situation two fold; first it explains the WHO's apathy to international law and second coincides with member States non receptiveness to the Regulations. The medical-technical methodology utilizes medical or technical resources at the local level up therefore the need for international law is circumvented (Fidler, 1998). The current Regulations are based on international cooperation; therefore, it explains that if international law is avoided then member States can become un-receptive to set Regulations since consequences simply don't exist if Regulations are not followed. Prior to WWII States cooperated because the consequence was the burden of imposed travel and trade quarantine.

But what specific factors support the introduced hypothesis? Factors supporting the introduced hypothesis include the following ideas. First the medical-technical methodology was born in the wake of scientific progress against infectious diseases. This facilitated States understanding of the infectious disease process and allowed them to agree on rules of behavior because there was scientific evidence backing up set Rules (Fidler, 1998). Further advances in health and science (vaccines and antibiotics) allowed health officials to fight the pathogen directly; this resulted in the other control methods

not to be employed. There is no doubt or argument the discovery and use of vaccines and antibiotics has improved infectious disease control; however, the doubt and argument lies when using it as the only method for infectious disease control.

Science became a double edge sword in the realm of public health; on one hand the healing arts of medicine and science are very effective but their effectiveness caused obscurity of the evolutionary process of the microbial world with the added economic, social, environmental, and political problems to human infectious diseases (Fidler, 1998). This obscurity has caused pathogenic microbes to respond and the increasing consequence is antimicrobial resistance. These pathogens whether emerging or re-emerging are approaching with an advantage because throughout the era we have allowed a breakdown of the public health infrastructures, environmental deprivation, urbanization, poverty, continued civil war, and changes in human behavior (reliance on the healing arts) which give microbes the advantage (Fidler, 1998).

The results based legitimacy, which is the governing institutions ability to deliver good outcomes, was a factor Choi brought up in relation to if an institutional has competence, effective authority, and authoritative legitimacy (2008). At the 2007 WHO proceedings Lawrence Gostin reaffirms questioning WHO legitimacy by pointing out that over the sixty years of the international agency existence they have only produced two Regulations and one treaty for international health law (Gonzalez et al., 2007). In the same proceedings Gian Luca Burci conveys issue of the WHO being the only global public health agency but they have neglected to participate in the rule making for international trade, environmental protection, or any other aspect related to international law. Interestingly Burci cites the same factors discussed by Fidler to causes of WHOs

apathy to international law with the addition of international Regulations (infrastructure, surveillance, notification) were viewed as slow and costly to member States in lieu of medical-technical (vaccines and antibiotics) (Gonzalez et al., 2007).

What role does the Regulations play on international law and what is the correspondence to member States? The Regulations were first introduced in 1851 at the First International Sanitary Conference and as we have learned throughout this paper much simply didn't change within the Regulations until 2005 when the re-emergence of old infectious diseases and emergence of the newly infectious disease SARS forced necessary adjustments. But what adjustments were done to the Regulations?

The adjustments were based upon the sought after balance between States rights and people's health without undue interference with necessary travel and trade (Fidler & Gostin, 2006). The first change to the Regulations was the mission, "ensure the maximum security against the international spread of diseases with a minimum interference with world traffic" (Gostin, 2004, p. 2624). The second major change there was no longer specific diseases to be reported. The language was changed to encompass any event, despite of origin, which could cause a public health emergency of international concern. The third major change was in surveillance. Surveillance is no longer limited to a country reporting an event; the Regulation opened the subject to include receiving surveillance data and information from all sources and intelligence networks globally. The fourth change was in the national public health systems capacities. Instead of being limited to international carriers and borders the recommendation was to expand States to develop and maintain national core capacities for both surveillance and response (Fidler & Gostin, 2006; Gostin, 2004). The fifth change addresses human rights principles. The

Regulations were revised to address discrimination, rights, and consent before examination and treatment. The last change is in the governance of the Regulations. Previous governance was opaque while new governance offers more transparency with verification of data, open communication, and public availability of data reported.

Jurisprudence and Regulations come down to an elegant yet uncomplicated parallel made by international law scholar Louis Henkin. Henkin stated the primary reasons States obey or disobey international rules isn't because of sanctions; but States will comply if it is in their best interest to do so and if they are in violation then they have outweighed the advantages of the violation to the advantages of the adherence (Aginam, 2002).

Global Health. Quarantine

Global health quarantine dates back to the Old Testament to prevent the spread of disease under Mosaic Law. Today the United States legal authority for isolation and quarantine follow under Federal Law. Isolation separates people who are sick from people who are not; while quarantine separates and restricts the travel of people who were exposed to an infectious disease and to monitor them and see if they become sick.

The United States Federal government received authority for both isolation and quarantine under the Commerce Clause from the U.S. Constitution under section 361 of the Public Health Service Act (42 U.S. Code §264) the U.S. Secretary of Health and Human Services is authorized to prevent entry of infectious diseases into the United States or between States (CDC, 2014b). The U.S. Secretary of Health and Human Services delegated authority to the Centers for Disease Control and Prevention to carry

out authorized functions to ensure safety and security from infectious disease spread. Ultimately the Federal governments are in charge with State, Local, and Tribal authorities following to further support and enforce Federal laws.

The first U.S. federal quarantine law was passed in 1796 due to a deadly outbreak of yellow fever; the Commerce Clause was enacted to pass the law (Jaikumar, 2014). This law was later adjusted in 1799 to further expand federal authority to help other agencies because states and local governments struggled to enforce the quarantine law. The continued struggle to enforce quarantine in the U.S. takes us to the Spanish influenza of 1918-1919 in which 550,000 Americans died. It was during this time the authorities realized there was a serious problem in public health response and Congress enacted the Public Health Service Act in 1944; the act allows a federal agency the authority to activate quarantine on its own (Jaikumar, 2014).

In May 2007 the first person since 1963 was placed under federal quarantine upon his return to the United States; the individual was carrying a rare and deadly strain of drug resistant tuberculosis and left the United States against local, state, and federal public health authorities (Jaikumar, 2014). As Gostin addresses the public health paradox of should we do something or not gives the following remedy; the best solution to the problem is the reality of a clear, fair, and human system of starting and put in force quarantine and isolation measures when necessary (Gostin, Gravely, Shakman, Markel, & Cetron, 2004).

What about international quarantine? From the international quarantine inception in the 14th century up to the 19th century States struggled not only with their own regulations but with regulations between nation States (Maglen, 2003). Why the

struggle? Because according to Maglen international cooperation was a challenge because quarantine policies were often reflective of issues (economic and political agendas) rather than protection from the infectious disease itself (2003).

This similar struggle was seen within and between States and Nations. The infectious disease SARS in the 21st century is an example of that struggle. But as we go forward how does global health break quarantine conundrums from the past? Quarantine laws need to be in line with current science, theories, and methodologies and contain the legalities of due process and equal protection; nations should be implementing quarantine laws that coincide with their culture (Gostin et al., 2004).

Chapter 3. Methodology

This chapter covers the study's overall strategy and methodology used to further evaluate the problem.

Research Design

The WHO IHR was designed to provide global public health governance and protection internationally. The IHR came into effect in 1969 and was amended in 1973, 1981, and 2005. The 2005 amendment was based upon the following reasoning's; (a) growth in international travel and trade, (b) the emergence and re-emergence of international disease threats and, (c) other public health risks (WHO, 2008a). The amended 2005 IHR is based upon the expanded principles within the WHO to "prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade" (WHO, 2008a, p. 1).

The amendments made in the 2005 IHR include: (a) scope no longer limited to a specific disease but covered any illness or condition that present significant harm to humans, (b) member States obligation to develop, implement, and sustain core public health capacities, (c) member States responsibility to notify WHO of any event that may constitute a public health emergency of international concern, (d) protection of human rights and travelers, and (e) establishments of contact points for urgent communications between member States and WHO (WHO, 2008a). The above amendments and provisions began prior to the 2003 SARS outbreak; however, the 2003 SARS outbreak

created an emergence to finish the amendments and put them into force. The 2005 IHR amendments were intended to maintain relevance and applicability regardless of the evolution of diseases and factors associated with continued emergence of new infectious diseases or re-emergence of known infectious diseases (WHO, 2008a).

This brings us to the research problem. The WHO and WHA anticipated issues within the IHR because of the growth of international trade and travel and the continued emergence and re-emergence of international infectious disease threats. Therefore, they began revisions of the Regulations in 1995; and in 2003 the SARS outbreak pushed them to finish the amendment in 2005 and enactment in 2007. However, despite the added scope and amendments within the IHR, in 2014 the world faced the largest Ebola virus disease outbreak in recorded history. What failed within the amended Regulations to prevent the international spread of the disease filovirus to eight Countries? The premise of the amendment was to prevent, protect against, control, and provide public health response to the international spread of infectious disease. A brief from the WHO on the 2014 Ebola outbreak highlighted key concerns of the amended 2005 IHR. These concerns included gaps in core public health capacities of member States and the WHOs inability to monitor the core capacities development, gaps in timely notification from member States to the WHO of events that can result in public health emergency of international concern, and gaps with WHOs enforcement of IHR requirements (WHO, 2015a).

Previously published literature and historical infectious disease outbreaks confirm the gaps within the Regulations and between member States. These issues were addressed in the literature review in Chapter two.

This study aims to measure gaps in delays in timely notification to the WHO of events that could result in public health emergency of international concern; and evaluate the gaps in core public health capacities (capacities to detect, respond, and handle public health emergencies of international concern) and gaps in the enforcement of the Regulations by the WHO to member States.

The study researched, collected, and analyzed historically recorded filovirus outbreaks. The following information was obtained for each filovirus outbreak for composing the data set: filovirus type, index case city/Country of outbreak, outbreak year, onset of the disease (first known case), the spread of the outbreak (the furthest distance from the first known case to the last known case), date outbreak was reported and to whom (MOH and WHO), what were the final number of cases and deaths at the end of the outbreak, and the duration of outbreak (days).

This study used a comparative case study approach to measure the delays and gaps in the timely notification by member States to the WHO using the filovirus disease as a lens. This study used multivariate time series graph trending and bivariate correlation to analyze the differences of the filoviruses breadth/depth of the outbreak (spread, number of cases and deaths, duration, and delay in timely notification to the WHO) pre and post 2005 IHR amendment. The trending differences revealed pre and post 2005 IHR amendment should authenticate or refute the gaps and delays in the timely notification from member States to the WHO. From the trending differences within the delay we can further evaluate the gaps in core public health capacities, and the gaps in the enforcement of the Regulations based upon the data as well as published literature backing up the evaluation analysis.

The methods of analysis applied to the data include; (a) times series graph trending; allows for analysis of multiple dependent time series at different points in time to extract meaningful statistics and other characteristics of the data, (b) bivariate correlation; allows for analysis of the relationship between variables within the data set analyzing pre and post IHR amendment.

Trending and correlation allows us to determine if we see any differences and if the differences are significant within the variables of interest. The analysis and evaluation will address what trending if any is seen pre and post amended 2005 IHR among the variables of interest.

Sample

The sample selection for this research study includes ex post facto data from recorded outbreaks of human cases of filoviruses, Marburgvirus and Ebolavirus. The sample selection was defined by the cases documented of filoviruses epidemic outbreaks from its inception in 1967 into the human population to last recorded outbreak that began in 2014. The sample was already selected prior to this research as the data is ex post facto.

The inclusion criteria include areas and humans infected by the filoviruses Marburgvirus and Ebolavirus across the globe. The exclusion criteria include two Ebolaviruses, Reston Ebola virus and Lloviu Ebola virus, and case counts less than ten within an outbreak. The two Ebolaviruses will not be included in this research study data because documented data and known facts of these two filoviruses do not affect humans only non-human primates (Chippaux, 2014).

The sample size was pre-determined as the data is ex post facto from the filovirus cases from 1967-2014. Therefore, the total sample size for pre IHR data, *n*=15 (number of outbreaks) with a total of 2279 cases and the total sample size for the post IHR data, *n*=9 (number of outbreaks) with a total of 29,301 cases.

Setting

The demographics or setting of this study include the areas internationally in which the filoviruses outbreaks have surfaced in humans from 1967-2014. Those areas include; Zaire, Sudan, Gabon, Democratic Republic of the Congo (DRC), Uganda, Guinea, Germany, and Angola.

The sites are known as the data was pre-collected by the WHO and subsidiaries working in conjunction with the WHO regarding filovirus outbreaks. The subsidiary organizations include but are not limited to: Centers for Disease Control and Prevention; Department of Medicine, University of the Witwatersrand; Johannesburg General Hospital; Department of Tropical Medicine, Liverpool School of Tropical Medicine; Tulane School of Public Health and Tropical Medicine; International Scientific and Technical Committee for Marburg Hemorrhagic Fever Control in the Democratic Republic of the Congo; National Institutes of Health; National Center for Emerging and Zoonotic Infectious Diseases; Ministry of Health, Kampala, Uganda; Uganda Virus Research Institute; Ministry of Health, Gabon; National Institute for Communicable Disease, Johannesburg, South Africa, Ministry of Health, Kinshasa, Democratic Republic of the Congo, Institut Pasteur, Cayenne, French Guiana; Uganda Virus Research Institute; Ministry of Health, Kampala, Uganda; Institute National de Recherche Biomédicale, Kinshasa, Democratic Republic of the Congo; Institute for Virology, Phillipps-

Universität Marburg, Marburg, Germany; and the International Federation of Red Cross and Red Crescent Societies.

The outbreak references associated with the data can be found in Appendix B. Filovirus Data Sourced.

Methodology, Instrumentation, and Measures

Multivariate time series graph trending. Allowed for analysis of multiple dependent time series at different points in time to extract statistics and characteristics of the data. The study of trending allows determination of differences and if those differences are significant with variables of interest. Previous literature has looked at filovirus outbreaks using time series graph trending to forecast and model the disease spread (Kiskowski & Chowell, 2015; World Health Organization Ebola Response Team, 2014). Their evidence indicates the comparison of periods before and after a specific event within the outbreak reveals trending and changes in relation to the event. This study is comparing trending over time of filovirus outbreaks to an event change, the 2005 IHR amendment.

Times series graphing and trending allows analysis of more than one outcome variable at a time throughout time. The purpose is to analyze these variables to study the type of trending and causality pre and post 2005 IHR implementation. To compare the trending over time of filovirus outbreaks to an event the proposal is to analyze the variables spread (distance in km), cases and deaths (final number at the end of the outbreak), and duration (length of the outbreak in days) of documented filovirus outbreaks. However, for this study the time series graph trending will be analyzing one variable at a time to the event, pre and post 2005 IHR amendment.

The data was loaded into Excel spreadsheet and then uploaded to the statistical software Stata/IC 12.0 software to run the data analysis. The multivariate time series graph trending for this study analyzed the variable, date reported to the WHO of the outbreak to the variables; spread, cases, deaths, and duration. This allows us to visually see any trending of individual variables pre and post 2005 IHR amendment. However, the time series graph trending does not statistically measure the relationship of the variable within the time series. Linear regression was used to model the relationship between the variable delay in reporting the outbreak to WHO in days to the variables spread, cases, deaths, and duration. The linear regression produced a numerical measurement of the association between the two variables, resulting in the correlation coefficient. Note: the variables date reported to the WHO of the outbreak and delay in reporting the outbreak to the WHO are the idealistically the same variable. The first is depicted as an actual date while the second is a numerical value derived from subtracting the date the outbreak was reported to the MOH and the date the outbreak was reported to the WHO.

The filovirus outbreaks used for this study are listed in Appendix B. Filoviruses data sourced. The multivariate time series graphs and linear regression graphs are in Appendix C. Figures C13-C24. The linear regression table is in Appendix C Table C4.

Bivariate correlation allows for the analysis of two variables to determine the empirical relationship between them. The study of the bivariate correlation analysis allows for testing simple association. The analysis of two variables allows determination of differences and if those differences are significant with the variables of interest. Previous literature has looked at infectious disease outbreaks using modeling to compare

two variables and the relationship between them (Pinzon et al., 2004; Runge-Ranzinger, McCall, Kroeger, & Horstick, 2014). Their evidence with using the correlation value indicates the relation between variables and measures the extent to which the variables change together. For example, in Runge-Ranzinger article their correlation was used to find the relationship between certain groups and reporting of outbreak (2014).

This study is using the correlation coefficient to see if there is a relationship between two variables and to describe the strength of the relationship. This correlation is measured pre (1967-2004) and post (2005-2014) and then compared to the event change, the 2005 IHR amendment.

To compare the bivariate correlation, the proposal analyzed the variables spread (distance in km), cases and deaths (final number at the end of the outbreak), and duration (length of the outbreak in days) of documented filovirus outbreaks to the variable delay in reporting the filovirus outbreak to the WHO.

The data was loaded into Excel spreadsheet and then uploaded to the statistical software Stata/IC 12.0 software to run the data analysis. Bivariate correlation was measured using correlation with a pairwise deletion and Bonferroni multiple-comparison procedure to adjust for probability estimate and to calculate significance level for the number of observations for each variable. The bivariate correlation analyzed the variable delay in reporting outbreak to the WHO as the independent variable, cause or predictor, to the dependent variables spread, cases, deaths, and duration. This allows us to visually see any graphical representation of the relationship between two variables pre and post 2005 IHR amendment and statistically measure the strength of the relationship.

The filovirus outbreaks used for this study are listed in Appendix B. Filoviruses data sourced. The bivariate correlation graphs are in Appendix C. Figures C1-C12 and the bivariate correlation tables are in Appendix C Tables C1-C2. The bivariate regression correlation table is in Appendix C Table C3.

Data Collection

The data collected was historical data extracted from documents and archival records that has been collected by the WHO and its affiliates on filovirus outbreaks from 1967-2014. The sources in which the data was extracted for each filovirus outbreak can be found in Appendix B. Filovirus data sourced. Appendix B depicts the filovirus outbreak, city and Country of outbreak of index case, outbreak year, and column data indicates data set for this study.

Data Analysis

The analysis procedures for the data were a mixed method approach including a combination of quantitative, qualitative, descriptive analysis, and descriptive epidemiology.

The analysis used the multivariate time series analysis graph trending and Bivariate Correlation. The raw data for this analysis was initially put into an Excel spread sheet. Raw data was extrapolated from previous historical reports from the WHO and subsidiaries working in conjunction with the WHO regarding filovirus outbreaks and epidemics since its inception in 1967 to 2014.

Data was entered into Excel then uploaded into Stata/IC 12.0 software for analyses to be performed. Although the data is historical and published the extrapolated

data was stored within an encrypted data container. The extrapolated data allowed us to use a variation of quantitative and qualitative analysis through the use of time series graphs, plots, statistical and descriptive comparisons.

Ethical Considerations

Ethical principles and institutional review board processing of the project were incorporated within the design of the action plan. These basic principles included beneficence and non-malfeasance. Unmistakably we must always do no harm and ultimately do good when conducting any type of research. What does this mean to us and how do we implement it in a project? For this project although the research being done was within an organization and its member States we will still uphold to the ethical principles and standards by ensuring the following; obtain informed consent from all participants, protect participants anonymity and keep their information and responses confidential, we will not use any practices that are deceptive, and participants will be informed throughout the process and know that they may withdraw from participating at anytime, and keep risk of harm (if necessary) to a minimum (Laerd Dissertation, 2014). However, because this project is global and works on a global scale we must take additional measures when dealing with informed consent in developing countries due to guidelines, policies, and documents that may be misconstrued.

Although this projects data is historical information and the participants were a part of the organizations who studied them this project continued the same ethical considerations. This study did not have participant interaction but used previously historical and demographic data collected during historical filovirus outbreaks.

The researcher and this study maintained the highest level of objectivity throughout the dissertations research and beyond.

Chapter 4. Results

Introduction

The purpose of this study was to objectively gain insight and examine the 2005 IHR framework in relation to the outbreaks for the infectious disease filovirus; pre and post amendment. The premise of the 2005 IHR amendment was to prevent, protect against, control, and provide public health response to the international spread of infectious disease. This study specifically examined international reporting, response, and enforcement of the 2005 IHR of member States and the WHO. Literature reviews and statements from the WHO have identified continued gaps and issues within the amended 2005 IHR. Some of these issue include developing countries lack the capabilities for public health core capacities in surveillance, data and response; inattention to laws and policies within the IHR; and lack of notification of public health events of international concern. This study focused on three specific gaps; delay in timely notification to the WHO of events that could result in public health emergency of international concern, core public health capacities to respond and handle public health emergencies of international concern, and gaps in enforcement of the Regulations by the WHO to member States.

Description of the Sample

A purposive sample option, based upon the criterion that the cases meet a particular condition, was used in determining the study sample. The condition the sample selection had to meet was inclusion of known filovirus outbreaks from 1967-2014. The sample size was pre-determined as the data is ex post facto. The sample size included;

pre IHR, *n*=15 (total number of outbreaks) with a total of 2,279 cases, and post IHR, *n*=9 (total number of outbreaks) with a total of 29,301 cases.

Research Methodology Applied to Data Collection and Analysis

The research methodology applied to the data collection and analysis included; theoretical framework, correlation of variables, methods of data collection and analysis.

Theoretical research frameworks. The theoretical research frameworks used for the research process included public health theory with sub-theories social epidemiological theory and miasmic theory. Public health theory itself as described by Wilson and Mabhala is a dynamic process in which has been influenced by chronological eras which have led to public health strategies and applications for practice (2009). Public health theory fit this study because it reflects the chronological eras related to the research study; sanitary movement era, germ theory era, and chronic disease era.

The sanitary movement in the nineteenth century allowed public health to transform from the thought process that communicable infectious diseases were caused by miasma theory to understanding diseases were caused by germs and not by the once thought harmful odors or particles within the air. This is a crucial theory to this research because there is a current understanding how the filoviruses is contracted and spread; therefore, containment of the disease can be implemented to control further spread.

The current theoretical trend is divided into two segments; the first is the micro level working within the molecular and genetic order, while the second is a macro level working on a social level in which incorporates the social production and spread of the disease and the political economy of health (Wilson & Mabhala, 2009). There is a

discussion that diseases are the consequences of many causes such as biological, social, political, environmental, economical, and demographics (all combined to represent an ecosocial theory) (Wilson & Mabhala, 2009). For this study the ecosocial theory in which those factors listed are each significantly responsible for formulating patterns of health as well as disease in the population; specifically, with the filovirus disease being primarily in the Sub Saharan African region.

The filovirus is a known disease linked to bat reservoirs (specifically but not exclusively the *R. aegyptiacus* bat) (Brauburger et al., 2012). Isolated caves and mines inhabited by these bats have been linked to outbreaks in man; however, so has the eating or exposure to infected bats and bush meat (variety of animals within Africa including chimpanzee) and the shipment of contaminated monkeys from Africa to other countries (Brauburger et al., 2012). Ecologically filovirus is a zoonotic disease found in reservoir hosts (bats) in endemic areas of Africa; however, the natural host to the disease is still unknown. How do specifically the filovirus disease and the political economy of health correlate with each other? Africa's Countries with decreased food resources and supplies cause individuals and families to seek food within the bush often resulting in contraction of the filovirus disease if the meat source was contaminated (IRIN, 2003).

Correlation. Data analysis allows for identification of relationships between variables. A correlational relationship is defined as changes in one variable go together with changes in another variable (Bordens & Abbott, 2014). This is useful for this study to indentify the relationships between variables to find the trending differences pre and post amended 2005 IHR. The interest for this research is to determine if the variables covary to the amended 2005 IHR. This is accomplished by using the developing

measures of the variables pre and post amendment to further establish observed relationships.

Methods of data collection. The dissertation research design and theoretical framework guided the research investigation. This led to one form of data collection method; secondary research data in the form of reference literature on the research topic.

The method of data collection for this study was observational. Observational study is the best method because the study is attempting to understand cause-and-effect relationship. The cause for this study was the amended 2005 IHR; while the effect was what trending was seen on the variables of interest pre and post amendment.

Quantitative data gathering strategies for this study included; evaluation and recording of a defined event and obtaining relevant data from a source with management information systems (the WHO). For this study the quantitative data event was the historically recorded filovirus outbreaks from 1967- 2014; the data was extracted from ex post facto filovirus outbreaks the WHO and their subsidiaries have been collecting.

Qualitative data gathering strategies for this study included document review. The documents reviewed were ex post facto filovirus outbreaks from 1967-2014. Documents included for review were documents written by the WHO, Centers for Disease Control and Prevention, and any other author or subsidiary working in conjunction with the WHO on the filovirus outbreak(s).

Methods and data analysis. The data collected was extracted, coded, and analyzed according to the researcher's best knowledge and with no intentional bias. The data sets were uniformly given consistent forms of data analysis to assess the validity of the findings and seek answers to the research questions presented by this study. The data

was recorded and coded into an Excel program then uploaded into Stata/IC 12.0 software for the analyses to be performed.

The data analysis used for the quantitative approach included; time series trending and linear regression, bivariate correlation with significance test, and descriptive statistics deriving the central tendency and dispersion of the variables.

The data analysis used for the qualitative approach included; evaluating each variable separately to further examine their relationship to the event (amended 2005 IHR), analysis of the collected data highlights the framework of the study and how it affects the understanding of the results, and puts wording on the statistics.

Data Collection Analysis Procedures

A considerable quantity of ex post facto data was collected from the archival records from historical data that has been collected by the WHO and their affiliates. The historical data is critical to the credibility of the evidence gathering activities.

The data collection methods, while integrated, represent consistent data sources which improve the reliability and credibility of the research conducted. The reliability of the reported data, especially ex post facto data, may introduce bias as we are relying on the archival records from historical data to be accurate. Despite these limitations, these sources provide the most useful information for analysis because they are collected at the population level, specific for a particular event, readily linked together for a specific disease outbreak (filovirus) and consistent across all organizations.

For the collection of the ex post facto data, the following logistics applied. Extensive searches were conducted to find the historical data from credible sources.

These searches included known outbreaks of filoviruses that were sourced from scientific literature, the WHO and their affiliates. Initial searches of the scientific literature were completed using WHO and CDC Official sites for each recorded filovirus outbreak. This initial sourcing led to additional relevant papers that were abstracted and if relevant outbreak specific epidemiological information was present then the paper was sourced. The citations within the references were obtained to extract information about the outbreak in detail in order to obtain the epidemiological data relating to the index case, geographical spread, reporting of outbreak to authorities (MOH and WHO), measures taken to contain the outbreak, length of the outbreak, and case and fatality numbers.

A critical component of the data process was to assess the quality of the collected ex post facto data. A thorough data quality assessment was performed following each data collection to determine if there were any serious data quality issues that would impact the study's conclusions that should be addressed before conducting statistical analysis of the data. One focus of the data quality assessment was to ensure the historical data was from primary sources who gathered data or sources such as the WHO and affiliate team members collectively a part of the process. The appropriate data sources were identified, extracted, analyzed, and put into the appropriate data analysis instruments; Excel and Stata IC/12.0 software. This process may potentially lead to data that are below the minimum data quality standards needed to conduct an unbiased analysis. This can result from significant amounts of missing or invalid data, evidence of inaccurate data, and the use of unreliable methods by coalitions for collecting outcome measures. The following measures were taken to minimize these variable problems.

Evidence of potentially inaccurate data was identified using a number of quality checks, including:

1. Identifying significant amounts of missing or invalid data within a variable
2. Identifying significant deviations from published data on related outcomes in participating organizations
3. Comparison of reported outcomes to published information; variances in reported outcomes within affiliates to the published information located within the WHO and CDCs filovirus outbreaks chronology
4. Performing statistically-based analysis for reported data
5. Establishing criteria that may be indicative of invalid or inaccurate responses such as the reporting of 100% or 0% of related outcomes

The data was manually entered into Excel, coded, and transferred into a statistical program were the statistical analyses were performed using Stata/IC version 12.1 software. Prior to analyses to ensure that the manually encoded data was free from errors secondary independent verification of extracted data was performed both at extraction and data form to the computer record entered. Additional measures were taken by running specialized computer program cross data checks within the Stata/IC version 12.1 to check for potential problems within the dataset.

Analysis, Synthesis, and Findings

Multivariate time series. The multivariate time series intervention analysis interpreted changes in the series before (pre 1967-2004) the intervention and after (post 2005-2014) the intervention; the intervention for this study is the amended 2005 IHR.

The multivariate time series graphs, linear regression graphs and statistics gave the following results. For the variable spread of the outbreak to the delay in reporting the

outbreak the graphs indicate no discernible trend between the variable and the delay in reporting the outbreaks to the WHO pre (1967-2004) or post (2005-2014) amendment (Figures C13-C15). There is no significant relationship between the variable spread and the delay in reporting pre (1967-2004); t (12) = - 0.37, p>0.001, ß= - 0.110; reflecting a weak relationship. There is no significant relationship between the variable spread and the delay in reporting post (2005-2014); t (8) = -0.31, p>0.001, ß= - 0.115; reflecting a weak relationship. The variable final number of cases to the delay in reporting the outbreak the graphs indicates no discernible trend between the variable and the delay in reporting the outbreak to the WHO pre (1967-2004) or post (2005-2016) amendment (Figures C16-C18). There is no significant relationship between the variable final number of cases and the delay in reporting pre (1967-2004); t (12) = 0.11, p>0.001, ß= 0.032; reflecting a weak relationship. There is no significant relationship between the variable final number of cases and the delay in reporting post (2005-2014); t (8) = - 0.27, p>0.001, ß= - 0.102; reflecting a weak relationship. For the variable final number of deaths to the delay in reporting the outbreak the graphs indicate no discernible trend between the variable and the delay in reporting the outbreaks to the WHO pre (1967-2004) or post (2005-2014) amendment (Figures C19-C21). There is no significant relationship between the variable final number of deaths and the delay in reporting pre (1967-2004); t (12) = 0.28, p>0.001, ß= 0.084; reflecting a weak relationship. There is no significant relationship between the variable final number of deaths and the delay in reporting post (2005-2014); t (8) = - 0.28, p>0.001, ß= - 0.104; reflecting a weak relationship. The variable duration of the outbreak in days to the delay in reporting the outbreak the graphs indicates a discernible trend between the variable and the delay in

reporting the outbreak to the WHO pre (1967-2004) and post (2005-2014) (Figures C22-C24). There is a significant relationship between the variable duration of the outbreak to the delay in reporting pre (1967-2004); t (12) = 7.28, p<0.001, ß= 0.910; reflecting a strong relationship. There is no significant relationship between the variable duration of the outbreak to the delay in reporting post (2005-2014); t (8) = 0.16, p>0.001, ß= 0.058; reflecting a weak relationship. The trending seen for the pre (1967-2004) is a linear upward trend showing the longer the delay in reporting the outbreak the longer the duration of the outbreak. The trending seen for the post (2005-2014) is also a linear upward trend; however, the linear trending is not significant.

The analysis indicates that for the variables spread, cases, and deaths for the filovirus outbreaks did not reveal the event (amended 2005 IHR) had an impact pre or post on the variable. However, for the variable duration the analysis indicates the event did have an impact on the variable post the implementation of the 2005 IHR amendment. The analysis suggests the trending from 1967-2004 as significant upward trending in the delay in reporting to the duration of the outbreak; however, after the event (amended 2005 IHR) the data indicates the trending from 2005-2014 as being greatly reduced in comparison to 1967-2014 as the trending line although upward is more horizontal than vertical.

Time series graphs are in Appendix C, Figures C13, 16, 19, and 22. The linear regression table is in Appendix C, Table C4 and the graphs are in Appendix C, Figures C14, 15, 17, 18, 20, 21, 23, and 24.

Bivariate correlation. The variable of interest was the delay in reporting of the filovirus outbreak to the WHO; as this addresses the study's aim to measure gaps within

the 2005 IHR reporting standards. This variable is of interest because the hypothesis is the longer the delay in reporting the greater the effect the variable has on the other variables. The study was interested in finding what correlation if any exists and how this correlation could have been affected by the amended 2005 IHR. The question is which variables had the strongest relationship to the variable of interest? This question was addressed through estimation and interpretation of the correlation to determine the strength of the relationship statistically.

The variables spread (outbreak spread measured in km), cases (final number of outbreak cases), deaths (final number of outbreak deaths), and duration were of interest as outcomes to the predictor variable delay (delay in reporting of outbreak in days).

The bivariate correlation gave the following results. For the variable spread of the outbreak to the delay in reporting the outbreak; pre 1967-2004 (n=13) showed a weak correlation with reported r = - 0.1103 value and post 2005-2014 (n=9) showed a weak correlation with reported r = - 0.1159 value. For the variable final number of cases to the delay in reporting the outbreak pre 1967-2004 (n=13) showed a weak correlation with reported r = 0.0324 value and post 2005-2014 (n=9) showed a weak correlation with reported r = - 0.1021 value. For the variable final number of deaths to the delay in reporting the outbreak pre 1967-2004 (n=13) showed a weak correlation with reported r = 0.0841value and post 2005-2014 (n=9) showed a weak correlation with reported r = - 0.1046 value. For the variable duration of the outbreak to the delay in reporting the outbreak pre 1967-2004 (n=13) showed a strong correlation with reported r = 0.9101value with a significance at the 0.05 level probability the correlation is significant

at the $p < 0.001$ level and post 2005-2014 (n=9) showed a weak correlation with reported $r = 0.0587$ value.

The analysis indicates that for all of the variables analyzed only the dependent variable duration revealed a strong and statistically significant relationship to the independent variable delay for the analyses of all the filovirus outbreaks from 1967-2014 and the filovirus outbreaks in 1967-2004. However, for the filovirus outbreaks in 2005-2014 did not reveal a strong relationship between the two variables. The variables spread, cases, and deaths revealed weak relationships both pre and post amendment.

The bivariate correlation tables are in Appendix C, Tables C1-C3. Scattergram graphs are in Appendix C, Figures C1-C12.

Descriptive statistics and epidemiology were performed at the longitudinal (measures across time) level; analyses included looking at accumulated statistics for the time periods pre and post 2005 IHR amendment. The analyses presented here concentrated on summarizing the distribution of the variables spread, cases, deaths, duration, and delay. Histograms and descriptive statistical summary tables were used to illustrate and summarize the distribution of the data. The descriptive statistics and epidemiology interpreted the distribution of the variables and if there was a change in disease frequency over time to the amended IHR pre and post.

The descriptive statistics and epidemiology gave the following results. For the variable spread the post (2005-2014) has a higher disperse distribution than pre (1967-2004) overall. The variable final number of cases has a higher disperse distribution in post (2005-2014) than pre (1967-2004) overall. The variable final number of deaths has a higher disperse distribution in post (2005-2014) than pre (1967-2004) overall. The

variable duration of outbreak has a higher disperse distribution in pre (1967-2014) than post (2005-2014) overall. The variable delay of outbreak notification to WHO has a higher disperse distribution in pre (1967-2014) than post (2005-2014) overall.

The analysis indicates for variables spread, cases, and deaths the 2005-2014 has a higher disperse of distribution during the post amended period than 1967-2004 pre amended period. The variables delay and duration has a higher disperse of distribution during the pre amended period 1967-2004 than the post amended period 2005-2014.

The descriptive statistics data can be viewed in appendix C, Table C5 and Figures C25-C34.

Summary

The study examined the communicable infectious disease filovirus from its first known inception in 1967-2014. The data extracted from these filovirus outbreaks through time allowed for an evaluation of the variables pre and post 2005 IHR amendment.

For this study the variable delay in reporting the disease outbreak to the WHO served as the independent variable of interest as the cause or predictor variable. The other variables became dependent variables of interest to see what effect or outcome the independent variable had on them.

The data analysis revealed that the variable duration (length of the outbreak) had a significant impact pre amendment. We can say significant because the statistical analysis probability revealed it was significant. However, the variable duration had a weak impact post amendment. The analysis of the filovirus outbreaks pre and post amendment

revealed the duration of the outbreak is an effect from the delay in reporting. The pre amendment analysis indicated the longer the delay in reporting the longer the duration of the outbreak. The correlation between the two variables was very strong. The post amendment analysis indicated a similar trend, the longer the delay in reporting the longer the duration of the outbreak. However, this correlation between the two variables was a weak trend and non-significant when statistically valued.

Similar trending was seen between other variables particularly in the post amendment period. Further post amendment analysis revealed strong relationships between the variables spread to cases, deaths, and duration; cases to deaths and duration; and deaths to duration. The longer the delay in reporting the outbreak the longer the duration of the outbreak. The further the spread of the disease the more impact on the number of cases, deaths, and the longer the duration of the outbreak in days. The increase in cases has significant impact on the number of deaths. And the longer the duration of the outbreak is in days there was a strong relationship to the spread of the outbreak and the number of cases and deaths.

The descriptive statistics and epidemiology allowed us to measure and analyze the distribution and frequency of the outbreaks pre and post amendment. The data analysis revealed consistent patterns. The pre amendment, 1967-2004, experienced fifteen filovirus outbreaks while the time post amendment, 2005-2014, experienced nine filovirus outbreaks. In analyzing the spread of the outbreak the data revealed the post 2005-2014 had a higher disperse of distribution than pre 1967-2004. The analysis of the final number of cases and deaths revealed the post 2005-2014 had a higher disperse distribution than pre 1967-2004. This data coincides with the higher disperse of

distribution of the spread; the further the spread the more people effected (cases) resulting in higher incidences of mortality. The analysis of the duration of the outbreak revealed the higher disperse of distribution of the duration of the outbreak was in the pre 1967-2004. The last analysis was the delay in reporting the outbreak to the WHO; the pre had a higher disperse distribution than post.

Chapter 5. Discussion, Implications, and Recommendations

Introduction

The purpose of this study was to objectively gain insight to the amended 2005 WHO's IHR framework on reporting, response, and enforcement in relation to the control of international spread of communicable infectious diseases. To obtain this objective the study used the disease filovirus as the lens for evaluation.

The study was based on findings in existing literature research, addressed in chapter two, of known issues between member States and the WHO IHR. According to the United Nations the WHO has the responsibility of international public health and to control the international spread of communicable infectious diseases. These responsibilities are bundled within the IHR doctrine to ensure jurisprudence of the international statutes. Several amendments have been made to the IHR since its adoption in 1969; however, the interest for this study is the new 2005 IHR amendment pledging protection and governance that surpasses previous amendments.

The basis of the IHR Articles and member States begins with Article 3 of the Regulations requesting the following, "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to legislate and to implement legislation in pursuance of their health policies. In doing so they should uphold the purpose of these Regulations" (WHO, 2008a, p. 10). This Article lays the foundation of international agreements between the WHO and member States.

Member States are requested by the WHO Regulations to develop core public health capacities in accordance to the Regulations to ensure that surveillance, data, and

information regarding events of international concern are in place and implemented accordingly; WHO Article 5 (WHO, 2008a). The Regulations also requests member States to collaborate with the WHO and notify them within twenty-four hours of events that may constitute a public health emergency of international concern; WHO Articles 6 and 7 (WHO, 2008a). The algorithmic decision instrument discussed earlier incorporates specific diseases that can cause serious public health impact with rapid international spread; of the diseases on the list include viral haemorrhagic fevers (Ebola and Marburg) referenced as filoviruses within this study. Lastly; member States are requested through the Regulations, Article 13, to further develop core public health capacities and regulations to ensure they are prepared to provide a response to any public health event or emergency of international concern.

These Articles are of incredible importance in relation to this study as reasoning for the basis of the paper is due to issues of delays and non-compliance from member States with the WHO IHR Articles in reporting events of international concern, upholding core capacities, timely notification of events of interest, and timely sharing of information.

Historical events such as the large international outbreaks of the communicable infectious diseases SARS in 2003 and Ebolavirus disease in 2014 has revealed three gaps; delay in timely notification to the WHO of events that could result in a Public Health emergency of international concern, member States core public health capacities to respond and handle public health emergencies of international concern, and gaps in enforcement of the Regulations by the WHO to member States.

Within the continent of Africa almost every Country is a member State and entered into force with the 2005 IHR except Western Sahara, Libya, Sao Tome and Principe (WHO, 2008a). This is important due to Sub-Sahara Africa being identified by the World Bank as being the poorest and least developed region in the world with increased violence, conflict, and recurring Ebola virus disease pandemics (2016). These factors are drivers for the continued prevalence of emerging and re-emerging communicable infectious diseases in Sub-Sahara Africa.

The continued epidemic and pandemic outbreaks of filoviruses and the Countries continuous lacking in capacities to respond in many remote areas causes the question of why is there lack of enforcement by the WHO to member States who do not comply with Regulations they agreed to?

Within the Articles of the IHR the WHO and WHA have clarified member States responsibilities and the time frame for which they have to be compliant. For example, under Article 5 Surveillance, it states "1. Each State Party shall develop, strengthen and maintain, as soon as possible but no later than five years from the entry into force of the Regulations for that State Party, the capacity to detect, assess, notify and report events in accordance with these Regulations, as specified in Annex 1" (WHO, 2008a, p.11). However, what is not found within the 2005 amended IHR is the consequences for member States who are non-compliant who do not meet the Regulations agreement. When member States do not have the appropriate core capacities in place to handle communicable infectious disease the world will continue to see outbreaks such as the Ebola outbreak in 2014. The data collected revealed the Zaire Ebola virus outbreak began on December 2, 2013 in Meliandou, Gueckedou Prefecture, Guinea. By the end of

the outbreak the total number of cases was 28,652 resulting in 11,325 deaths lasting for 482 days and spreading a total of 9,184km over eight Countries (data is located in Appendix B Table B1).

Review of Research Problem and Purpose

The influence of emerging and re-emerging communicable infectious diseases has pushed an international focus on meeting the needs and providing solutions to the populations who are the poorest throughout the world. Although science has taken the world to global surveillance, health infrastructure, and international public health law; these factors become sidelined when the needs and solutions of the poorest are not met. This was reflective from review of the historical data collected as one avenue causing filovirus outbreaks to continue to occur in the twenty-first century was the handling and consumption of contaminated bush meat.

The globe continues to struggle with controlling communicable infectious diseases due to delays in reporting, non-compliance of core capacities, and continued gaps regardless of the set WHO Regulations. Delays, non-compliance, and gaps can be byproducts of some other factor(s). For this study the focus was on the three factors; however, other factors can include rifts between authoritative power from governments to WHOs authoritative international powers, gaps in enforcement of Regulations, and entities have not encountered interference from international outbreaks.

The rifts between authoritative power from governments and WHOs authoritative power can be a byproduct from the concern for national sovereignty. The global institution WHO adds more layers of governance in which national officials must answer

to; with more additional policies and decisions can lead to authoritative rifts. There is speculation this factor contributes toward delays in reporting and non-compliance of core capacities. Literature reviews have indicated the WHO has not enforced the Regulations to member States, but only made recommendations with minimal to no consequences to member States when not followed (Choi, 2008; Fidler, 1998).

A recent example of this is the last Ebola virus disease outbreak that began in Guinea 2014. The index case became ill December 2, 2013 however the disease outbreak was not reported to the Minister of Health (MOH) authorities until March 10, 2014. The delay in MOH knowing of the outbreak is unknown however literature research indicates symptoms are often misdiagnosed as other diseases at first and/or kept from health authorities due to cultural beliefs. According to the IHR guidelines and regulations this event should have been reported within twenty-four hours as a public health event of international concern by following the algorithm. However, the outbreak was not reported to the WHO until March 21, 2014 when the outbreak over expanded the countries core capacities. The 2014 outbreak met the conditions for the WHO Emergency Committee to declare a Public Health Emergency of International Concern has been met; the first for the organization. Although this outbreak was the largest in recorded history the Countries affected did not encounter serious interference. Travel and trade were not restricted to individuals who were not confirmed cases or contacts but given travel warnings with entrance and exit screening.

The premise of the study is summed up by the continued influence of communicable infectious diseases and the easy movement of these pathogens from the developing to the developed countries with global struggles to control them.

Summary of Results

The study examined the communicable infectious disease filovirus from its first known inception in 1967 to 2014. The data extracted from the filovirus outbreaks allowed for an evaluation of the outbreaks variables pre and post 2005 IHR amendment. The purpose was to see if the 2005 IHR amendment changes of; (a) scope of diseases no longer limited but based upon threat to human population, (b) member States obligation of public health core capacities to ensure they can control event(s) that threaten the human population, and (c) member States responsibility to notify WHO of an event of public health concern, are reflective in the data analysis pre and post amendment. Amendments are made with the intention of change; the WHO 2005 IHR was amended to prevent, protect, and control international spread of disease (WHO, 2008a). What this study aimed to evaluate if there where measureable changes in the post amendment variables to the pre amendment variables of filovirus outbreaks in relation to the 2005 IHR amendment changes.

The study's sample included recorded epidemic outbreaks of the communicable infectious disease filovirus. The qualitative and quantitative analysis allowed for the identification of relationships between variables pre and post amended 2005 IHR to further evaluate the above amendment changes. The study findings showed correlation among some variables but not all; however, there was not an anticipation to see correlations among every variable examined.

The data analysis was performed using the variables spread (distance the outbreak spread), cases (number of individuals contracting the disease), deaths (number of individuals who died from contracting the disease), duration (the length of time the

outbreak of the disease lasted), and delay (delay in reporting the disease outbreak to the WHO). The variables have dependence on each other. If the duration of the outbreak is long, previous trending has indicated there may be a higher number of cases, deaths, and spread of the disease. For this study the variable delay in reporting the disease outbreak to the WHO served as the independent variable of interest as the cause or predictor variable; the other variables became dependent variables of interest to see what effect or outcome the independent variable had on them.

The data analysis revealed that the variable duration (length of the outbreak) had a significant impact pre amendment. We can say significant because the statistical analysis probability revealed it was significant. However, the variable duration had a weak impact post amendment. What does this data then reveal about the amended IHR in relationship to the variable duration (length of outbreak)? The intention of the WHO with the amended IHR was to control the international spread of disease through protection and governance by Regulations. The analysis of the filovirus outbreaks pre and post amendment revealed the duration of the outbreak is an effect from the delay in reporting. The pre amendment analysis indicated the longer the delay in reporting the longer the duration of the outbreak; the correlation between the two variables was very strong. The post amendment analysis indicated a similar trend, the longer the delay in reporting the longer the duration of the outbreak; however, this correlation between the two variables was a weak trend and non-significant when statistically valued.

Similar trending was seen between other variables particularly in the post amendment period. Further post amendment analysis revealed strong relationships between the variable spread to the variables cases, deaths, and duration; the variable

cases to the variables deaths and duration; and the variable deaths to the variable duration. From this data we can extrapolate the following: the longer the delay in reporting the outbreak the longer the duration of the outbreak; the further the spread of the disease the more impact on the number of cases, deaths, and the longer the duration of the outbreak; the increase in cases has significant impact on the number of deaths; and the longer the duration of the outbreak is there was a strong relationship to the spread of the outbreak and the number of cases and deaths. However, the trending was not the same for the pre amendment period. The variables with strong relationships pre amendment were the number of cases to the number of deaths and the delay in reporting of the outbreak to the duration of the outbreak.

This type of trending may be indicative of what the WHO was trying to address within the Regulations; the growth in international travel and trade, the emergence and re-emergence of international disease and public health threats, and the ease of pathogens moving from developing to the developed Countries (WHO, 2008a). Perhaps further analysis of the distribution and frequency may shed some light on why we are seeing this type of trending from the pre and post data analysis.

Descriptive statistics and epidemiology allowed us to measure, analyze, and interpret the distribution and frequency of the outbreaks pre and post 2005 IHR amendment. The data analysis revealed consistent patterns with the above trending; however, some of the trending needs further analyzing for clarification.

The pre amendment, 1967-2004, experienced fifteen filovirus outbreaks; the post amendment, 2005-2014, experienced nine filovirus outbreaks. In analyzing the spread of the outbreak the data revealed the post 2005-2014 had a higher disperse of distribution

than pre 1967-2004. This data is somewhat anticipated due to the inexpensive, ease, and different modes of travel allow for further spread; however, the amended 2005 IHR was intended to address this factor. The analysis of the final number of cases and deaths revealed the post 2005-2014 had a higher disperse distribution than pre 1967-2004. This data coincides with the higher disperse of distribution of the spread; the further the spread the more people effected (cases) resulting in higher incidences of mortality. The analysis of the duration of the outbreak and delay in reporting both revealed the higher disperse of distribution of the duration of the outbreak was in the pre 1967-2004-time period. But why would we see this when the other patterns suggest the higher disperse of distribution for duration should have been post? There was one outbreak during the pre period that had extenuating circumstances resulting in a delay in reporting and longer length of the outbreak. The 1998 outbreak of the Marburgvirus in Durba, Democratic of the Congo lasted 731 days due to the significant remoteness of the area and civil war caused delayed access and evaluation of the outbreak. The chief medical officer of the region reported the outbreak as soon as he could to the proper authorities; however soon after the chief medical officer became ill with the Marburgvirus and died. His death and additional factors of the remoteness of the area and civil war caused a severe delay (seven months) before an investigative team was able to enter the area. Without this one circumstance the higher disperse of distribution of the duration of the outbreak would have been reflective in the post amendment period. The highest delay in reporting during the post amendment period was 119 days; this was due to the delay in surveillance, reporting, and diagnostics within that outbreak per investigators (MacNeil et al., 2011).

The above data summary allows us to begin to answer the question; did the amendment of the 2005 IHR change the measureable outcomes of the international spread of filovirus disease? We examine this question further with further analysis and evaluation of the study variables with the incorporation of findings from researcher's evaluation of the filovirus outbreaks.

Analysis, Synthesis, and Evaluation

The purpose of the study was to gain insight to the amended 2005 IHR and what impact if any it has on the control, protection, and governance of international spread of disease. To examine this, historical data was gathered on filoviruses to compare outbreak variables pre and post amendment using qualitative and quantitative methods. For the filovirus diseases the historical data collected contained the following; date and location of outbreak, index case, first reported date to authorities (MOH), date reported to the WHO, final number of cases and deaths, last known case to end the outbreak, and control measures (quarantine, isolation, community mobilization).

The variable data was used to compose multivariate time series graphs and bivariate correlation to investigate the variables trend of the outbreak to an event in time; the amended 2005 IHR. For this study the issues of delays and non-compliance from member States has a relationship within the data variable delay in reporting the outbreak to the WHO. Were there any trends between the delay in reporting the outbreak and the other variables before the intervention (pre amendment) and after the intervention (post amendment)? If there were trends how could we know they were significant and what relationship did the dependent variables have on the independent variable?

The summary of the data revealed the duration of the filovirus outbreak is an effect from the delay in reporting of the outbreak to the WHO. This trending pattern was consistent both pre and post amendment; with the pre data showing the relationship to be stronger than in the post data when statistically valued. Other variables reflected strong patters between them which were more prevalent within the post amendment period. For example, the further the spread of the outbreak the more impact on the number of cases, deaths, and the longer the outbreak duration.

We can correlate how the variable duration of the outbreak is an effect from the delay in reporting and how this directly goes back to the gap in timely notification from member States to the WHO of events that can result in public health emergency of international concern; this trending is seen within the analysis of the study data. How can we interpret the data for the rest of the issues being evaluated in this study for the gaps in core public health capacities of member States and the gaps with WHO enforcement of the IHR requirements? This study shows the relationship using the data acquired in conjunction with filovirus outbreak analysis within the field.

Member States gaps in core public health capacities include; capacities to detect, respond, and handle an event that could result in a public health emergency of international concern. The capacities include epidemiological surveillance (identifying index case and mode of transmission), outbreak response (setting up isolation areas, laboratory access for identification, and barrier techniques implemented), and data collection which have been indicated within research studies (Brauburger et al., 2012).

The control of an outbreak is dependent on detection and response, lack of both can result in further spread of the disease, increased transmission resulting in increased

cases and deaths prolonging the duration of the outbreak (MacNeil et al., 2011; WHO, 1978a). These issues were identified within filovirus outbreaks pre and post 2005 IHR amendment. The following published filovirus outbreaks identified gaps in core public health capacities to detect, respond, and handle filovirus outbreaks.

Table1. Gaps in core public health capacities pre and post amendment

Pre – 1967-2004 IHR Amendment	**Post – 2005-2014 IHR Amendment**
Ebola Sudan 1976 • Lack of surveillance and response	Marburg Angola 2005 • Delay in surveillance and response • Data collection issues
Ebola Zaire 1976 • Lack of surveillance and response • No known information about Sudan's outbreak	Bundibugyo Uganda 2007 • Delay in surveillance and response • Inadequate data collection
Ebola Gabon 1994 • Surveillance issues led to lack of responses • Data collection issues due to logistics problems, cultural and political constraints	Ebola DRC 2007 • Delay in surveillance and response due to inaccessibility of area
Ebola DRC 1995 • Inadequate surveillance and reporting • Breakdown in public health infrastructure causing an additional delay in response	Ebola DRC 2012 • Delay in surveillance causing a delay in response • Data collection issues
Marburg DRC 1998 • Lack of surveillance and response • Lack of infrastructure to the area • Data collection issues	Ebola DRC 2014 • Delay in surveillance and response due to remoteness of affected area
Ebola DRC 2003 • Lack of surveillance and response • Data collection issues	Ebola Guinea 2014 • Delay in surveillance and response

Note. Sources Pre: (Bausch et al., 2006; Georges et al., 1999; Muyembe-Tamfum et al., 1999; WHO, 1978a; WHO, 1978b; and WHO, 2003b)
Note. Sources Post: (IRIN, 2012; Kratz et al., 2015; Leroy et al., 2009; MacNeil et al., 2011; Roddy et al., 2012; University of Minnesota, 2005; Wamala et al., 2010; WHO, 2012d; WHO, 2015a; WHO, 2015b)

Table 1 identifies the filovirus outbreak with recorded identified gaps in core public health capacities to detect, respond, and handle of the filovirus outbreak. There was a total of 15 filovirus outbreaks pre 2005 IHR amendment. Of the fifteen outbreaks six identified gaps in core public health capacities, two (Gabon 1996 [WHO, 1996c] and Uganda 2000 [Okware et al., 2002]) reported quick surveillance and response with proper data collection, and seven of the outbreaks did not provide information. However, there

was total of 9 filovirus outbreaks post 2005 IHR amendment. Of the nine outbreaks six identified gaps in core public health capacities, three (Ebola DRC 2005 [Nkoghe et al., 2011], Ebola Uganda 2012 [WHO, 2012d], and Marburg Uganda 2012 [Knust et al., 2012]) reported quick surveillance and responses with proper data collection.

It is evident from the data acquired and published articles there is an association between the gaps in core public health capacities and the gaps in timely notification; as they are dependent on detection, response, and timely notification.

The IHR defined the rights and responsibility of the member States to develop minimum core capacities to put into operation the IHR in an effective manner. The WHO provided a framework of nine core capacities for member States to implement: legislation, coordination, surveillance, response, preparedness, risk communication, human resources, laboratory, points of entry, and specific hazards including zoonosis and food safety (WHO, 2008a). The compliancy for implementation of core capacities from member States is five years after entering into the agreement of the Regulations with a possible two-year extension due to exceptional circumstances (WHO, 2008a). This study did not have access to the agreements and extensions granted to member States by the WHO regarding core public health capacities. However, taking this into consideration this would take each member State to minimum compliancy by year 2012 and maximum compliancy by the year 2014 giving the WHO statement 'five years after entering into force of the Regulations'; the regulations were put into force in 2007.

This leads us to our last gap, the gap in enforcement of the Regulations by the WHO. The study data and the published research articles identify the gaps in detection, timely notification, and response of member States for the infectious disease filovirus.

These identified gaps lead us to the gap in the enforcement of the Regulations by the WHO. According to the WHO 2005 IHR regulations the WHA and the WHO set and adopted the Regulations to prevent, protect, and control international spread of disease. However, regardless of the recommendations and expectancy the Regulations have to the member States there is no listed consequence if member States do not meet the compliancy. The WHO reported that as of 2015 there were 196 States Parties including all the member States of the WHO; of these only 64 of the States Parties informed the WHO Secretariat that they have achieved the set core capacities within the amended 2005 IHR (WHO, 2008a).

Implications of Findings

The conclusions that can be drawn from this study are the following. The historical outbreaks and literature research have exposed issues between member States non compliance and the WHOs lack of enforcement of the International Health Regulations. The Regulations were devised back in 1830 to help prevent the spread of infectious diseases from crossing geopolitical boundaries. Today we are still faced with the issue of infectious diseases crossing geopolitical boundaries. But have the amendments within the IHR help to control the spread of the disease and protect the population from the spread? The data suggest that the amended IHR has not significantly controlled the international spread of infectious disease or protect the population from the spread of infectious disease.

Limitations and Future Research

This dissertation is limited in several ways. First although the data analysis relies on data there were a few missing pieces of data that were of direct interest to the study. Of the data collected on the twenty-four filovirus outbreaks included in this study only two data pieces were missing. Despite extensive research of historical literature articles, the reporting of the filovirus outbreaks in 1994 to authorities (MOH) could not be found, the information available was when it was reported to the WHO and the 1967 outbreak in Marburg Germany there was no data presented that clarified the outbreaks were reported to the WHO. However, a side note, in 1967 it was not mandated to report haemorrhagic fevers to the WHO.

The second limitation is the scope of the study. The study was narrowed using the filovirus as a lens to examine the 2005 amended IHR framework. The filovirus outbreaks, although limited in the number of outbreaks throughout history, the disease is one that has demonstrated the ability to cause serious international public health impact due to the disease ability to spread rapidly internationally.

The third limitation was comparability, as the study was limited to the variable delay in reporting the outbreak to the WHO. However, even with the limitation of comparability the use of the variable delay in reporting was the best choice. The variables spread, number of cases and deaths, and duration are dependent to the cause, delay in reporting the outbreak.

The fourth limitation was the reporting of filovirus outbreaks. Literature research indicates that from 1830 until the 2005 amendment member States were not required to report viral haemorrhagic fevers to the international authority. The viral haemorrhagic

fevers were reported to the WHO pre amendment; however, this may be due to the WHO and affiliates virology expertise in the virus. The pre amendment reporting of the outbreak to WHO ranged from 0- 157 days while the post amendment reporting of the outbreak to WHO ranged from 0-119 days.

The fifth limitation was the study's inability to effectively analyze quarantine. Although the study was interested in the topic of quarantine and its effects on the spread of communicable diseases it was only enacted in three of the outbreaks all within the pre amendment period not allowing for a post amendment comparison. Future research may focus on the effect of community mobilization and isolation versus use of quarantine using forecast modeling.

In spite of the dissertations limitations, the examination of the issues of delays and non-compliance was conducted using multivariate time series trending with linear regression, bivariate correlation, descriptive statistics and epidemiology.

Future research may correct the limitations listed and create new knowledge of factors not presented. Some of the findings in this study can provide guidance to other researchers to further understand Regulations and their effects on communicable infectious diseases and binding members.

Concluding Thoughts

Communicable infectious diseases have been a global health concern since the history of mankind. And despite the conventions and conferences over the last 200 years' mankind is still battling for protection against the international spread of communicable infectious diseases.

To end where we began, this paper has endeavored to address the question, why should we be paying attention to the health of people around the world especially health affected by communicable infectious diseases (Gonzalez-Martin et al, 2007; Skolnik, 2008)?

References

Aginam, O. (2002). International law and communicable diseases. *Bulletin of the World Health Organization, 80*(12), 946-950.

Amblard, J., Obiang, P., Edzang, S., Prehaud, C., Bouloy, M., & Guenno, B. L. E. (1997). Identification of the Ebola virus in Gabon in 1994. *The Lancet, 349*(9046), 181-182.

Baize, S., Pannetier, D., Oestereich, L., Rieger, T., Koivogui, L., Magassaouba, N. . . . Gunther, S. (2014). Emergence of Zaire Ebola virus disease in Guinea. *The New England Journal of Medicine, 371*(15), 1418-1425. Doi: 10.1056/NEJMoa1404505

Baron, R. C., McCormick, J. B., & Zubeir, O. A. (1983). Ebola virus disease in southern Sudan: Hospital dissemination and intrafamilial spread. *Bulletin of the World Health Organization, 61*(6), 997-1003.

Bausch, D. G., Borchert, M., Grein, T., Roth, C., Swanepoel, R., Libande, M. L. . . . Rollin, P. E. (2003, December). Risk factors for Marburg hemorrhagic fever, Democratic Republic of the Congo. *Emerging Infectious Diseases, 9*(12), 1531-1537.

Bausch, D. G., Nichol, S. T., Muyembe-Tamfum, J. J., Borchert, M., Rollin, P. E., Sleurs, H. . . . Swanepoel, R. (2006, August 31). Marburg hemorrhagic fever associated with multiple genetic lineages of virus. *The New England Journal of Medicine, 355*(9), 909-919.

Bordens, K., & Abbott, B. (2014). Choosing a research design. *Research design and methods A process approach* (Ninth ed., pp. 99-122). New York, NY: McGraw-Hill Education.

Brauburger, K., Hume, A., Mühlberger, E., & Olejnik, J. (2012). Forty-five years of Marburg virus research. *Viruses, 4*(10), 1878-1927. Doi: 10.3390/v4101878

Centers for Disease Control and Prevention. (2005a, March 30). Outbreak of Marburg virus hemorrhagic fever in Angola. Retrieved from https://stacks.cdc.gov/view/cdc/25136

Centers for Disease Control and Prevention. (2005b, June 10). National center for infectious diseases emerging infectious diseases. Retrieved from http://www.cdc.gov/ncidod/diseases/eid/index.htm

Centers for Disease Control and Prevention. (2012, July 2). Severe acute respiratory syndrome SARS basic fact sheet. Retrieved from http://www.cdc.gov/sars/about/fs-sars.html

Centers for Disease Control and Prevention. (2014a, April 7). Viral hemorrhagic fevers, Filoviridae. Retrieved from http://www.cdc.gov/vhf/virus-families/filoviridae.html

Centers for Disease Control and Prevention. (2014b, October 8). Quarantine and isolation legal authorities for isolation and quarantine. Retrieved from http://www.cdc.gov/quarantine/AboutLawsRegulationsQuarantineIsolation.html

Centers for Disease Control and Prevention. (2014c, October 9). Marburg hemorrhagic fever (Marburg HF) chronology of Marburg hemorrhagic fever outbreaks. Retrieved from http://www.cdc.gov/vhf/marburg/resources/outbreak-table.html

Centers for Disease Control and Prevention. (2015, September 17). Ebola outbreaks 2000-2014. Retrieved from http://www.cdc.gov/vhf/ebola/outbreaks/history/summaries.html

Centers for Disease Control and Prevention. (2016a, March 23). Zika virus. Retrieved from http://www.cdc.gov/zika/index.html

Centers for Disease Control and Prevention. (2016b, March 31). 2014 Ebola outbreak in West Africa. Retrieved from http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/index.html

Centers for Disease Control and Prevention. (2016c, March 31). Ebolavirus disease outbreaks chronology: Ebolavirus disease. Retrieved from http://www.cdc.gov/vhf/ebola/outbreaks/history/chronology.html

Choi, K. J. (2008). A journey of a thousand leagues: From quarantine to international health regulations and beyond. *University of Pennsylvania Journal of Translational Law, 29 U. Pa.J.Int'l L.989*, 989-1020.

Chippaux, J-P. (2014). Outbreaks of Ebola virus disease in Africa: the beginnings of a tragic saga. *Journal of Venomous Animals and Toxins including Tropical Diseases*, 20(44), http://www.hvat.org/content/20/1/44.

Coghlan, D., & Brarnnick, T. (2014). *Doing action research in your own organization, 4th edition* (4th ed.). Los Angeles: Sage Publications.

Daszak, P., Cunningham, A. A., & Hyatt, A. D. (2001). Anthropogenic environmental change and the emergence of infectious diseases in wildlife. *Acta Tropica*, *78*(2), 103-116. doi:http://dx.doi.org/10.1016/S0001-706X(00)00179-0

Fidler, D. (1998). The future of the world health organization: What role for international health law? *Vanderbilt Journal of Transnational Law, 31*(5), 1080-1126.

Fidler, D. P., & Gostin, L. O. (2006). The new international health regulations: An historic development for international law and public health. *The Journal of Law, Medicine & Ethics, 34*(1), 85-93.

Georges, A., Leroy, E. M., Renaut, A. A., Benissan, C. T., Nabias, R. J., Ngoc, M. T., . . . Geroges-Courbot, M. (1999). Ebola hemorrhagic fever outbreaks in Gabon, 1994 - 1997: Epidemiologic and health control issues. *The Journal of Infectious Diseases, 179*(Suppl 1), S65-S75.

Geroges-Courbot, M., Lu, C. Y., Lansound-Soukate, J., Leroy, E., & Baize, S. (1997). Isolation and partial molecular characteristics of a strain of Ebola virus during a recent epidemic of viral haemorrhagic fever in Gabon. *The Lancet, 349*(9046), 181.

Gomes, M., Patore y Piontti, A., Rossi, L., Chao, D., Longini, I., Halloran, M., & Vespignani, A. (2014, September 2). Assessing the international spreading risk associated with the 2014 West African Ebola outbreak. *PLOS Current Outbreaks,* (Edition 1), May 11, 2016. Doi: 10.1371/currents.outbreaks.cd818f63d40e24aef769dda7df9e0da5

Gonzalez-Martin, F., Gostin, L. O., & Burci, G. L. (2007). A proposal for a framework convention on global health. *Proceedings of the Annual Meeting (American Society of International Law), 101*, 249-256. Retrieved from http://www.jstor.org/stable/25660197

Gostin, L. O. (2004). International infectious disease law revision of the world health organization's international health regulations. *Jama, 291*(21), 2623-2627.

Gostin, L. O., Gravely, S. D., Shakman, S., Markel, H., & Cetron, M. (2004). Quarantine: Voluntary or not? *The Journal of Law, Medicine & Ethics, 32*(4), 83-86.

Grard, G., Biek, R., Muyembe-Tamfum, J., Fair, J., Wolfe, N., Formenty, P. . . . Leroy, E. (2011). Emergence of divergent Zaire ebola virus strains in Democratic Republic of the Congo in 2007 and 2008. *The Journal of Infectious Diseases, 204*(Suppl 3), S776-S784. doi:10.1093/infdis/jir364

Integrated Regional Information Networks. (2012, August 23). *Bushmeat blamed for ebola outbreak*

International Federation of Red Cross and Red Crescent Societies. (2003a, August 19). *Republic of the Congo: Ebola epidemic.* (Final repot). International Federation of Red Cross and Red Crescent Societies.

International Federation of Red Cross and Red Crescent Societies. (2003b, November 18). *Republic of Congo: Ebola epidemic.* (Information Bulletin No. Information

Bulletin N (degree) 2/03). International Federation of Red Cross and Red Crescent Societies.

International Federation of Red Cross and Red Crescent Societies. (2007, September 20). *Democratic Republic of the Congo: Ebola haemorrhagic fever in western Kasai.* (DREF bulletin No. DREF Bulletin no. MDRCD001 GLIDE no. EP-2007-000167-COD). International Federation of Red Cross and Red Crescent Societies.

International Federation of Red Cross and Red Crescent Societies. (2012). *DREF operation update democratic republic of Congo: Ebola outbreak.* (Operation update No. DREF operation n (degree) MDRCD011 GLIDE n (degree) EP-2012-000143-COD). International Federation of Red Cross and Red Crescent Societies.

International Federation of Red Cross and Red Crescent Societies. (2013, July 31). *DREF final report Democratic Republic of Congo: Ebola outbreak.* (Final Report No. DREF operation n (degree) MDRCD011 GLIDE n (degree) EP-2012-000143-COD). International Federation of Red Cross and Red Crescent Societies.

IRIN. (2003, November 19). *Congo: Congo: Ebola cases increase in Cuvette ouest.* (Relief Web report). Nairobi: UN Office for the Coordination of Humanitarian Affairs.

Jaikumar, A. K. (2014). Red flags in federal quarantine: The questionable constitutionality of federal quarantine after NFIB v. Sebelius. *Columbian Law Review, 114*(3), 677-714.

Khan, A. S., Tshioko, F. K., Heymann, D. L., Le Guenno, B., Nabeth, P., Kerstiens, B., . . . Ksiazek, T. G. (1999). The reemergence of Ebola hemorrhagic fever, Democratic Republic of the Congo, 1995. *The Journal of Infectious Diseases, 179*(Suppl 1), S76-S86.

Kilbourne, E. D. (2006). Influenza pandemics for the 20th century. *Centers for Disease Control and Prevention, Emerging Infectious Diseases, 12*(1) doi:10.31201/eid1201.051254

Kiskowski, M., & Chowell, G. (2015). Modeling household and community transmission of Ebola virus disease: epidemic growth, spatial dynamics and insights for epidemic control, *Virulence*, DOI: 10.1080/21505594.2015.1076613

Knust, B., Schafer, I. J., Wamala, J., Nyakarahuka, L., Okot, C., Shoemaker, T. . . . Rollin, P. E. (2012). Multidistrict outbreak of Marburg virus disease - Uganda, 2012. *The Journal of Infectious Diseases,* S1-S10. doi:10.1093/infdis/jiv351

Kratz, T., Roddy, P., Oloma, A. T., Jeffs, B., Ciruelo, D. P., de la Rosa, O., & Borchert, M. (2015). Ebola virus disease outbreak in Isiro, Democratic Republic of the Congo,

2012: Signs and symptoms, management and outcomes. *PLoS One, 10*(6) Doi: 10.1371/journal.pone.0129333

Laerd Dissertation. (2014). Principles of research ethics. Retrieved from Retrieved from http://dissertation.laerd.com/principles-of-research-ethics.php

Lamunu, M., Lutwama, J. J., Kamugisha, J., Opio, A., Nambooze, J., Ndayimirije, N., & Okware, S. (2004). Containing a haemorrhagic fever epidemic: The Ebola experience in Uganda (October 2000 - January 2001). *International Journal of Infectious Diseases, 8*(1), 27-37. Doi: 10.1016/j.ijid.2003.04.001

Leroy, E. M., Epelboin, A., Mondonge, V., Pourrut, X., Gonzalez, J., Muyembe-Tamfum, J. J., & Formenty, P. (2009). Human Ebola outbreak resulting from direct exposure to fruit bats in Leubo, Democratic Republic of Congo, 2007. *Vector-Borne and Zoonotic Diseases, 9*(6), 723-728. doi:10.1089/vbz.2008.0167

MacNeil, A., Farnon, E.C., Morgan, O.W., Gould, P., Boehmer, T.K., Blaney, D.D., Wiersam, P., Tappero, J.W., Nichol, S.T., Ksiazek, T.G., Rollin, P.E. (2011). Filovirus Outbreak Detection and Surveillance: Lessons from Bundibugyo. *The Journal of Infectious Disease*, 204(Suppl 3), S761-S767. doi: 10.1093/infdis/jir294

Maganga, G. D., Kapetshi, J., Berthet, N., Ilunga, B. K., Kabange, F., Kingebeni, P. M..., Leroy, E. M. (2014, November 27). Ebola virus disease in the Democratic Republic of Congo. *The New England Journal of Medicine, 371*(22), 2083-2091. doi: 10.1056/NEJMoa1411099

Maglen, K. (2003). Politics of quarantine in the 19th century. *Jama, 290*(21), 2873.

Martini, G. A. (1973). Marburg virus disease. *Postgraduate Medical Journal, 49*, 542-546.

Martini, G.A. & Siegert, R. (Ed.). (1971). *Marburg virus disease* (1st ed.). Berlin Heidelberg: Springer-Verlag. Doi: 10.1007/978-3-662-01593-3

Mawudeku, A., & Blench, M. (2005). *Global public health intelligence network (GPHIN).* Unpublished manuscript.

Muyembe-Tamfum, J. J., Kipasa, M., Kiyungu, C., & Colebunders, R. (1999). Ebola outbreak in Kikwit, Democratic Republic of the Congo: Discovery and control measures. *The Journal of Infectious Diseases, 179*(Suppl 1), S259-S262.

National Institutes of Health, U.S. National Library of Medicine. (2016, March 25). Infectious disease. Retrieved from https://www.nlm.nih.gov/medlineplus/infectiousdiseases.html

Nkoghe, D., Formenty, P., Leroy, E. M., Nnegue, S., Obame Edou, S. Y., Iba Ba, J. . . . Toung Mve, M. (2005). Multiple Ebola virus haemorrhagic fever outbreaks in Gabon, from October 2001 to April 2002. *Bull Soc Pathol Exot, 98*(3), 224-229.

Nkoghe, D., Kone, M. L., Yada, A., & Leroy, E. (2011). A limited outbreak of Ebola haemorrhagic fever in Etoumbi, Republic of Congo, 2005. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 105*, 466-472. Doi: 10.1016/j.trstmh.2011.04.011

Okware, S. I., Omaswa, F. G., Zaramba, S., Lutwama, J. J., Kamugisha, J., Rwaguma, E. B. . . . Lamunu, M. (2002). An outbreak of Ebola in Uganda. *Tropical Medicine and International Health, 7*(12), 1068-1075.

Olival, K. J., Islam, A., Yu, M., Anthony, S. J., Epstein, J. H., Khan, S. A. . . . Daszak, P. (2013). Ebola virus antibodies in fruit bats, Bangladesh. *Emerging Infectious Diseases, 19*(2), 270-273. doi:http://doi.org/10.3201/eid1902.120524

Pinzon, J.E., Wilson, J.M., Tucker, C.J., Arthur, R., Jahrling, P.B., & Formenty, P. (2004). Trigger Events: Envrioclimatic Coupling of Ebola Hemorrhagic Fever Outbreaks. *Am J Trop Med Hyg*, 71(5), 664-674.

Relief web. (2013). Uganda: Ebola outbreak - Jul 2012. Retrieved from http://reliefweb.int/disaster/ep-2012-000124-uga

Roddy, P., Howard, N., Van Kerkhove, M. D., Lutwama, J., Wamala, J., Yoti, Z. . . . Borchert, M. (2012, December). Clinical manifestations and case management of Ebola haemorrhagic fever caused by a newly identified virus strain, Bundibugyo, Uganda, 2007-2008. *PLoS One, 7*(12), 1-12.

Runge-Ranzinger, S., McCall, P.J., Kroeger, A., & Horstick, O. (2014). Dengue disease surveillance: an updated systematic literature review. *Tropical Medicine and International Health*, 19(9), 1116-1160. Doi: 10.1111/tmi.12333

Schabas, R. (2007). Public health, is the quarantine act relevant? *CMAJ, 176*(13), 1840-1842.

Semenza, J. C., Lindgren, E., Balkanyi, L., Espinosa, L., Almqvist, M. S., Penttinen, P., & Rocklov, J. (2016). Determinants and drivers of infectious disease threat events in Europe. *Centers for Disease Control and Prevention, Emerging Infectious Diseases, 22*(4), 581-589. doi: http://dx.doi.org/10.3201/eid2204.151073

Simpson, D. (1978). Viral haemorrhagic fevers of man. *Bulletin of the World Health Organization, 56*(6), 819-832.

Skolnik, R. (2008). Introduction and The Principles and Goals of Global Health. In Riegelman R. (Ed.), *Essentials of global health*. Sudbury, MA: Jones & Bartlett Learning.

Slenczka, W. & Dieter Klenk, H. (2007). Forty years of Marburg virus. *Journal of Infectious Diseases, 196*(Suppl 2), S131-S135. doi: 10.1086/520551

Sohn, M., Sapsin, J., Gibson, E., & Matthews, G. (2004). Globalization, public health, and international law. *The Journal of Law, Medicine & Ethics, 32*(4), 87-89.

Tomasulo, A. (2012, November 14). The disease daily ebola strikes again in Uganda. Retrieved from http://www.healthmap.org/site/diseasedaily/article/ebola-strikes-again-uganda-111412

Towner, J., Khristova, M., Sealy, T., Vincent, M., Erickson, B., Bawiec, D. . . . Nichol, S. (2006, July). Marburgvirus genomics and association with a large hemorrhagic fever outbreak in Angola. *Journal of Virology, 80*(13), 6497-6516. doi:10.1128/JVI.00069-06

United Nations. (1945). *Charter of the United Nations and statute of the international court of justice.* (Charter). San Francisco: Charter of the United Nations.

University of Minnesota Centers for Infectious Disease Research and Policy. (2005, November 10). Angola declares worst Marburg outbreak over. Retrieved from http://www.cidrap.umn.edu/news-perspective/2005/11/angola-declares-worst-marburg-outbreak-over

Wamala, J. F., Lukwago, L., Malimbo, M., Nguku, P., Yoti, Z., Musenero, M. . . . Okware, S. I. (2010). Ebola hemorrhagic fever associated with novel virus strain, Uganda, 2007-2008. *Emerging Infectious Diseases, 16*(7), 1087-1092. doi:10.3201/eid1607.091525

Watson, A. (1987). Hedley bull, states systems and international societies. *Review of International Studies, 13*(2), 147-153. Retrieved from http://www.jstor.org/stable/20097109

Wilson, F., & Mabhala, M. (Eds.). (2009). *Key concepts in public health*. Los Angeles: Sage.

World Bank. (2015, May 29). South Asia. Retrieved from http://www.worldbank.org/en/region/sar/overview#1

World Bank. (2016, March 28). Africa. Retrieved from http://www.worldbank.org/en/region/afr/overview#1

World Health Organization. (1976). Weekly epidemiological record suspected viral haemorrhagic fever outbreaks in Sudan and Zaire. *Weekly Epidemiological Record, 51*(41), 317-324.

World Health Organization, International Study Team. (1978a). Ebola haemorrhagic fever in Sudan, 1976. *Bulletin of the World Health Organization, 56*(2), 247-270.

World Health Organization, International Commission. (1978b). Ebola haemorrhagic fever in Zaire, 1976. *Bulletin of the World Health Organization, 56*(2), 271-293.

World Health Organization. (1979). Weekly epidemiological record viral haemorrhagic fever. *Weekly Epidemiological Record, 54*(41), 313-320.

World Health Organization. (1995). Weekly epidemiological record Ebola haemorrhagic fever. *Weekly Epidemiological Record, 70*(34), 241-248.

World Health Organization. (1996a). Weekly epidemiological record Ebola haemorrhagic fever. *Weekly Epidemiological Record, 71*(9), 65-72.

World Health Organization. (1996b). Weekly epidemiological record outbreak of Ebola haemorrhagic fever in Gabon officially declared over. *Weekly Epidemiological Record, 71*(17), 125-132.

World Health Organization. (1996c, October 15). Emergencies preparedness, response 1996 - Ebola haemorrhagic fever in Gabon (new outbreak) - update. Retrieved from http://www.who.int/csr/don/1996_10_15b/en/

World Health Organization. (1996d, October 18). Emergency preparedness, response 1996 - Ebola haemorrhagic fever in Gabon (new outbreak) - update 2. Retrieved from http://www.who.int/csr/don/1996_10_18/en/

World Health Organization. (1996e, November 18). Emergency preparedness, response 1996 - Ebola haemorrhagic fever in south Africa. Retrieved from http://www.who.int/csr/don/1996_11_18/en/

World Health Organization. (1996f, December 24). Emergencies preparedness, response 1996 - Ebola haemorrhagic fever in Gabon (new outbreak) - update 9. Retrieved from http://www.who.int/csr/don/1996_12_24/en/

World Health Organization. (1999, May 6). Emergency preparedness, response 1999 - Marburg disease in democratic republic of Congo - update 2. Retrieved from http://www.who.int//csr/don/1999_05_06/en/

World Health Organization. (2001, February 28). Emergency preparedness, response 2001 - Ebola haemorrhagic fever in Uganda - the outbreak is officially over. Retrieved from http://www.who.int/csr/don/2001_02_28b/en/

World Health Organization. (2003a). Weekly epidemiological record Ebola haemorrhagic fever, republic of the Congo - update. *Weekly Epidemiological Record, 78*(48), 409-416.

World Health Organization. (2003b). Weekly epidemiological record outbreak(s) of Ebola haemorrhagic fever in the republic of the Congo, January - April 2003. *Weekly Epidemiological Record, 78*(33), 285-296.

World Health Organization. (2003c). Weekly epidemiological record outbreak(s) of Ebola haemorrhagic fever, Congo and Gabon, October 2001 - July 2002. *Weekly Epidemiological Record, 78*(26), 217-228.

World Health Organization. (2004, January 6). *Ebola haemorrhagic fever in the republic of the Congo - update 6.* (DON No. Update 6). Geneva Switzerland: World Health Organization.

World Health Organization. (2005a). Weekly epidemiological record outbreak of Ebola haemorrhagic fever in Yambio, South Sudan, April - June 2004. *Weekly Epidemiological Record, 80*(43), 369-376.

World Health Organization. (2005b, November 7). Marburg haemorrhagic fever in Angola - update 26: MOH declares outbreak over. Retrieved from http://www.who.int/csr/don/2005_11_07a/en/

World Health Organization. (2007). Weekly epidemiological record Ebola virus haemorrhagic fever, Democratic Republic of the Congo - update. *Weekly Epidemiological Record, 82*(40), 345-356.

World Health Organization. (2008a). *International health regulations (2005) second edition* (Second Edition Ed.). Switzerland: WHO Press.

World Health Organization. (2008b). Weekly epidemiological record Ebola haemorrhagic fever, Uganda - end of the outbreak. *Weekly Epidemiological Record, 83*(10), 89-96.

World Health Organization. (2009, February 17). *Emergencies preparedness, response end of Ebola outbreak in the Democratic Republic of the Congo*. Geneva Switzerland: World Health Organization.

World Health Organization. (2012a). Weekly epidemiological record Ebola haemorrhagic fever, Uganda. *Weekly Epidemiological Record, 87*(36), 337-344.

World Health Organization. (2012b). Weekly epidemiological record Ebola haemorrhagic fever, Uganda - update. *Weekly Epidemiological Record, 87*(49/50), 493-508.

World Health Organization. (2012c, July 29). *Emergencies preparedness, response Ebola in Uganda.* (DON). Geneva Switzerland: World Health Organization.

World Health Organization. (2012d, August). *Ebola in Uganda.* Geneva Switzerland: World Health Organization.

World Health Organization. (2012e, August 17). *Emergencies preparedness, response ebola outbreak in democratic republic of Congo.* Geneva Switzerland: World Health Organization.

World Health Organization. (2012f, October 4). Emergencies preparedness, response end of Ebola outbreak in Uganda. Retrieved from http://www.who.int/csr/don/2012_10_04/en/

World Health Organization. (2012g, October 21). Emergencies preparedness, response Marburg haemorrhagic fever in Uganda. Retrieved from http://www.who.int/csr/don/2012_10_21/en/

World Health Organization. (2012h, November 17). Emergency preparedness, response Ebola in Uganda. Retrieved from http://www.who.int/csr/don/2012_11_17/en/

World Health Organization. (2012i, November 23). Emergency preparedness, response Ebola in Uganda. Retrieved from http://www.who.int/csr/don/2012_11_23_ebola/en/

World Health Organization. (2014a), *Ebola response roadmap situation report.* (Situation Report) http://apps.who.int/iris/bitstream/10665/137376/1/roadmapsitrep_29Oct2014_eng.pdf?ua=1;)

World Health Organization. (2014b). Global alert and response (GAR) Democratic Republic of Congo: "classic" ebola in a country experiencing its seventh outbreak. Retrieved from http://www.who.int/csr/disease/ebola/ebola-6-months/drc/en/

World Health Organization. (2014c, March 23). Ebola virus disease in guinea. Retrieved from http://www.afro.who.int/en/clusters-a-programmes/dpc/epidemic-a-pandemic-alert-and-response/outbreak-news/4063-ebola-virus-disease-in-guinea.html?tm

World Health Organization. (2014d, March 28). Situation report 1 Ebola virus disease, Guinea, 28 March 2014. Retrieved from http://www.afro.who.int/en/clusters-a-programmes/dpc/epidemic-a-pandemic-alert-and-response/sitreps/4070-sitrep-1-ebola-guinea-28-march-2014.html

World Health Organization. (2014e, August 8). Statement on the 1st meeting of the IHR emergency committee on the 2014 Ebola outbreak in west Africa. Retrieved from http://www.who.int/mediacentre/news/statements/2014/ebola-20140808/en/

World Health Organization. (2014f, August 29). WHO: Ebola response roadmap situation report 1. Retrieved from http://www.who.int/csr/disease/ebola/evd-sitrep1-20140828.pdf

World Health Organization. (2014g, September 22). Study warns swift action needed to curb exponential climb in ebola outbreak. Retrieved from http://www.who.int/mediacentre/news/releases/2014/ebola-study/en/

World Health Organization. (2014h, October 1). Ebola virus disease - United States of America. Retrieved from http://www.who.int/csr/don/01-october-2014-ebola/en/#

World Health Organization. (2015a). *IHR and ebola.* (Executive Board Special session on Ebola and 136th session No. EBSS/3/INF./4 and EB136/INF./7). Geneva Switzerland: World Health Organization.

World Health Organization. (2015b, January). Classical Ebola virus diseases in the democratic republic of Congo. Retrieved from http://www.who.int/csr/disease/ebola/one-year-report/drc/en/#

World Health Organization. (2015c, July). Cholera. Retrieved from http://www.who.int/mediacentre/factsheets/fs107/en/

World Health Organization. (2016a). Emergency preparedness response, Smallpox. Retrieved from http://www.who.int/csr/disease/smallpox/en/

World Health Organization. (2016b). HIV/AIDS data and statistics. Retrieved from http://www.who.int/hiv/data/en/

World Health Organization. (2016c). Origin and development of health cooperation. Retrieved from http://www.who.int/global_health_histories/background/en/

World Health Organization. (2016d, March). Tuberculosis. Retrieved from http://www.who.int/mediacentre/factsheets/fs104/en/

World Health Organization. (2016e, March 30). Ebola virus disease outbreak. Retrieved from http://www.who.int/csr/disease/ebola/en/

World Health Organization Ebola Response Team. (2014, September 23). Ebola Virus Disease in West Africa — The First 9 Months of the Epidemic and Forward Projections. *The New England Journal of Medicine NEJM* September 23, 2014 DOI: 10.1056/NEJMoa1411100

Appendix A. Exclusions of Sample Selection

The following data were excluded from the sample selection.

Table A1. List of sample selection exclusions

filovirus	Year	Location	Case/ Death	Exclusion Reason
Marburgvirus	1975	South Africa	3/1	Below case set
Sudan Ebola virus	1976	England	1/0	Laboratory accident
Zaire Ebola virus	1977	Zaire	1/1	Below case set
Marburgvirus	1980	Kenya	2/1	Below case set
Marburgvirus	1987	Kenya	1/1	Below case set
Reston Ebola virus	1989	USA	0/0	No human transmission
Reston Ebola virus	1989	Philippines	3/0	No human transmission
Reston Ebola virus	1990	USA	4/0	No human transmission
Marburgvirus	1990	Russia	1/1	Laboratory accident
Reston Ebola virus	1992	Italy	0/0	No human transmission
Taï Forest Ebola virus	1994	Côte d'Ivoire	1/0	Below case set
Reston Ebola virus	1996	Philippines	0/0	No human transmission
Reston Ebola virus	1996	USA	0/0	No human transmission
Zaire Ebola virus	1996	South Africa	2/1	Below case set
Zaire Ebola virus	1996	Russia	1/1	Laboratory accident
Zaire Ebola virus	2004	Russia	1/1	Laboratory accident
Marburgvirus	2007	Uganda	4/1	Below case set
Marburgvirus	2008	USA	1/0	Below case set
Marburgvirus	2008	Netherlands	1/1	Below case set
Reston Ebola virus	2008	Philippines	6/0	No human transmission
Sudan Ebola virus	2011	Uganda	1/1	Below case set

(CDC, 2014c; CDC, 2016c)

Appendix B. Data Source: Filovirus Outbreaks 1967-2014

Table B1: Data sourced: Sources used for historical filovirus data

Filovirus Type (name)	Index Case City/Country (city, Country)	Outbreak Year	Data
Marburg virus	Marburg, Germany	1967	26
Martini, G. A. (1973). Marburg virus disease. *Postgraduate Medical Journal, 49*, 542-546.			
Martini, G.A. & Siegert, R. (Ed.). (1971). *Marburg virus disease* (1st ed.). Berlin Heidelberg: Springer-Verlag. doi:10.1007/978-3-662-01593-3			
Simpson, D. (1978). Viral haemorrhagic fevers of man. *Bulletin of the World Health Organization, 56*(6), 819-832			
Slenczka, W. & Dieter Klenk, H. (2007). Forty years of Marburg virus. *Journal of Infectious Diseases, 196*(Suppl 2), S131-S135. doi:10.1086/520551			
Zaire Ebola virus	Yambuku, Zaire	1976	1
World Health Organization. (1976). Weekly epidemiological Record Suspected viral haemorrhagic fever outbreaks in Sudan and Zaire. *Weekly Epidemiological Record, 51*(41), 317-324			
World Health Organization, International Commission. (1978b). Ebola haemorrhagic fever in Zaire, 1976.*Bulletin of the World Health Organization, 56*(2), 271-293			
Sudan Ebola virus	Nzara, Sudan	1976	2
World Health Organization. (1976). Weekly epidemiological Record Suspected viral haemorrhagic fever outbreaks in Sudan and Zaire. *Weekly Epidemiological Record, 51*(41), 317-324			
World Health Organization, International Study Team. (1978a). Ebola haemorrhagic fever in Sudan, 1976. *Bulletin of the World Health Organization, 56*(2), 247-270			
Sudan Ebola virus	Nzara, Sudan	1979	4
Baron, R. C., McCormick, J. B., & Zubeir, O. A. (1983). Ebola virus disease in southern Sudan: Hospital dissemination and intrafamilial spread. *Bulletin of the World Health Organization, 61*(6), 997-1003			
World Health Organization. (1979). Weekly epidemiological record viral haemorrhagic fever. *Weekly Epidemiological Record, 54*(41), 313-320			
Zaire Ebola virus	Mékouka, Gabon	1994	5
Amblard, J., Obiang, P., Edzang, S., Prehaud, C., Bouloy, M., & Guenno, B. L. E. (1997). Identification of the ebola virus in Gabon in 1994. *The Lancet, 349*(9046), 181-182			
Georges, A., Leroy, E. M., Renaut, A. A., Benissan, C. T., Nabias, R. J., Ngoc, M. T., . . . Geroges-Courbot, M. (1999). Ebola hemorrhagic fever outbreaks in Gabon, 1994 - 1997: Epidemiologic and health control issues. *The Journal of Infectious Diseases, 179*(Suppl 1), S65-S75			
Geroges-Courbot, M., Lu, C. Y., Lansound-Soukate, J., Leroy, E., & Baize, S. (1997). Isolation and partial molecular characteristics of a strain of ebola virus during a recent epidemic of viral haemorrhagic fever in Gabon. *The Lancet, 349*(9046), 181			
Zaire Ebola virus	Kikwit, DRC	1995	7
Khan, A. S., Tshioko, F. K., Heymann, D. L., Le Guenno, B., Nabeth, P., Kerstiens, B., . . . Ksiazek, T. G. (1999). The reemergence of Ebola hemorrhagic fever, Democratic Republic of the Congo, 1995. *The Journal of Infectious Diseases, 179*(Suppl 1), S76-S86			
Muyembe-Tamfum, J. J., Kipasa, M., Kiyungu, C., & Colebunders, R. (1999). Ebola outbreak in Kikwit, Democratic Republic of the Congo: Discovery and control measures. *The Journal of Infectious Diseases, 179*(Suppl 1), S259-S262			
World Health Organization. (1995). Weekly epidemiological record ebola haemorrhagic fever. *Weekly Epidemiological Record, 70*(34), 241-248			

Table B1: Filoviruses data sourced, sources used for historical filovirus data (continued)

Filovirus Type (name)	Index Case City/Country (city, Country)	Outbreak Year	Data
Zaire Ebola virus	Mayibout, Gabon	1996	8
Amblard, J., Obiang, P., Edzang, S., Prehaud, C., Bouloy, M., & Guenno, B. L. E. (1997). Identification of the ebola virus in Gabon in 1994. *The Lancet, 349*(9046), 181-182			
Georges, A., Leroy, E. M., Renaut, A. A., Benissan, C. T., Nabias, R. J., Ngoc, M. T., . . . Geroges-Courbot, M. (1999). Ebola hemorrhagic fever outbreaks in Gabon, 1994 - 1997: Epidemiologic and health control issues. *The Journal of Infectious Diseases, 179*(Suppl 1), S65-S75			
Geroges-Courbot, M., Lu, C. Y., Lansound-Soukate, J., Leroy, E., & Baize, S. (1997). Isolation and partial molecular characteristics of a strain of ebola virus during a recent epidemic of viral haemorrhagic fever in Gabon. *The Lancet, 349*(9046), 181			
World Health Organization. (1996a). Weekly epidemiological record Ebola haemorrhagic fever. *Weekly Epidemiological Record, 71*(9), 65-72.			
World Health Organization. (1996b). Weekly epidemiological record outbreak of Ebola haemorrhagic fever in Gabon officially declared over. *Weekly Epidemiological Record, 71*(17), 125-132			
Zaire Ebola virus	Booué, Gabon	1996	9
Amblard, J., Obiang, P., Edzang, S., Prehaud, C., Bouloy, M., & Guenno, B. L. E. (1997). Identification of the ebola virus in Gabon in 1994. *The Lancet, 349*(9046), 181-182			
Georges, A., Leroy, E. M., Renaut, A. A., Benissan, C. T., Nabias, R. J., Ngoc, M. T., . . . Geroges-Courbot, M. (1999). Ebola hemorrhagic fever outbreaks in Gabon, 1994 - 1997: Epidemiologic and health control issues. *The Journal of Infectious Diseases, 179*(Suppl 1), S65-S75			
Geroges-Courbot, M., Lu, C. Y., Lansound-Soukate, J., Leroy, E., & Baize, S. (1997). Isolation and partial molecular characteristics of a strain of ebola virus during a recent epidemic of viral haemorrhagic fever in Gabon. *The Lancet, 349*(9046), 181			
World Health Organization. (1996c, October 15). Emergencies preparedness, response 1996 - ebola haemorrhagic fever in Gabon (new outbreak) - update. Retrieved from http://www.who.int/csr/don/1996_10_15b/en/			
World Health Organization. (1996d, October 18). Emergency preparedness, response 1996 - ebola haemorrhagic fever in Gabon (new outbreak) - update 2. Retrieved from http://www.who.int/csr/don/1996_10_18/en/			
World Health Organization. (1996e, November 18). Emergency preparedness, response 1996 - ebola haemorrhagic fever in south Africa. Retrieved from http://www.who.int/csr/don/1996_11_18/en/			
World Health Organization. (1996f, December 24). Emergencies preparedness, response 1996 - ebola haemorrhagic fever in Gabon (new outbreak) - update 9. Retrieved from http://www.who.int/csr/don/1996_12_24/en/			
Marburg virus	Durba, DRC	1998	31
Bausch, D. G., Borchert, M., Grein, T., Roth, C., Swanepoel, R., Libande, M. L. . . . Rollin, P. E. (2003, December). Risk factors for Marburg hemorrhagic fever, Democratic Republic of the Congo. *Emerging Infectious Diseases, 9*(12), 1531-1537			
Bausch, D. G., Nichol, S. T., Muyembe-Tamfum, J. J., Borchert, M., Rollin, P. E., Sleurs, H. . . . Swanepoel, R. (2006, August 31). Marburg hemorrhagic fever associated with multiple genetic lineages of virus. *The New England Journal of Medicine, 355*(9), 909-919			
World Health Organization. (1999, May 6). Emergency preparedness, response 1999 - Marburg disease in democratic republic of Congo - update 2. Retrieved from http://www.who.int//csr/don/1999_05_06/en/			

Table B1: Filoviruses data sourced, sources used for historical filovirus data (continued)

Filovirus Type (name)	Index Case City/Country (city, Country)	Outbreak Year	Data
Sudan Ebola virus	Gulu, Uganda	2000	11
Lamunu, M., Lutwama, J. J., Kamugisha, J., Opio, A., Nambooze, J., Ndayimirije, N., & Okware, S. (2004). Containing a haemorrhagic fever epidemic: The ebola experience in Uganda (October 2000 - January 2001). *International Journal of Infectious Diseases, 8*(1), 27-37. Doi: 10.1016/j.ijid.2003.04.001			
Okware, S. I., Omaswa, F. G., Zaramba, S., Lutwama, J. J., Kamugisha, J., Rwaguma, E. B. . . . Lamunu, M. (2002). An outbreak of ebola in Uganda. *Tropical Medicine and International Health, 7*(12), 1068-1075			
World Health Organization. (2001, February 28). Emergency preparedness, response 2001 - Ebola haemorrhagic fever in Uganda - the outbreak is officially over. Retrieved from http://www.who.int/csr/don/2001_02_28b/en/			
Zaire Ebola virus	l'Ogooué-Ivindo, Gabon	2001	12, 13
Nkoghe, D., Formenty, P., Leroy, E. M., Nnegue, S., Obame Edou, S. Y., Iba Ba, J. . . . Toung Mve, M. (2005). Multiple Ebola virus haemorrhagic fever outbreaks in Gabon, from October 2001 to April 2002. *Bull Soc Pathol Exot, 98*(3), 224-229.			
World Health Organization. (2003c). Weekly epidemiological record outbreak(s) of Ebola haemorrhagic fever, Congo and Gabon, October 2001 - July 2002. *Weekly Epidemiological Record, 78*(26), 217-228.			
Zaire Ebola virus	Cuvette-Ouest, DRC	2002	14
International Federation of Red Cross and Red Crescent Societies. (2003a, August 19). *Republic of the Congo: Ebola epidemic.* (Final repot). International Federation of Red Cross and Red Crescent Societies			
World Health Organization. (2003b). Weekly epidemiological record outbreak(s) of Ebola haemorrhagic fever in the republic of the Congo, January - April 2003. *Weekly Epidemiological Record, 78*(33), 285-296			
Zaire Ebola virus	Cuvette-Ouest, DRC	2003	15
International Federation of Red Cross and Red Crescent Societies. (2003b, November 18). *Republic of Congo: Ebola epidemic.* (Information Bulletin No. Information Bulletin N(degree)2/03). International Federation of Red Cross and Red Crescent Societies			
World Health Organization. (2003a). Weekly epidemiological record Ebola haemorrhagic fever, Republic of the Congo - update. *Weekly Epidemiological Record, 78*(48), 409-416			
World Health Organization. (2004, January 6). *Ebola haemorrhagic fever in the Republic of the Congo - update 6.* (DON No. Update 6). Geneva Switzerland: World Health Organization			
Sudan Ebola virus	Yambio, Sudan	2004	16
World Health Organization. (2005a). Weekly epidemiological record outbreak of Ebola haemorrhagic fever in Yambio, South Sudan, April - June 2004. *Weekly Epidemiological Record, 80*(43), 369-376			
Marburg virus	Uige Province, Angola	2004	32
Centers for Disease Control and Prevention. (2005a, March 30). Outbreak of Marburg virus hemorrhagic fever in Angola. Retrieved from https://stacks.cdc.gov/view/cdc/25136			
Towner, J., Khristova, M., Sealy, T., Vincent, M., Erickson, B., Bawiec, D. . . . Nichol, S. (2006, July). Marburgvirus genomics and association with a large hemorrhagic fever outbreak in Angola. *Journal of Virology, 80*(13), 6497-6516. doi:10.1128/JVI.00069-06			
University of Minnesota Centers for Infectious Disease Research and Policy. (2005, November 10). Angola declares worst Marburg outbreak over. Retrieved from http://www.cidrap.umn.edu/news-perspective/2005/11/angola-declares-worst-marburg-outbreak-over			
World Health Organization. (2005b, November 7). Marburg haemorrhagic fever in Angola - update 26: MOH declares outbreak over. Retrieved from http://www.who.int/csr/don/2005_11_07a/en/			

Table B1: Filoviruses data sourced, sources used for historical filovirus data (continued)

Filovirus Type (name)	Index Case City/Country (city, Country)	Outbreak Year	Data
Zaire Ebola virus	Etoumbi, DRC	2005	17
Nkoghe, D., Kone, M. L., Yada, A., & Leroy, E. (2011). A limited outbreak of ebola haemorrhagic fever in Etoumbi, Republic of Congo, 2005. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 105*, 466-472. Doi: 10.1016/j.trstmh.2011.04.011			
Zaire Ebola virus	Ndogo 2 village, DRC	2007	18
International Federation of Red Cross and Red Crescent Societies. (2007, September 20). *Democratic Republic of the Congo: Ebola haemorrhagic fever in western Kasai.* (DREF bulletin No. DREF Bulletin no. MDRCD001 GLIDE no. EP-2007-000167-COD). International Federation of Red Cross and Red Crescent Societies.			
Leroy, E. M., Epelboin, A., Mondonge, V., Pourrut, X., Gonzalez, J., Muyembe-Tamfum, J. J., & Formenty, P. (2009). Human ebola outbreak resulting from direct exposure to fruit bats in Leubo, democratic republic of Congo, 2007. *Vector-Borne and Zoonotic Diseases, 9*(6), 723-728. doi:10.1089/vbz.2008.0167			
World Health Organization. (2007). Weekly epidemiological record ebola virus haemorrhagic fever, Democratic Republic of the Congo - update. *Weekly Epidemiological Record, 82*(40), 345-356			
Bundibugyo Ebola Virus	Bundibugyo, Uganda	2007	19
Roddy, P., Howard, N., Van Kerkhove, M. D., Lutwama, J., Wamala, J., Yoti, Z. . . . Borchert, M. (2012, December). Clinical manifestations and case management of ebola haemorrhagic fever caused by a newly identified virus strain, Bundibugyo, Uganda, 2007-2008. *PLoS One, 7*(12), 1-12			
Wamala, J. F., Lukwago, L., Malimbo, M., Nguku, P., Yoti, Z., Musenero, M. . . . Okware, S. I. (2010). Ebola hemorrhagic fever associated with novel virus strain, Uganda, 2007-2008. *Emerging Infectious Diseases, 16*(7), 1087-1092. doi:10.3201/eid1607.091525			
World Health Organization. (2008b). Weekly epidemiological record ebola haemorrhagic fever, Uganda - end of the outbreak. *Weekly Epidemiological Record, 83*(10), 89-96.			
Zaire Ebola virus	Luebo, DRC	2008	20
Grard, G., Biek, R., Muyembe-Tamfum, J., Fair, J., Wolfe, N., Formenty, P. . . . Leroy, E. (2011). Emergence of divergent Zaire ebola virus strains in Democratic Republic of the Congo in 2007 and 2008. *The Journal of Infectious Diseases, 204*(Suppl 3), S776-S784. doi:10.1093/infdis/jir364			
World Health Organization. (2009, February 17). *Emergencies preparedness, response end of ebola outbreak i the Democratic Republic of the Congo*. Geneva Switzerland: World Health Organization			
Sudan Ebola virus	Kibaale, Uganda	2012	22
Relief web. (2013). Uganda: Ebola outbreak - Jul 2012. Retrieved from http://reliefweb.int/disaster/ep-2012-000124-uga			
Tomasulo, A. (2012, November 14). The disease daily ebola strikes again in Uganda. Retrieved from http://www.healthmap.org/site/diseasedaily/article/ebola-strikes-again-uganda-111412			
World Health Organization. (2012b). Weekly epidemiological record ebola haemorrhagic fever, Uganda - update. *Weekly Epidemiological Record, 87*(49/50), 493-508			
World Health Organization. (2012c, July 29). *Emergencies preparedness, response ebola in Uganda.* (DON). Geneva Switzerland: World Health Organization.			
World Health Organization. (2012d, August). *Ebola in Uganda.* (). Geneva Switzerland: World Health Organization			
World Health Organization. (2012f, October 4). Emergencies preparedness, response end of ebola outbreak in Uganda. Retrieved from http://www.who.int/csr/don/2012_10_04/en/			

Table B1: Filoviruses data sourced, sources used for historical filovirus data (continued)

Filovirus Type (name)	Index Case City/Country (city, Country)	Outbreak Year	Data
Sudan Ebola virus cont.	Kibaale, Uganda	2012	22
World Health Organization. (2012h, November 17). Emergency preparedness, response ebola in Uganda. Retrieved from http://www.who.int/csr/don/2012_11_17/en/			
World Health Organization. (2012i, November 23). Emergency preparedness, response ebola in Uganda. Retrieved from http://www.who.int/csr/don/2012_11_23_ebola/en/			
Bundibugyo Ebola Virus	Isiro, DRC	2012	24
Centers for Disease Control and Prevention. (2015, September 17). Ebola outbreaks 2000-2014. Retrieved from http://www.cdc.gov/vhf/ebola/outbreaks/history/summaries.html			
Integrated Regional Information Networks. (2012, August 23). *Bushmeat blamed for ebola outbreak*			
International Federation of Red Cross and Red Crescent Societies. (2012). *DREF operation update democratic republic of Congo: Ebola outbreak.* (Operation update No. DREF operation n(degree) MDRCD011 GLIDE n(degree) EP-2012-000143-COD). International Federation of Red Cross and Red Crescent Societies			
International Federation of Red Cross and Red Crescent Societies. (2013, July 31). *DREF final report democratic republic of Congo: Ebola outbreak.* (Final Report No. DREF operation n(degree) MDRCD011 GLIDE n(degree) EP-2012-000143-COD). International Federation of Red Cross and Red Crescent Societies			
Kratz, T., Roddy, P., Oloma, A. T., Jeffs, B., Ciruelo, D. P., de la Rosa, O., & Borchert, M. (2015). Ebola virus disease outbreak in Isiro, Democratic Republic of the Congo, 2012: Signs and symptoms, management and outcomes. *PLoS One, 10*(6) Doi: 10.1371/journal.pone.0129333			
World Health Organization. (2012e, August 17). *Emergencies preparedness, response Ebola outbreak in Democratic Republic of Congo.* Geneva Switzerland: World Health Organization			
Marburg virus	Kitumba, Kabale, Uganda	2012	35
Knust, B., Schafer, I. J., Wamala, J., Nyakarahuka, L., Okot, C., Shoemaker, T. . . . Rollin, P. E. (2012). Multidistrict outbreak of Marburg virus disease - Uganda, 2012. *The Journal of Infectious Diseases,* S1-S10. doi:10.1093/infdis/jiv351			
World Health Organization. (2012g, October 21). Emergencies preparedness, response Marburg haemorrhagic fever in Uganda. Retrieved from http://www.who.int/csr/don/2012_10_21/en/			
Zaire Ebola virus	Meliandou, Gueckedou Prefecture, Guinea	2013	25
Baize, S., Pannetier, D., Oestereich, L., Rieger, T., Koivogui, L., Magassaouba, N. . . . Gunther, S. (2014). Emergence of Zaire Ebola virus disease in Guinea. *The New England Journal of Medicine, 371*(15), 1418-1425. doi:10.1056/NEJMoa1404505			
Centers for Disease Control and Prevention. (2016b, March 31). 2014 ebola outbreak in West Africa. Retrieved from http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/index.html			
Gomes, M., Patore y Piontti, A., Rossi, L., Chao, D., Longini, I., Halloran, M., & Vespignani, A. (2014, September 2). Assessing the international spreading risk associated with the 2014 west African Ebola outbreak. *PLOS Current Outbreaks*, (Edition 1), May 11, 2016. Doi: 10.1371/currents.outbreaks.cd818f63d40e24aef769dda7df9e0da5			
World Health Organization. (2014c, March 23). Ebola virus disease in Guinea. Retrieved from http://www.afro.who.int/en/clusters-a-programmes/dpc/epidemic-a-pandemic-alert-and-response/outbreak-news/4063-ebola-virus-disease-in-guinea.html?tm			
World Health Organization. (2014d, March 28). Situation report 1 Ebola virus disease, Guinea, 28 March 2014. Retrieved from http://www.afro.who.int/en/clusters-a-programmes/dpc/epidemic-a-pandemic-alert-and-response/sitreps/4070-sitrep-1-ebola-guinea-28-march-2014.html			
World Health Organization. (2014e, August 8). Statement on the 1st meeting of the IHR emergency committee on the 2014 Ebola outbreak in west Africa. Retrieved from http://www.who.int/mediacentre/news/statements/2014/ebola-20140808/en/			

Table B1: Filoviruses data sourced, sources used for historical filovirus data (continued)

Filovirus Type (name)	Index Case City/Country (city, Country)	Outbreak Year	Data
Zaire Ebola virus cont.	Meliandou, Gueckedou Prefecture, Guinea	2013	25
World Health Organization. (2014f, August 29). WHO: Ebola response roadmap situation report 1. Retrieved from http://www.who.int/csr/disease/ebola/evd-sitrep1-20140828.pdf			
World Health Organization. (2014g, September 22). Study warns swift action needed to curb exponential climb in ebola outbreak. Retrieved from http://www.who.int/mediacentre/news/releases/2014/ebola-study/en/			
World Health Organization. (2014h, October 1). Ebola virus disease - united states of America. Retrieved from http://www.who.int/csr/don/01-october-2014-ebola/en/#			
Zaire Ebola virus	Inkanamongo village, Boende town, Equateur Province, DRC	2014	25a
Centers for Disease Control and Prevention. (2015, September 17). Ebola outbreaks 2000-2014. Retrieved from http://www.cdc.gov/vhf/ebola/outbreaks/history/summaries.html			
Maganga, G. D., Kapetshi, J., Berthet, N., Ilunga, B. K., Kabange, F., Kingebeni, P. M. . . . Leroy, E. M. (2014, November 27). Ebola virus disease in the democratic republic of Congo. *The New England Journal of Medicine, 371*(22), 2083-2091. doi:10.1056/NEJMoa1411099			
World Health Organization. (2014b). Global alert and response (GAR) democratic republic of Congo: "classic" ebola in a country experiencing its seventh outbreak. Retrieved from http://www.who.int/csr/disease/ebola/ebola-6-months/drc/en/			
World Health Organization. (2015b, January). Classical Ebola virus diseases in the democratic republic of Congo. Retrieved from http://www.who.int/csr/disease/ebola/one-year-report/drc/en/#			

Appendix C. Data Tables and Figures

Table C1. Bivariate correlation in reporting filovirus outbreak to the WHO 1967-2004

pwcorr spread cases deaths duration reportwho, bon obs sig star (5)

	spread	cases	deaths	duration	reportwho1
spread	1.0000				
	15				
cases	-0.1656	1.0000			
	1.0000				
	15	15			
deaths	-0.2057	0.9381*	1.0000		
	1.0000	0.0000			
	15	15	15		
duration	-0.0099	0.2027	0.2739	1.0000	
	1.0000	1.0000	1.0000		
	15	15	15	15	
reportwho1	-0.1103	0.0324	0.0841	0.9101*	1.0000
	1.0000	1.0000	1.0000	0.0002	
	13	13	13	13	13

Note. In this table, the listwise correlation between deaths and cases is r=0.9381. The asterisk indicates this is significant at the 0.05 level. Below the correlation is the probability at the $p < 0.001$ level. Below the probability is the observation number. Table was produced using Stata/IC 12.1 version statistical software.

Table C2. Bivariate correlation in reporting filovirus outbreak to the WHO 2005-2014

pwcorr spread cases deaths duration reportwho, bon obs sig star (5)

	spread	cases	deaths	duration	reportwho1
spread	1.0000				
	9				
cases	0.9997*	1.0000			
	0.0000				
	9	9			
deaths	0.9996*	1.0000*	1.0000		
	0.0000	0.0000			
	9	9	9		
duration	0.9450*	0.9430*	0.9424*	1.0000	
	0.0012	0.0014	0.0014		
	9	9	9	9	
reportwho1	-0.1159	-0.1021	-0.1046	0.0587	1.0000
	1.0000	1.0000	1.0000	1.0000	
	9	9	9	9	9

Note. In this table, the listwise correlation between deaths and spread is r=0.9996*. The asterisk indicates this is significant at the 0.05 level. Below the correlation is the probability at the $p < 0.001$ level. Below the probability is the observation number. Table was produced using Stata/IC 12.1 version statistical software.

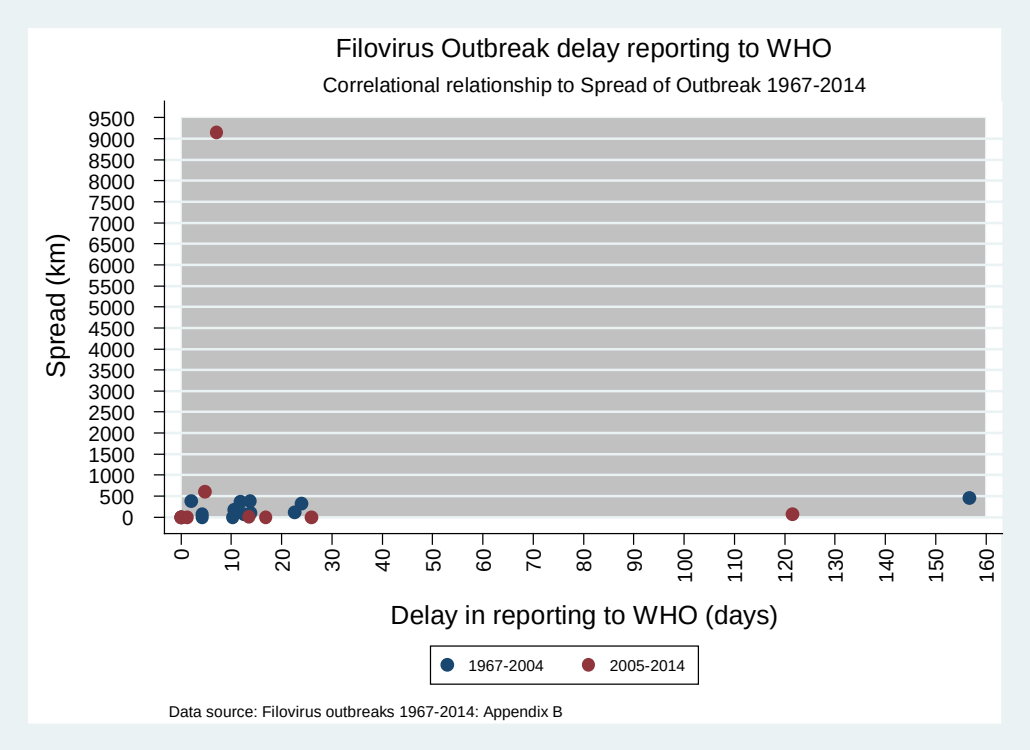


Figure C1. Bivariate correlation: the listwise correlation between spread and delay in reporting filovirus outbreak to the WHO

Scattergram graph shows a weak correlation between spread of disease (distance km) and delay in reporting outbreak to the WHO (time is in days). Scattergram graph is a pair wise correlation using Bonferroni multiple comparison procedure.

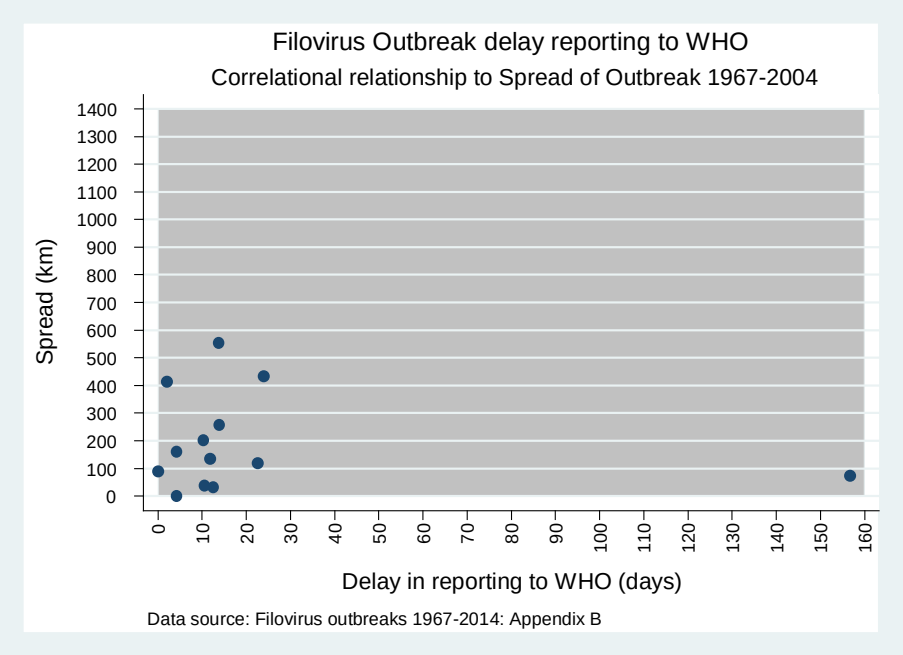


Figure C2. Bivariate correlation: the listwise correlation between spread and correlation between spread and delay in reporting filovirus outbreak to the WHO 1967-2004

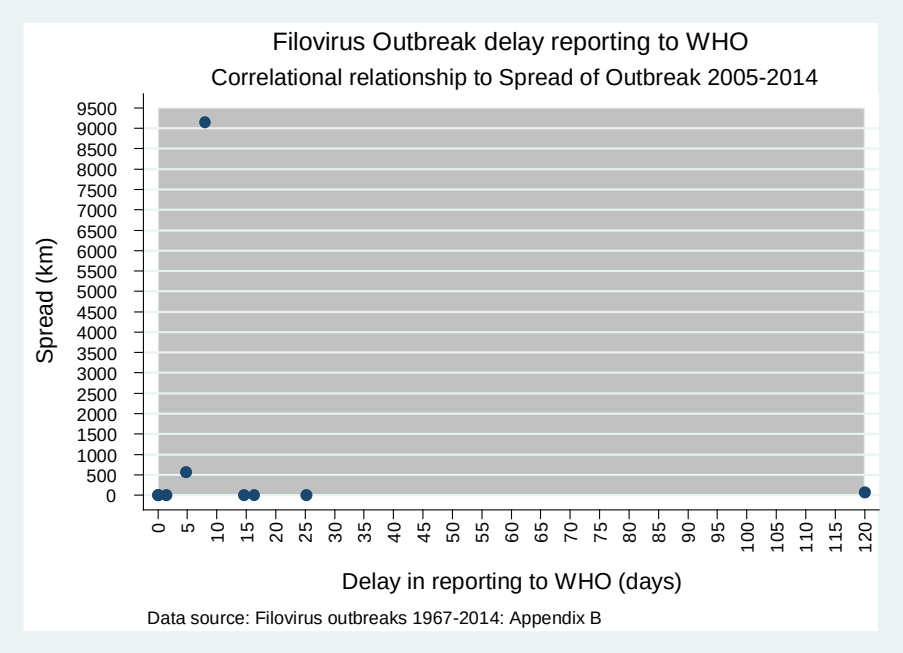


Figure C3. Bivariate correlation: the listwise correlation between spread and correlation between spread and delay in reporting filovirus outbreak to the WHO 2005-2014

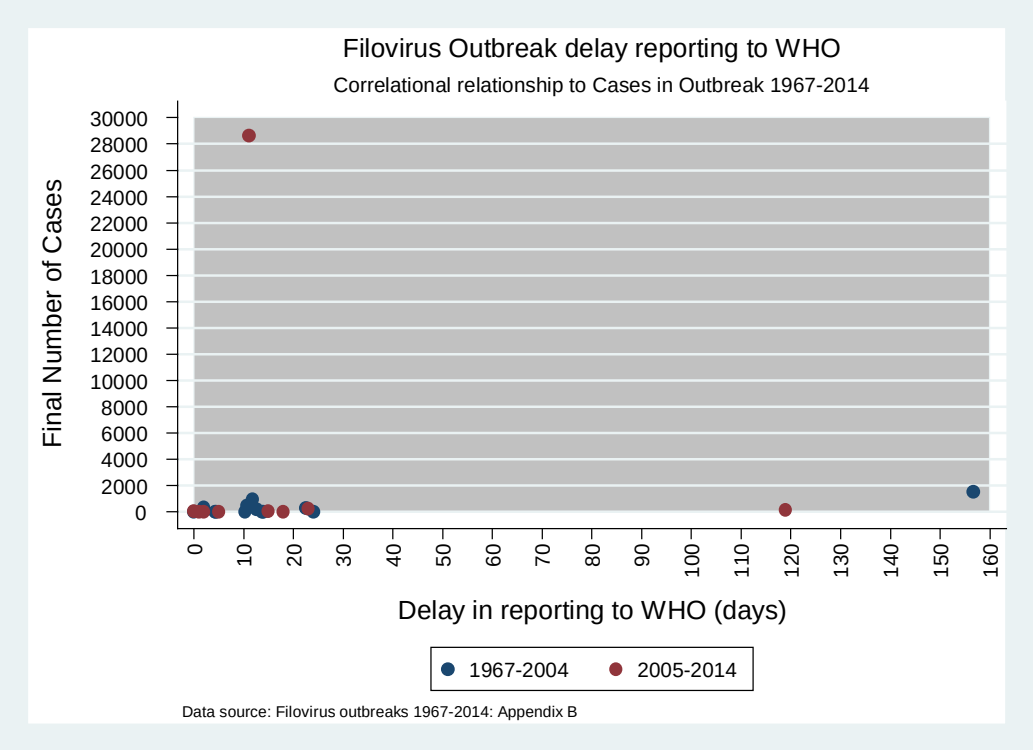


Figure C4. Bivariate correlation: the listwise correlation between final number of cases and delay in reporting filovirus outbreak to the WHO

Scattergram graph shows a weak correlation between final number of cases (count) and delay in reporting outbreak to the WHO (time is in days). Scattergram graph is a pair wise correlation using Bonferroni multiple comparison procedure.

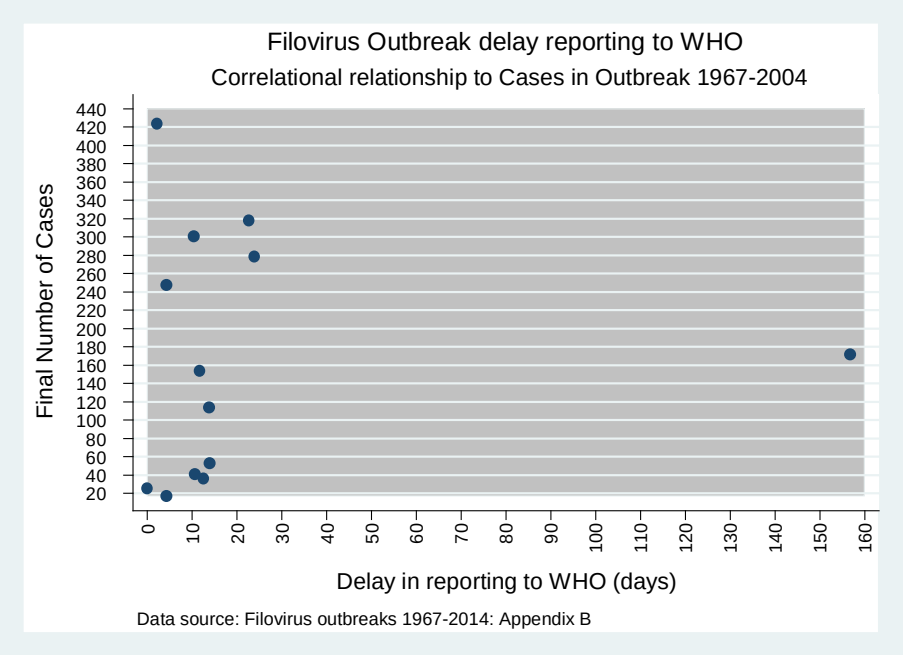


Figure C5. Bivariate correlation: the listwise correlation between cases and delay in reporting filovirus outbreak to the WHO 1967-2004

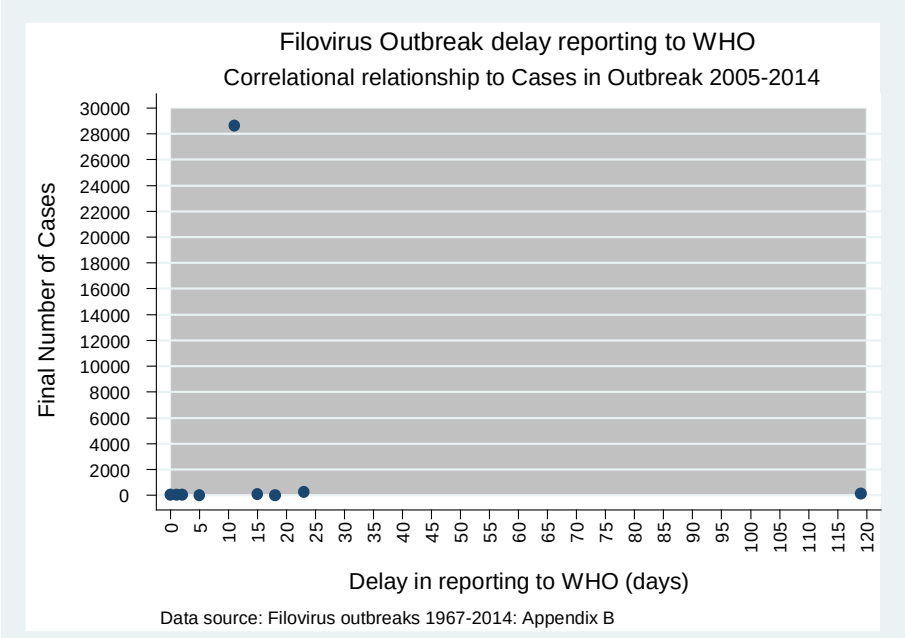


Figure C6. Bivariate correlation: the listwise correlation between cases and delay in reporting filovirus outbreak to the WHO 2005-2014

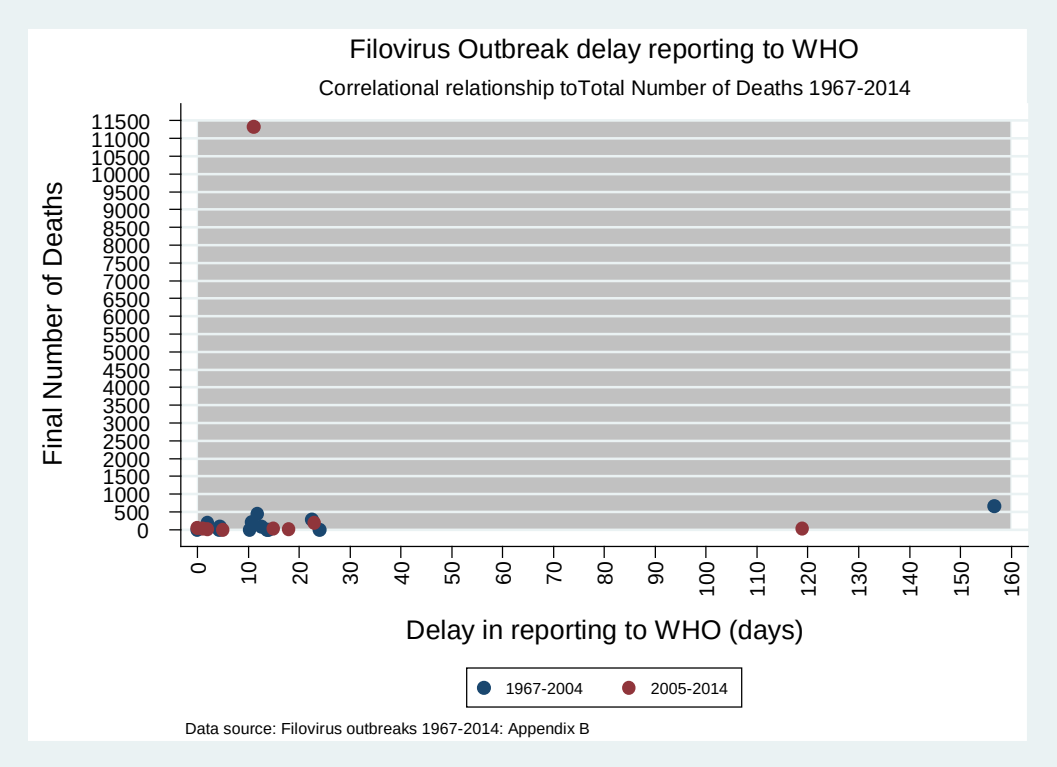


Figure C7. Bivariate correlation: the listwise correlation between final number of deaths and delay in reporting filovirus outbreak to the WHO

Scattergram graph shows a weak correlation between final number of deaths (count) and delay in reporting outbreak to the WHO (time is in days). Scattergram graph is a pair wise correlation using Bonferroni multiple comparison procedure.

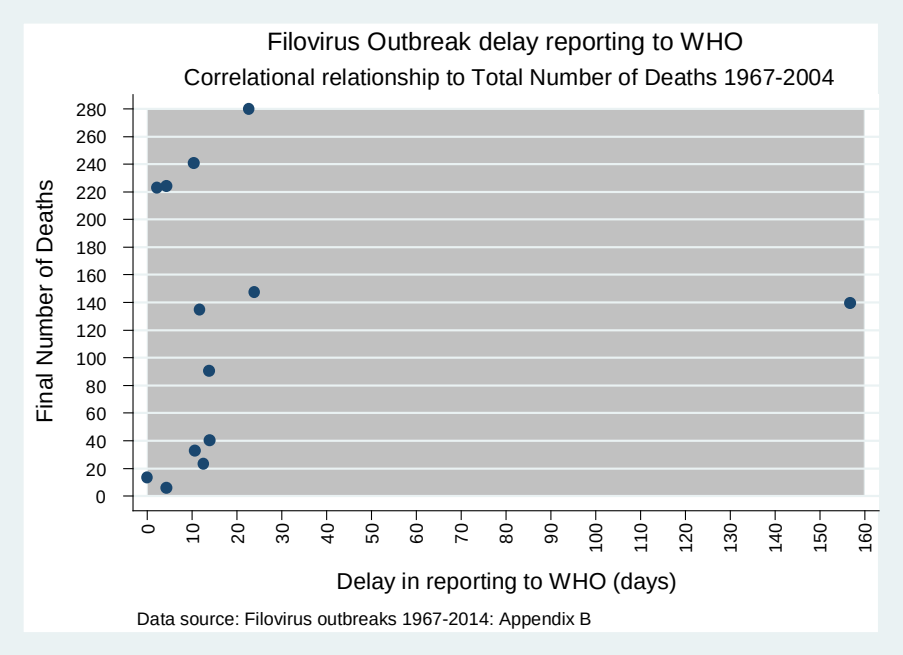


Figure C8. Bivariate correlation: the listwise correlation between deaths and delay in reporting filovirus outbreak to the WHO 1967-2004

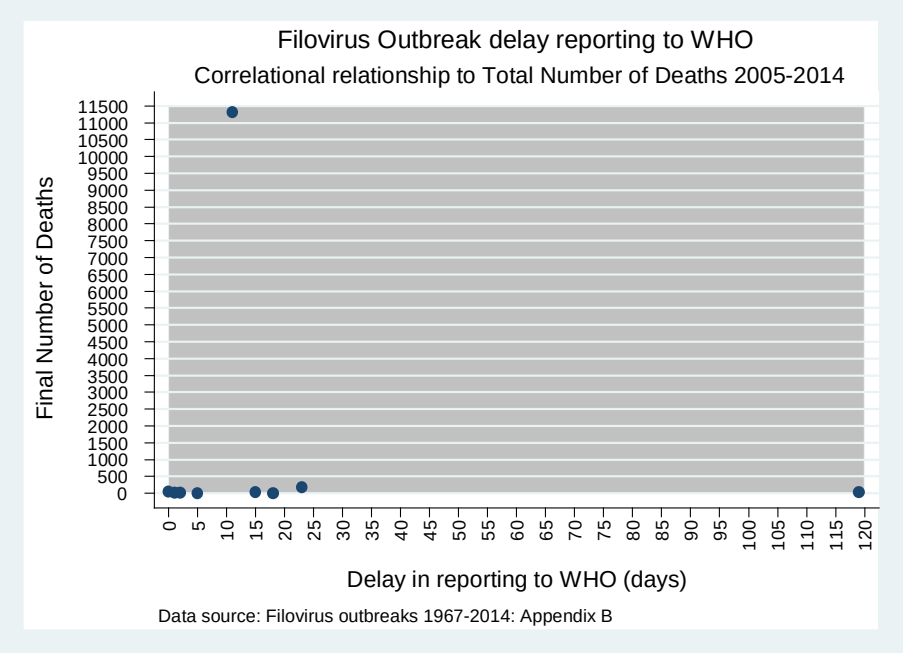


Figure C9. Bivariate correlation: the listwise correlation between deaths and delay in reporting filovirus outbreak to the WHO 2005-2014

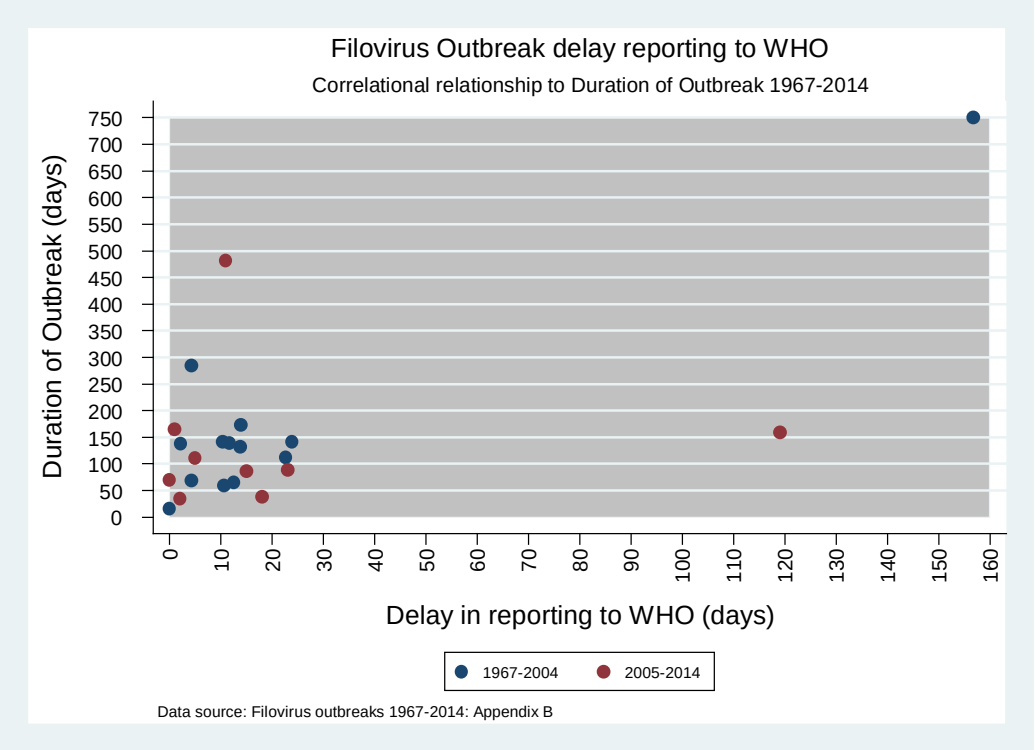


Figure C10. Bivariate correlation: the listwise correlation between duration of the outbreak and delay in reporting filovirus outbreak to the WHO

Scattergram graph shows a strong correlation between duration of outbreak (time span measured in days) and delay in reporting outbreak to the WHO (time is in days). Scattergram graph is a pair wise correlation using Bonferroni multiple comparison procedure.

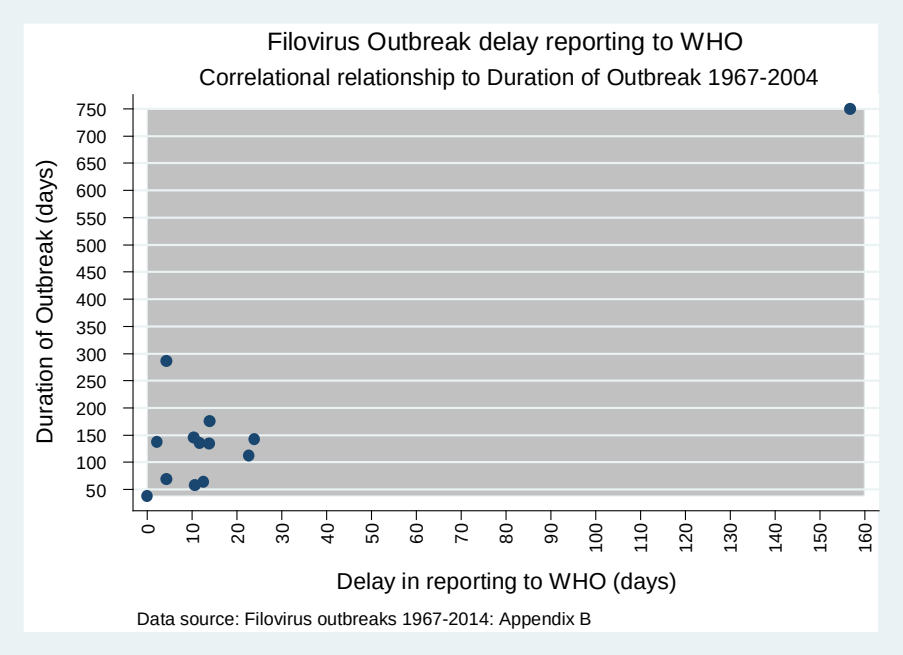


Figure C11. Bivariate correlation: the listwise correlation between duration and delay in reporting filovirus outbreak to the WHO 1967-2004

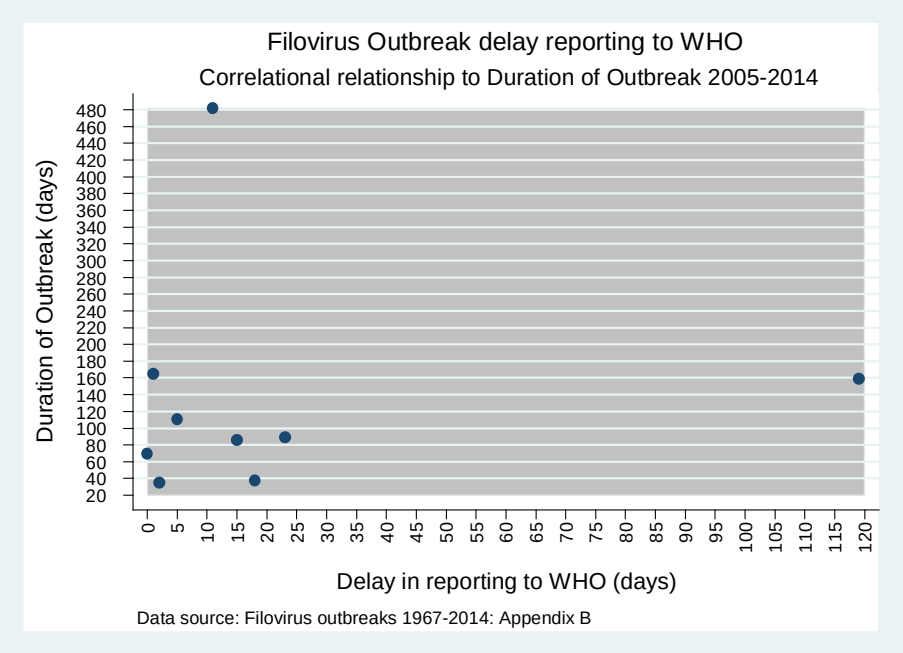


Figure C12. Bivariate correlation: the listwise correlation between duration and delay in reporting filovirus outbreak to the WHO 2005-2014

Note: Figures C1-C12 was produced using Stata/IC 12.1 version statistical software.

Table C3. Bivariate regression correlation in reporting filovirus outbreak to the WHO 1967-2014

Year	Number of Observations	F	Prob > F	R^2	Adj R^2	Root MSE	t	P>| t |	Beta
Bivariate regression correlation for spread									
1967-2004	13	0.14	0.7197	0.0122	-0.0776	937.83	-0.37	0.720	-0.1103
2005-2014	9	0.10	0.7665	0.0134	-0.1275	3220.5	-0.31	0.766	-0.1159
1967-2014	22	0.13	0.7260	0.0063	-0.0434	1972.7	-0.36	0.726	-0.0792
Bivariate regression correlation for cases									
1967-2004	13	0.01	0.9163	0.0010	-0.0898	141.63	0.11	0.916	0.0323
2005-2014	9	0.07	0.7939	0.0104	-0.1310	10128	-0.27	0.794	-0.1020
1967-2014	22	0.07	0.7984	0.0035	-0.0465	6220.7	-0.26	0.798	-0.0577
Bivariate regression correlation for deaths									
1967-2004	13	0.08	0.7847	0.0071	-0.0832	100.7	0.28	0.785	0.0841
2005-2014	9	0.08	0.7888	0.0109	-0.1303	3998	-0.28	0.789	-0.1046
1967-2014	22	0.07	0.7985	0.0033	-0.0465	2451.3	-0.26	0.799	-0.0577
Bivariate regression correlation for duration									
1967-2004	13	53.07	0.0000	0.8283	0.8127	78.18	7.28	0.000	0.9101
2005-2014	9	0.02	0.8807	0.0034	-0.1389	146.41	0.16	0.881	0.0587
1967-2014	22	13.62	0.0014	0.4052	0.3754	127.86	3.69	0.001	0.6365

Note. In this table, F= F test, R^2=R-squared, Adj R^2=adjusted R squared, Root MSE=root mean squared error, t=t test, P>|t|=probability level. Table data produced using Stata/IC 12.1 version statistical software.

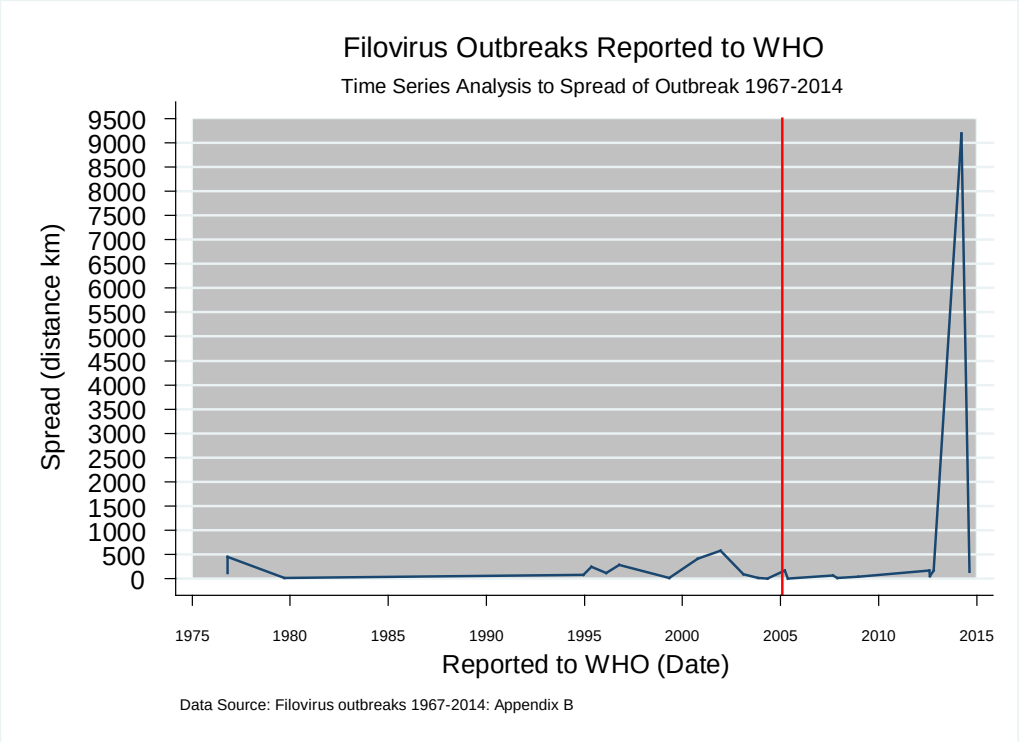


Figure C13. Multivariate time series graph, spread of the outbreak and delay in reporting filovirus outbreak to the WHO

Note: redline is amended IHR in 2005.

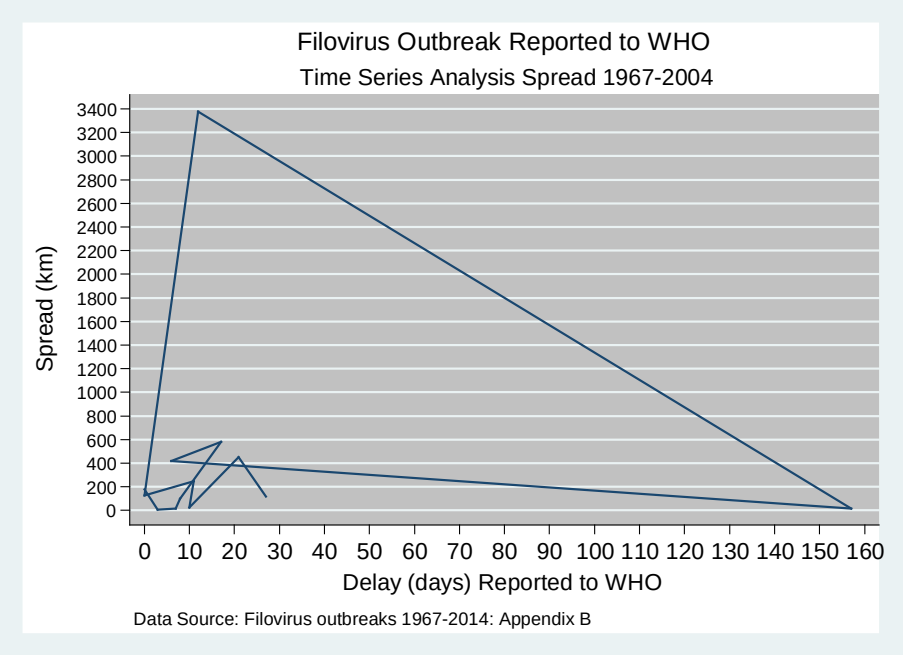


Figure C14. Linear regression graph, spread of the outbreak and delay in reporting filovirus outbreak to the WHO, pre IHR amendment, 1967-2004

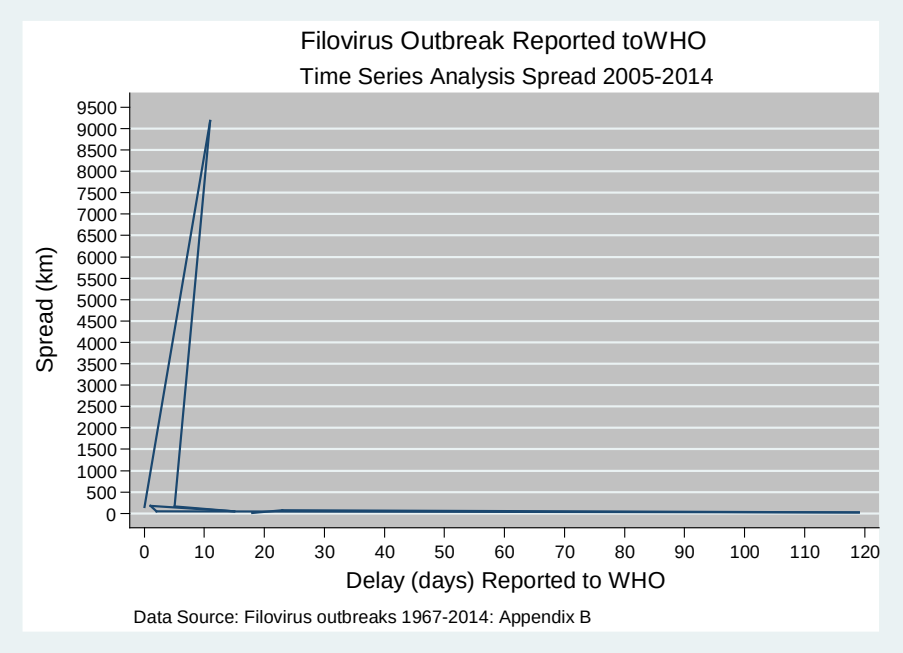


Figure C15. Linear regression graph, spread of the outbreak and delay in reporting filovirus outbreak to the WHO, post IHR amendment, 2005-2014

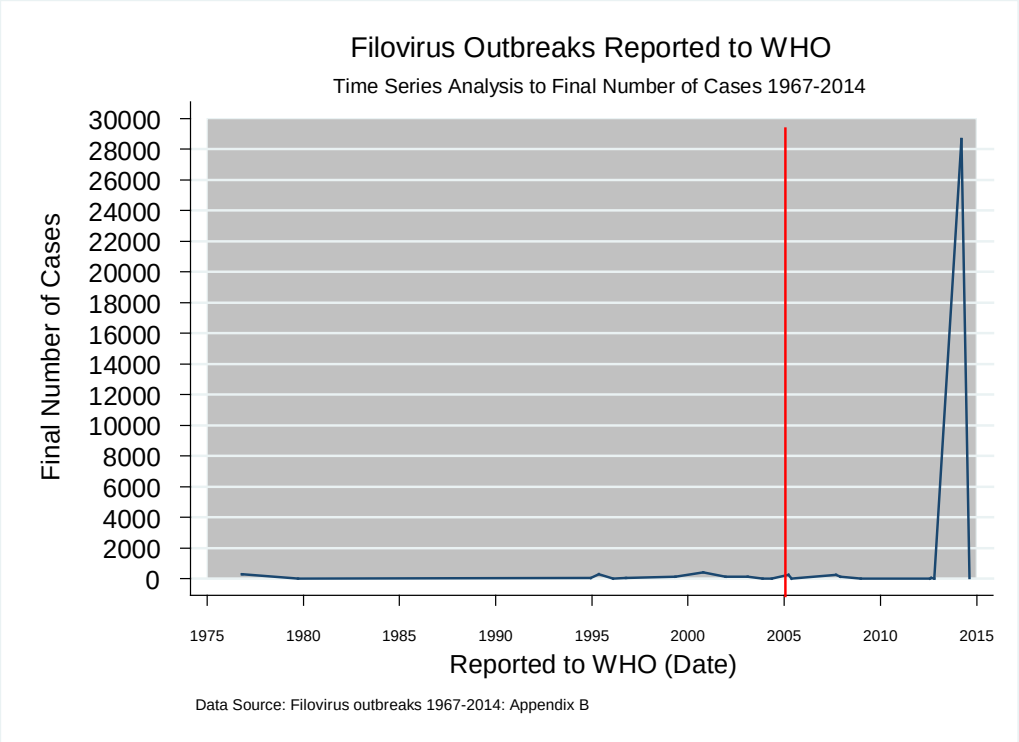


Figure C16. Multivariate time series graph, final number of cases of the outbreak and delay in reporting filovirus outbreak to the WHO.

Note: redline is amended IHR in 2005.

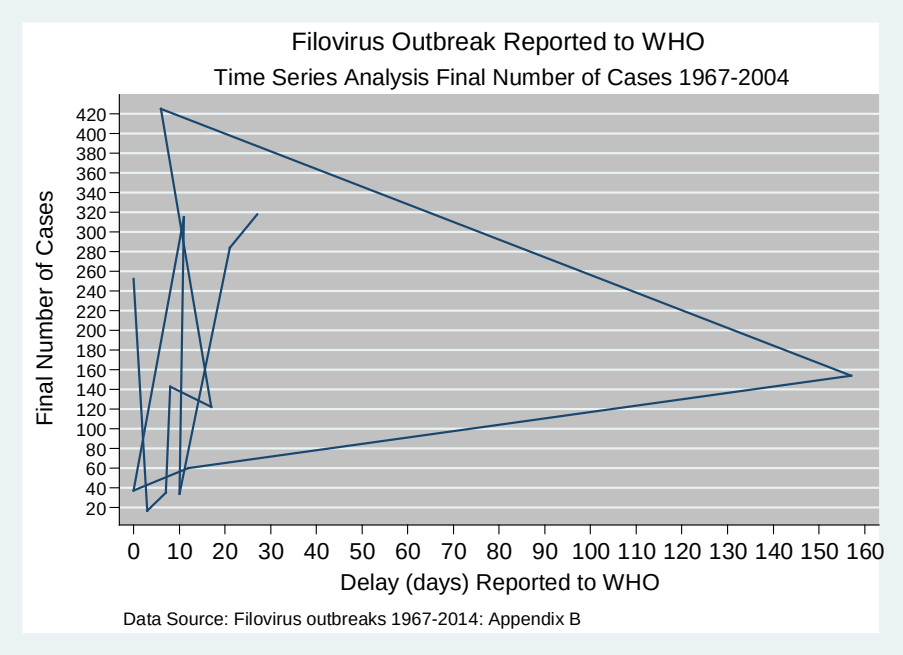


Figure C17. Linear regression graph, final number of cases of the outbreak and delay in reporting filovirus outbreak to the WHO, pre IHR amendment, 1967-2004

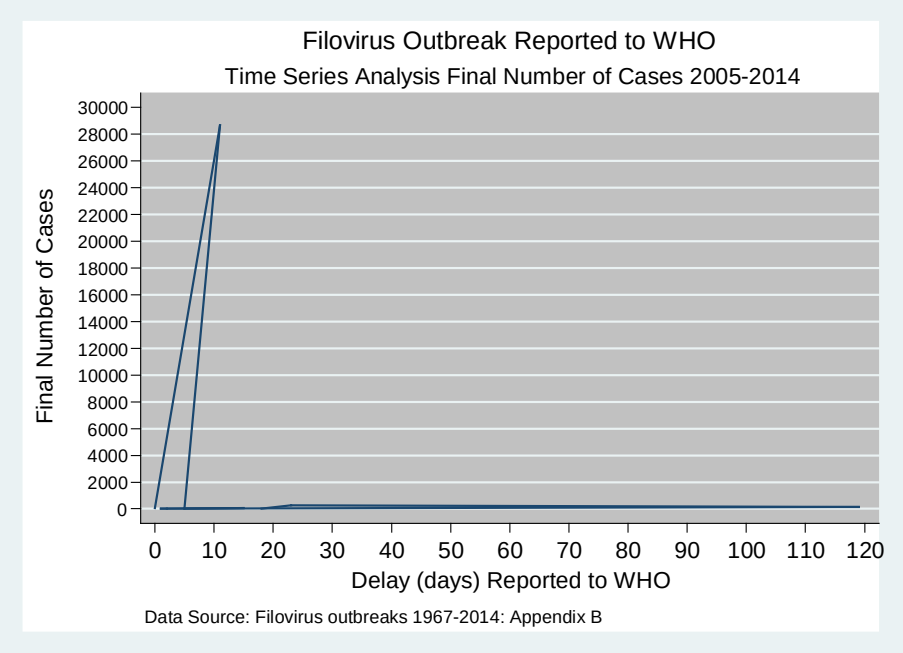


Figure C18. Linear regression graph, final number of cases of the outbreak and delay in reporting filovirus outbreak to the WHO, post IHR amendment, 2005-2014

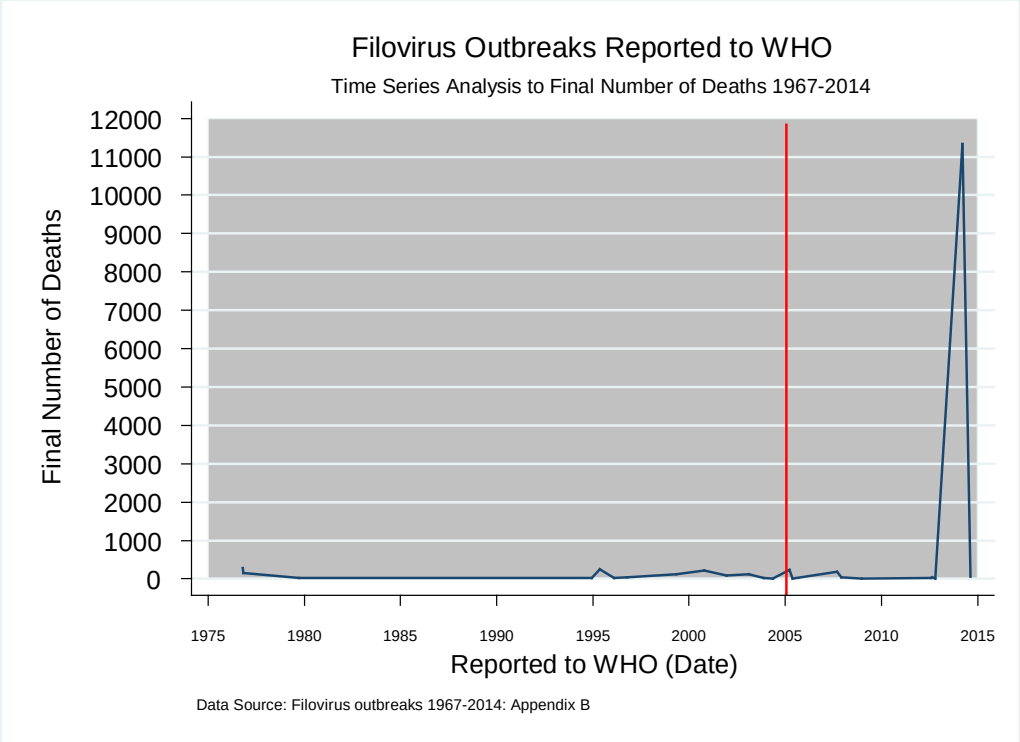


Figure C19. Multivariate time series graph, final number of deaths of the outbreak and delay in reporting filovirus outbreak to the WHO

Note: redline is amended IHR in 2005.

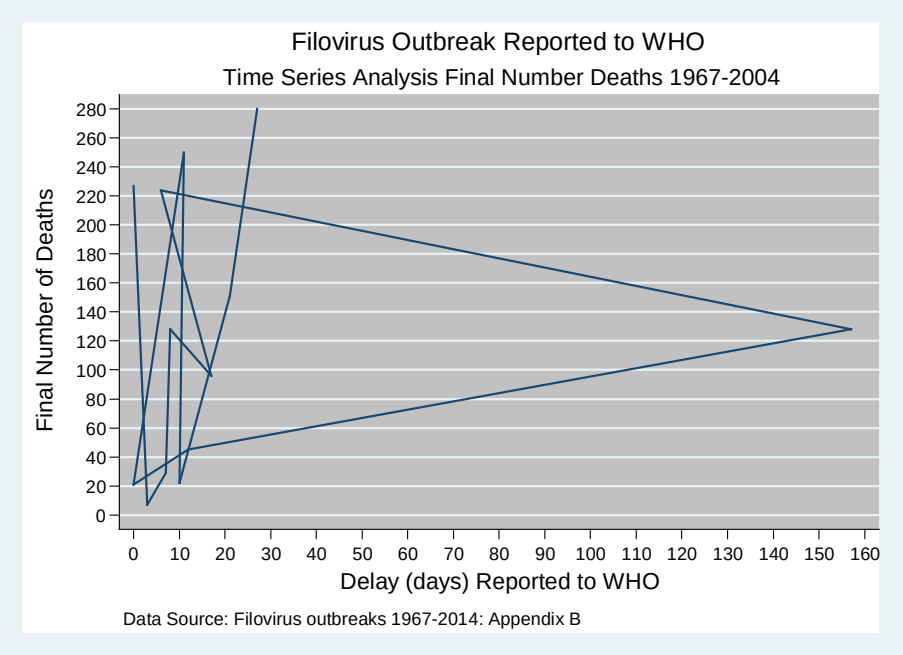


Figure C20. Linear regression graph, final number of deaths of the outbreak and delay in reporting filovirus outbreak to the WHO, pre IHR amendment, 1967-2004

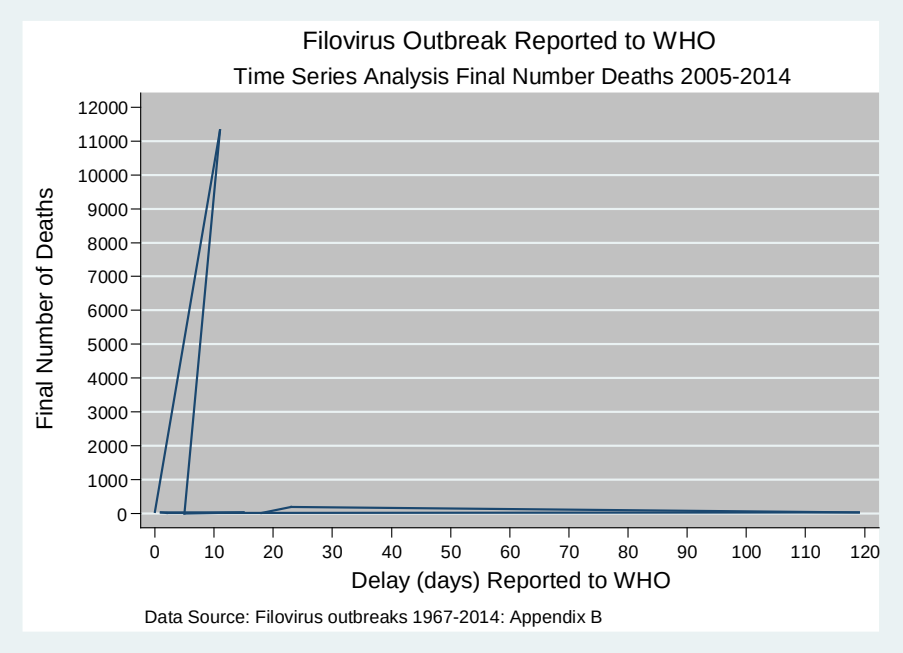


Figure C21. Linear regression graph, final number of deaths of the outbreak and delay in reporting filovirus outbreak to the WHO, post IHR amendment, 2005-2014

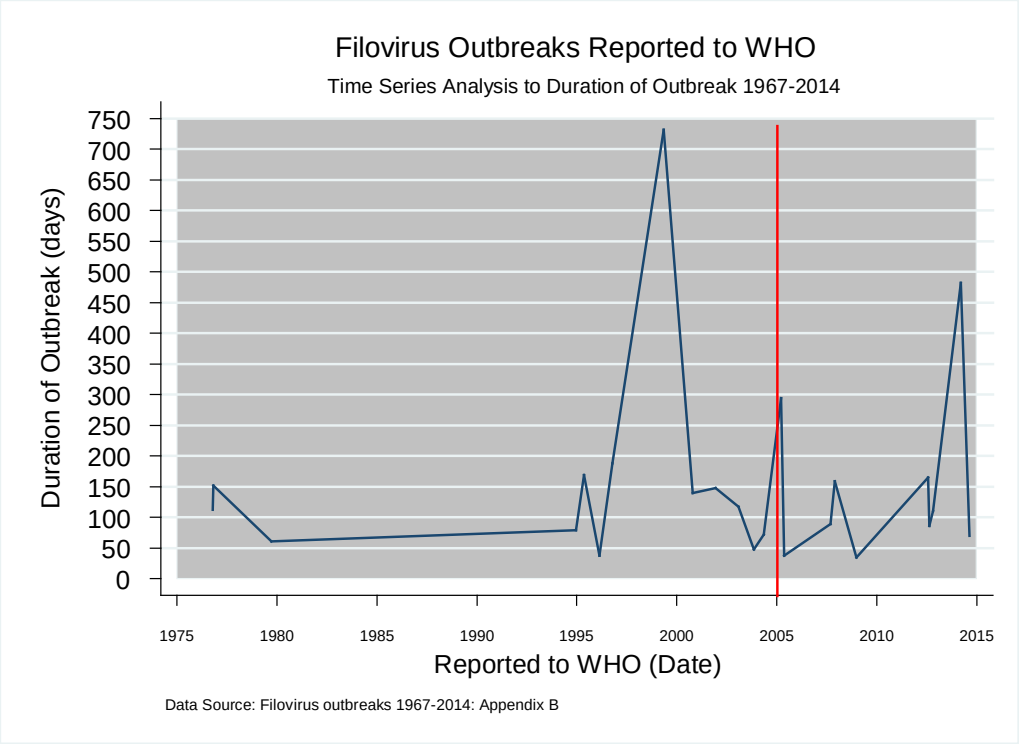


Figure C22. Multivariate time series graph, duration of the outbreak and delay in reporting filovirus outbreak to the WHO

Note: redline is amended IHR in 2005.

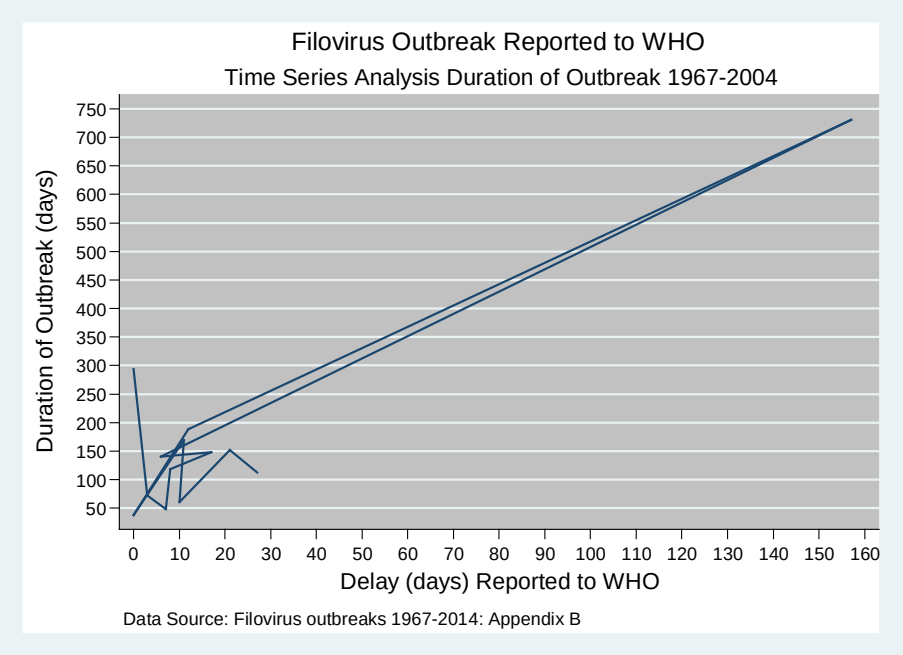


Figure C23. Linear regression graph, duration of the outbreak and delay in reporting filovirus outbreak to the WHO, pre IHR amendment, 1967-2004

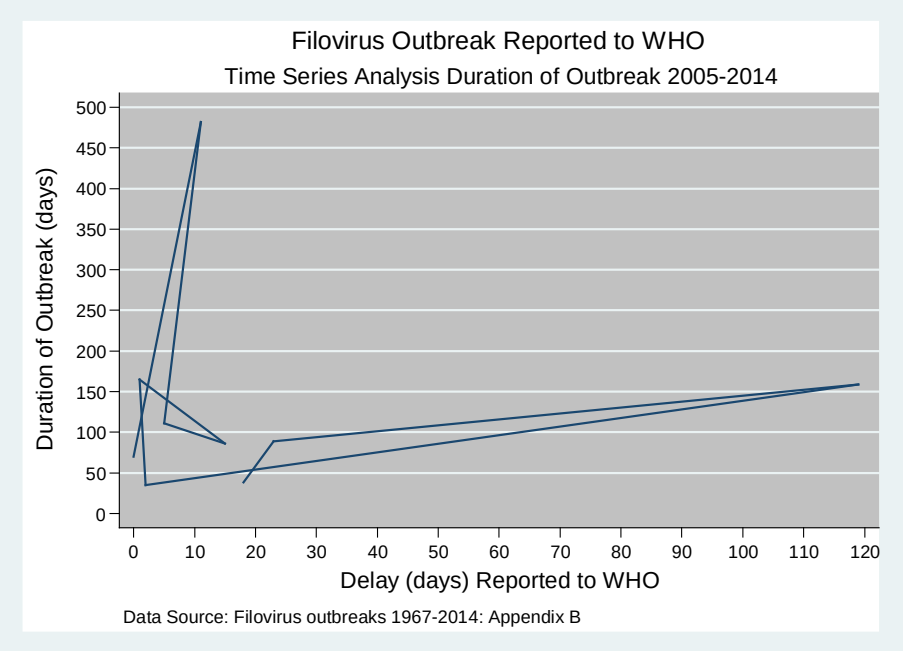


Figure C24. Linear regression graph, duration of the outbreak and delay in reporting filovirus outbreak to the WHO, post IHR amendment, 2005-2014

Note: Figures C13-C24 was produced using Stata/IC 12.1 version statistical software.

Table C4. Linear regression, delay in reporting filovirus outbreak to the WHO 1967-2014

Year	No. of Obs.	F	Prob > F	R^2	Adj R^2	Root MSE	t	P>| t |	Beta	Coef.	Std. Err.
Linear regression for spread											
1967-2004	13	0.14	0.719	0.012	-0.077	937.83	-0.37	0.720	-0.110	-2.403	6.52
2005-2014	9	0.10	0.766	0.013	-0.127	3220.5	-0.31	0.766	-0.115	-9.392	30.41
Linear regression for cases											
1967-2004	13	0.01	0.916	0.001	-0.089	141.63	0.11	0.916	0.032	0.105	0.98
2005-2014	9	0.07	0.793	0.010	-0.131	10128	-0.27	0.794	-0.102	-25.97	95.66
Linear regression for deaths											
1967-2004	13	0.08	0.784	0.007	-0.083	100.7	0.28	0.785	0.084	0.196	0.70
2005-2014	9	0.08	0.788	0.010	-0.130	3998	-0.28	0.789	-0.104	-10.51	37.76
Linear regression for duration											
1967-2004	13	53.07	0.000	0.828	0.812	78.18	7.28	0.000	0.910	3.963	0.54
2005-2014	9	0.02	0.880	0.003	-0.138	146.41	0.16	0.881	0.058	0.215	1.382

Note. In this table, No.=number, Obs =observations, F= F test, R^2=R-squared, Adj R^2=adjusted R squared, Root MSE=root mean squared error, t=t test, P>|t|=probability level, Coef. =coefficient, Std. Err. =standard error. Table data produced using Stata/IC 12.1 version statistical software.

Table C5. Descriptive Statistics, variables spread, case, deaths, duration, and delay in reporting for filovirus outbreaks 1967-2014

	Mean	Median	Standard Deviation	Minimum	Maximum	Skewness
Spread 1967-2004	474.27	127	877.37	5	3378	2.69
Spread 2005-2014	1097.77	70	3032.96	9	9184	2.47
Cases 1967-2004	151.93	122	133.42	17	425	0.678
Cases 2005-2014	3255.67	66	9523.97	12	28652	2.47
Deaths 1967-2004	109.73	96	96.96	7	280	0.49
Deaths 2005-2014	1298.33	36	3760.41	4	11325	2.47
Duration 1967-2004	164.33	118	169.62	38	731	2.69
Duration 2005-2014	137.22	89	137.18	35	482	1.97
Delay in Reporting 1967-2004	21.46	10	41.48	0	157	2.98
Delay in Reporting 2005-2014	21.56	11	37.43	0	119	1.97

Note: The descriptive statistics for each variable was analyzed by pre (1967-2002) and post (2005-2014) IHR amendment. Skewness represents the third moment of the distribution (positive value is a positive skew; negative value is a negative skew). Table data produced using Stata/IC 12.1 version statistical software.

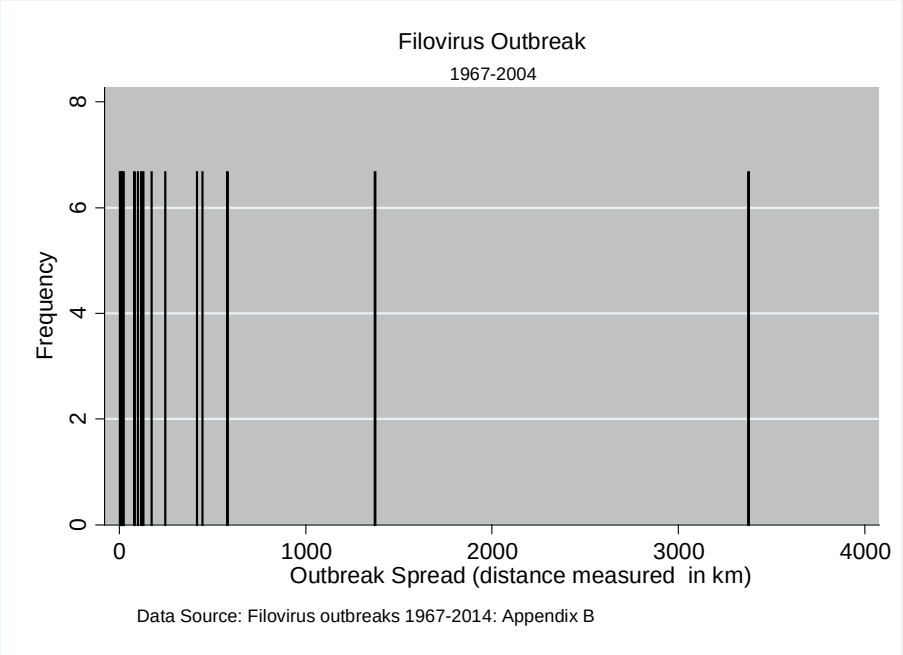


Figure C25. Frequency, filovirus outbreak to outbreak spread 1967-2004

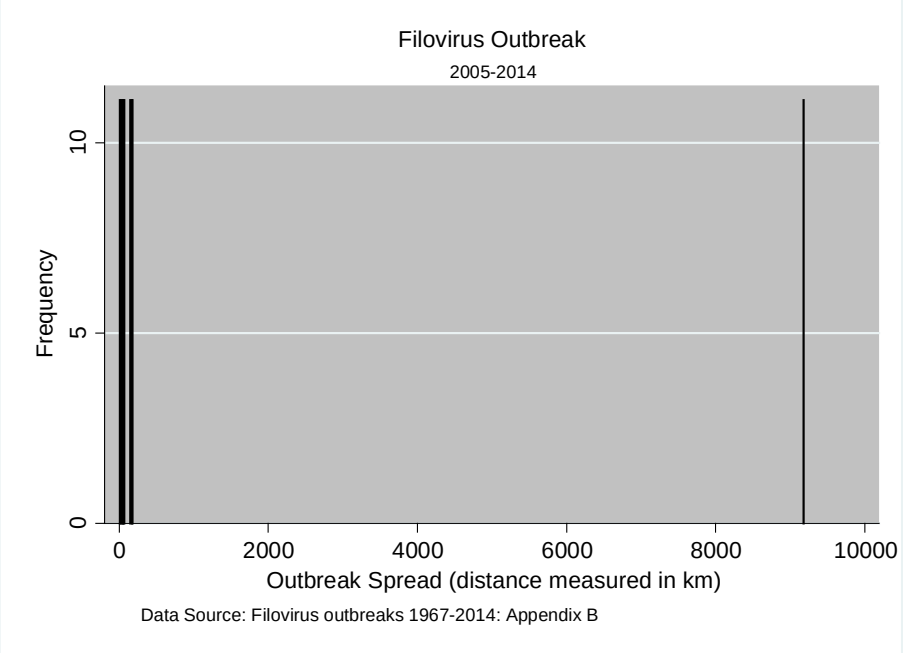


Figure C26. Frequency, filovirus outbreak to outbreak spread 2005-2014

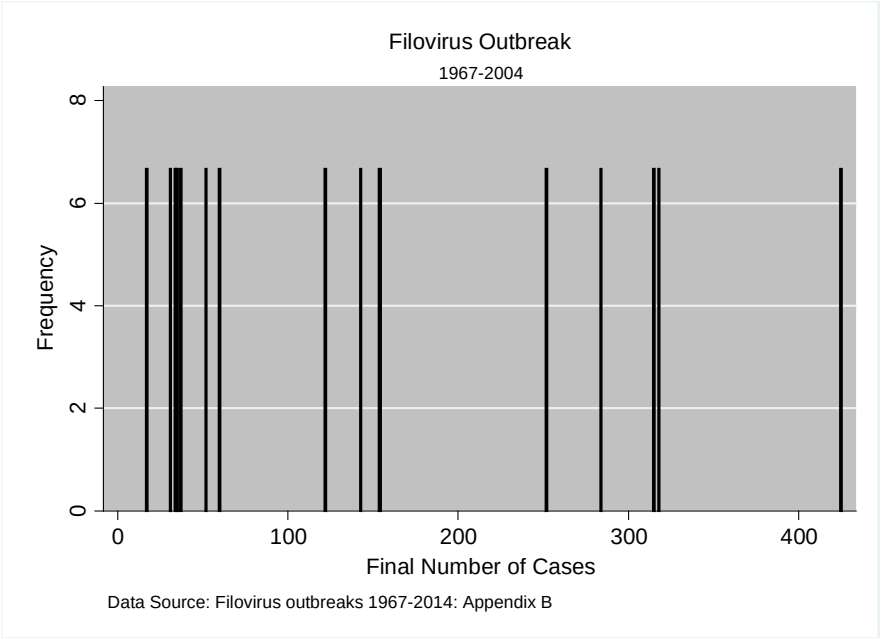


Figure C27. Frequency, filovirus outbreak to final number of cases 1967-2004

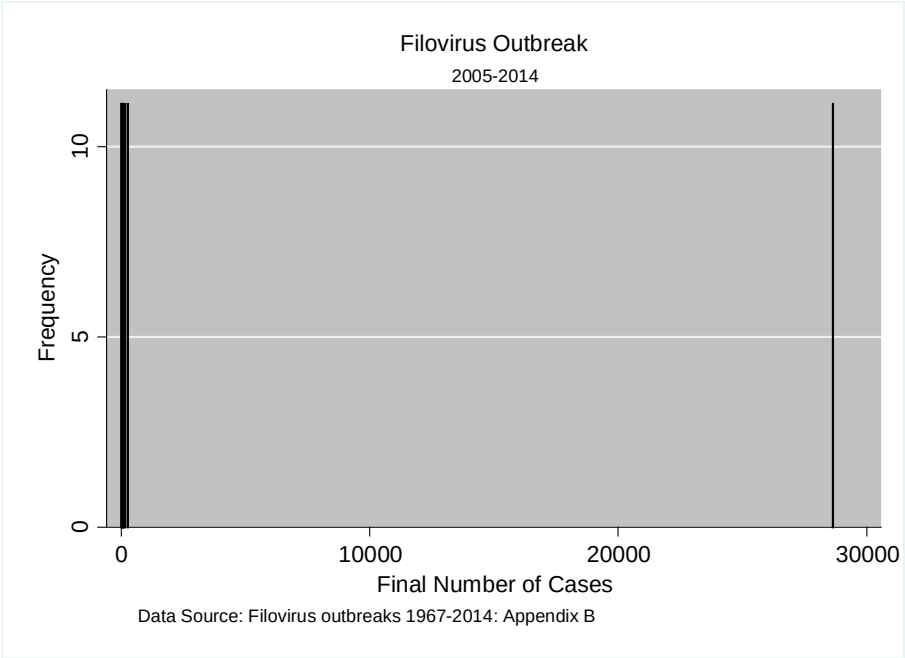


Figure C28. Frequency, filovirus outbreak to final number of cases 2005-2014

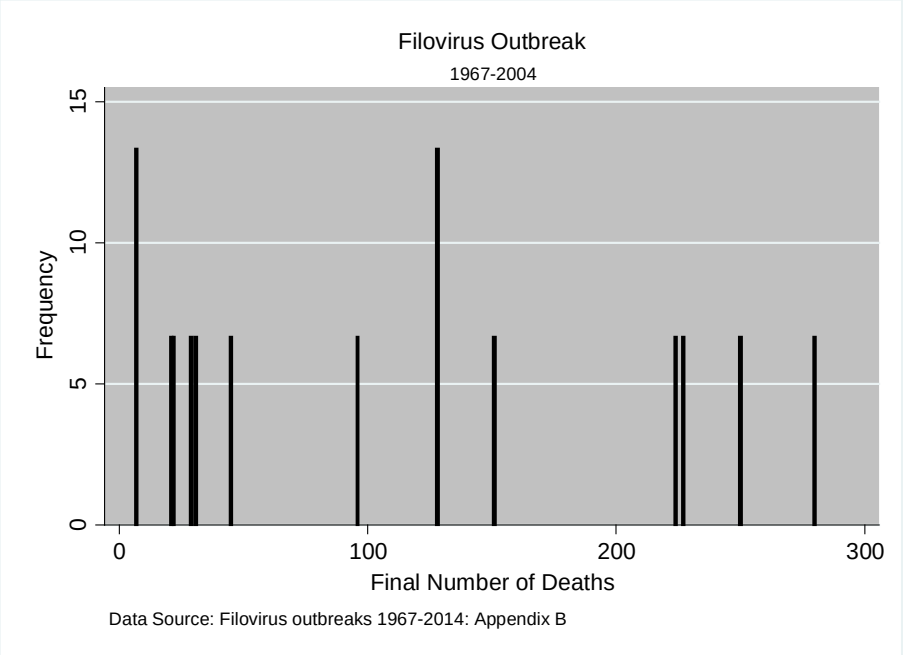


Figure C29. Frequency, filovirus outbreak to final number of deaths 1967-2004

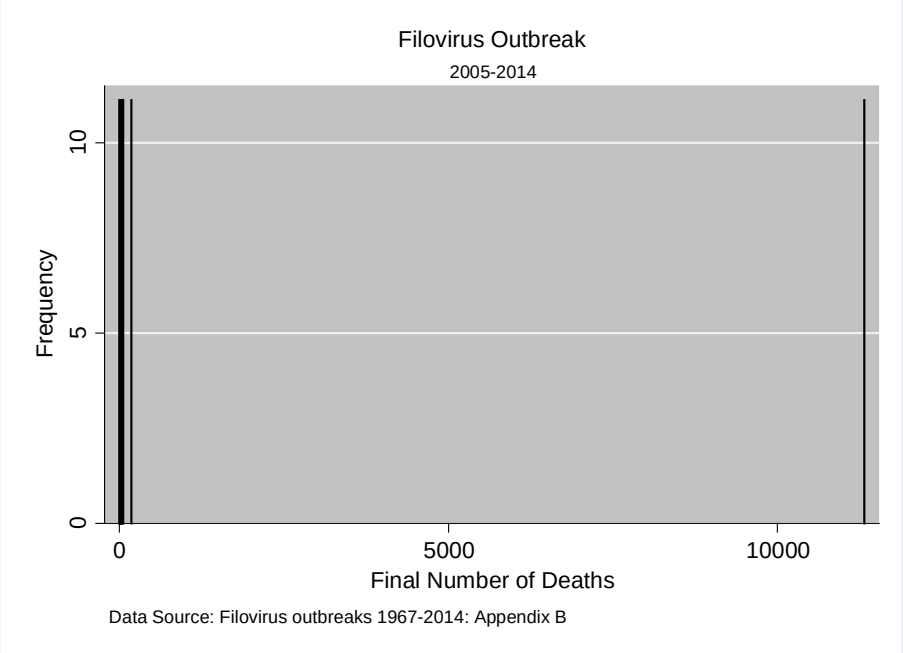


Figure C30. Frequency, filovirus outbreak to final number of deaths 2005-2014

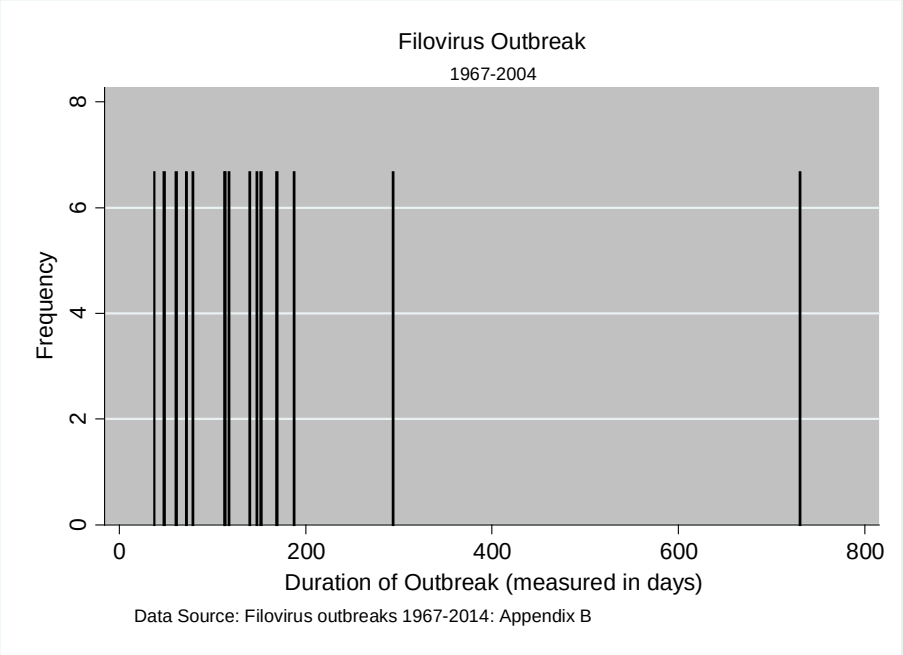


Figure C31. Frequency, filovirus outbreak to duration of outbreak 1967-2004

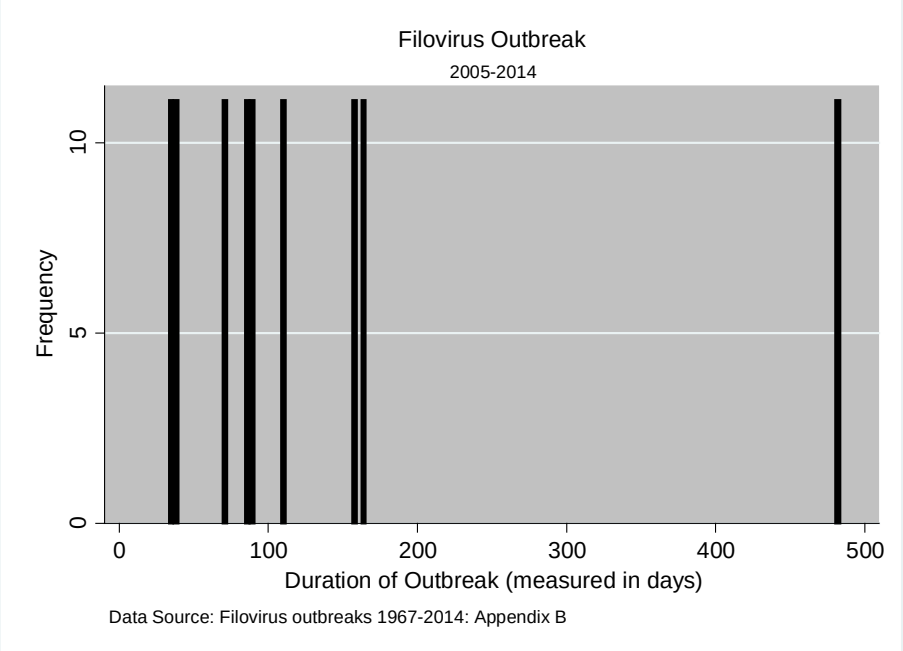


Figure C32. Frequency, filovirus outbreak to duration of outbreak 2005-2014

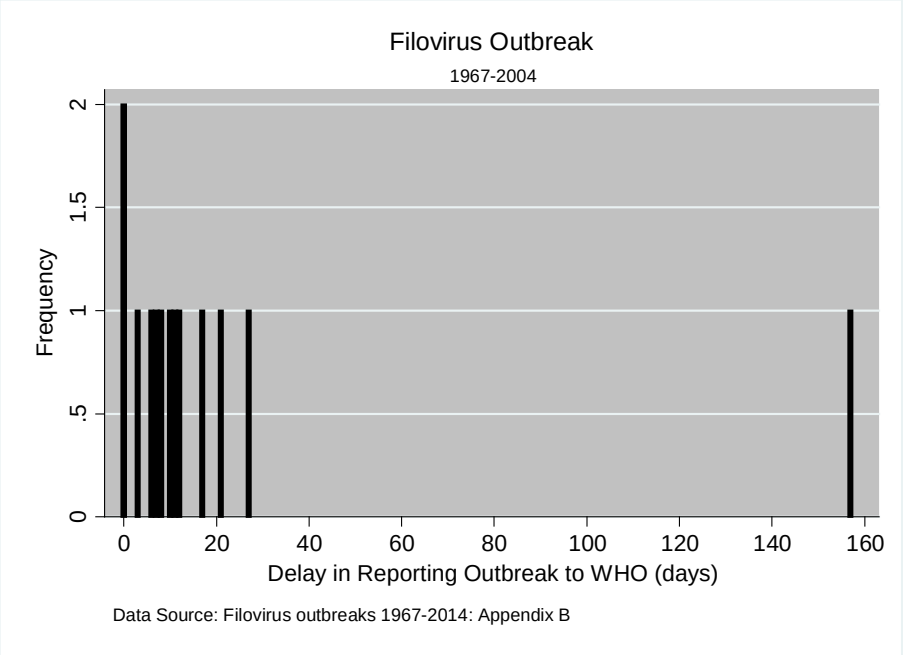


Figure C33. Frequency, filovirus outbreak to delay in reporting of outbreak 1967-2004

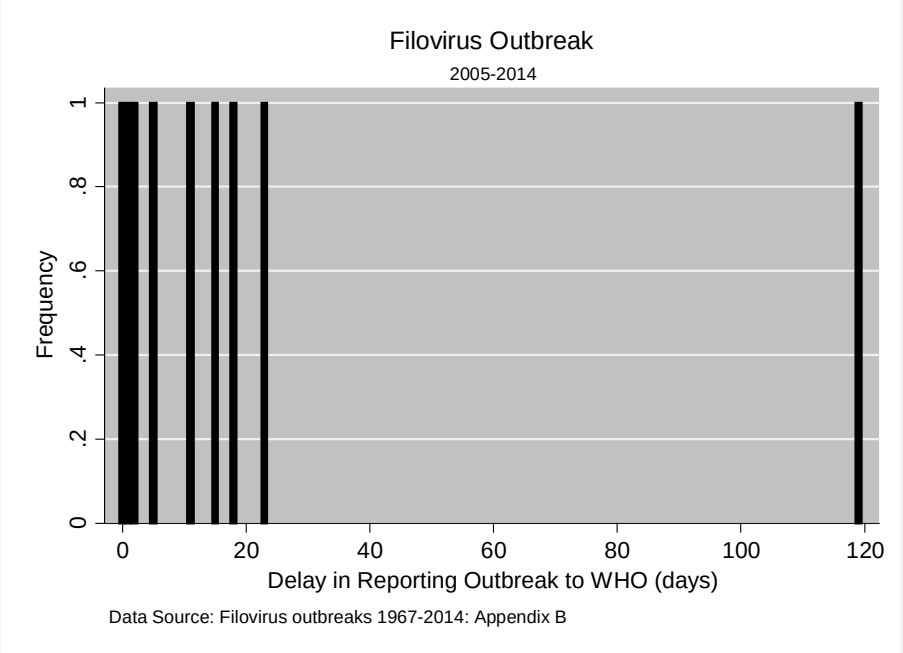


Figure C34. Frequency, filovirus outbreak to delay in reporting of outbreak 2005-2014

Note: Figures C25-34 was produced using Stata/IC 12.1 version statistical software.